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Cooling India

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Annual 2018

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Publisher's Letter

Hello and welcome once again to **Cooling India**, the leading monthly magazine on the HVACR industry in the country. I wish you all a Happy New Year.

Here, we would like to begin the New Year on a positive note with forecast on Indian HVAC Market. As per TechSci Research, the HVAC market in India is projected to reach USD 3.97 billion by 2019. This projection is anticipated due to growth trajectory in retail, hospitality and commercial sectors, significantly giving a boost to the demand for HVAC systems in the country. These sectors require large-scale application of these systems in organized retail outlets, shopping complexes, hotels, etc. Apart from this, with an expected growth in FDI (Foreign Direct Investment), several international players have evinced their interest in the Indian retail market.

Further, CRISIL Research estimates the cold chain industry to log a compound annual growth rate (CAGR) of 14-16% over the five fiscals through 2022, to about ₹ 500 billion from ₹ 250 billion in 2017. Bulk of the growth would be in the Temperature Controlled Warehouse (TCW) segment, which accounts for 90% of the industry revenue. Within this segment, multi-purpose cold storages dominate, and their share of segment revenue is estimated to rise from 77-79% in fiscal 2016 to 84-86% by fiscal 2022.

Moving ahead, in this Annual issue, we trace the history of technological advancements of cooling towers in industrial applications. In the article *Asphyxiation Accidents in Refrigeration*, the author explores asphyxiation as a personal safety hazard associated with refrigeration. Insightful article *Ameliorating Value Chain by Food Processing* suggests that the farmers are now growing more number of crops in a year in order to get periodic and expecting higher income. A shift from cultivation to market needs to be urgently transformed to market to cultivation to prevent gluts and prevent market prices below cultivation costs periodically.

While giving a glimpse of green building sector in *India as an Engine of Green Growth*, the author expects that the rate of green building in India is also only expected to grow over the coming years. According to the Dodge Data & Analytics World Green Building Trends 2016 SmartMarket report, global green building is expected to double every three years and emerging economies like China, India and Brazil will be engines of green growth.

Hope you enjoy reading this issue as much as we have in putting this together for you. Do send in your comments to me at pravita@charypublications.in.

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Danfoss to Open 3000m² Flammable Refrigerant Compressor Testing Center

Danfoss will extend its existing ATEX (Atmosphere Explosive) compressor testing laboratory in March 2018. Located in Trevoux, France, the 3000m² facility will be a strategic asset for the transition to flammable refrigerants.The strategic investment is a response to the growing use of flammable, lower-GWP refrigerants in air conditioning and refrigeration systems. It ensures Danfoss can replicate its full suite of lab tests with refrigerants upto A3 class, and support customers moving to A2L / A3 flammable alternatives. Six times the size of the Danfoss's existing ATEX laboratory, the center will have over 50 testing benches, capable of compressor tests from 0.5 to 60 TR and compressor manifold tests from 0.5 up to 240 TR per circuit. The plan includes performance testing rooms for energy, capacity, and acoustic testing—as well as reliability rooms for oil and endurance tests.

"More and more, the HVAC-R industry is turning to flammable refrigerants as it seeks to reduce Global Warming Potential (GWP) levels and the environmental impact of our industry. We're ready to support that move," says Noel Ryan, President for Danfoss Commercial Compressors.

"That transition to alternative refrigerants is quickening, so we at Danfoss are accelerating our own development to meet the new demand. Danfoss' first batch of DSF Scroll compressors with Intermediate Discharge Valves (IDVs) for use with A2L refrigerants shall be released in the second quarter of 2018. We expect most of our major air conditioning components to also qualify at the same time," he adds. ■

Carrefour, Partner of a Study into Low-Carbon Solutions

As well as committing to reducing its carbon emissions by 40% between now and 2025, Carrefour is also playing a key role in getting the consumer goods sector to limit global warming to 2°C. At the One Planet Summit, two years after the Paris climate change agreement was adopted, Carrefour and other members of the Consumer Goods Forum have just published a study into low-carbon solutions for the consumer goods sector. The study sets out to ensure that they are adopted by as many stakeholders as possible, thus, reducing the sector's carbon footprint.

These companies are taking concrete action to reduce their carbon footprints by:

- Using active and passive energy efficiency solutions;
- Using renewable energies – particularly, solar and geothermal;
- Systematically reducing greenhouse gas emissions throughout the lifecycles of their products;
- Developing new materials and low-carbon solutions;
- Reducing food wastage and packaging;
- Adopting long-term investment strategies that actively encourage the energy transition.

As a major player in the retail sector, in 2015 Carrefour implemented a low-carbon strategy designed to slash its CO2 emissions by 40% between now and 2025, and by 70% between now and 2050 (compared with 2010 levels). At the same time, the retailer is working alongside its competitors and partners on transforming modes of production and consumption.

Alexandre Bompard, Chairman and Chief Executive Officer of the Carrefour Group says: "The climate change challenge calls for a global transition from all sectors, and all value chains in order to limit global warming between 1.5°C and 2°C. From this point of view, our competitors are also partners with whom we can, and must, share the most relevant solutions." ■

Air Conditioning Market in India to Grow at a CAGR of 10.3%

The air conditioning market in India is forecast to grow at a CAGR of 10.39% during the period 2017-2021. The report, Air Conditioning Market in India 2017-2021, has been prepared based on an in-depth market analysis with inputs from industry experts. The report covers the market landscape and its growth prospects over the coming years. The report also includes a discussion of the Key vendors operating in this market.

The latest trend gaining momentum in the market is the increased demand for solar-powered ACs. The most effective way of reducing power shortage is to reduce the load on the power supply. Consumers have started investing in energy-efficient products, which consume less power. This shortage of power has led many vendors to invest in R&D and energy-efficiency products like solar-powered ACs.

According to the report, one of the major drivers for this market is the increase in electronic retail stores and e-commerce. Electronic retail stores are organized stores where electronic goods of different brands are available. These stores are expected to grow at a CAGR around 2% during the forecast period. Indian consumers demand stores that offer a good ambience, multiple brands, and correctly priced goods under one roof. The increase in changing lifestyle and rise in the income of consumers are driving the electronic retail market in India. The increase in financial services and easy payment modes are the other attributes increasing the volume sales of ACs at electronic retail stores. ■

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Steggles Fined $84,000 after Equipment Failures Causes Ammonia Leak

The Land and Environment Court has convicted and fined Steggles Foods Mt Ku-ring-gai Pty Ltd $84,000 after a fault with the company's refrigeration system caused an ammonia gas leak, causing harm to two company employees on 3 December 2015.

Two workers were exposed to the escaping ammonia gas, which can be toxic to humans. As there were concerned about the health of one of the workers, he was taken to the nearby Hornsby Hospital for further assessment and treatment. He sustained abdominal and chest burning, breathlessness, eye irritation, light-tenderness and nausea. NSW Fire and Rescue officers required personal protective equipment, including safety breathing apparatus, to enter the refrigeration compressor room and identify and stop the source of the ammonia leak.

It took two attempts to stop the leak, which was eventually fixed when nuts and bolts were replaced and a faulty gasket repaired. Steggles holds an environment protection licence, issued to it by the NSW Environment Protection Authority (EPA), to process livestock and produce general animal products at their Mundowi Road Ku-ring-gai factory. The leak occurred in a compressor unit, which operates one of the factory's refrigeration systems.

The ammonia gas leak occurred when a nut used to secure a bolt on a flange joint was not attached, and a gasket used to secure that flange joint on a discharge pipe failed. Each of these mechanical faults arose from failures on behalf of Steggles to maintain the equipment in a proper and efficient manner – a requirement of Steggles' environment protection licence. ■

Mitsubishi Electric to Open Factory for Room Air Conditioners in Turkey

Mitsubishi Electric Corporation announced that the new factory of Mitsubishi Electric Turkey Klima Sistemleri Üretim Anonim Şirketi, designed for the development and manufacture of room air conditioners in Turkey, will commence production on December 12.

Mitsubishi Electric aims to expand business in Turkey and Europe, where the demands for room air conditioners are expected to increase. Annual production of 500,000 sets (indoor and outdoor units) is targeted by the fiscal year ending March 2021.Mitsubishi Electric's air conditioning and refrigeration-systems business in Europe is expanding steadily and the demand in Turkey expected to increase in line with the country's economic and population growth. The new factory is expected to play a key role in accelerating localization to ensure a flexible supply chain capable of responding to fluctuating demands and meeting specific local market, preferences and environmental requirements in both Turkey and Europe.■

EPA Proposes Rule to Boost HC Charge Limit for Household Fridges

The US Environmental Protection Agency (EPA) is proposing to increase the charge limit for propane, isobutane and R441A to 150 g from 57 g in new household refrigerators and freezers under the Significant New Alternatives Policy (SNAP) program, a move that would open the US domestic market to hydrocarbon-based refrigeration appliances.

The EPA's new use condition for flammable (A3) refrigerants is linked to UL 60335-2-24, Edition, which was revised in late April of this year to increase the hydrocarbon charge allowed in US domestic refrigerators to 150 g from 57 g, the amount allowed under the previous standard, UL 250. The previous 57 g limit was widely seen as an impediment to the adoption of energy-efficient hydrocarbon refrigeration in the US domestic market. Elsewhere in the world, where 150 g has long been the charge limit for domestic refrigerators, hydrocarbon units have gained substantial market share. The Environmental Investigation Agency (EIA) and the North American Sustainable Refrigeration Council (NASRC) submitted a petition in September asking that the EPA take this step.

"The US market has lagged behind the rest of the world for many years in adopting climate-friendly fridges, due to an outdated restrictive standard that had prevented hydrocarbon refrigerators used globally from entering the market," said Avipsa Mahapatra, Climate Campaign Lead for the Washington, DC-based EIA. "This rule will allow innovative American appliance manufacturers to catch up with the rest of the world."

Each year US consumers purchase about 12 million new household refrigerators and freezers. Replacing the HFC commonly used as refrigerant (R134a) in this sector with hydrocarbons could avoid emissions of upto 3.7 million metric tons of direct CO2 equivalent annually, according to EIA. Hydrocarbon fridges are also found to be more efficient than HFC units, the NGO noted.

In a report called "Bringing the US Fridge Market into the 21st Century," EIA pointed out that multinational companies like AB Electrolux of Sweden, Samsung Electronics and Haier selling domestic refrigerators with R134a in the US are already producing and selling models using hydrocarbons in other markets. Efforts are also underway globally and in the US to increase the allowable hydrocarbon charge in commercial refrigerators above 150 g. The IEC is considering raising the limit for flammable A3 refrigerants to 500 g. ■

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Luvata Completes Sale of Heat Transfer Solutions Division

Following a satisfactory completion process, Luvata is pleased to announce the sale of its Heat Transfer Solutions Division to Modine Manufacturing Company. The SPA for the sale was announced on 6th September 2016. Luvata was purchased in 2005 from Outokumpu Oyj under Private Equity by Nordic Capital. Representing a significant expansion for Modine, the US-based division will become Modine Commercial and Industrial Solutions. The Division has 18 plants across the globe, excellent operations, extensive customer and supplier relationships, and is a leading presence in many international heat-transfer markets.

Jyrki Vesaluoma, MD and CFO of Luvata Group comments: "We are proud to hand over the HTS Division to its new owners. The Division has possibly the world's most comprehensive proposition to the HVACR markets and represents a significant expansion for Modine. In its time under Luvata's leadership, HTS has gone from strength-to-strength becoming, among other things, the world's largest supplier of heat-exchanger coils, and the market-leading supplier of coils and coolers to the data-centre-cooling industry."

Modine President and Chief Executive Officer, Thomas A. Burke adds: "The combination of Modine and Luvata HTS provides a complete product portfolio as well as agile manufacturing capabilities across the globe, all of which will allow superior response to customer needs." ■

Beijing Airport Makes Progress on Greening Operations

Beijing Capital International Airport, China's largest with 94.39 million passengers passing through in 2016, is making steady progress on greening its operations, but can do more to minimize its environmental impact, new UN research said. According to the Assessment Report on Beijing Capital Airport, use of gasoline and diesel by airport vehicles declined 45 per cent and 49 per cent respectively between 2010 and 2016, while overall carbon dioxide emissions were cut by almost 16 per cent between 2014 and 2016.

This is despite the airport adding roughly ten million annual passengers since 2010, a growth rate that is comparable to the increase in Beijing's Gross Domestic Product. "Beijing Capital International Airport has shown strong commitment towards sustainability, balancing growth in air, cargo and passenger traffic with enhanced environmental performance," said Steven Stone, Chief, Resources and Markets Branch, Economy Division of UN Environment. "With focused actions in the right places – including electric vehicles, renewables and better transport links among them –- the airport can continue its leadership in environmental stewardship."

The airport has contributed upto 9.7 per cent of Beijing's economic output and employed up to 6 per cent of the city's working population directly and indirectly, making it a cornerstone of the city's growth and jobs. However, this growth brings pressure on natural resources and the environment, which Beijing Capital will have to manage carefully, says the report – which was produced in collaboration with the UN Environment-Tongji Institute of Environment for Sustainable Development.

In response, the airport is switching from isolated issues of energy consumption, greenhouse gas emissions, and noise reduction towards the systemic consideration of its overall operation. Of the airport's 4,000 vehicles, more than 60 per cent are special-purpose. Beijing Airport aims to switch at least 10 per cent of these, and 20 per cent of the general-purpose vehicles, to electric powered-alternatives by 2020.The airport is also increasing water-use efficiency to help cope with the chronic water shortage facing Beijing. The airport's per-capita water consumption declined from 23.75 litres in 2012 to 21.24 litres in 2015, a reduction of 10.6 per cent. Performance in terms of indoor air quality and wastewater treatment is fully up to national standards, while efforts to encourage recycling among passengers are innovative. ■

Empower to provide its Services to Dubai's Museum of the Future

Emirates Central Cooling Systems Corporation, Empower, the world's largest district cooling services provider, recently signed a contract with the Museum of the Future to provide 2,459 refrigeration tonnes of district cooling capacity. The agreement reflects the positive reception and increasing interest of the property sector in investing in environmental sustainability as a key factor to improve growth.

It also underscores the economic advantage of adopting district cooling in real estate development. Ahmad Bin Shafar, CEO of Empower, said, "A hub for the future of humanity is being built right here in Dubai. Providing the Museum of the Future with a sustainable cooling solution is in line with the UAE's sustainability agenda and Empower will ensure that the air-conditioning requirements of the technology centre will meet the highest international standards." ■

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CBRE Acquires Italian Local Facilities Management Provider Geico

CBRE Group announced that it has acquired Geico Lender S.p.A (Geico Lender), a leading building technical engineering services provider in Italy. Geico Lender will operate as part of CBRE's Global Workplace Solutions (GWS) business in Italy and adds extensive specialist technical services capabilities to the integrated suite of services for occupier clients throughout Italy. Founded in 1989, Geico Lender employs more than 300 staff members operating from six locations across Italy. The company provides a broad range of services focused on the maintenance and installation of HVAC, building automation and other technological systems for financial institutions and other private sector companies.

Ian Entwisle, CEO of CBRE GWS EMEA, said, "This acquisition adds extensive and complementary market-leading facilities management expertise to our existing GWS platform. Furthermore, it provides a strong platform from which to continue to build our facilities management capabilities in Italy and across Europe as a vital part of integrated occupier services for our clients. There is a growing trend amongst Italian corporations to outsource technical services and now with the expertise of Geico Lender within CBRE, we are in an even stronger position to deliver exceptional outcomes for our clients."

Clemente Cilli, CEO and Founder of Geico Lender, said, "CBRE's global footprint and broad occupier service offering is a critical factor which will enable us to deliver more advantages to our clients. We believe CBRE is the right cultural fit for us and importantly, we share a common ambition to continue to build and expand the business and to ensure we deliver world-class service to our clients." ■

Emerson to Acquire Cooper-Atkins

Emerson has agreed to acquire Cooper-Atkins, a leading manufacturer of temperature management and environmental measurement devices and wireless monitoring solutions for foodservice, healthcare and industrial markets. Cooper-Atkins is a longtime technology leader in foodservice markets with a comprehensive offering of temperature management and monitoring products for spot inspection and fixed location uses, including restaurants, supermarkets and other places where food is handled, prepared and stored. Their solutions are modernizing food quality management utilizing mobile and cloud-based quality, safety and compliance systems. "Temperature management in food retail and restaurants is a dynamic market due to increasing regulatory requirements, rising labor costs and the proliferation of locations where fresh foods are prepared and served," said Robert T. Sharp, Executive President, Emerson Commercial & Residential Solutions. "This acquisition further strengthens our ability to meet the evolving needs of our cold chain customers – from grower to retailer – to help provide consistent and safe control of food and other temperature-sensitive goods."

Cooper-Atkins is a strong complement to Emerson's global cold chain business, which includes the ProAct™ Services portfolio for supermarkets and the cargo solutions business, which provides real-time perishable cargo tracking and monitoring services. "We see food safety as a critical need that will shape demand in our end markets," said Emerson Chairman and Chief Executive Officer David N Farr. "Cooper-Atkins' strong brand reputation and leading portfolio of automated temperature and monitoring solutions broadens our access to the foodservice industry." Cooper-Atkins' food quality portfolio strategically expands Emerson's broad cold chain portfolio of products and services for producer, retail, industrial and transportation customers. Emerson's market-leading compressor technologies, controls and connected solutions optimize energy consumption and operational performance in the assets powering supermarket, foodservice and refrigerated shipping operations. ■

EU Reaches Deal on Energy Standards for Buildings

The European Union backed new rules on energy standards for all new public buildings in the 28-country bloc and improvements for existing buildings, which account for over a third of EU greenhouse gas and emissions. The rules, proposed by the European Commission, are one of eight legislative packages aimed at ensuring the EU meets its climate goals. The new rules aim to boost energy performance in new buildings and encourage renovations to adopt more efficient energy systems. "The fight against climate change starts 'at home', given that over a third of EU's emissions is produced by buildings. By renovating and making them smart, we are catching several birds with one stone – the energy bills, people's health, and the environment," Commission Vice-President Maros Sefcovic said in a statement. The new rules are part of a set of proposals to implement the bloc's climate goals of reducing greenhouse gas emissions by at least 40 percent below 1990 levels by 2030, in line with the Paris Agreement to limit further global warming to no more than 2 degrees. ■

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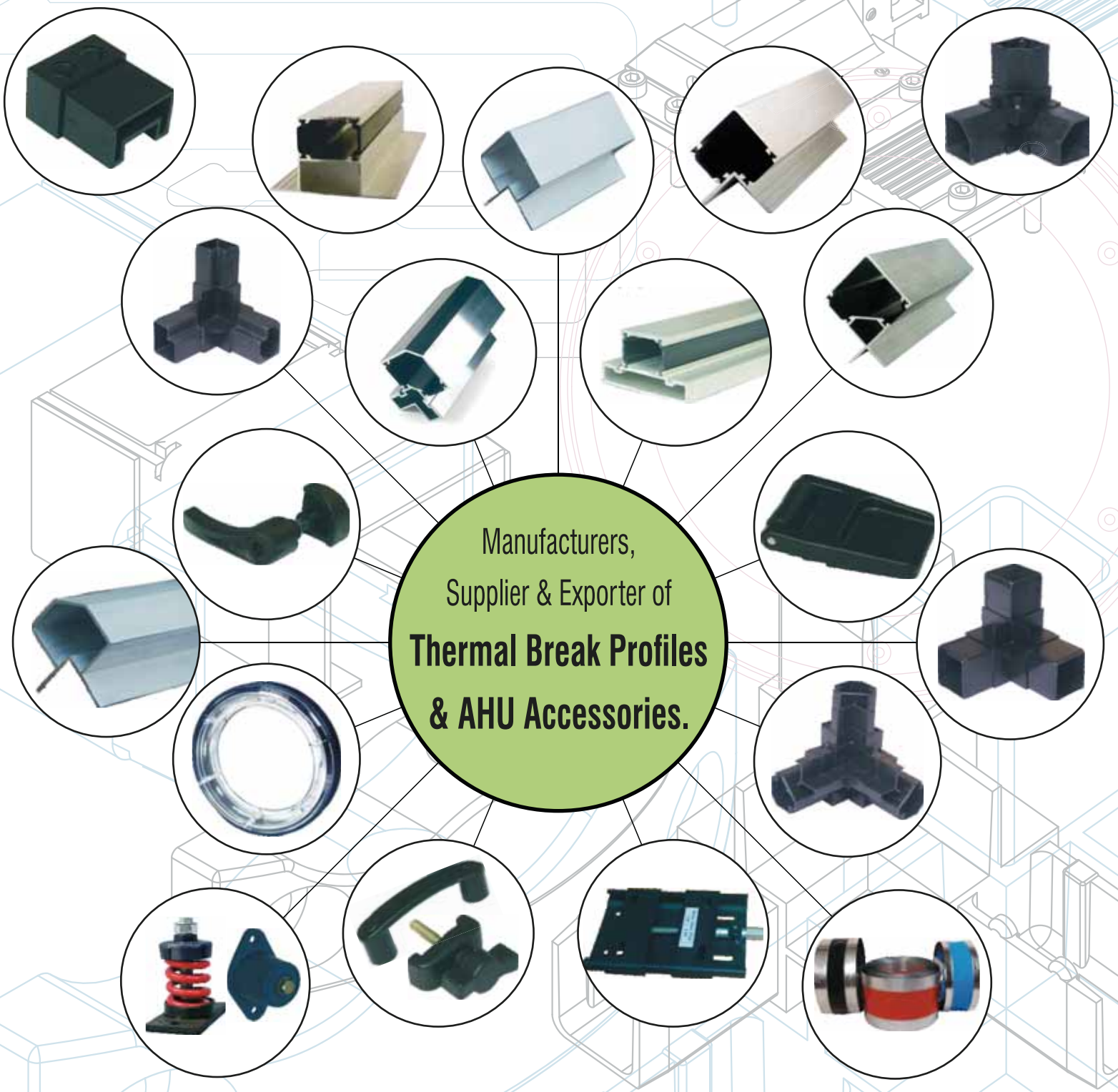

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DiversiTech Expands Leadership Team

Daniel McInerney joins as Vice President, Logistics; Ted Zerafa joins as Vice President, Global Sourcing Highly experienced leaders will help enhance best-in-class customer service and product portfolio DiversiTech Corp, a leading aftermarket manufacturer and supplier of highly-engineered components for residential and light commercial heating, ventilating, air conditioning and refrigeration (HVAC/R), announced the appointment of Daniel McInerney as Vice President, Logistics and Ted Zerafa as Vice President, Global Sourcing, effective immediately.


Daniel McInerney (left) & Ted Zerafa (right)

As Vice President, Logistics, McInerney will be responsible for creating a new paradigm in logistics strategy and distribution, working across DiversiTech's network of four manufacturing facilities and 11 distribution/light assembly facilities. As Vice President, Global Sourcing, Zerafa will be responsible for the enhancement and execution of DiversiTech's global procurement and sourcing strategy, helping to build on the company's leading product portfolio in both existing and new categories. "As we continue to build on our commitment to providing our customers with the highest level of service and an even broader, more attractive portfolio of products, we're pleased to welcome Dan and Ted to the DiversiTech team," said Jon Evans, Chief Operations Officer of DiversiTech. "They are both proven supply chain leaders who will bring critical strategic insights and experience to help fuel our growth.

We look forward to working closely with them to enhance our supply chain capabilities going forward." McInerney noted, "DiversiTech's strong customer value proposition underscores its status as a leader within the HVAC/R industry, and I'm delighted be joining the Company during such an exciting period of growth. I am eager to work with the team across the Company's network of facilities to help ensure we are providing our customers with best in class service supported by an efficient and cost-effective logistics and distribution strategy." ■

Simon Aspin to be Managing Director of HTG

HTG Trading, which owns Hubbard Systems and Taylor UK, has announced major changes to its senior management structure. Simon Aspin, currently commercial director of Hubbard, will become Managing Director of HTG from January 1st 2018. At the same time Taylor's commercial director, Pete Gray, becomes managing director of Taylor. Meanwhile, Martin Wood will step down from his role as chief executive of HTG Trading to become non-executive chair of the company. HTG's subsidiaries look after many of the UK's leading foodservice equipment brands and are known for the quality of their customer service and support. Hubbard Systems is the exclusive UK distributor of Scotsman icemakers and Comenda ware washers. Taylor UK is exclusive distributor for Taylor frozen drinks and dessert machines and clamshell grills, Frigomat ice cream equipment, and Prática combi ovens, as well as being the principal UK distributor of ISA refrigerated displays and Turbochef ovens.


Simon Aspin

"HTG's succession planning in recent years has been focused on developing internal candidates for senior management positions," says Martin Wood. "We believe that the arrangements that are in place will allow the company to continue its successful growth path."

Wood has been CE of HTG Trading for over 18 years, during which time the business has flourished – in the last five years alone sales have risen by 86%. His ongoing association with the company over the next few years will allow him to help with its continuing progression.

"Martin's contribution to the company's success has been immense," says Simon Aspin. "We are very grateful that we will continue to benefit from his business acumen." ■

Anderson is Capital CEO

James Anderson, former MD of Capital Cooling, has been confirmed as the CEO of new company Capital Cooling Refrigeration.Anderson is joined on the board of the new company by former Capital Cooling product development director Graham Frew. Capital Cooling Refrigeration was formed following the £300,000 acquisition of Edinburgh-based Capital Cooling's refrigerated cabinet sales business in a pre-pack deal from the administrator KPMG. The failure of Capital Cooling saw the company fall into administration on December 20. Capital Cooling Refrigeration is being backed by London-based private equity company Rcapital Partners. "Rcapital's investment has enabled incumbent CEO James Anderson to progress plans to further develop the business and take advantage of significant growth opportunities," the company said. "We are extremely pleased to have successfully completed a significant financial investment in our business which will allow us to pursue our ambitious growth strategy over the next 1-2 years," said new CEO James Anderson. ■

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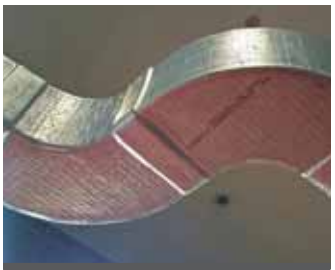

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ASHRAE Earns Prestigious UN Environment Award

ASHRAE has received the prestigious Partnership Award from the United Nations Environment Programme's (UN Environment) Ozone Secretariat for its extraordinary commitment and contribution to the progress and achievements of the Montreal Protocol on Substances that Deplete the Ozone Layer. The award was presented to ASHRAE at the 2017 Ozone Awards ceremony in Montreal. The Partnership Award recognizes the work of civil society and other international organizations that have played a critical role in the development of the Kigali Amendment and/or implementation of the Montreal Protocol, which is celebrating its 30th anniversary. "We could not be more pleased to have earned this recognition. Receiving the Partnership Award is a great honor and acknowledgment of the tireless work ASHRAE and our members are doing to support the phase-out activities of ozone-depleting substances around the world," said 2017-2018 ASHRAE President Bjarne W Olesen, Ph.D. "We are proud to be a part of this initiative and look forward to continuing our partnership with UN Environment as we work toward a more sustainable built environment."

Bjarne W Olesen holds the UN Environment Award for Partnership as he stands with Catherine McKenna, Canada's Minister of Environment and Climate Change.

Commonly referred to as "the treaty that saved the ozone layer," the Montreal Protocol, signed in 1987, is an international agreement designed to substantially reduce emissions of substances that deplete the stratospheric ozone layer.

The Protocol has led to the phase-out of more than 99 percent of nearly 100 ozone-depleting chemicals and significantly contributed to climate change mitigation, according to UN Environment. "I congratulate ASHRAE for this well-deserved award honoring its exceptional efforts to support the advancement of technologies which help protect the ozone layer. We appreciate the organization's dedication to the Montreal Protocol and its contribution to the success of the treaty," said Tina Birmpili, Head of the Ozone Secretariat. ■

Daikin's Sky Air A-series Wins Accolade at Energy Awards 2017

Daikin won the award, "On the strength of the AC giant's commitment to continually improving the technology." "The savings that the manufacturer has wrought have not just future-proofed their range, but show others what the future could be," said the judges.

Sky Air A-series really is a major achievement for Daikin UK and reflects the important progress.

Rewarding excellence in the energy business, the Energy Awards are feted as the most respected energy event in the industry. Daikin joined other major energy-conscious brands such as Marks & Spencer, The Co-op and Tesco, each of which collected major award wins at the ceremony in London's Hilton Hotel in Park Lane. Mark Dyer, Commercial Director at Daikin UK said, "To win another award for the Sky Air A-series really is a major achievement for Daikin UK and reflects the important progress we are making to lead the market towards lower global warming technologies. The judges' recognition that we have delivered innovations and energy savings across the board with the new Sky Air A-series is incredibly positive – and I look forward to awareness of this spreading out to the wider market."

As the Energy Awards winners' brochure explains, "The Sky Air A-series claims energy efficiencies of up to A++ and SEER (seasonal energy efficiency ratio) up to 7.7 reducing running costs and carbon footprint. The manufacturer notes that thanks to its use of R32 refrigerant, it starts off at around 10 per cent more efficient than the predecessor, but with the addition of VRT (Variable Refrigerant Technology, which automatically adjusts the refrigerant temperature to meet the required demand) in the top-spec Alpha, the energy savings are nearer 21 per cent."

Martin Passingham, Product Manager for DX at Daikin UK, added: "We are delighted that this award recognizes that our Sky Air A-series genuinely leads the way, offering an ideal solution for reducing both energy consumption and running costs while complying with the continuing F-Gas phase down." ■

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Data Center Cooling Market worth $ 14.28 bn by 2021

The data center cooling market is driven by factors such as the growing need to improve the overall data center efficiency, reduce additional heat generated by increased data center power densities, and increase focus on developing cost effective and eco-friendly data centers solutions...

The data center cooling market is estimated to grow from USD 7.12 Billion in 2016 to USD 14.28 Billion by 2021, at a Compound Annual Growth Rate (CAGR) of 14.95%. The data center cooling market is driven by factors such as the growing need to improve the overall data center efficiency, reduce additional heat generated by increased data center power densities, and increase focus on developing cost effective and eco-friendly data centers solutions.

Increase in the power consumption levels and the need to enhance overall data center efficiency is expected to fuel the data center cooling market demand over the forecasted timeline. Implementation of hot and cold aisles, installation of blanking panels and usage of close-coupled cooling are among the factors to improve the overall efficiency and provide energy efficient solutions to notoriously energy-intensive data centers.

Liquid cooling solutions segment is expected to witness the highest CAGR during the period 2016 to 2021. Liquid cooling solutions make use of advanced engineered coolants that reduce the overall carbon footprint making them a more environment-friendly solution. Moreover, they provide efficient cooling for high power and server density data centers. These benefits are driving the market and are anticipated to help in propelling the data center cooling market to grow at the highest CAGR during the forecast period.

The maintenance and support services segment is expected to grow at the highest CAGR during the forecast period owing to the rapid adoption of data center cooling solutions in enterprise and large data centers, which require third-party assistance for maintenance of the cooling infrastructure and additional support for the liquid cooling infrastructure.

North America is expected to dominate the data center cooling market during the forecast period. The data center cooling market segments the global market on the basis of regions, which include North America, Asia-Pacific (APAC), Europe, Middle East & Africa (MEA), and Latin America. North America is expected to hold the largest share of the data center cooling market in 2016 due to the technological advancements and larger adoption of data center cooling technologies across a large number of industries in this region. The market in APAC is expected to grow at the highest CAGR between 2016 and 2021. The primary driving force for this growth is the increasing requirement for energy efficient and cost effective solutions in various industries.

The report also encompasses different strategies, such as mergers & acquisitions, partnerships & collaborations, and product developments, adopted by major players to increase their share in the market. Some of the major technology vendors include Schneider Electric SE (France), Black Box Corporation (US), Nortek Air Solutions, LLC (US), Airedale International Air Conditioning Ltd. (UK), Rittal GmbH & Co KG (Germany), STULZ GmbH (Germany), Vertiv Co (US), Asetek (Denmark), AdaptivCOOL (US), and Coolcentric (US). ■

Energy-Efficient Refrigeration Systems

The demand for HVAC industry for various needs like preservation of food, medicines and especially, human comfort has always been there and is now at its peak. In the process, to meet this demand man has been depleting resources and polluting the environment for years. The use of natural refrigerants is the best solution to check environmental destruction...

Refrigeration plays a significant role in our daily life which allows keeping the temperature below the environmental temperature for human comfort. The energy from fossil fuels is used to run the conventional HVAC systems. But, the fossil fuels are being rapidly depleted. Also, the increased demand for refrigeration and air-conditioning has contributed to two major environmental issues namely, global warming and ozone layer depletion caused due to the refrigerants that are being used. Therefore, finding novel ways towards green technology without compromising comfort and indoor air quality remains a challenge for research and development. There are different techniques, which can be implemented on HVAC systems to improve their energy efficiency and also new refrigerants can be used to reduce the negative environmental impact. The natural refrigerants like ammonia, hydrocarbons and CO_2 are considered as environmental friendly and future refrigerants. The control and optimization strategies have been used recently to improve the energy consumption rates of these systems. However, implementing these strategies is either expensive or complicated, and requires constant monitoring. The other way to achieve energy efficiency is to combine different HVAC components to create an energy-efficient configuration. The modifications can result in substantial savings in the long term by reducing maintenance costs associated with control and optimization strategies.

Environmental Impact of Refrigerants

The refrigerants play a very crucial role in HVAC industry. The substances chosen as refrigerants decide many factors of a refrigeration system such as compressor work, COP and the extent to which global warming and ozone layer depletion are affected. The natural refrigerants such as water, methyl chloride, sulphur dioxide, carbon dioxide and ammonia were used in the beginning of the invention of mechanical refrigeration. But unfortunately, most of those refrigerants proved to be toxic and flammable. Thus, chlorofluorocarbon, (CFC) refrigerants came into picture and served as excellent and efficient refrigerants for years till the 1970s. In 1973 Prof James Lovelock discovered Freon to possess high ozone layer depletion potential (ODP). The Montreal protocol stopped the production and consumption of such ozone layer depleting CFC refrigerants. Then, the hydro fluorocarbon (HFC) refrigerants were used as alternatives to CFCs. But, HFCs have also high global warming potential (GWP). More than 190 countries gathered in Kigali, in 2016 and adopted an amendment to the 1989 Montreal Protocol to eliminate HFC gases. Now, the search for new alternative refrigerants which can replace the conventional CFC and HFC refrigerants, without compensating the performance of the system has become a challenge to the scientists and researchers working in this area.

The natural refrigerants like CO_2, NH_3 and hydrocarbons have zero ODP and

Table 1: Properties of different refrigerants

Refrigerant	Chemical Formula	Replaces	Molecular Mass (Kg/kmol)	NBP (°C)	Critical Temperature (°C)	ODP	GWP
R-12	CCl2F2	-	120.93	-29.79	112	0.820	580
R-134a	CF3CH2F	R-12	102.03	-26.07	101.1	0	1300
R-152a	C2H4F2	R-12,R-134a	66.05	-24	113.3	0	120
R-600a	C4H10	R-12,R-134a	58.12	-11.6	134.7	0	~20
R-1234yf	C3F4H2	R-134a	114.04	-30	94.85	0	4
R-1234ze	CF3CH=CHF	R-134a	114	-18.95	109.4	0	<1
R-22	CHClF2	-	86.47	-40.8	96.2	0.034	1700
R-32	CH2F2	R-410A	52.02	-51	78.4	0	580
R-404A	CF3CHF3(44%) CF3CH3 (52%) CF3CH2F (4%)	R-22	97.6	-46.5	72.1	0	3800
R-410A	CH2F2 (50%) CHF2CF3(50%)	R-22	72.58	-51.53	72.5	0	2000

GWP and are considered to be the long term replacements to CFCs and HFCs. The natural refrigerants failed back in those days, due to the problems of toxicity and flammability. The present day technology can easily handle such problems. Thus, the use of natural refrigerants could be the best possible solution to stop the environmental destruction caused by the conventional CFC and HFC refrigerants.

Properties of Refrigerants

The properties of refrigerants play a vital role in economic and environmental friendly application. The thermo-physical properties of different refrigerants along with their ODP and GWP have been shown in table 1. Some of the desirable properties of refrigerant are as follows:

- The refrigerant should have low boiling point and low freezing point.
- It must have high critical pressure and temperature to avoid large power requirements.
- It must have low specific heat and high latent heat. Because high specific heat decreases the refrigerating effect per kg of refrigerant and high latent heat at low temperature increases the refrigerating effect per kg of refrigerant.
- It should have low specific volume to reduce the size of the compressor.
- It must have high thermal conductivity to reduce the area of heat transfer in evaporator and condenser.
- It should be non-flammable, non-explosive, non-toxic and non-corrosive.
- It should give high COP in the working temperature range. This is necessary to reduce the running cost of the system.
- It should have zero ODP and very low GWP.

Performance of simple Vapour Compression Refrigeration (VCR) system

The performance of a simple vapour compression refrigeration system using different refrigerants has been broadly studied by researches. The main objective of testing different refrigerants in VCR system is to identify proper replacements to conventional refrigerants which have high ODP and GWP values and to develop new environmental friendly refrigerants. Thus, as shown in table 1, R600a has been found to be a replacement for R12 and R134a. The R1234ze and R1234yf are suitable replacements for R134a. Also, the refrigerants R32 and R410a are noted to replace R22. The variations of compressor input power and COP with evaporator temperature at a constant condenser temperature of 50°C for a simple vapour compression refrigeration system have been shown in figures 1 and 2 respectively (Mohanraj *et al.*, 2008). The trend in variation of COP and compressor input power has been noticed for refrigerant R134a and its replacements R152a, R600, R600a, R1270 and R290. The compressor input power for R1270 is the highest and for R600 is the lowest. The compressor input power of R290 and R1270 are about 42% and 54% higher than that of R134a, respectively. R600a, R600, and R152a are about 46%, 65%, and 4% lower than that with R134a. It is shown from figure that R600 and R600a yield highest COP and R1270 and R290 yield the lowest. The COP of R152a is higher than that of R134a by about 7–9% across the considered range of operating temperatures. The COP of R290 and R1270 are lower than that of R134a by about 2.5% and 2%, respectively. The COP of R600a and R600 are higher than that of R134a by about 2.4% and 6.9% respectively.

Limitations of Vapour Compression Refrigeration Cycle

It is well known that a simple vapour compression refrigeration system is the most commonly used system for the purpose of refrigeration and air-conditioning. But, when the atmospheric temperature is high and a very low temperature is to be maintained, this simple vapour compression refrigeration system becomes inefficient. In case of

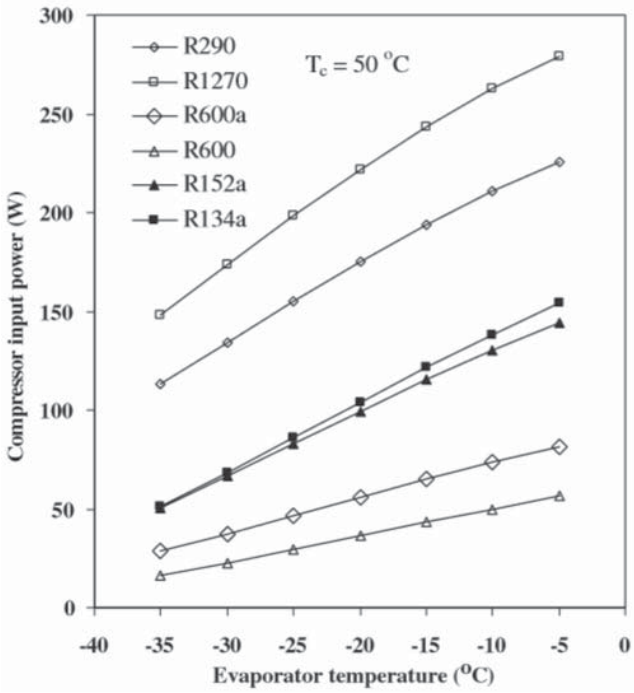

Figure 1: Effect of evaporator temperature on compressor input power

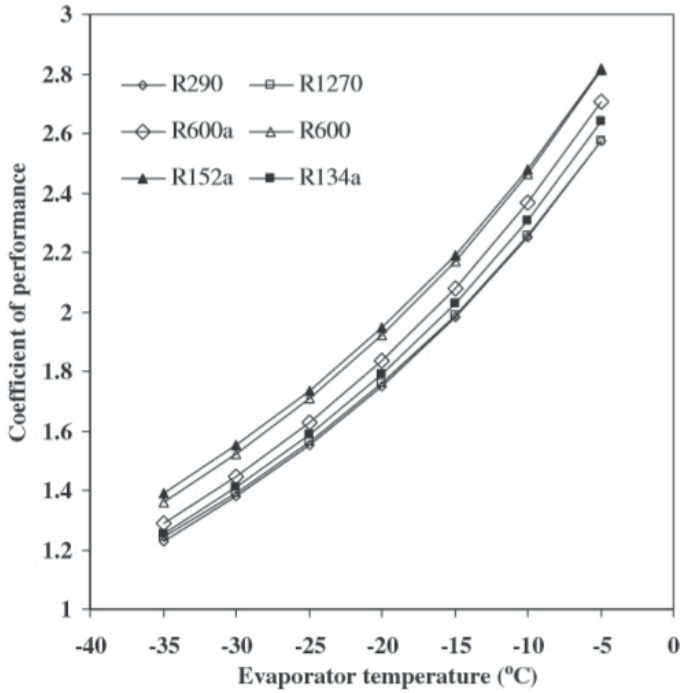

Figure 2: Effect of evaporator temperature on COP

high temperature difference between evaporator and condenser (Temperature Lift), compressor power requirement increases and the specific refrigeration effect decreases. This leads to the operation of system for a long period of time to meet the desired load which sometimes results in failure of the compressor. So, the application of simple vapour compression refrigeration system for high temperature lift is not advisable. The major drawbacks in operating a simple vapour compression refrigeration system with high temperature lift are:

- Throttling loss increases
- Superheat loss increases
- Compressor discharge temperature increases
- Quality of the vapour at the inlet to the evaporator increases
- Specific volume at the inlet to the compressor increases
- Refrigeration effect decreases
- Volumetric efficiency decreases

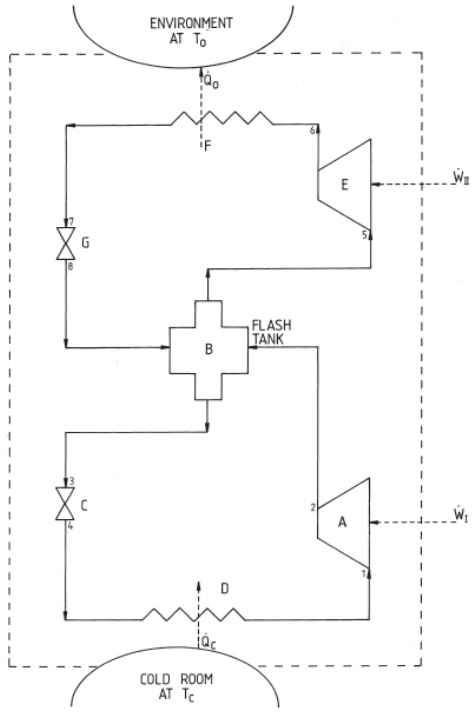

Figure 3: Two-stage vapour-compression plant with flash intercooler.

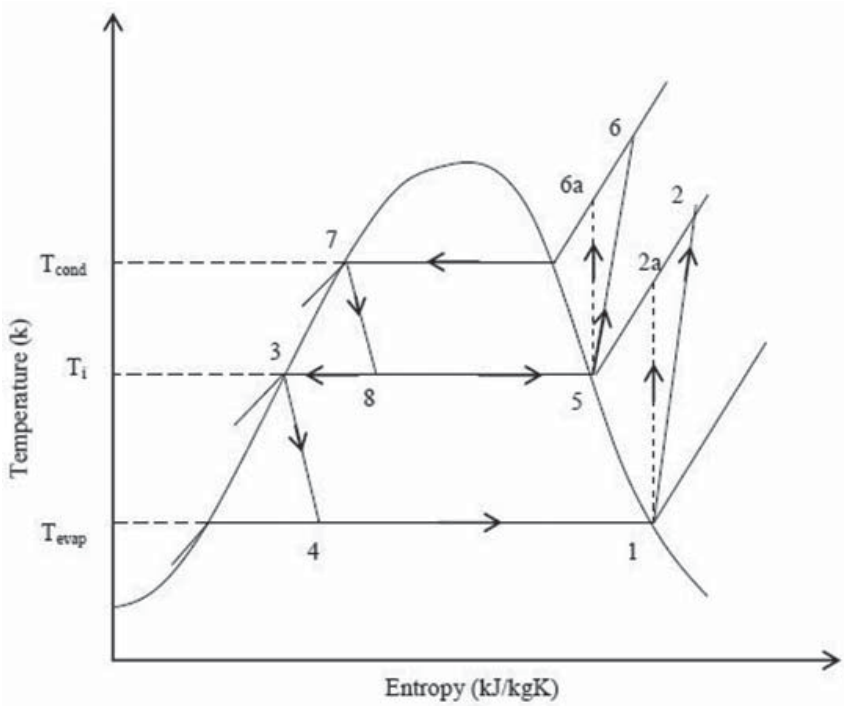

Figure 4: Temperature versus entropy diagram for two stage refrigeration cycle.

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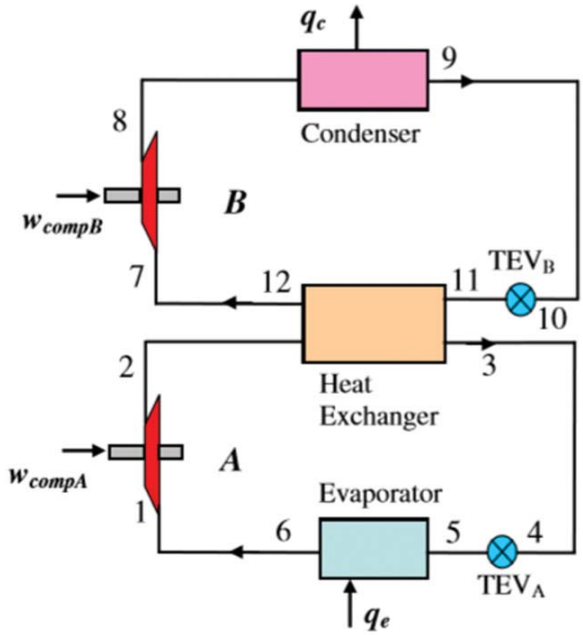

Figure 5: Schematic diagram of the vapour cascade refrigeration system

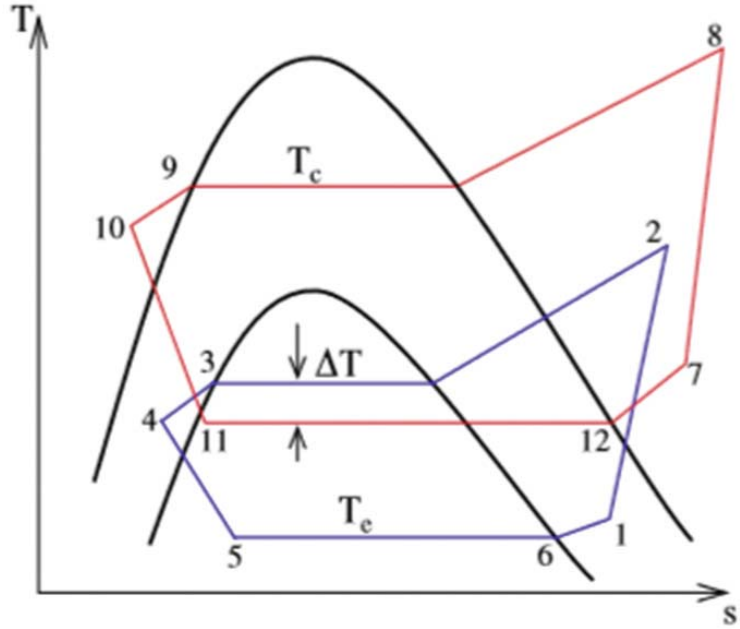

Figure 6: Vapour cascade refrigeration system in T-s plot.

- Compressor work increases
- Energy requirement increases

Thus, as the temperature lift increases the single stage systems become inefficient and impractical.

Remedies

All the above mentioned drawbacks resulting from high temperature lift, lead to increased consumption of energy and decreased efficiency of the system. These issues can be overcome by modifying and using different configurations of vapour compression refrigeration system . Some of such configurations have been discussed below.

1. Multi Stage Vapour Compression Refrigeration System with Flash Intercooling

The working of two stage vapour compression refrigeration system with flash intercooling along with its representation on T-s plane has been shown in the figures 3 and 4 respectively. The configuration consists of an evaporator, low pressure compressor, high pressure compressor, condenser, high pressure throttle valve, low pressure throttle valve and a flash chamber. The refrigerant in the evaporator absorbs heat from the cooling space that has to be cooled and gets converted into vapour. The refrigerant vapour is then compressed in a low pressure compressor. The compressed refrigerant vapour from the low pressure compressor and the condensed liquid refrigerant expanded in the high pressure throttle valve are sent into the flash chamber. In the flash chamber the liquid and the vapour refrigerant are separated and the refrigerant vapour is sent to the high pressure compressor while the liquid refrigerant goes to the low pressure expansion valve, where it expands to the evaporator pressure. In this configuration, the amount of vapour entering the evaporator which is also known as flash gas is reduced due to presence of flash chamber. The amount of flash gas entering the evaporator should be as minimum as possible as the flash gas is already in vapour state and does not contribute to the refrigerating effect and increases the pressure drop in the evaporator.

2. Cascade Refrigeration System

The cascade refrigeration system is a freezing system that uses two kinds of refrigerants having different boiling points, which run through their own independent freezing cycle and are joined by a heat exchanger. In a cascade refrigeration system, two simple vapour compression refrigeration cycles (Low temperature cycle (LTC) and high temperature cycle (HTC)) are connected with each other in series with a cascade heat exchanger. Figure 5 shows a two stage vapour compression cascade refrigeration system, which consists of low and high side refrigeration systems indicated as A and B respectively. The refrigeration systems A and B are coupled to each other by means of a heat exchanger in which the total heat from refrigeration system A is rejected to refrigeration system B. The refrigerants flowing in both systems are usually different from each other although there are some cases where the same refrigerant can be used in both systems. The refrigerant circulating through system B has a higher boiling temperature than the refrigerant in system A. The process has been represented on T-s plane as shown in figure 6. As the system allows use of refrigerants that have suitable temperature characteristics for each of the higher-temperature side and the lower-temperature side the energy is saved.

3. Vapour compression refrigeration system with dedicated subcooler

The complete system is constructed by coupling two cycles in series. The schematic diagram of the complete system has been shown in the figure 7 and the corresponding p-h plot has been

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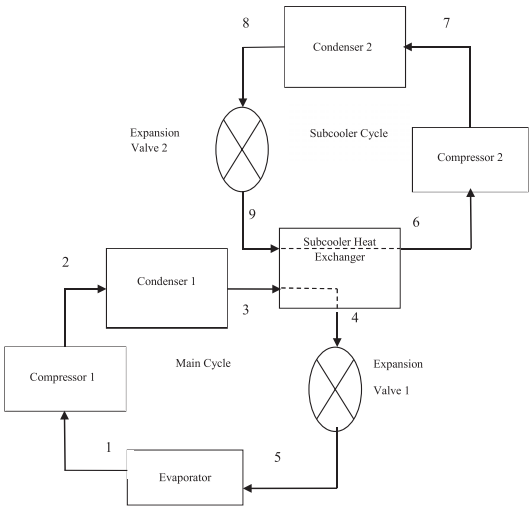

Figure 7: Schematic diagram of the vapour compression refrigeration system with dedicated subcooler

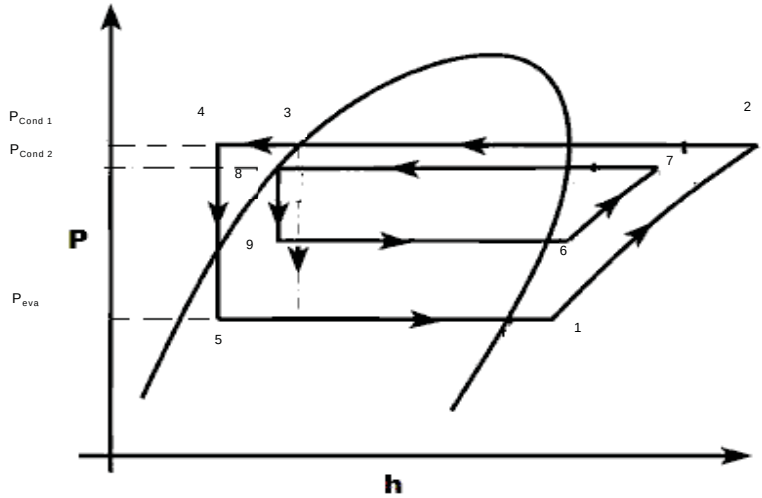

Figure 8: Vapour compression refrigeration system with dedicated subcooler in p-h plot.

presented in figure 8. The main cycle is connected to the dedicated subcooler system through a heat exchanger. This heat exchanger serves two purposes. It acts as a subcooler for the main cycle and evaporator for the dedicated subcooler cycle. Components of the main cycle are bigger in size than those of the dedicated subcooler cycle. In the main cycle refrigerant leaves the evaporator at state 1 and enters the main cycle compressor. Refrigerant leaves the compressor at state 2 and enters the condenser. Main cycle refrigerant rejects heat to the environment in the condenser and leaves it as a saturated liquid at state 3. Then this saturated liquid enters the subcooler heat exchanger to get cooled below its saturation temperature (state 4). It then enters into the expansion valve in the main cycle and leaves it as low quality vapour and enters the evaporator. On the other hand, subcooler cycle refrigerant gets evaporated by taking the heat from the main cycle refrigerant in the subcooler and enters in to the dedicated cycle compressor at state 6. Compressed high pressure and high temperature refrigerant is then entered into the condenser in the dedicated cycle at 7 and leaves the condenser at state point 8 as saturated liquid and enters in the expansion valve.

4. Vapour compression refrigeration system with integrated subcooler

The major components of an integrated mechanical subcooling vapor-compression refrigeration system includes two reciprocating compressors, two expansion valves, condenser, evaporator, receiver and a subcooler. The system consists of two simple cycles coupled to each other via a subcooler as shown in figure 9, while its pressure enthalpy diagram is shown in figure 10. The bigger cycle is known as the main cycle and the smaller cycle is known as the subcooler cycle. The two cycles have a common condenser, and the components of the two cycles are

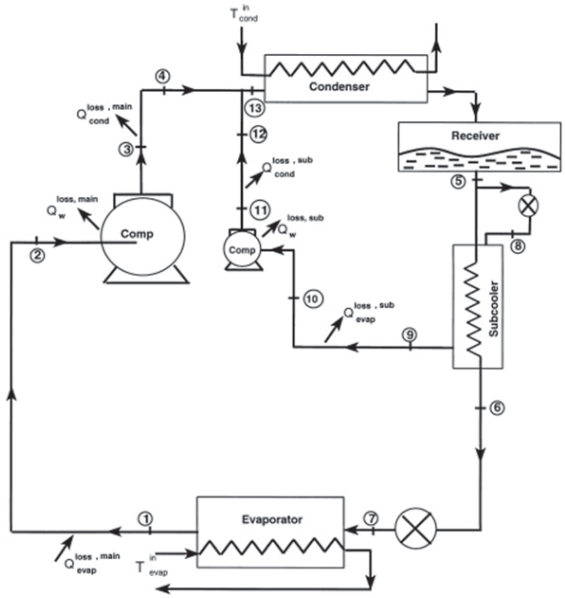

Figure 9: Schematic diagram of the vapour compression refrigeration system with integrated subcooler.

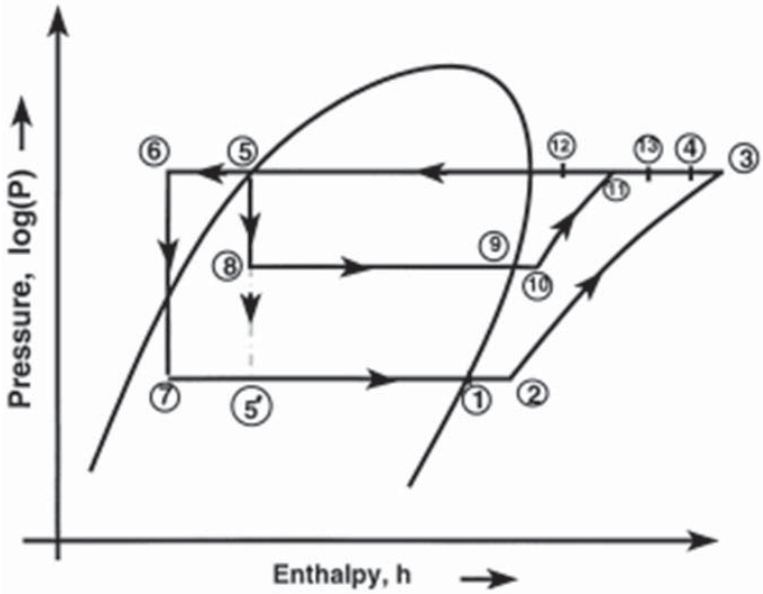

Figure 10: Vapour compression refrigeration system with integrated subcooler in p-h plot.

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Table 2: Basic assumption for the simulation

Parameters	Values	Parameters	Values
Evaporator load, Qeva	10 kW	Evaporator Temperature, TE	-15ºC to -30ºC
Isentropic efficiency of both compressor, ηS	75%	Effectiveness of the subcooler heat exchanger	80%
Both condensers temperature. TC	40ºC to 55ºC	Ambient Temperature, T0	25ºC

connected in a closed loop through a piping system that has heat transfer with the surroundings. The figure shows that the main-cycle refrigerant leaves the main-cycle evaporator at state 1 as a low pressure, low temperature, saturated vapor and enters the main cycle compressor at state 2. The refrigerant, from state 1 to 2 takes heat from the surroundings in the suction line. At state 3, it leaves the compressor as a high temperature, high pressure, superheated vapor. The refrigerant, from state 3 to 4 rejects heat to the surroundings in the discharge line. At state 4, it mixes with the subcooler cycle refrigerant coming from the subcooler cycle compressor and attains state 13, and the mixture enters the condenser. The mixture after leaving the condenser is collected in the receiver. Some of this liquid refrigerant mixture is extracted from the receiver and is expanded in the expansion valve of the subcooler cycle and is then passed through the subcooler. The remaining liquid refrigerant in the receiver enters the subcooler, where it is cooled below the saturated liquid state at a constant pressure to state 6 by the subcooler cycle refrigerant. It enters the main cycle expansion valve and at state 7 it leaves the expansion valve as a low quality vapor and enters the evaporator. In the evaporator, it is evaporated at a constant pressure to the saturated vapor state. The subcooler-cycle refrigerant after cooling the main-cycle refrigerant in the subcooler, leaves as a low-pressure, low-temperature, saturated vapor at state 9 and enters the subcooler cycle-compressor at state 10. The refrigerant from state 9 to 10 takes heat from the surroundings. At state 11, it leaves the compressor as a superheated vapor where it is mixed with the main cycle refrigerant coming from the main-cycle compressor, and attains state 13.

Apart from multistage vapour compression refrigeration there are many other methods which can be used for energy saving in HVAC industry. The evaporative cooling technology has been widely used for years. It uses water as the working fluid and hence it does not cause any negative environmental effects. Another important technology is the ground-coupled technology which relies on the fact that, at depth, the earth has a relatively constant temperature that is colder than the air temperature in summer and warmer than the air temperature in winter. The thermal storage systems are quite important as they shift the energy usage of the HVAC systems from on-peak to off-peak periods to avoid peak demand charges. In this system, energy for cooling is stored at low temperatures normally below 20°C for cooling, while energy for heating is stored at temperatures usually above 20°C. The heat recovery techniques can be used to recover energy that might otherwise be wasted. The objective of heat recovery is to reduce the cost of operating an HVAC system by transferring heat between two fluids such as exhaust air and fresh air. Also, many studies have been carried out on energy savings for HVAC systems by using materials with enhanced capacity to absorb, store and release the mass or heat.

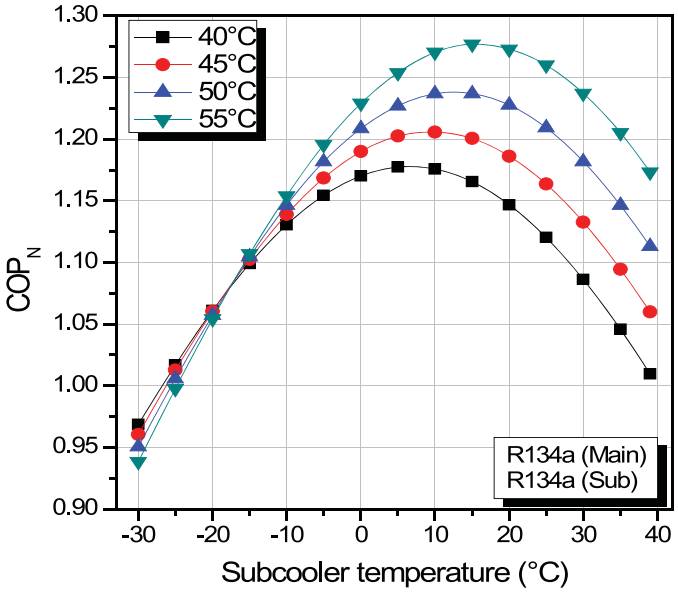

Figure 11: Effect of subcooler temp. on normalized COP for different condenser temp. for fixed evaporator temp. of -30°C.

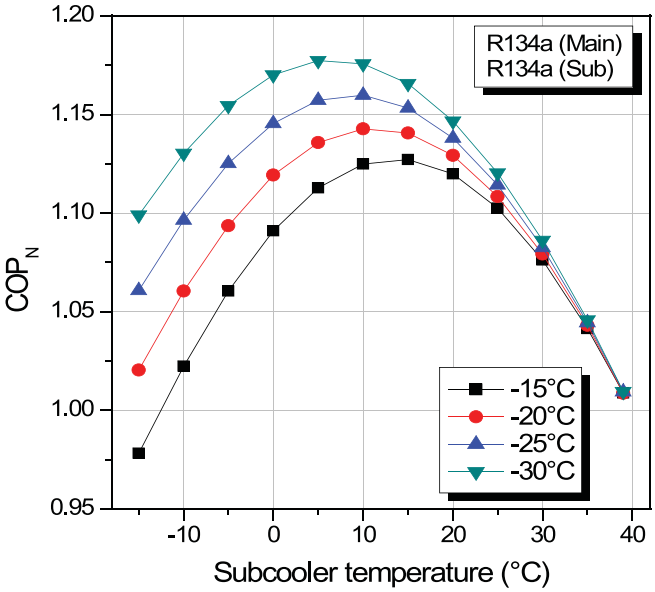

Figure 12: Effect of subcooler temp. on normalized COP for different evaporator temp. for fixed condenser temp. of 40°C.

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Table 3: Performance Comparison of VCR System with and without Subcooler

Without Subcooler				With Subcooler		Improvement	
T_c (°C)	T_eva (°C)	W (kW)	COP	W (kW)	COP	W (%)	COP (%)
40	-30	5.596	1.787	4.752	2.104	15.08	17.74
40	-25	4.946	2.022	4.264	2.345	13.79	15.97
40	-15	3.808	2.626	3.378	2.961	11.29	12.76
45	-30	6.288	1.590	5.215	1.917	17.06	20.57
45	-25	5.577	1.793	4.703	2.127	15.67	18.63
45	-15	4.335	2.307	3.770	2.653	13.03	15.00
50	-30	7.074	1.414	5.713	1.750	19.24	23.76
50	-25	6.288	1.590	5.172	1.934	17.75	21.64
50	-15	4.923	2.031	4.188	2.388	14.93	17.58
55	-30	7.979	1.253	6.251	1.600	21.66	27.69
55	-25	7.103	1.408	5.678	1.761	20.06	25.07
55	-15	5.589	1.789	4.636	2.157	17.05	20.57

Case study with dedicated sub cooler

The performance of a vapour compression refrigeration system can be improved by subcooling of condensed saturated liquid which permits the low quality refrigerant to absorb more heat from the refrigerated space in the evaporator. A performance enhancement model for a vapour compression refrigeration system by adding a small dedicated mechanical subcooler system to the main system has been developed to operate with comparatively large temperature difference between the evaporator and the condenser. Subcooler cycle provides subcooling to the main cycle refrigerant by absorbing heat from the condensed liquid of the main cycle refrigerant. R134a is chosen as main cycle refrigerant, whereas, R152a and R134a are separately considered as subcooler cycle refrigerants. Engineering Equation Solver (EES) has been used to analyze the performance of the system and compared with two different refrigerants in the subcooler cycle. The basic assumptions for the simulations have been tabulated in table 2. It is found that the overall performance of the system is improved for using both R152a and R134a as subcooler cycle refrigerants. Results also depict that R152a shows slightly better performance compared to the R134a as the subcooler cycle refrigerant. Predicted results show that an optimal subcooler temperature exists for fixed condenser and evaporator temperature.

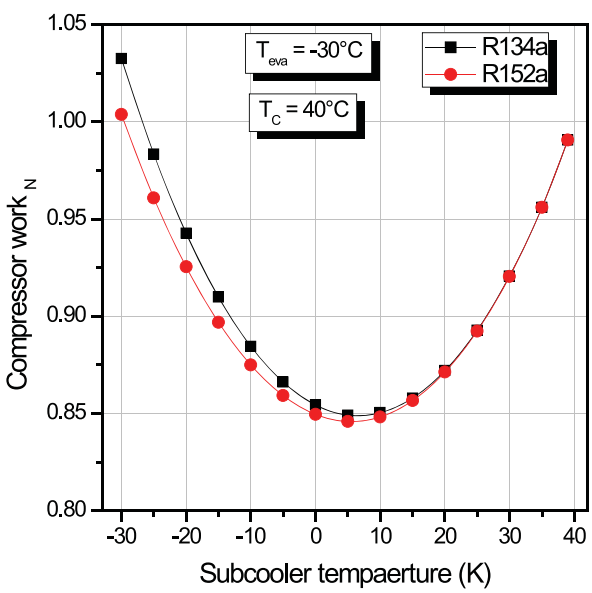

Figure 13: Effect of subcooler temperature on normalized compressor power for specified evaporator and condenser temperature.

The improvement in the performance characteristics of the refrigeration cycle with dedicated subcooler over vapour compression refrigeration cycle without subcooler the can be expressed by plotting the predicted results in the normalized curve. Normalized compressor work for a particular condenser and evaporator temperature can be expressed as:

$$W_N = \frac{W_{Total}}{W_{WS}} \quad (1)$$

where WTotal is the total required work by the refrigeration system with dedicated subcooler and WWS is the total compressor power requirement by the refrigeration system without subcooler. The normalized COP can be expressed as:

$$COP_N = \frac{COP_{Overall}}{COP_{WS}} \quad (2)$$

and similarly here, COPWS and WWS are the COP of the system and compressor power without subcooler respectively.

At first, simulation has been carried out taking R134a in both the cycles as refrigerant keeping the evaporator temperature constant at -30°C and condenser temperature is varied from 40°C to 55°C. Effect of subcooler temperature on the normalized COP of the system for different main cycle condenser temperatures has been shown in figure 11. Also, variation of normalized COP with subcooler temperature for different evaporator temperatures in the main cycle has been shown in figure 12. It can be seen from the figure 9 that normalized COP initially increases, reaches its maximum value and then decreases with the increase in subcooler temperature.

This is because, as subcooler temperature increases beyond a certain value, the subcooler cycle COP increases but the COP of the main cycle decreases. It can also be noted from the figure that maximum normalized COP is achieved when condenser temperature is maximum. It is clear that COP reaches its peak at the subcooler temperature midway between the evaporator and condenser temperature. The results show that at optimal condition of the subcooler the system with subcooler cycle shows almost 28% higher COP compared to that of the without subcooler cycle at condenser temperature of 55°C.

In figure 12, evaporator temperature is varied from -15°C to -30°C while condenser temperature is kept constant at 40°C and refrigerant R134a is considered in both the cycle for the analysis. The figure depicts that with the decrease in evaporator temperature in the main cycle, normalized COP increases. For a particular evaporator temperature, COP first increases and then decreases with the increase in subcooler saturation temperature. Therefore, an optimum point exists where system shows its highest performance. It can also be observed from the figure that the optimal condition is obtained at the subcooler temperature which is at the mean temperature between the corresponding condenser and evaporator temperature. Predicted results showed about 18% enhancement in COP over the simple VCR cycle when the subcooler cycle is attached to the main cycle at evaporator temperature of -30°C.

The variations of normalized compressor power with subcooler temperature for fixed evaporator and condenser temperatures of -30°C and 40°C respectively have been presented in figure 13. In the figure, red line and black line represents the normalized compressor power consumed by the system using R152a and R134a as subcooler cycle refrigerants respectively. It is clearly seen from the figure that compressor power requirement initially decreases and reaches the minimum value and then again increases with the increase in subcooler temperature. As the subcooler temperature increases, the amount of subcooling in the main cycle decreases. This leads to increase in refrigerant mass flow rate in the main cycle which results in increase in compressor power in the main cycle. It is evident from the figure that compressor power requirement is slightly less for the system with R152a in the subcooler. Differences in compressor power for both R152a and R134a subcooler configurations have been calculated and it is found to be 15.5% and 15.1% less than that of the without subcooler system. Also, the comparison of system with and without subcooler has been shown in table 3. The percentage improvement in COP for system with subcooler over the system without subcooler varied from 17.74 to 20.57 in the given range of evaporator and condenser temperatures.

Conclusions

In a scenario where fossil fuels are fast depleting and the demand for HVAC is growing rapidly, it is now high time to look for alternatives which can save energy usage in HVAC industry. Energy-efficient HVAC system can be designed into new configurations of conventional systems that make better use of existing parts. The alternative configurations of vapour compression refrigeration system have proved to be effective and energy efficient especially in case of high temperature lift. The other methods like evaporative cooling, thermal storage systems and heat recovery systems should be implemented in HVAC to increase the energy-efficiency of the systems. The demand for HVAC industry for various needs like preservation of food, medicines and especially human comfort has always been there and is now at its peak. In the process, to meet this demand man has been depleting resources and polluting the environment for years. The use of natural refrigerants is the best solution to check environmental destruction. Now, the world has to come together to stop the damage by carrying research and developing technologies which result in minimum energy resource depletion and destruction of our environment. ■

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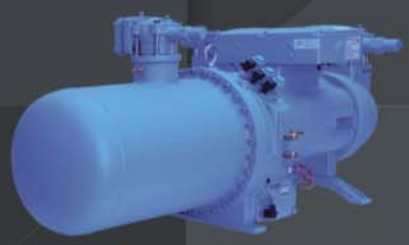

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Huayi-Trucool Compressor Launch

Vikash Sekhani, Safe Refrigerations

Susan, International Sales Head, Huayi Compressors Company Ltd.

Huayi Compressor Company Limited, Jingdezhen & Safe Refrigeration Private Limited formally launched the world famous refrigeration compressors in the brand name of Huayi-Trucool at a National Launch Program held at Hotel Crowne Plaza, Okhla Phase -1 Delhi on December 8th, 2017.

This program was attended by officers from Huayi Compressors Company Limited, Safe Refrigeration Private Limited, key industry colleagues and pan India Huayi-Trucool business associates. Huayi Compressor Company Limited Jingdezhen, China, has appointed SAFE Refrigerations (P) Limited as its sales & marketing partner for India from 2014.

Huayi Compressors have wide variety of applications including White Goods Refrigerators, Deep Freezers, Water Coolers, Bottle Coolers, Display Cabinets & host of other Refrigeration Appliances.

Safe Refrigerations private limited has appointed wholesalers across India & has started active engagement with key equipment manufacturers. They have also made these compressors available locally, provided application-engineering support & offer after sales replacement warranty. It also plans to conduct customer education seminars at key location in India in few months. Speaking on this occasion Susan, International Sales Head, Huayi Compressors Company Limited said, we are excited to partner with Safe Refrigerations to jointly market these compressors in India. Both the companies have good synergy in terms of providing best products and services to the Indian customers. We provide best quality, energy efficient and tropicalized design products for Indian customers. Over the next few months, we will continue to expand our range of models in India through Safe Refrigerations. We closely work with our customers on education and training to ensure we have minimal field failure situations.

Vikash Sekhani speaking on behalf of Safe Refrigerations stated on this occasion that Huayi-Trucool brand compressors have good synergy with the current lines of business. We believe in having long-term customer relationship, high service orientation and actively work on customers, feedback. We have set up a dedicated organization to promote Huayi-Trucool compressors across India and have appointed sales & application engineers to support this business. In addition, we also providing unique 18 months replacement warranty on these compressors that very few companies offer in India. Huayi Compressor Company Limited globally has an annual turnover of $1 billion+, has plants in China and Barcelona. It has an employee strength of 7,500 and annual manufacturing capacity of 45 million pieces. World famous Cubigel brand is owned by Huayi Compressors Company since 2012. Huayi brand compressors have been regularly used in India as well for last few years by leading White Goods Refrigerators and Commercial Refrigerator manufacturers and are known for its high efficiency , high reliability and tropicalized design.

SAFE Refrigeration Private, a professionally managed company, has 50 + years of expertise in Pan India distribution of key HVAC&R products. Few key products in its portfolio are Highly Rotary Compressors, Harris Brazing Alloys & Equipment, Aspen Condensate Pumps etc. SAFE Refrigeration Private Limited has been successfully serving equipment manufacturers, wholesalers and contractors across India. ■

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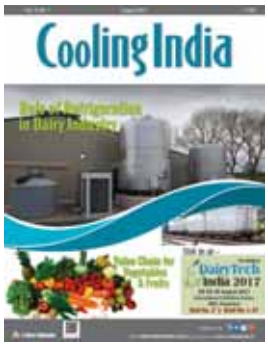

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Australians Wasting $1.3 bn on Air Conditioners

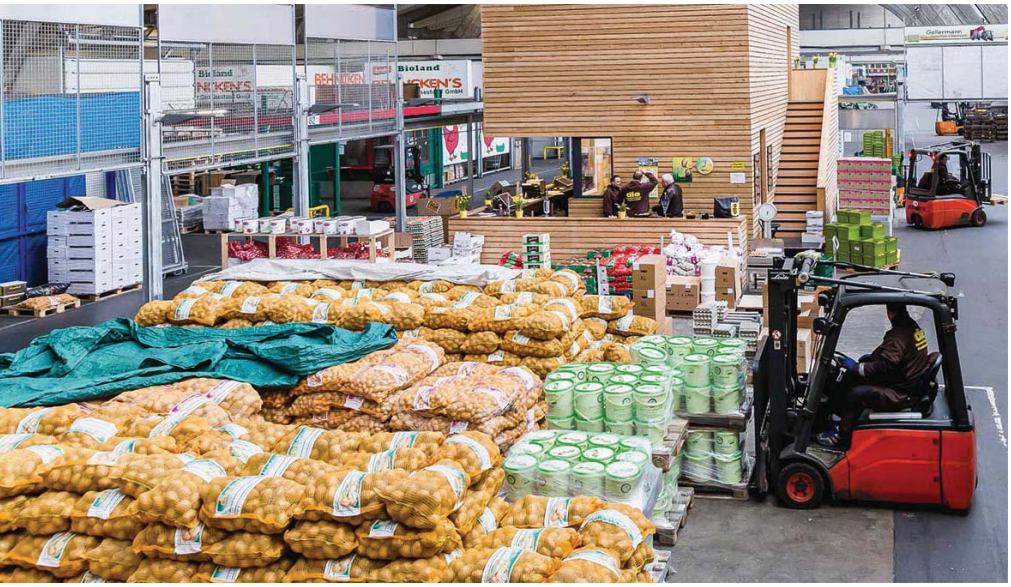
Australians are predicted to waste more than a billion dollars on air-conditioning use this summer due to bad habits, a survey by finder.com.au has found. With severe heatwave conditions consistently sweeping across the country, air-conditioning users are being warned that leaving units running when they are not home could be clocking up a hefty electricity bill. The survey consisting of 2017 respondents reveals that 23 percent of Australians – equivalent to 2.3 million households – admit to leaving their air-conditioning units running when they are not home. This aircon indulgence is wasting an average of 4.1 hours in energy per day, costing up to USD 1.3 billion in wasted energy expenditure over the summer months. This could be adding USD 578 to the household's quarterly electricity bill.

"When faced with a heatwave and temperatures as high as 40 degrees, we don't usually think of our electricity bill some three months away – we just want to instantly cool down," finder.com.au money expert Bessie Hassan said. "But after a few scorchers, this way of thinking can leave you with post-summer bill shock." The typical split-cycle air-conditioning unit consumes around 5.0 kWh and costs around 2.7 cents to run per minute, which can cost close to $13 per night if users leave it running overnight. "There are more wallet-friendly ways to keep cool in summer such as keeping blinds closed during the day to keep the sun out, and opting for a fan instead," Hassan said. "If you find you really can't live without air-con invest in a timer. That way you can set it to turn off once you fall asleep." It is believed generation Z (18 to 22 year olds) are the least savvy and keep the cooling running for 5.6 hours a day on average while not home.

In comparison, the survey found that generation Y (Millennials) wasted about four hours while not at home compared to generation X wasting 3.6 hours. However, Baby Boomers are recorded at indulging in 4.2 hours of cooling while not at home. Women are slightly more prone to aircon over-indulgence, wasting on average 253 minutes per day, in comparison to men who waste 233 minutes. ■

Future is Integrated

Players are clubbing warehouse and reefer services to tap demand and investments...



Integrated cold chains, which offer a combination of temperature controlled warehouse (TCW) and temperature controlled vehicle (TCV) services, are the hot new trend in logistics. Although only a few big players offer integrated services today, the number is expected to rise in years to come.

The spurs are all too conspicuous. CRISIL Research estimates the cold chain industry to log a compound annual growth rate (CAGR) of 14-16% over the five fiscals through 2022, to about ₹ 500 billion from ₹ 250 billion in 2017. Bulk of the growth would be in the TCW segment, which accounts for 90% of the industry revenue. Within this segment, multi-purpose cold storages dominate, and their share of segment revenue is estimated to rise from 77-79% in fiscal 2016 to 84-86% by fiscal 2022. However, TCVs, or reefers, which accounts for 10% of industry revenue, is expected to log relatively sedate growth – at 8-10% CAGR – to ₹ 26 billion in fiscal 2021 from ₹ 18 billion in fiscal 2017.

Investments in the sector are expected to mirror the revenue split. Of the ₹ 150-200 billion investments expected in the five years, about 90% is seen going into TCWs. The bulk of the money will go into multi-purpose cold storages, which offer higher rentals compared with single-commodity cold storages, and also early payback. The TCV segment is expected to get only 10% of the investments. Despite the need, investors are not comfortable with committing more to the segment mainly because it is highly fragmented and offers low margins. The main reason for the subdued growth in TCVs, which provide first- and last-mile connectivity to cold storages, is that end user industries are not willing to pay high rentals Also, unavailability of return load leads to inefficient utilisation of vehicles, which acts as a major inhibitor.

This is why it makes sense for a player providing both TCW and TCV services to offer an integrated package to clients willing to pay, rather than as standalone services.

Need For Cold Chains

India is the second-largest producer of fruits and vegetables, the largest producer of milk, and one of the leading producers of meat and fish. But it is also ranks among the top in wastage of food. As per The Central Institute of Post-Harvest Engineering and Technology, Ludhiana, the annual wastage of harvest and post-harvest losses of major agricultural produce is 10-16% of the total across categories. At 15-16%, wastage is the highest in fruits and vegetables, followed by marine products at 10%. This is mainly because India lacks proper infrastructure facilities for storage of perishables such as fruits, vegetables, meat, and seafood, etc. Lack of adequate back-end infrastructure results in the produce not reaching the market in the small window available before it perishes. Yet, the penetration of cold chains in India is low, at 0.1 cubic metre cold storage space available per capita, compared with 0.35 cubic metre in the US. This suggests there is much headroom for growth.

Rise in QSR Demand

Strong growth in quick service restaurant or QSR segment, rising imports and exports of processed food, and increasing regulatory requirements for the pharmaceutical industry are expected to be the key growth drivers for cold chains. In the QSR industry, both established and new players are expanding their reach by opening new outlets. In pharmaceuticals, the biopharma products – particularly vaccines – need to be maintained at lower temperatures, thus, making the cold chains indispensable.

Also, processed foods, fruits and vegetables, and frozen foods -- the main users of cold storage facilities – comprise

half of India's total exports. Imports of fresh fruits and vegetables have increased in the past two years as preference for exotic fruits and vegetables/ herbs rises. Rising seafood exports have also contributed to the growth of multipurpose cold storages. At 1.1 MT, India's seafood exports in fiscal 2017 jumped 20% on-year, mainly due to demand from the US. Over the next three years, CRISIL Research expects seafood exports to log a 14-16% CAGR as aquaculture production rises.

Challenges Remain

If anything, India's energy infrastructure is extremely lacking and is as a huge impediment in integrating cold chain capabilities across the supply chain. Also, lack of awareness of modern cold storage facilities and unwillingness of end-user industries to pay higher charges makes it difficult for players to charge higher rentals. However, given subsidies from the government, multi-purpose cold storage players have gradually started investing in reefer vehicle assets. The focus is gradually shifting from merely holding commodities in cold storages to offering an entire cold chain solution as per the custom requirements.

Technology a Differentiator for New Players

Organised multi-purpose players are using environment-friendly refrigerant products and diverse technologies depending on the nature of commodity, the type and stage of processing, and the sophistication of the value chain. New entrants are deploying modern technologies, while most of the earlier-generation cold storages remain dependent on manual modes of monitoring and conventional measuring systems. In the context, new technologies that are likely to be embraced are systems based on radio-frequency identification (RFID) for unit level measurement, wireless sensor network (WSN) for a local unit, and Internet of Things (IoT) for covering the entire supply chain. ■

Binaifer Jehani
Director
CRISIL Research

"Thermal imaging cameras are perfect tool for identifying faults"

Thermal Imaging is gaining fast popularity among the proponents of non-destructive industrial tests. It has versatile advantages including cost saving, which perhaps is the topmost priority among the business runners today. **T P Singh, Director & Country Manager, FLIR Systems** takes through the applications and benefits of this technology in the field of HVACR during an interaction with **Cooling India**...

What is thermography and how it works?

Almost all objects around us emit infrared (IR) radiations which our eyes cannot see. Infrared thermography is the art of transforming an infrared image into a radiometric one; every pixel in a radiometric image is actually a temperature measurement, so temperature values to be read from the image. Thermal imaging cameras are the perfect tool for locating and identifying faults/failures because they make the invisible visible.

What are the unique advantages of this technology?

Infrared (IR) inspection is a powerful and non-invasive means of monitoring and diagnosing the condition of buildings. An IR camera can identify problems early, allowing them to be documented and corrected before becoming more serious and more costly to repair.

An infrared inspection within building diagnostics help:

- Visualize energy losses
- Detect missing or defective Insulation
- Find moisture in the insulation, in roof and walls, both internal and outside
- Detect mold and badly insulated areas
- Locate thermal bridges
- Locate leaks in flat roofs
- Source air leaks

- Detect breach on hot-water pipe
- Detect construction failures
- Locate radiant floor heating faults
- Monitor the drying of buildings
- Detect electrical faults
- Find faults in supply line and district heating

What are the application areas for this technology in buildings?

Detecting Poor Insulation and Air Leaks

Infrared thermography (thermal imaging) is an outstanding tool to locate building defects such as missing insulation, delaminating render, and condensation problems. Thermography also helps assess flat roofs for damaged insulation and trapped moisture.

Insulation Defects

The typical thickness of the insulation varies from country to country. In cold climates, the insulation usually is thick. In countries with warmer temperate climates, there is less thickness or nothing at all. On the other hand, in warmer climates, cooling inside is often used which calls for thick insulation to take care of the energy. Using an IR camera the rule of thumb is that it should be at least 10 °C temperature difference between outside and inside temperature the sides of the wall to get good, easy to see patterns. Using a camera with higher resolution and thermal sensitivity, the temperature difference can be less.

Detection of Air Leaks

It is not unusual to find air leaks through the envelope of a building. An air leak leads to higher energy consumption, often causing problems with the ventilation system, as well as causing condensation in the construction which makes the indoor climate poor. 90% of air leaks are caused by the defect in the climate shelf. To detect air leaks with an infrared camera a temperature difference and a pressure difference over the construction is needed. The air itself is not possible to see. With an infrared camera, however, you detect the characteristic patterns that occur when cold air is coming through a leak in the construction - goes along a surface and cools it down. The infrared inspection should always take place on the side of the construction with negative pressure.

Moisture Detection

Moisture damage is the most common form of deterioration for a house. Air leakage can cause condensation to form within walls, floors, or ceilings and wet insulation takes a long time to dry and becomes a prime location for molds and fungi. Scanning with an infrared camera can locate moisture that creates an environment conducive to molds - locations that may never be seen with the human eye. One might smell its presence, but not know where it is forming. An infrared survey will determine where inherently moist areas are located that promote potentially serious mold and health problems.

Thermal Bridges

A thermal bridge is an area with less insulation due to the construction; such as a metal fastener, concrete beam, slab or column. Heat will flow the easiest path from the heated space to the outside - the path with least resistance. Very often heat will 'short circuit' through an element which has a much higher conductivity than surrounding material, which can be described as a thermal bridge.

Typical effects of thermal bridges are:

- Decreased interior surface temperatures; in the worst cases this can result condensation problems, particularly at corners.
- Significantly increased heat losses.
- Cold areas in buildings.

Supply Lines and District Heating

In cold climates heating of pavements and gangways are used. It is also common with district heating, a system for distributing heat generated in a centralized location for residential and commercial heating requirements. A thermographic survey can easily detect any defects in heating systems under ground. Even if there is snow on the ground, the heating pipe lines are visible with an infrared camera.

Electrical Faults

One of the most common faults in buildings is electrical faults.

What kind of experience or training is required to develop skill in working with this technology?

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What are the latest models from FLIR that are available in India these days?

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What are your suggestions to the potential buyers from the HVACR industry?

The main message from my side will be to choose right product for your application. If the object is smaller and distance is longer, a good high resolution Thermal Camera is required for accurate measurement. The main technical name to choose a product keeping this requirement in mind is IFOV (Instantaneous Field of View). Choosing a wrong or low resolution product can be dangerous as it may not see potential problems and hence main purpose of using time, money, and energy can go waste. ■

Cooling Water System of Thermal Power Plant

The cooling water, thus, used will be sent through cooling towers to reject the heat into atmosphere and cooled water will again circulated through condenser. In this type of system make up water will be used in the stream to maintain the cooling water flow quantity on account of evaporation and blow down losses. This water is accounted as water consumption...

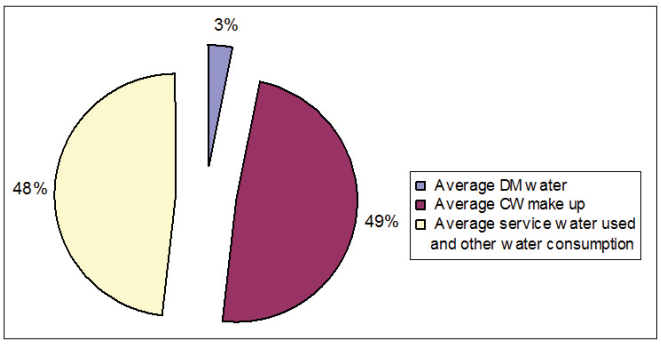
The present installed capacity of power generation in India is about 331.1 GW, out of which 66.26 % is through thermal generation. Water used for energy is about 2.68 % of the total water consumption. The projected water demand for energy sector increases over the year from 2.68 to 3.95 % in the year 2025 and to 6.47 % in the year 2050. Though the majority of water is used for irrigation in India, the growing water demand is envisaged for energy sector due to huge thermal generation capacity addition.

Study carried out on units of capacity ranging from 55 MW to 500 MW with total station capacity of 55 MW to 2340 MW. Water requirement in power plant varies mainly based on the type of cooling deployed in it. Older power plants uses once through cooling system to remove the heat from condenser and the hot cooling water is discharged into the same water source at a higher temperature than the intake at downstream of the water body. This water is accounted as water withdrawal. Whereas other power plants use large wet cooling towers to remove the heat from condenser. The cooling water, thus, used will be sent through cooling towers to reject the heat into

Table 1: Average water consumption in a coal fired thermal power plant with closed loop wet cooling system.

Sl. No.	Particular	Value, ml/kWh	%
1	Average DM water	145.9	3.4
2	Average CW make up	2051.8	48.3
3	Average service water used and other water consumption	2053.6	48.3
4	Total	4251.3	100.0

Figure 1: Average water consumption pattern in a coal fired thermal power plant with closed loop wet cooling system.



atmosphere and cooled water will again circulated through condenser. In this type of system, make up water will be used in the stream to maintain the cooling water flow quantity on account of evaporation and blow down losses. This water is accounted as water consumption. Hence, the water which is withdrawn for use and again discharged back to the stream is accounted as water withdrawal mainly in once through cooling system and others which are used in the process are accounted as water consumption. Raw water is taken from the water body will be clarified and this water will be treated and used for service water requirement, for making DM water for the main process, firefighting and hydrant purpose, auxiliary cooling, drinking water, etc.

Findings and Discussions

Average water consumption pattern in a coal fired thermal power plant with wet cooling tower system is given in Table 1 represented schematically in Figure 1. Average water consumption pattern in a coal fired thermal power plant with once through cooling system is given in Table 2 and is represented schematically in Figure 2.

From the Table 2 and Figure 2, it can be seen that about 48% of the water consumed is accounted for cooling water make up followed by 48 % for service water purposes and 3% for DM water consumption.

In power plants with once through cooling water system, about 82 % of the consumption is accounted for service water purposes and balance 18% is accounted for DM water consumption. Variation of specific CW makeup water consumption with plant load for coal fired power plants with closed loop cooling tower are given in Figure 3.

Figure 3 shows that the specific CW makeup water consumption is not showing any variation with plant load. This trend is mainly due to non-monitoring of the quantity of makeup required in the CW system and lack of quantification and accounting of water usage for this purpose. Further, in some of the plants it was observed that, the CW makeup pumps are run continuously without monitoring the CW fore bay level and sometimes pumps in throttled condition.

The total specific CW makeup consumption in coal fired thermal power plants with closed loop cooling water system with various capacity range are classified and given in Table 3.

From the above Table 3, it can be observed that the specific CW makeup water consumption for coal fired thermal power plants varies from 1400 ml/kWh to 2500 ml/kWh. As per the study done in USA, the average specific overall water consumption of a thermal power plant with closed loop cooling system in USA is 2000 ml/kWh. This figure of 2000 ml/kWh includes specific CW makeup water consumption as one part of the total water consumed in a thermal power station. Compared to this the specific CW makeup water consumption alone in Indian thermal power station is high. This high CW makeup water consumption is mainly attributed to evaporation, blow down losses from cooling towers and large quantity of hot CW system being tapped for transportation of ash in wet ash disposal system. One of the reasons for this high water consumption is due to a large quantity of water required to transport the very high ash quantity being disposed off from Indian power plants attributing to very high ash content (ranging form 35 % to as high as 50 %) in Indian coal compared to coal being used in USA.

Table 2: Average water consumption in a coal fired thermal power plant with once through cooling system.

Sl. No.	Particular	Value, ml/kWh	%
1	Average DM water	60.0	17.6
2	Average service water used and other water consumption	281.6	82.4
3	Total	341.6	100.0

Figure 2: Average water consumption in a coal fired thermal power plant with once through cooling system.

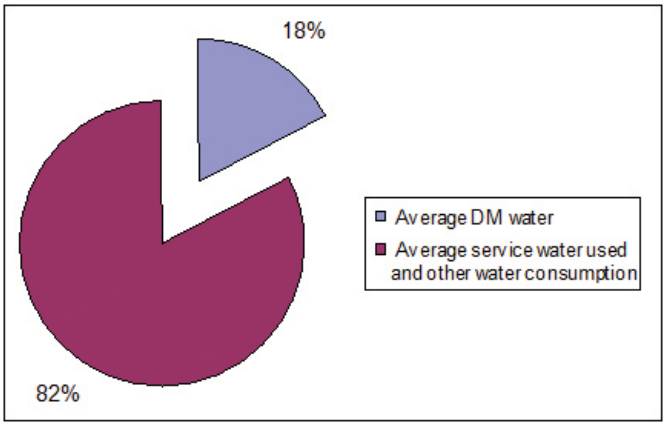


Table 3: Range of CW makeup consumption in coal fired thermal power plants

Specific CW makeup Consumption, ml/kWh			
	Min	Max	Avg
55 - 500 MW	1800.0	2300.0	1995.8
500 - 1000 MW	2000.0	2500.0	2170.0
Above 1000 MW	1400.0	2300.0	1966.7

Issues Related with Cooling Water System

Some of the thermal power plants are being shut due to acute water shortage during summer.

Further, large number of thermal power plants are being installed which more need water for power generation. Water and energy nexus is inseparable in the energy generation chain. Hence, thought should be given to conserve water in the existing power plants as well as in the new plants being installed. As cooling water consumption requirement is about 50 % of the total water consumption in power plant, it is time to think about water conservation in the cooling water system.

Wet type cooling towers are present in thermal power plants, which are in operation. In this system, the cooling water from the condenser falls through the tower which will be cooled by the air which flows through the falling stream of water by natural or induced draft mode according to the design of the cooling tower. Thus, in this process of heat removal water is also lost in the form of evaporation and drift through the cooling tower.

Figure 3: Variation of specific CW makeup water consumption with plant load

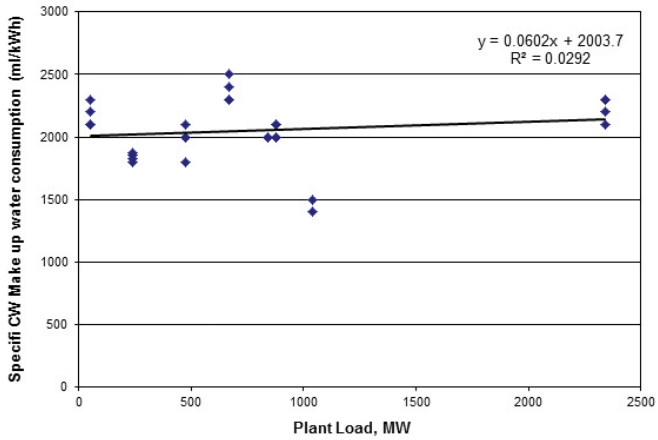


Table 4: Water quality parameters and its impact on cooling system

Water quality parameter	Impact on cooling water system
Hardness	Scale formation Calcium in the form of $CaCO_3$, Magnesium with high silica level will lead to formation of Magnesium Silicate.
Alkalinity	Scale formation Important parameter to predict formation of $CaCO_3$ potential.
Silica	Scale formation
Total Suspended Solids	Scale and Corrosion. Suspended solids can adhere to biofilms and cause under-deposit corrosion.
Phosphate	1. At higher concentration level above 20 mg/l with calcium > 1000mg/l leads to Calcium Phosphate scaling 2. Nutrient for biofilms. 3. At concentration level below 4 mg/l and controlled pH from 7 to 7.5 acts as corrosion protection.
Ammonia	1. Enhances biofilms on heat exchanger and cooling tower fills. 2. Corrosive to copper alloys at concentration as low as 2 ppm.
Iron	1. Specialised polymers used for inhibition of calcium phosphate scaling will be deactivated. 2. Along with phosphate, it will form foulants.
Chloride	Corrosive to most metals.
Zinc	1. At levels between 0.5 to 3.0 mg/l is beneficial. 2. At level above 3.0 mg/l lead to deposits.
Heavy Metals such as Copper, Nickel and Lead	Cause localised galvanic corrosion that can rapidly penetrate thin steel heat exchanger tubes.
Algae	1. Provide a nutrient source for bacterial growth. 2. Deposit on surface contributes to localized corrosion process. 3. Loosened deposits can block and foul pipework and other heat exchange surfaces.
Fungi	Proliferate to high number and foul heat exchanger surfaces
Bacteria	1. Some types of pathogenic bacteria, such as Legionella, may cause health hazards. 2. Sulphate reducing bacteria can reduce sulphate to corrosive hydrogen sulphide. 3. Cathodic depolarization by removal of hydrogen from the cathodic portion of corrosion cell. 4. Acid producing bacteria produce organic acids, which cause localized corrosion of deposit laden distribution piping and also provide the potential for severe pitting corrosion of heat exchanger surface.

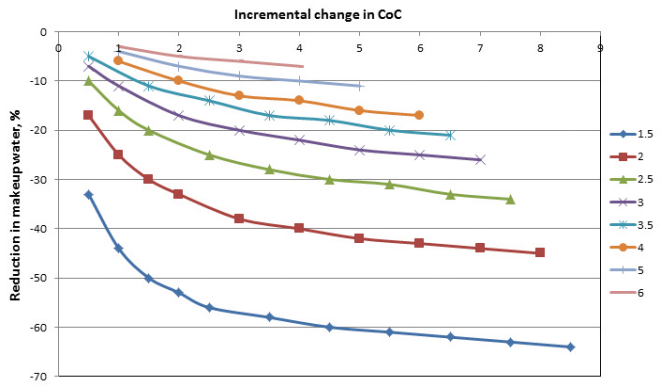


Figure 4: Reduction in makeup water % Vs incremental change in CoC

Other water related problems

Other water related problems are due to:

Corrosion: Corrosion is an electrochemical oxidation process. This will destruct the metals of the cooling system equipment such as copper, etc. If this is not controlled, this will lead to equipment failure, plugging of corroded passages in condenser resulting in decreased heat transfer and energy efficiency. Corrosion products deposit on heat transfer area acts a layer of insulator and decreases the thermal conductivity.

Scale: Scaling is a chemical process resulting of increase in dissolved salts concentration in cooling water. This increased concentration of dissolved salts exceeds its solubility limit and precipitates in the forms of salts of calcium or magnesium. The insolubility becomes more with higher water temperature and prone to form deposits at cooling tower heat transfer surface such as fills. The scale formation reduces and blocks the water and air flow path and thus, reduces the air water interaction inside the cooling tower and reduces the performance. Further, due to the scale formation on the fill material, increases the weight of the fill substantially over a period of time and thus, leading to collapsing of the fill packs leaving void spaces inside the cooling tower.

Deposition: Deposition in any cooling system is a cause of carryover of air borne suspended matter from the surroundings of the site. This may be due to process such as leakage of oil from coolers and suspended matters in the makeup water. The effect of this deposition will be similar to scaling, reduces the thermal insulation leading to poor heat transfer and less efficiency.

Biological Fouling: Slime and algae formations in heat transfer area such as fill and other structures of cooling tower may reduce heat transfer, promote corrosion, and harbor pathogens such as Legionella. This too will act similar to the above discussed scale and deposition.

Some of the water quality parameters and its impact on cooling system is given in the Table 4.

Remedial Measures

Different type of Cooling System

In newer plants dry cooling system can be considered. The

Table 5: Recommended water quality parameters for control of corrosion and scale

Property of Water	Recommended Level
pH	6.5 to 9.0
Hardness as $CaCO_3$	30 to 750 ppm
Alkalinity as $CaCO_3$	500 ppm maximum
Total Dissolved Solids (TDS)	1500 ppm maximum
Conductivity	2400 micromhos
Chlorides	250 ppm maximum Cl (410 ppm maximum as NaCl)
Sulphates	250 ppm maximum
Silica	m maximum

dry cooling system can be classified as follows:

1. Direct dry cooling system
2. Indirect dry cooling system

In direct dry cooling system, the exhaust steam from the low pressure turbine is sent through finned heat exchangers. Air will be used as the medium to transfer heat from this using natural draft or through induced draft using fans.

In indirect dry cooling system the exhaust steam from the low pressure turbine will be passed through surface of jet condenser. The heat from the steam will be carried by water in the other side. This hot water will be passed through finned heat exchangers. Air will be used as the medium to transfer heat from this using natural draft or through induced draft using fans.

By using the above system the power plants can save about 50 % of the water consumption directly. The disadvantage of this system is the output of the plant reduces by about 7% due to deployment of dry cooling system. Further, the heat rate increases and there will be a marginal increase in auxiliary power. Considering all the above, the dry type cooling towers cannot techno economically replace the wet cooling towers but it is an alternative costly option for a site where water is not adequately available.

Water Conservation

The Figure 4 shows the reduction in makeup water % with respect to incremental change in CoC from the existing CoC. For example, if the operating CoC is 6 and if the CoC is maintained at 10, the reduction in makeup water is 7%. Similarly if the operating CoC is 1.5 and if the CoC is maintained at 6, the reduction in make up water is 60 %.

Maintaining very high CoC increases the cost of water quality to be maintained and thus, the operating cost. Thus, there is a tradeoff to be made to find out the optimum CoC to be maintained according to the raw water quality available at the site.

Water Quality Improvement

Corrosion & Scale Control

The specific measures required for corrosion and scale control vary from system to system and are largely dependent on the following:

i. Chemistry of the makeup water
ii. Metallurgy of the heat transfer devices in contact with the recirculating water and piping
iii. Operating temperature of the cooling water system

Control

Scale can be controlled or eliminated by application of one or more proven techniques.

Typical measures taken to control scale are:

i. Controlling cycles at a set level
ii. Chemical scale inhibitor treatment
iii. pH adjustment by acid addition
iv. Softening of cooling water system makeup

Controlling Cycles at a set level

In normal conditions, the blow down/bleed which is continuous flow of a small portion of the recirculating water to drain is sufficient enough to control the concentration of dissolved solids and in turn to control scale and corrosion. Further, installation of a high quality system for automatic blow down based on conductivity or metered makeup will control the cycles.

Chemical Scale Inhibitors

Most of the system requires chemical scale and corrosion inhibitors which raise the allowable level of dissolved solids without the risk of scale and corrosion. Chemical scale inhibitors function by either selective adsorption on growing scale crystals, converting the crystal structure into a non-scaling type which does not form a hard scale, or through chemical reactions with the scale forming ions, converting them into non-scale forming materials.

pH Adjustment

Control of scale with pH adjustment by acid addition functions via chemical conversion of the scale forming materials to more soluble forms. Thus, calcium carbonate is converted to calcium sulphate (using sulphuric acid for pH adjustment), a material several times more soluble. Normally, it is not desirable to add sufficient acid to convert all of the scale forming materials due to a substantial increase in the corrosivity of the cooling water if this is accomplished. Addition of excessive acid to the cooling water results in depressed pH values and extremely rapid corrosion of all system metals.

Makeup Softening

Scale can be completely eliminated by softening all cooling system makeup water. Using softened makeup water for scale control is the safest, most cost-effective method available for obtaining high cycles, or zero blow down, with hard makeup water. Normally, the added cost of softened makeup water is balanced by the decreased chemical and water usage resultant from the increased cooling system cycles made possible by the soft water. Controlling of corrosion and scale can be achieved by maintaining the following water parameters given in Table 5:

Chemical Treatment Requirements

Chemical treatment needs the following:

i. Compatibility of the chemicals to be used with the materials of construction, pipes, heat exchanger, etc. of the cooling system.
ii. Automatic feeders must be used to introduce chemical scale

and corrosion inhibitors into the circulating water system. The feeding point should be such a way that it ensures total mixing and dilution before reaching the cooling equipment. Widely preferred location in a cooling system is at the discharge side of the circulating pump. As these chemicals can severely damage areas directly contacted, these should not be batch fed directly into the cold water basin or water distribution system.

iii. If chlorine is being added to the system, it must be ensured that it does not exceed 1 ppm as exceeding this limit may accelerate corrosion.

Deposition Control

Measures taken to control deposition depend on the cause of the problem. Process contamination problems are best corrected by elimination of the process leakage, while most suspended solids deposition can be controlled by addition of dispersant or surfactant chemicals to the cooling water. These materials function by charge neutralization of the suspended particles and emulsifying binding agents, breaking up existing deposits and preventing agglomeration of the particles to form new deposits.

Heavier concentration of suspended solids deposition can be treated with a combination of chemical dispersants/surfactants and an element filter, hydrocyclone or media filter in a side stream configuration. 2 to 35 microns range of suspended solids in recirculating water is not difficult to control. Below 2 microns dispersants are the effective control for deposits. Above 35 micron level, simple sedimentation of hydrocyclones is effective. Automatic backwashing filters are the most effective for removal of suspended solids in the critical range of 2 to 35 microns. If a cooling system needs to be operated at over six cycles of concentration, bypass filtration is required. In heavy dusty atmospheric conditions, such filtration is required regardless of the chemistry or cycles of concentration at which the cooling system is being operated.

Biological Fouling Control

Formation of anaerobic areas under the biological fouling layer results in a substantial corrosion rate increase. Widely used biocides classified in two major classes (i) oxidizing and (ii) non-oxidizing.

Oxidizing Biocides

Cellular structure of the bio fouling organism is effectively destroyed and killed by chemical oxidation by oxidizing biocides. As this is a destructive form of action, it is impossible for any organism to show, or develop, significant immunity to an oxidizing biocide. Oxidizing biocides are usually quite cost effective due to their low unit cost, rapid effect on the target organism, and low effective dosage. Oxidizing biocides have the following disadvantages:

i. Some of them can decrease cooling water pH in an uncontrolled manner.

ii. Most of them increase the corrosive nature of the cooling water.

iii. Oxidizing biocides such as chlorine produce undesirable by-products from an environmental viewpoint.
iv. Some corrosion and scale control chemicals can be inactivated by contact with specific oxidizers.
v. None of the oxidizing biocides have any dispersant effect for removal of deadmicrobiological growth.

Non-oxidizing Biocides

Non-oxidizing biocides are generally quite costly due to the high effective dosage, long contact times, and often high unit cost.

Non-oxidizing biocides do have advantages over the oxidizing biocides:

i. No effect on corrosivity is evident from their use.
ii. Do not interfere with corrosion and scale control chemicals.
iii. Specific type of organism can be targeted and treated.
iv. Definite dispersant effect for removal of dead microbiological growth.

Conclusion

About 50 % of the water consumption in a thermal power plant is accounted for cooling water system. The following measures in cooling tower, CW system will lead to water and energy conservation:

- Control in drift losses of cooling tower by use of efficient drift eliminators, maintaining optimum cycle of concentration, etc. will lead to water conservation on account of cooling water system in a thermal power station.
- Other technological options available are: adopting hybrid cooling technologies at design stage, mapping of water use at each stage and system of the plant using water meters with transmitters to integrate into the existing data acquisition system.
- Stringent water quality monitoring aimed at optimization of CW makeup water in the cooling tower, avoiding throttling in the water pumping network and use of variable frequency drives, etc. are the other available operational optimization avenues in a thermal power plant.
- Optimisation of hot CW water for ash disposal and ash to water ratio optimization in ash handling system will lead to significant water and energy saving.
- It is high time for the water and energy conservation to go hand in hand as water too is becoming a scare commodity. ■

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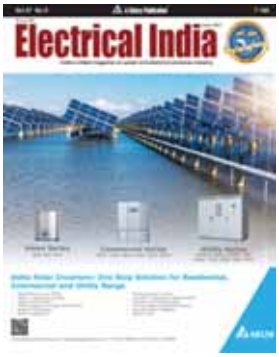

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Welcome to ICEHOTEL

The entire ICEHOTEL opened on December 15 on the riverbank in Jukkasjärvi, Sweden. With a total of 35 uniquely designed art- and deluxe suites, ice bar, ice ceremony hall and ice gallery, the guests are welcomed to experience an unforgettable night on ice and snow. 36 artists from 17 different countries have created 15 totally unique art suites, a magnificent Main Hall, and a special ice ceremony hall. Everything, including the artwork, can only be experienced at ICEHOTEL during the winter in Jukkasjärvi. When the winter season is over, it all melts down and return to Torne River as part of a perfect cycle. The permanent part of ICEHOTEL will remain, with ICEBAR BY ICEHOTEL and 20 suites of ice and snow; three of which are completely new art suites. Amongst the seasonal suites, the guests can climb down in an underground mine with elements of crystal clear ice, created by the British brothers Hugh & Howard Miller. The gardener's daughter and jewelry designer Nina Kauppi, raised in a greenhouse, has together with her partner Johan Kauppi created a formidable jungle of Monstera-plants.

And Alem Teklu from Ethiopia has together with Anne Karin Krogevoll from Norway made a suite inspired by the boat refugees' journey across the Mediterranean Sea, with the name "Daily Travellers". Accompanying, the new year-round suites is the deluxe suite "34 meters" where artists Dave Ruane and Luca Roncoroni have carved a labyrinth of a 34-meter ice wall. The labyrinth leads to the heart of the suite – the bed. Lena Kriström and Nina Hedman have in the deluxe suite "The invisible invincible" created an army of marching women, 3 meters tall, invincible and anything but invisible. German artist Franziska Agrawal has made the art suite "Danger: Thin Ice" where guests enter a bridge and walk across thin ice to get to bed.

Mongolia, Ecuador, Argentina, USA, England, Ethiopia and Sweden are some of the countries represented at this year's art symposium in Jukkasjärvi. Some of the artists have visited ICEHOTEL before, while others have never even seen or experienced snow. What all of them have in common, is that they've been selected by ICEHOTEL's jury and invited to participate in this year's creation. ■

Cooling Towers and its History

Cooling towers play vital role in industrial applications. Various technological advancements over the years have resulted in enhancing the performance of cooling towers to a larger extent...

Cooling towers (CT) are heat exchangers used to transfer process waste heat to the atmosphere though cooling of water or any working fluid stream to a lower temperature. Cooling towers may either use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature (called water or wet cooling towers) or rely solely on air to cool the working fluid to near the dry-bulb air temperature (called air or dry cooling towers). The comparison between wet and dry cooling towers is given in Table 1. Wet cooling towers are most commonly used.

Construction

Water CT mainly consists of a casing, heat and mass transfer fill matrix and water and air circulation system. Hot water flows in counter or cross flow with ambient air, transferring heat and mass to the ambient air through a fill matrix and the resultant cold water is collected at the

Table 1: Comparison between Wet & Dry Cooling Towers

Sl. No.	Particular	Wet CT	Dry CT
1	Specific thermal capacity	Higher than dry CT	Lower due to absence of evaporative cooling
2	Outlet water temperature from CT	Lower and depends on atmospheric WBT	Higher and depends on atmospheric DBT
3	Location of plant & CT	Should be nearer to source of water	Since water is not required, plant location is flexible
4	Environmental impact	Drift and fogging are major problems	No environmental pollution
5	Capital investment	Less than for dry CT	For same application, investment is 3 to 4 times more than wet CT
6	Maintenance	More because use of chemicals, cleaning due to scaling & fouling	Less expensive to maintain
7	Power drawn by the fan	Comparatively less	Higher for same CT capacity
8	Make up of water	Upto 2 % of makeup water is required.	No need of makeup water

bottom. Cooling towers are generally used for four major applications, viz heat rejection from condensing of turbine exhaust steam in thermal and nuclear power stations; heat rejection from refrigeration plants; heat rejection from mechanical equipment like DG set, air compressor, bearings of large pumps & fans; and heat removal from furnaces and processes.

Small CTs are generally single integral and skid mounted and large CTs are square shaped modular type as cells and insitu constructed. The cooling towers are specified by the TR or MWt of heat handled, approach to the wet bulb temperature, cooling range and quantity of water handled (m3/h). Water CTs are generally built from 5 TR to any capacity.

Heat Rejection

The type of heat rejection in a cooling tower is termed "evaporative" in that it allows a small portion of the water being cooled to evaporate into a moving air stream to provide significant cooling to the rest of that water stream. The heat from the water stream transferred to the air stream raises the temperature of air and its relative humidity and this air is discharged to the atmosphere. Evaporative heat rejection devices such as cooling towers are commonly used to provide significantly lower water temperatures than achievable with "air cooled" or "dry" heat rejection devices, like the radiator in a car, thereby achieving more cost-effective and energy efficient operation of systems in need of cooling.

If cooled water is returned from the cooling tower to be reused, some water must be added to replace or make-up the portion of the water that evaporates. Because evaporation consists of pure water, the concentration of dissolved minerals and other solids in circulating water will tend to increase unless some means of dissolved-solids control, such as blow-down, is provided. Some water is also lost by droplets being carried out with the exhaust air (drift), but this is typically reduced to a very small amount by installing baffle-like devices, called drift eliminators, to collect the droplets. The make-up amount must equal the total of the evaporation, blow-down, drift, and other water losses such as wind blowout and leakage, to maintain a steady water level.

History

With the invention of steam engine, heat energy was used to generate power and cooling tower became a necessity. James Watt's patent for condenser, discovery of combustion, followed by mechanical refrigeration, internal combustion and finally, electric power generation resulted in rapid development of industries. All of these generate waste heat that must be removed and dissipated to ambient, which necessitated the development of cooling towers.

The technique of evaporative cooling can be traced back to ancient times when rivers, seas, lakes, ponds, etc. were utilized as a medium of supply of cooling

Table 2: Major Developments Taken Place in Cooling Towers

Year	Major Development
1894	First chimney cooler, a type of cooling tower, installed in Germany
1896	Cooling tower for a power plant installed
1904	1400 wet cooling towers are in operation world over
1898	In USA, cooling tower is installed for the first time
1921	World's largest natural draught cooling tower with 43,000 m3/h cooling capacity is built for a power plant
1924	Spray pond cooling is introduced
1925	Spray nozzles are patented. Innovative shapes and materials and efficient designs are introduced
1929	Industrial cooling tower with atmospheric deck tower is introduced
1930	Mechanical draft tower with fan is introduced
1935	Mechanical draft cooling tower with a 10.4-meter diameter induced draft fan introduced
1936	Cross flow design is introduced. Induced draught spray coil type tower is installed
1938	Double flow tower is developed. First hyperbolic concrete natural draught cooling tower with over 50 m height installed in Germany
1940	Natural draft cooling towers growing taller as energy demand rises. Starting originally with a height of 20 meters, cooling towers are built today with heights in excess of 200 meters
1946	Type H fan with cast aluminum blades in sizes ranging from 0.3 to 1.3 m was developed
1956	First air cooled condenser is built in Germany
1960	Cross flow design using film type fill introduced. Air-cooled heat exchangers developed. A 100 TR evaporative condenser introduced
1961	First hyperbolic natural draft tower is installed in United States. Mechanical draft cooling towers are increasingly built as multi-cell installations.
1970	Multi-fan mechanical draft cooling towers introduced
1980	Fibre-glass used as structural material
1981	Combined wet/dry cooling tower introduced; Natural draft wet cooling tower with integrated flue gas desulphurization installed
1982	Counter flow type cooling tower are introduced for industrial applications
1984	The first complete indirect dry cooling system is built in South Africa, the largest in the world.
1992	First timber construction for a multi-cell hybrid cooling towers and an air-cooled condenser for a 700MW Combined Cycle Plant in United Kingdom.
1998	Natural draft cooling tower with integrated flue gas discharge for a 550 MW coal fired power plant installed
1999	Two natural draft cooling towers installed to withstand wind velocities of more than 300 km/h (highest wind load measured) in Australia

water. With the limited industrial activity of the past ages and plentiful resources, cold water was used in once through mode, discharged back and forgotten. Later, considering the thermal pollution, directly discharging the hot water back to its source was environmentally unacceptable. Hence, hot process water was either to be cooled before the discharge or cooled and recycled. When topographical considerations were taken into account in power plant site selection, large ponds or canals were employed to hold, cool, recirculate or discharge process water, which required large area. To reduce the area required, spray systems were introduced to aerate the water in holding plants and to promote faster cooling by generating more water surface.

The next logical development came when it was discovered that spraying downwards in a box, instead of upwards, lower temperature could be achieved. Shortly after this, instead of relying on prevailing winds for air movement, aerodynamically designed fans were incorporated. As mechanics and hydrodynamics of water cooling became better understood, fill or packing material was included in designs to slow the vertical fall of water and provided greater air / water interfacial contact for more cooling. Later splash and film type fills were developed for enhancing the heat transfer. Through the development of the mechanical draft cooling tower, the land area required were brought down up to 1000 times compared to a cooling pond or lake. Now modular type splash and film type fills, made up of PVC material, are available for ease of installation and also to minimize the maintenance. The major developments taken place since beginning in the area of cooling tower is presented in Table 2.

Conclusions

Cooling towers play vital role in industrial applications. Various technological advancements over the years have resulted in enhancing the performance of cooling towers to a larger extent. ■

S Jothibasu
Joint Director, Central Power Research Institute, Bangalore.

New Air Velocity & IAQ Measuring Instrument from Testo

The testo 440 combines a compact handheld measuring instrument with user-friendly measurement menus and wireless probes – for the versatile and convenient measurement of all air conditioning and ventilation parameters.

To celebrate the company's 60th anniversary, the measurement technology specialist Testo launches a new air velocity & IAQ measuring instrument in the market. The Testo 440 combines a compact handheld measuring instrument with user-friendly measurement menus and wireless probes – for the versatile and convenient measurement of all air conditioning and ventilation parameters.

As a market leader for portable and stationary measurement technology, Testo can look back on decades of experience in the development of cutting-edge products. Ventilation and air conditioning solutions from the Black Forest German company are in use all over the world, wherever a pleasant indoor climate and optimally adjusted ventilation systems are crucial: In offices and residential buildings as well as in laboratories or industrial production halls.

In this sector, Testo is extending the breadth of its range with the new air velocity & IAQ measuring instrument Testo 440. The innovation combines everything which makes the air velocity & IAQ measurement technology so successful – intuitive operation, precise measurement values and an extensive probe range – and extends these advantages by wireless convenience.

Intuitive Measurement Menus

The measurement of air velocity & IAQ and comfort parameters often takes place according to standardized procedures and norms. In order to simplify work for the user, clearly structured menus for the following measurements are pre-set in the testo 440: Volume flow measurement in ducts and at outlets, k-factor, degree of turbulence according to EN ISO 7730/ASHREA 55, cooling/heating load, mould indication and long-term measurement (recording of measurement values at set intervals).

More Applications with less Equipment

The Testo 440 probes are available for air velocity, temperature, humidity, degree of turbulence, CO2, CO and light intensity. Customers have the choice between wireless and fixed-cable models. The wireless Bluetooth® probes ensure more freedom of movement in measurement and save space in the measurement case. In addition to this, a probe handle can be universally combined with all corresponding probes and probe attachments. This allows you to switch in seconds from indoor air quality measurement to a determination of volume flow at a vent.

Clear, reliable and secure

The large display of the Testo 440 shows up to 3 measurement values simultaneously. It also allows easy configuration of the measurements as well as a view of results at a glance. The instrument's memory can record up to 7500 measurement protocols.

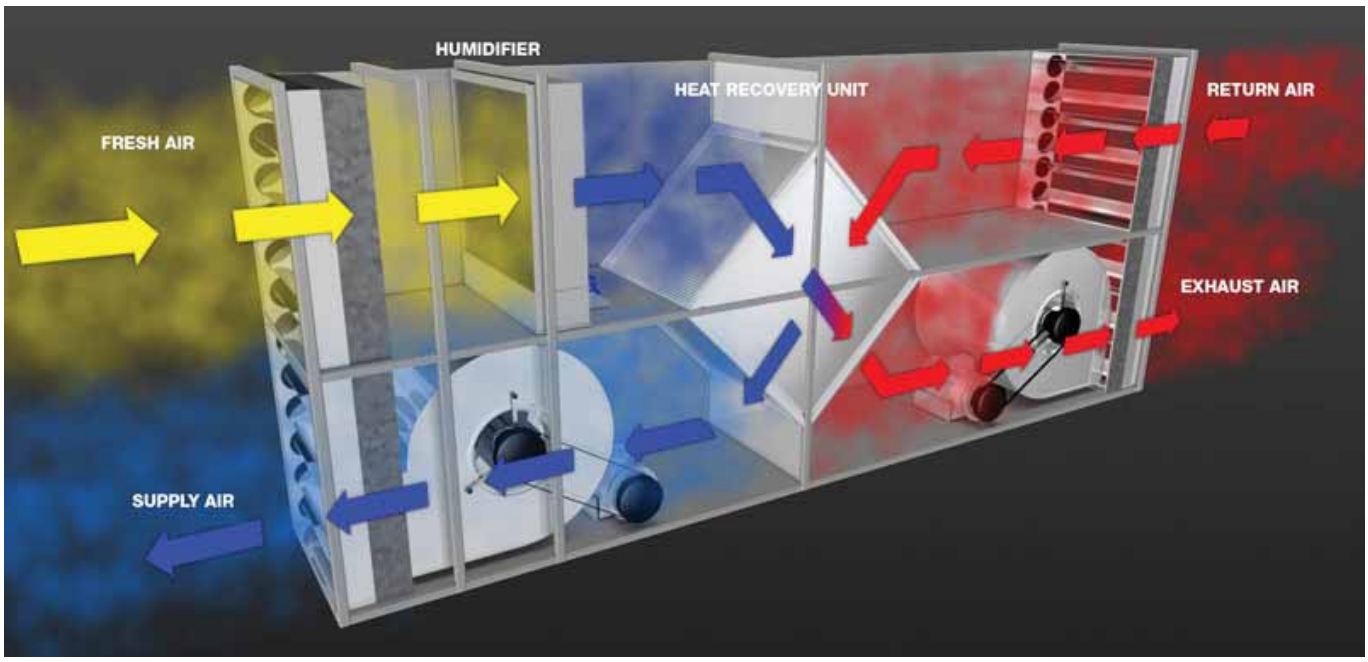
Kits and Model Versions

The Testo 440 multi-function measuring instrument is available in two versions. The model testo 440 dP is technically identical to the regular version, however, it has an additional, integrated differential pressure sensor. This makes measurements at filters as well as Pitot tube and k-factor measurements possible. Pre-configured kits consisting of measuring instruments, probes and accessories are available for the most important areas of application (incl. ducts, vents, indoor air quality and ventilation/air conditioning measurements in laboratories). ■

For more information, email: info@testo.in.

Indirect Evaporative Air-Conditioner

Indirect evaporative cooler (with dual-mode operation) is promising technology for composite climate due to its low energy consumption and high efficiency in its range of applications...



Evaporative cooling is a method of utilizing natural cooling effect to cool the building. The evaporative coolers appeared around 2500 BC, when porous clay jars containing water were used by the ancient Egyptians for air cooling purpose. This evaporative cooling mechanism was applied to cool the ancient Egypt buildings and then spread across the hot region of Middle East. In early 1950s, the evaporative coolers of modern type were developed in USA and available in wide range of market places including Canada, USA, and Australia. Evaporative cooling has several benefits including local fabrication, energy and cost saving, no synthetics chemicals, reduced peak demand, improved air quality, environmental friendly, etc.

The evaporative cooling (EC) technology is based on heat and mass transfer between air and cooling water. It is in general two types: direct and indirect. Direct evaporative cooling (DEC) is based on mechanical and thermal contact between air and water, while indirect evaporative cooling (IEC) is based on heat and mass transfer between two streams of air, separated by a heat transfer surface with a dry side where only air is cooling and a wet side where both air and water are cooling. Both DEC and IEC are characterized by very high energy efficiency but also by significant water consumption rates. DEC functions well in dry climate as the air is direct contact with water (humidity increases); however, not suitable for wet climate. Furthermore, air quality is strongly dependent on water purity as well as

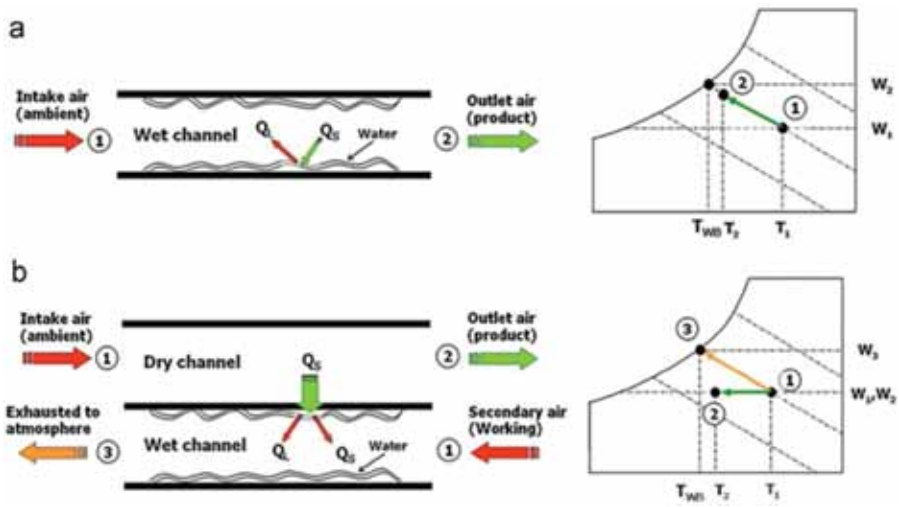


Figure 1: (a) Direct evaporative cooler and (b) indirect evaporative cooler

cooling pad quality due to direct contact (dirty or bad quality water and/or pad may lead to Legionnaire's disease). Hence, IEC is a better option as it works well for wet climate also and air quality is independent on water or pad quality. In this article, working principle, configuration, construction and commercial status of IEC are discussed in details.

Conventional Indirect Evaporative Cooler (IEC)

In the case of IEC technology, the primary (or product) air is cooling down in dry side and secondary (or working) air is cooling and humidified in the wet side. It is not as widely used as direct EC, but it is gaining popularity, because it cools air more than direct EC, and cools the air down from higher wet-bulb temperatures. As shown in Figure 1(a), the air temperature decreases by converting the sensible heat to the latent heat through water evaporation; however, the humidity of the air increases for DEC. In moist conditions, the relative humidity of the leaving air can reach as high as 80% and such a high humidity air is not suitable for direct supply to the space, because it may cause warping, rusting, and mildew of susceptible materials. Therefore, DEC is only suitable for dry and hot climates, or air conditioned spaces with simultaneous cooling and humidification demands. In view of this, indirect evaporative cooling (IEC), developed in 1903, is able to cool the air and avoids adding moisture to the air by separating water and air, which makes it more attractive in humid areas. IEC involves two air streams: primary air and secondary air as shown in Figure 1(b). The air directly cooled by water evaporation in wet channel is called the secondary air. The cool and moist secondary air is used to cool the primary air (the air to be supplied to air conditioned space) by a heat exchanger. At outlet, the primary air will have a lower temperature as at inlet, due to the transferred heat. The secondary (working) air is flowing inside the wet channels together with the water. The behavior of the air and water in the wet channel is similar with the DEC process. The water temperature is the wet bulb (WB) temperature of the secondary air. The heat transferred through the surface between the dry and wet channels is absorbed by the water as latent heat and a corresponding part of the water is evaporated being embedded by diffusion into the secondary air, increasing the moisture content of this air. If the secondary air arrives at the saturation state, after this stage forward the heat from the primary air is split as latent heat absorbed by the water and as sensible heat absorbed by the secondary air. Thus, the temperature of the secondary air at the outlet can be one of the following: (a) Lower than the WB temperature of the secondary air at the inlet (no saturation); (b) Equal with the WB temperature of the secondary air at the inlet (saturation is reached at the outlet); (c) Higher than the WB temperature of the secondary air at the inlet (saturation before the outlet).

The main advantage of the IEC is that primary air is cooled without modifying its moisture content. The main disadvantage of the IEC is that the cooling process of the primary air is limited by the WB temperature of the secondary air at the inlet. Because of this limitation, this type of equipment is also named wet bulb IEC.

According to the types of heat exchanger used in IEC, there are tubular type IEC, plate type IEC and heat pipe IEC, as shown in Figs. 2(a-c), respectively. In the plate and tubular type IEC, the first air and secondary air are separated by an air-to-air heat exchanger, while in the heat pipe IEC, the condenser section is used in

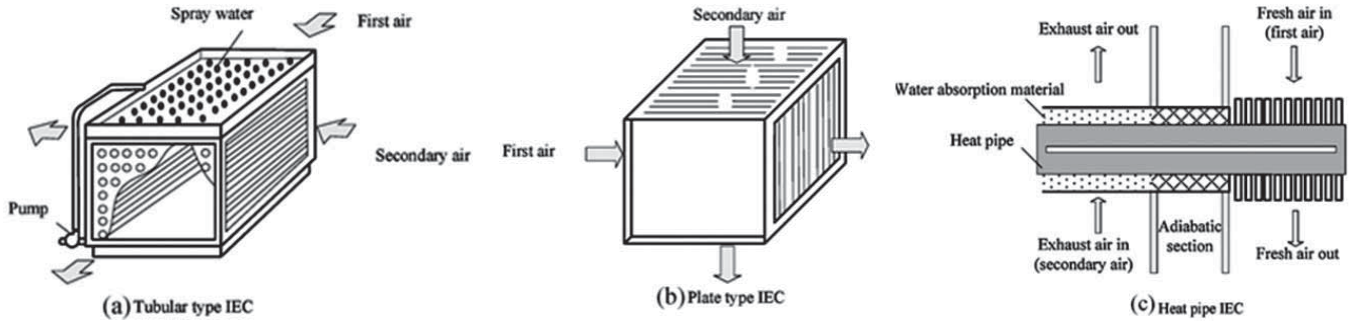


Figure 2: Heat exchangers of indirect evaporative cooler

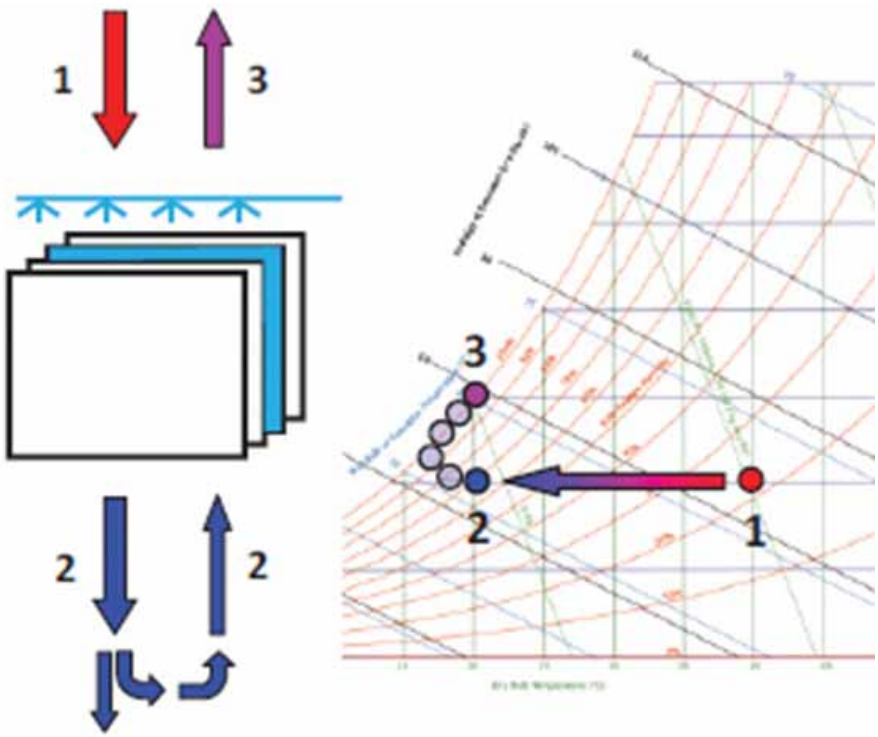


Figure 3: Schematics and psychrometric process of R-IEC

the secondary air flow channel, and the evaporator section is used in primary air flow channel. In IEC, the primary air is cooled without direct contact with water, thus the absolute humidity of the first air remains unchanged, while its temperature decreases. The heat exchanger used in IEC avoids the direct contact of the primary air with water; however, it is at the cost of the decreased efficiency. Usually, the efficiency of IEC is 50–70%, which is lower than that of DEC. The efficiency of the IEC mainly depends on the efficiency of the heat exchanger, inlet air states and the air flow rate ratio of the first air to the secondary air. Compared with the plate type IEC, the flow channel of the tubular IEC is broader and hence not easy to be blocked. But its heat transfer efficiency is lower than that of the plate type IEC. Much research has been conducted to enhance the heat transfer of the tubular IEC. In the heat pipe IEC, the outlet air temperature of the heat pipe IEC can be 2.5 °C lower and the corresponding cooling efficiency is 5–9% higher as compared with heat pipe heat exchangers. Flow arrangement between primary air and secondary air in the conventional IEC may by parallel flow, cross flow or counter flow.

Regenerative Indirect Evaporative Cooler (R-IEC)

The regenerative indirect evaporative cooling was developed to decrease the primary air temperature at the outlet, below the WB temperature of the secondary air at the inlet. The regeneration consists in extracting a part of the primary air at its outlet and using it as secondary air. In this case, because the secondary air is already cooled, the corresponding WB temperature is sensible lower than the WB temperature of regular (outside) secondary air and the limit at which the primary air can be cooled became considerably lower. As shown in Figure 3, the warm primary air (1) is flowing inside the dry channels and transfers heat through the heat surface to the wet channels. At its outlet, the primary air (2) will have a lower temperature than at inlet. A part of the outlet primary air is used as secondary air (much cooler than that of conventional IEC) being introduced in the wet channels. The working process of the primary air (1-2) is realized at constant moisture content and the final dry bulb temperature of the primary air is considerable lower than in the case of conventional IEC and below the WB temperature of the primary air at inlet. At limit, the cooling process of the primary air could continue until reaching the WB temperature of the secondary air at the inlet. This type of equipment is also named sub wet bulb IEC. The main advantage of the R-IEC is that primary air is cooled at constant moisture content below the WB temperature of the primary air. The main disadvantage of the R-IEC is that the flow rate of the primary air is lower than in the case of basic IEC.

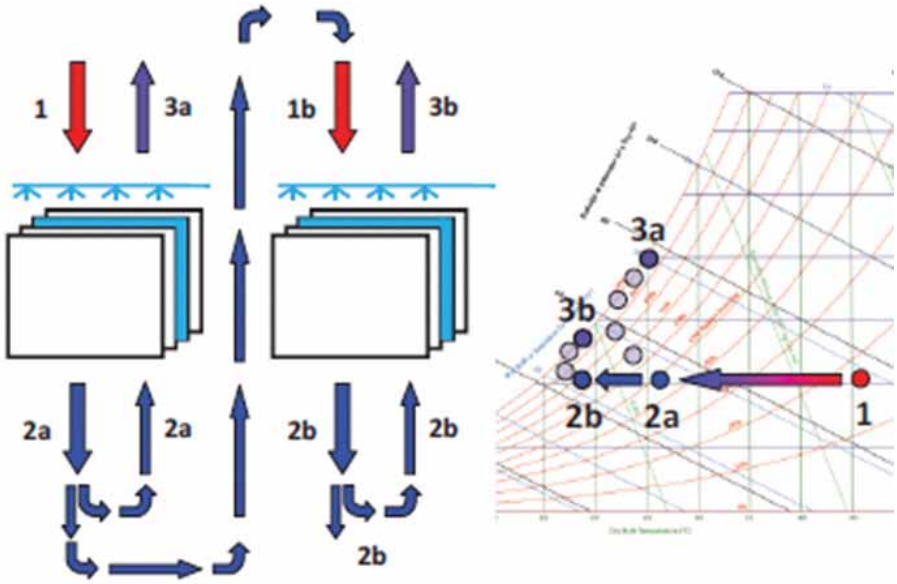


Figure 4: Schematics and psychrometric process of D-IEC

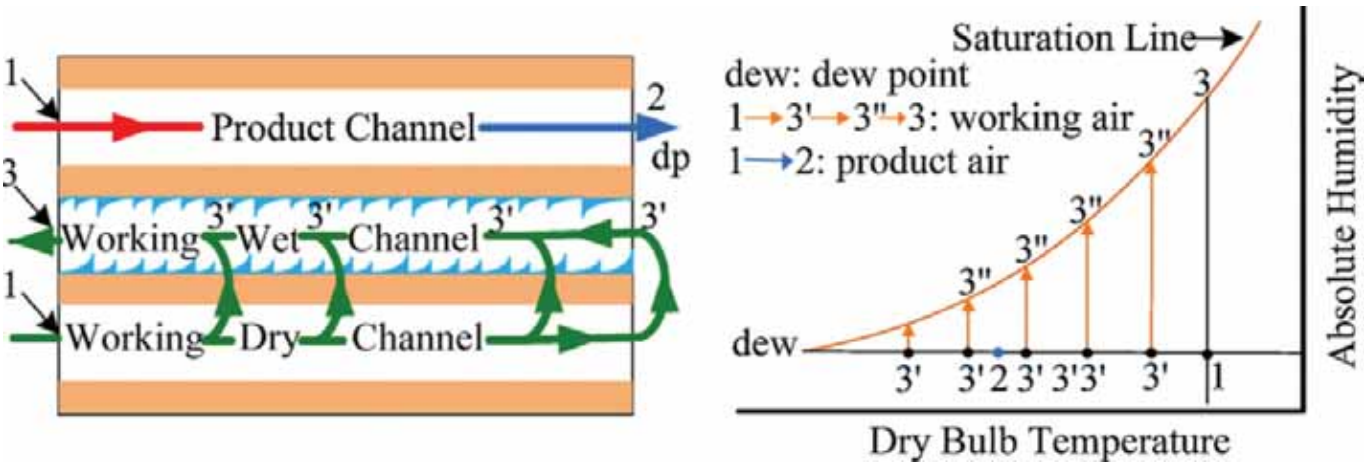


Figure 5: Schematics and psychrometric process of M-IEC

Dew Point Indirect Evaporative Cooler (D-IEC)

The dew point indirect evaporative cooler was developed to decrease the primary air temperature near the limit of the dew point (DP) temperature of the primary air at the inlet. The D-IEC consists in multiple stages of R-IEC equipment. The working principle of D-IEC equipment, with two stages of R-IEC is presented in Figure 4. The warm primary air (1) is flowing inside the dry channels and transfers heat through the heat surface to the wet channels. At outlet, the primary air (2a) will have a lower temperature. A part of the outlet primary air of the first stage is used as secondary air (always much cooler than that of basic IEC) of the first stage being introduced in the wet channels. The rest of the outlet primary air of the first stage is used as primary air of the second stage. The working process of the primary air (1-2a-2b) is realized at constant moisture and can approach the DP temperature of the primary air at the inlet on the first stage. The working process of the secondary air in all stages are (2a-3a), (2b-3b), etc., represented on the psychrometric chart. At limit, the cooling process of the primary air could continue near the DP temperature of the primary air at the inlet. This behavior of the primary air is justifying why these equipment are also named dry bulb IEC. The main advantage of the D-IEC is that primary air is cooled at constant moisture content almost near the DP temperature. The main disadvantage of the D-IEC is that flow rate of the primary air is decreasing with the number of stages.

Maisotsenko Indirect Evaporative Cooling (M-IEC)

The Maisotsenko indirect evaporative cooler, developed by Dr Maisotsenko in Russia, is representing an alternative possibility for cooling the primary air near the DP temperature of the inlet air. Figure 5 shows the schematics and psychrometric air handling process of an ideal M-IEC in which the working and product air have the same inlet condition. Similar to the structure of conventional IEC, there are two flow channels in the M-IEC: the dry flow channel designed for the product air stream and the working air stream channel. The main difference with conventional IEC is that, there are numerous holes distributed regularly in the air flow channels of the incoming working air. When the working air flows along the dry side of the working air channel, it is cooled and partially diverted to the wet side through the holes. The wet side of the working air channel is soaked in water, resulting in a change of stage from 1 to 3', in which 3 is variable depending on the structure of the holes. The air in the wet side of the working air channel is able to absorb heat from its two adjacent sides, which results in the changes of stage gradually from 3', 3' to 3". In the meantime, the product air flows over the other adjacent dry side (the product air dry channel) and is cooled from state 1 to 2. The driving force in the conventional IEC is the difference between the dry-bulb temperature of the primary air and the fixed wet-bulb temperature of the secondary air. However, in M-IEC, the difference between the dry-bulb temperature of the primary air and the decreasing web-bulb temperature or the

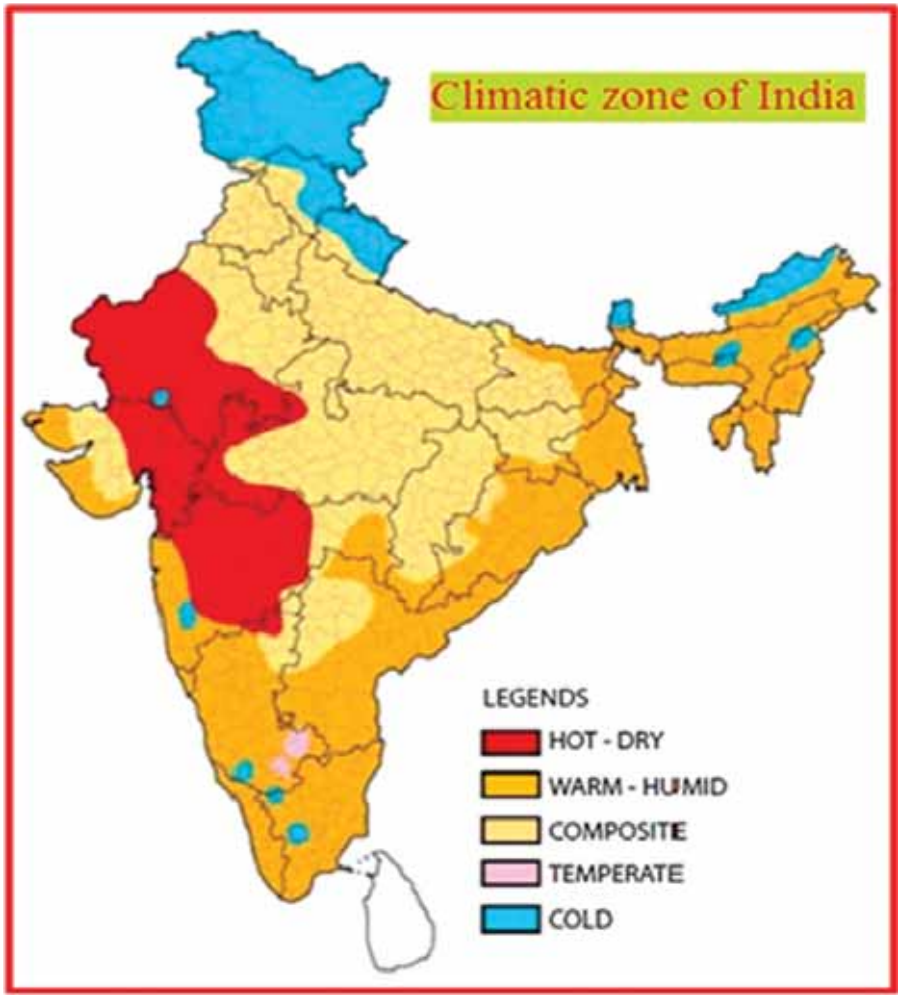


Figure 6: Various climate zones in India

dew-point temperature of the secondary air is the driving force. The lowest possible temperature of the primary air at the outlet of the M-IEC is the dew point temperature of the entering primary air. Therefore, the saturation efficiency of M-IEC based on the inlet wet-bulb temperature can be higher than 100%, and also higher than that of the conventional IEC. The main advantage of the M-IEC is that primary air is cooled without modifying the moisture content almost near the DP temperature. The main disadvantage of the M-IEC is the complex construction and flow scheme inside the equipment.

Application Opportunities in India

India possesses a large variation in climate and generally fall sunder five climatic zones i.e. hot-dry, warm-humid, composite, temperate and cold (Figure 6). Out of these, major areas undergo composite, hot-dry and warm-humid condition. In the warm-humid climatic zone, the direct evaporative cooler cannot be applied successfully because of the high relative humidity in the summer season of about 80–90%. Indirect evaporative cooler is also not so effective for this zone due to high specific humidity. Thermal comfort in this climate is possible only by using the air conditioner. In the hot-dry climatic zone, the direct evaporative cooling is more applied because of less relative humidity in the range i.e. 30–50%. The temperature and humidity can be easily controlled using direct evaporative cooling. For buildings and areas that do not have a central air conditioning system, direct air evaporative cooling can be a very economical and efficient way to reduce the temperature. In extremely dry climates, evaporative cooling of air has the added benefit of conditioning the air with more moisture for the comfort of building occupants. The major area of India undergoes composite climate zone. For this zone, DEC is best applied in dry season (March-June) and it is widely used; however, the IEC can be applicable in relatively humid season (June-September). It is interestingly to note that IEC can be operated in dual-mode (direct mode, i.e. outlet air of wet channel as product air in dry season and indirect mode, i.e. outlet air of dry channel as product air in wet season) and that IEC can be effectively and economically used for this climate zone. IEC can be effectively applied in coastal areas (humid-hot zone) also; however, the energy saving potential is much less than that in interior zone. The desiccant based IEC is another best option in the high humid zone, but not cost effective. In–overall, the indirect evaporative cooler has a high potential to use all climate zone (dual mode operation) and hence to save energy and to reduce green house gas emissions associated with cooling of buildings.

Commercial Status

Indirect evaporative cooler has many potential commercial applications including commercial kitchens, hotels and restaurants, hospitals, offices, other institutions, laundry and dry cleaning, industrial applications, agricultural applications, poultry sheds, transit buses and data centre. Several international manufacturers have developed the prototypes and some applications have been also reported. However, full-scale manufacturing as well as commercial applications has not stated yet may be due to the fact that IEC is immature technology, more complex and less cost effective compared to DEC. But, it is expected that this technology will become mature and available in common markets very soon. ■

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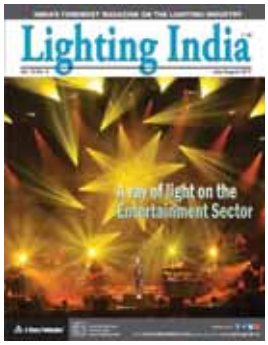

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Asphyxiation Accidents in Refrigeration

In this article, we explore Asphyxiation as a personal safety hazard associated with Refrigeration. In the last article by the author, published in December 2017, we discussed about Legionnaires Disease...

Asphyxiation is defined as deprivation of oxygen leading to unconsciousness or death. Atmosphere contains 21% of oxygen. Human body needs a certain amount of oxygen in the atmosphere. Lesser amount of oxygen content in the atmosphere below a threshold of 12%, stimulates some self-protective and self-regulatory mechanisms which sustains for a little while, beyond a certain time period, exposure to Oxygen deficient atmosphere causes severe disturbance to the bodily functions and in extreme cases can lead to death. Approximately, 5% of volume of air is consumed in each breath (about 21% O_2 in and about 16% O_2 out).

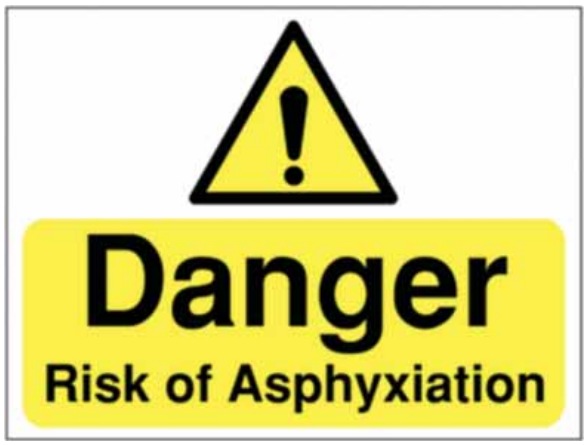

Figure 1: Safety Sign of Asphyxiation hazard

Oxygen Requirement

How much Oxygen is there for a person to survive in an air-tight enclosure?

0.617 kg of Oxygen per day for an average person at rest; 0.84 kg for an average person going about his regular duties, including sleeping and 7.2 kg for an average person that does continuous heavy exercise day and night

How long would it take to use up all the O_2 in 1 cubic metre (1 m^3 of space at sea level)?

0.48 days; 0.36 days; and 0.042 days respectively.

How long would it take to use up all the O_2 in 1 cubic metre (1 m^3 of space at sea level)

0.48 days; 0.36 days; and 0.042 days respectively.

According to psu.edu the lowest % Volume of O_2 a person can survive at standard pressure is about 17.5%. How long would it take to use up just the O_2 in 1 m^3 for life?

2 hrs; 1.5 hrs and 10 minutes respectively.

What about other spaces such as rooms, houses, etc.? How long would one person last?

Room: 12 ft wide x 12 ft long x 8 ft ceiling or 3.6 m x 3.6 m x 2.4 m of volume:31.1m^3 2.6 days; 1.9 days; and 5.3 hrs respectively

Oxygen Deficient Atmosphere

Effects of Exposure to Oxygen Deficient Atmosphere

- 15 – 19% O2- Co-ordination impaired
- 12 – 14% O2- Perception and judgment impaired
- 10 – 12% O2- Performance failure, poor judgment

Oxygen Requirement

AVG Liters of air breathed per minute

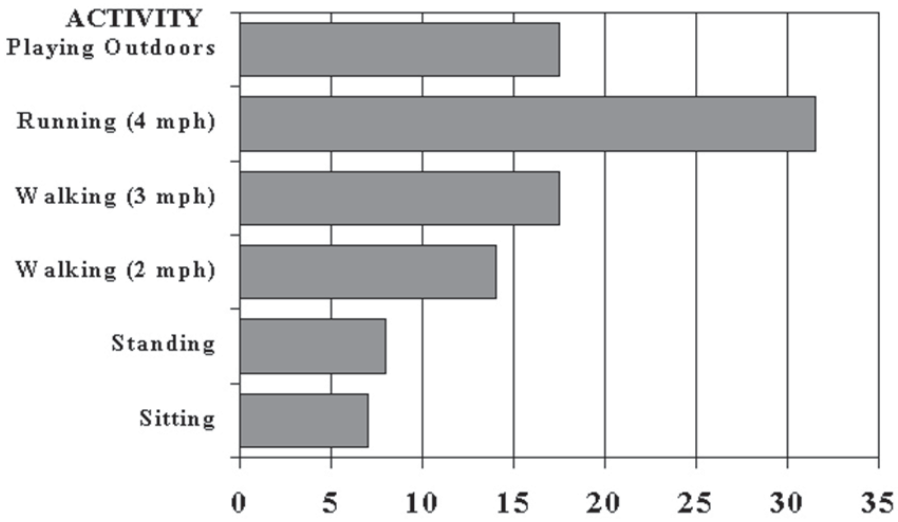

Figure 2: Amount of Air Breathed by Children

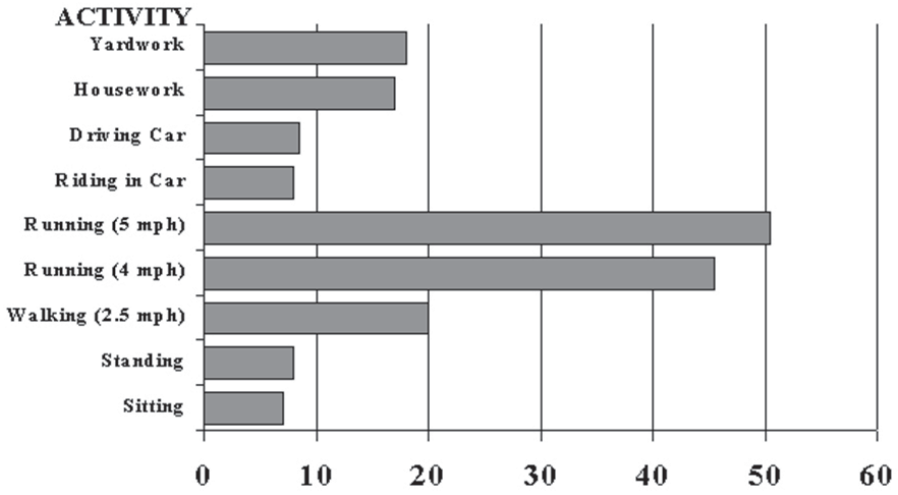

Figure 3: Amount of Air Breathed by Adult Females

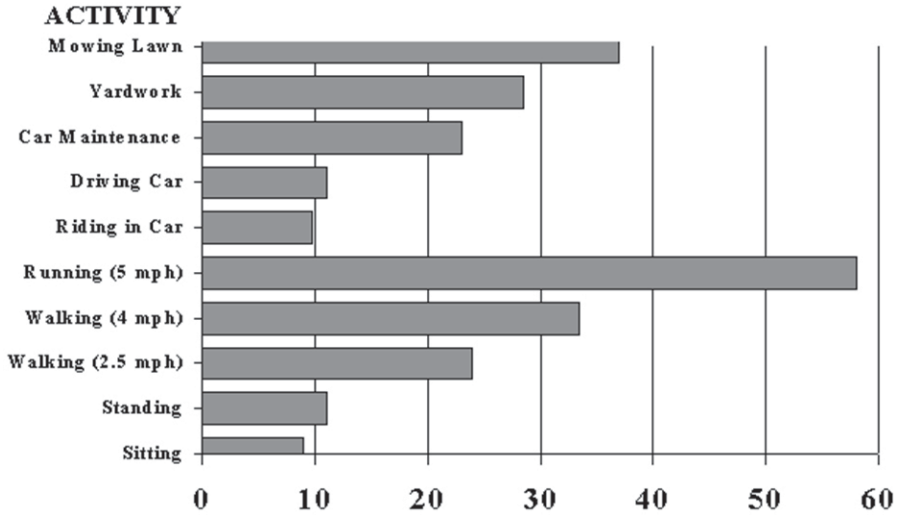

Figure 4: Amount of Air Breathed by Adult Males

Onset of Cyanosis

- 8 – 10% O2- Mental failure, unconsciousness
- 6 - 8% O2- 100% fatal after 8 minutes exposure
- 4% O2- Coma in 40secs, convulsions, death

Types of Asphyxiation Accidents

Asphyxiation Accidents could be of two types:

a) Due to leaking refrigerants
b) Due to release of gases from refrigerated products

Aphyxiation due to leaking refrigerants

Incident 1: Asphyxiation of a 24-year-old male assistant manager of a shopping mall ice skating rink inside a compressor room while attempting to shut off a refrigerant gas (R-22) leak

On May 20, 1991, a 24-year-old male assistant manager for a shopping mall ice skating rink was asphyxiated inside a compressor room while attempting to shut off a refrigerant gas (R-22) leak. The incident site was a refrigeration system compressor room that served an ice skating rink located within an indoor shopping mall complex. The compressor room measured approximately 25 feet long by 20 feet wide by 10 feet high; it was accessible through two self-closing steel doors (one double door, and one single door) located at opposite ends of the room. The compressor room was 4 feet below the ground-level floor of the shopping mall. The refrigeration system installed there had a maximum capacity of 4,000 pounds of R-22 refrigerant. It is about three times denser than air, with a relatively high vapor pressure at room temperature.

Two months before the incident, several slow leaks of R-22 during routine equipment checks had been reported. Nine days before the incident, R-22 leaks at the filter flange pipe were noticed. Two days before the incident, someone had attempted to stop a pinhole-sized leak in the filter flange pipe by tightening the pipe with a wrench, causing a section of pipe to break off, and produced a much larger leak. Someone

then plugged this leak by driving a makeshift plastic plug into the flange hole and sealing it with a putty-like material.

About 8:00 am on the day of the incident, a shopping mall maintenance worker performing routine maintenance checks, observed refrigerant oil "oozing" from under the doors to the compressor room. He could not open the locked doors, but he heard a "hissing sound." Looking through a crack between the doors, he saw the lower part of the compressor room engulfed in a "Freon mist," 4 feet deep. He left the area and reported the problem to the maintenance supervisor.

About 8:30 am, the maintenance supervisor entered the compressor room wearing an organic vapor cartridge gas mask. He attempted to isolate the leak but became disoriented. He de-energized the refrigeration system at the circuit panel and exited the compressor room. However, since the refrigerant was still under pressure, it continued filling the room. He complained that his chest hurt, and that his heart was racing. He reported the leak to the maintenance manager. By this time, about 685 pounds of R-22 refrigerant had leaked out of the refrigeration system

The victim (assistant ice rink manager) arrived at the ice rink at about 8:40 a.m., and entered the compressor room along with maintenance supervisor, and maintenance worker, carrying tools and wearing a cartridge-type respirator. This type or respirator provides inadequate protection in an oxygen-deficient atmosphere. The self-closing doors to the compressor room closed and automatically locked behind them to bar entry to, but allow exit from, the room.

By about 8:50 am, some of the leaking CFC-22 had flowed from the compressor room into an adjoining health club pool area where two male patrons were swimming. Both patrons found it difficult to breathe, and had to be rescued from the pool and they subsequently recovered.

About 8:56 am, after hearing a noise "like a bang or a pop," the ice skating director unlocked and opened the compressor room door. She saw the maintenance supervisor and maintenance worker #2 lying on the floor at the foot of the stairs, but did not see the victim, whom she knew was present. The victim was hidden to her view on the floor behind some refrigeration piping.

The firefighters and EMS team arrived at the scene at about 9:00 am. The slipperiness of the refrigerant oil which covered the compressor room floor and the clothing of the two injured workers made the rescue effort extremely difficult. Firefighters in full turnout gear and self-contained breathing apparatus (SCBA) entered the compressor room, located maintenance worker #2 and maintenance supervisor and removed them from the room.

By about 9:20 am, a total of 3,200 pounds of refrigerant had leaked out of the refrigeration system. The victim was not in plain sight, having fallen behind some refrigerant equipment and piping, and being covered with the mist. He was finally located at about 9:22 am. and was removed to the open air immediately outside the building. The victim received both CPR at the scene, and on the way to a local hospital, where he was pronounced dead by the attending physician. The maintenance supervisor and maintenance worker were transported to a local hospital where they subsequently recovered. The medical examiner listed the cause of death as asphyxiation by oxygen displacement with refrigerant (R-22).

Incident 2: Junior officer in a ship became unconscious while asleep because of leaking refrigerant vapor from the AC Blower Room *Source: DOLTHOYS September 2006*

A cadet in a ship became unconscious while asleep because of leaking refrigerant vapor from the AC Blower Room which got drawn into the Evaporator Blower and was carried along with the cold air into the accommodation spaces. His cabin was the closest to the AC Blower Room.

Accommodation air conditioning starboard side fan unit bearing broke down while running. The shaft along with the fan fell on the evaporator unit and damaged it. Four tubes of the evaporator got punctured and there was a heavy leakage of Freon refrigerant inside the AHU room. The extent of damage to the bearing, the shaft and the evaporator coil can be seen from the photographs. Through the air conditioning ducts, the leaking Freon got carried away

Figure 5: Damaged AC Blower

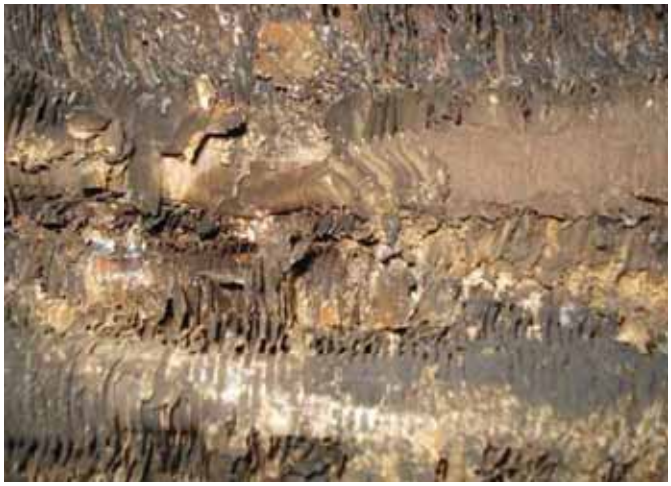

Figure 6: Damaged Evaporator tubes

Figure 7: Process of Respiration

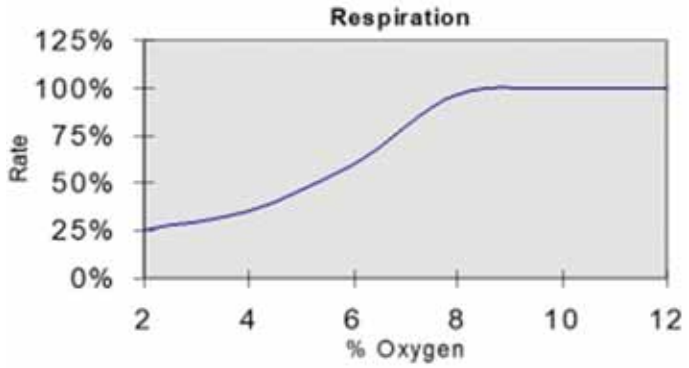

Figure 8: Respiration Rate vs Oxygen content

into the accommodation. The air conditioning plant was stopped immediately. All crew were informed and accommodation was ventilated. One deck cadet was found unconscious in his cabin. He was taken outside into the fresh air and was revived. Rest of the crew was found safe.

Lessons

Accommodation air conditioning blowers are generally situated outside the engine room in air handling rooms which form part of the accommodation / superstructure.

1. Because of their location, they tend to get neglected, often waterlogged because of condensation, dirt from insulation which gets dislodged and peeled off due to vibration.
2. No machinery will breakdown suddenly. There will be signs of degeneration which should be noticed by diligent watch keepers. If noticed sufficiently in advance, corrective action can be taken and major damage and disaster can be avoided.
3. The Planned Maintenance System is designed to prevent breakdowns of such nature. It is important that shipboard personnel give due importance to preventive maintenance of machinery by following PMS in totality. Otherwise, PMS simply becomes a futile exercise.
4. The above incident could have been fatal.

Bottom Line: Out Of Sight Does Not Mean Out Of Mind!

Incident 3: A reefer mechanic became unconscious immediately after entering AC Blower Room

A reefer mechanic became unconscious immediately after entering AC Blower Room as the room was having dangerously low oxygen content due to leaking refrigerant vapor from the reefer machinery.

Incident 4: Release of Ammonia from a packing plant slaughterhouse

In a 1986 incident in a packing plant slaughterhouse, a refrigeration line ruptured, releasing ammonia. Eight workers were critically injured, suffering respiratory burns from ammonia inhalation, and 17 others were less severely hurt.

Incident 5: Release of about 45,000 pounds of Ammonia in a frozen pizza plant

A 1989 ammonia release in a frozen pizza plant led to the evacuation of nearly all of the 6,500 residents of the town where the plant was located. The release started when an end cap of a 16-inch suction line of the ammonia refrigeration system was knocked off. Up to 45,000 pounds of ammonia was released, forming a cloud 24 city blocks long. About 50 area residents were taken to hospitals, where they were treated with oxygen and released, while dozens of others were treated with oxygen at evacuation centers.

Incident 6: Chief cook of a merchant vessel gets suffocated

The morning after taking three months' provisions aboard the vessel, the chief cook of a merchant vessel proceeded to fetch some meat from the refrigerated meat room. Upon opening the door, he was affected by the atmosphere of the meat room. His eyes and nose were severely irritated by the atmosphere and he immediately closed the door. The chief cook reported a 'smell' in the meat room to an officer who he encountered in the duty mess room. This officer subsequently entered the meat room to check for problems. After a period of 30 to 60 seconds, he started to feel light headed and left the room.

Further investigation by ship's staff revealed the cause to be dry ice that had

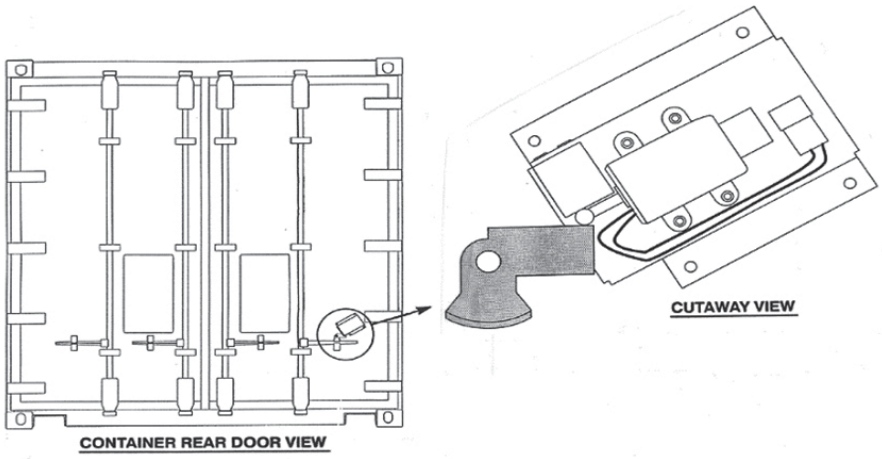

Figure 9: Door Safety in Controlled Atmosphere Containers

Figure 10: Safety Decal

Figure 11: Rear Door Curtain

been packed with ice cream that had been received with the stores on the previous day. The remains of the dry ice were disposed of and the meat room thoroughly ventilated.

As a corrective measure, the following measures were undertaken:

- The company's response to the incident:
- Publicize the incident to all vessels in its fleet
- Ensure that industry guidance including M Notices and other publications that contain guidance for catering ratings are integrated into or highlighted in the catering ratings' handbooks.
- Investigate the feasibility of fitting of CO_2 alarms to all unventilated rooms where frozen provisions are normally stored.
- Appropriate warning notices to be posted on the doors of rooms where frozen provisions are normally stored.
- Develop guidelines and best practice for the receipt handling and storage of provisions for ships' staff.
- Contact all approved suppliers to warn them of the dangers of supplying stores to ships with dry ice. All suppliers should be instructed to warn vessels of the presence of dry ice or other hazardous goods packed with stores.

Due to release of gases from refrigerated products

Cold Rooms, Reefer Containers, Refrigerated Cargo holds on ships are to be treated like enclosed spaces. Fruit cargoes, being live cargoes continue with the respiration process throughout their passage time on board. They consume oxygen in the refrigerated space and liberate carbon-dioxide. To make up for the consumed oxygen, voyage instructions include periodic ventilation of the cargo spaces. On reefer containers, air vents are kept partially open either continuously or

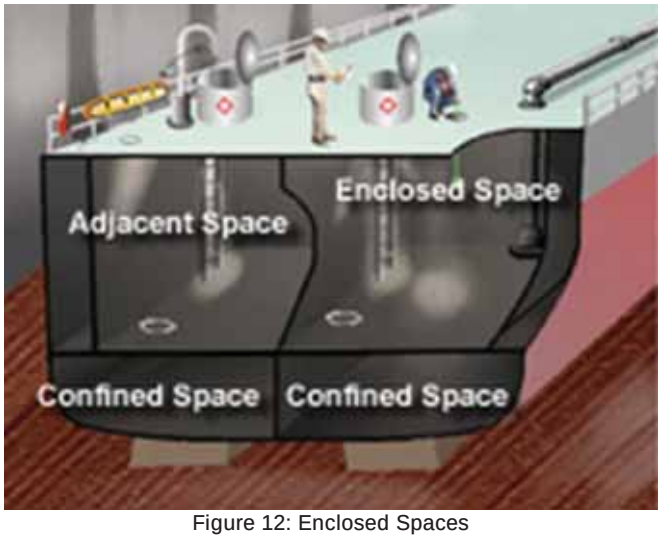

Figure 12: Enclosed Spaces

Figure 13: Controlled Atmosphere Storage Space

Figure 14: Banana Carrier

periodically throughput the voyage to allow the fruit cargo to breathe. In the newer version of reefer containers, this is achieved automatically (AFAM+). Here, even the information on degree and periodicity of opening of the air vent is fed into the controller as an input instruction along with other instructions like temperature set point, humidity content etc.

Controlled Atmospheres

There is a category of reefer spaces and containers which maintain oxygen deficient atmospheres within the refrigerated spaces. These are known as controlled atmospheres. For the purpose of prolonging the life of fruit cargo by bringing down the respiration rate, the oxygen content within the refrigerated space is maintained at between 2-4% as compared to 21% in the normal atmosphere.

This is achieved by use of additional special machinery components. The space is filled up with nitrogen which is supplemented by the carbon dioxide gas which is liberated due to respiration of the fruit cargo. Special personal safety precautions have been outlined to be followed before exposing technicians to these spaces. These spaces are to be treated as Enclosed Spaces.

Door Safety in Controlled Atmosphere Containers

The doors of these containers are provided with a special safety door lock which permits opening only when the oxygen content is above 20.3% and locks when oxygen content is below 19.8%.

Extra Safety Features in Controlled Atmosphere Containers

They are also provided with extra safety decals and a door curtain which will provide additional protection to the personnel preventing accidental exposure to the Controlled atmosphere inside the container.

Enclosed Spaces

These spaces are to be treated as Enclosed spaces and all personal safety precautions have to be taken before entering these spaces.

Incident 1: Stowaway found dead inside cargo hold of banana carrier

The dead body of a stowaway was found inside the cargo hold of a reefer vessel when the hatch covers were opened for cargo discharge at the discharge port. The ship was carrying bananas inside the hatch. The stowaway was overcome by the carbon dioxide and other gases liberated by the bananas and lost his life.

Along with carbon dioxide, fruit cargoes also liberate ethylene, the sweet smelling gas. This gas is addictive by nature. It is also present at petrol pumps (gas stations) being present in the atmosphere as it is gets separated out from the gasoline over a period of time. It is a sweet smelling poison and can overpower human beings if present beyond a certain TLV (Threshold Limit Value). ■

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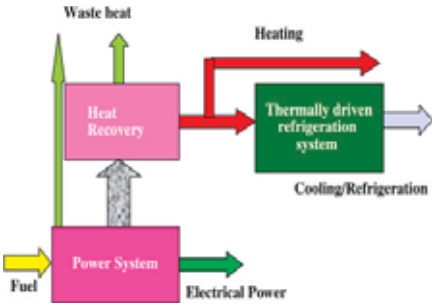
Tri-generation: Way of Sustainability

With the dramatic increase in the world primary energy consumption and the corresponding greenhouse gas emissions, combined cooling, heating and power generation presents a promising technology providing multiple energy products accompanied with highly efficient energy production, greenhouse gas emissions reduction...

The population growth and technological advancement exhibited in the last two decades along with the desire for higher life standards and comfort levels have led to an unprecedented increase in the energy consumption worldwide. Energy consumption has increased from 7140.7 million tons of oil equivalent (Mtoe) in1980 to about 12875.6 Mtoe in 2010. Asia and Oceania has the largest share in the energy consumed in 2010 with about 37.9% followed by North America with 23.1% and Europe with 16.4%. India's electricity consumption stands at 587 billion kWh in 2006, out of which currently 8% is being used by the commercial sector and 25% in the residential segment. 30% of energy consumed in the commercial sector in India is on account of HVACR. Energy demand is increasing and more than 25% of total electricity consumption is in residential/commercial sector put together. Projected annual increase in energy demand is 5.4 billion kWh in residential and commercial sector in India.

The total world energy consumption exhibits that the oil still the dominant resource with 33.1% of the global energy consumed followed by coal (29.9%) and natural gas (24%). Renewable energy resources contribution to the over all world energy consumption pattern is still less than 9% with 6.6% of hydro-electric power and less than 2% for all other renewables combined. This heavy reliance on conventional fossil fuels has led to an increase in the global energy-related CO_2 emissions by 1.4% to reach 31.6 Gigatonnes in 2012 with a historic peak exceeding 400 ppm in the atmosphere in May 2013. In addition, energy uses in buildings, mainly electric power, heating and cooling or refrigeration, contribute to about 20–40% of the over all energy consumption with similar contribution to carbon dioxide emissions. The majority of these buildings depend on large central stations or plants to provide their electricity demands employing oil, natural gas or coal as fuel resources. However, the operation of these central stations is usually characterized by high rates of energy losses mainly in the form of waste heat. With additional losses in the electric power transmission through high voltage lines and in the transformers, only 35–45% of the over all energy produced by these stations is delivered to the final user. Thus, the high investment cost and high incremental risks of these stations along with their high energy production environmental foot print and complex design favour the switch to more efficient and compact decentralized energy production systems and facilities.

One of the well-known and age old technology, combined heat and power generation systems (CHP) better known as cogeneration, allows the simultaneous generation of heat and power in a single energy process. It is estimated that the installation of 1 million micro-CHP units, with size range of 1–10 kWe, in the UK



residential sector would allow an annual cost reduction of about £176 million on the energy production and the mitigation of 2.1 million tons of CO_2.

Although combined heat and power (CHP), as a proven and reliable technology, mainly used in large scale centralized power plants and industrial applications, provides various technical, economic and environmental advantages compared to the separate production of heat and power in conventional separation production (SP) systems, such systems efficiency and capability decrease dramatically in hot climates, especially, in the summer months where the need for heating is minimal. Thus, a balanced and continuous heat and electricity demand profile all over the year is required to attain high cogeneration system over all efficiency. However, the case is very different in real climatic conditions where many regions exhibit a summer season with an increasing demand for cooling and air conditioning due to larger thermal loads, higher life standards, new buildings design and architectural characteristics and the desire for high levels of thermal comfort. Combining heat and power system (CHP) with a thermally activated cooling technology by harnessing the discharged waste heat from power generation systems to fulfill heating and cooling needs with power generation known as the combined cooling, heating and power (CCHP) tri-generation system, an effective way to improve the overall efficiency and reduce the negative environmental impacts green house gas (GHG) emissions.

The concept of integrating various units to form a combined heating, cooling and power generation system was first introduced in the early 1980s for municipal cooling and heating. A typical tri-generation system comprises a prime mover, electricity generator, thermally activated technologies, heat recovery unit and a management and control unit. Over the last three decades, tri- generation systems have attracted considerable interest, especially, small-scale systems (below 1MWe), with the development of different options and alternatives for thermally driven cooling technologies and cogeneration units. Potential tri-generation users are small and medium-scale applications ranging from less than 1 kW to more than 10 MW including multi-residential dwellings and communities, office buildings, hotels, hospitals, commercial and shopping malls, universities, restaurants and food industry. Compared to the conventional separate way of energy production (heat by boilers and electric power by central stations) and conventional cogeneration units, tri-generation systems enhance the over all energy production efficiency with various technical, environmental and socioeconomic benefits on different levels.

Employing CCHP, overall fuel energy utilization increases dramatically ranging from 70% to more than 90% compared with 30-45% of typical centralized power plants. In general, less primary energy is needed to obtain the same amount of electricity and thermal energy. In addition to the saving in primary energy, vast reduction in net fuel costs, transmission and distribution savings achieved. Based on a typical CCHP system, only 100 units of prime energy are needed for 33 units of electricity power, 40 units of cooling power and 15 units of heating power in summer day. The electricity generation efficiency of CCHP system is similar to centralized power plant, because electricity is consumed locally without loss on distribution lines, though small scale prime mover is less efficient than large prime mover in power plant. The keystone of full energy utilization of CCHP system lies on the recovery of waste heat from prime mover. Further, CCHP systems increase the reliability of the energy supply network. Weather and terrorism are fatal threats to centralized power plants. A smaller more flexible and dispersed system, CCHP might prevent these threats from becoming reality, and controlled repercussions and fast recovery could be achieved if these situations occurred.

An economical, efficient and of low emissions CCHP system should be designed with fully consideration of energy demands in a specific area, prime mover and other facilities' types and capacities, power flow and operation strategy, and the level of GHG emissions. The selection of facility types belongs to the design of the system configuration, which emphasizes on the selection of prime movers according to current available technologies, and on the system scale. The existing CHP/CCHP sites in the market sorted by prime movers, 42% Reciprocating engine, 23% steam turbine, 12% combustion turbine, 7% combined cycle and 16% others. With a selected CCHP system configuration, operation strategy is the key to achieve the most efficient way for the CCHP to operate. The operation strategy determines how much electricity or fuel should be input to the system according to the demands; which facility should be shut down to keep the whole system efficient; how the energy carries flow between facilities; and how much is the power one facility should operate at. With a designated configuration and an appropriate operation strategy suitable sizing and optimization can make the system operate in an optimal way.

Finally, it can be concluded that with the dramatic increase in the world primary energy consumption and the corresponding greenhouse gas emissions, combined cooling, heating and power generation presents a promising technology providing multiple energy products accompanied with highly efficient energy production, green- house gas emissions reduction, higher energy supply reliability and lower operational and maintenance costs. ■

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Ameliorating Value Chain by Food Processing

The farmers are now growing more number of crops in a year in order to get periodic and expecting higher income. A shift from cultivation to market, needs to be urgently transformed to market to cultivation to prevent gluts and prevent market prices below cultivation costs periodically...

India has been able to successfully transform its agricultural production from scanty to plenty situation after independence. Our policies and programmes have been directed mainly to increase the agricultural production to feed its increasing population by raising the supply of food and to maintain sufficient buffer stock. The increasing volume of agriculture production though saved the country from starvation but did not bring about enrichment of farming community. This policy served the purpose for some time but after reaching the threshold levels, further increasing the agricultural production is getting costlier for the farmers. The technological up-gradation in agricultural production system is cost intensive demanding more investments for the growers while higher production levels is creating gluts in the market generating lower returns and increasing wastage and deterioration. The farmers are now growing more number of crops in a year in order to get periodic and expecting higher income. A shift from cultivation to market, needs to be urgently transformed to market to cultivation to prevent gluts and prevent market prices below cultivation costs periodically.

But all these efforts are proving to be detrimental for their financial viability. Increasing farming income has not been the priority area in the past as of now. Income generation for the farming sector with higher returns can happen through industrial activities with proper backward and forward linkages only. So the solution for such situation seems to be development of agro based industry.

Agro Industry- A Window for Agriculture

An agro-industry is an enterprise that processes agricultural raw materials, including ground and tree crops as well as livestock into value added products that has greater shelf life, transformed for ready consumption and provide byproducts with different characteristics for complete usage with little wastage. Most agricultural products, including subsistence products, are processed to some extent. A nation, therefore, cannot fully use its agronomic resources without agro-industries. Processing adds value, saves consumer time and effort. As economies develop, these savings become more important to consumers. Thus, the demand and necessity for processing services increase as agricultural production increases.

Agro-industries are not merely reactionary; they also generate new demand backward to the farm sector for more or different agricultural output. A processing plant can open new crop opportunities to farmers and, by so doing,

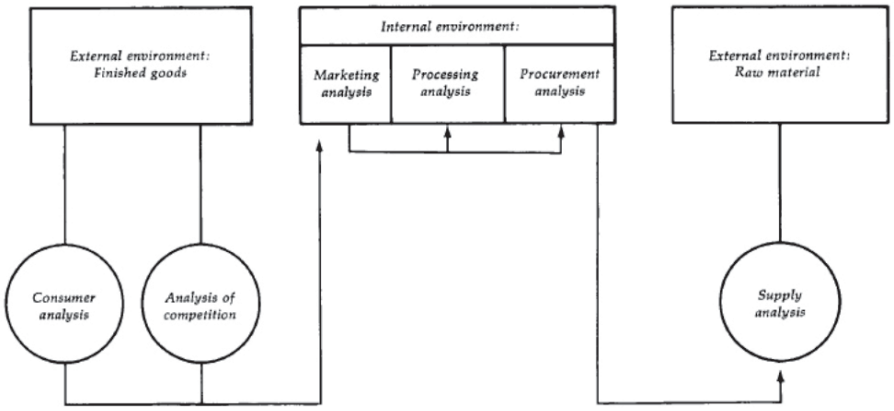

Figure1: Agro-industrial marketing analysis

create additional farm revenue. In some instances this has permitted subsistence farmers to increase their income by entering the commercial market. In other cases, it has enabled new lands or lands unsuitable for traditional crops to be brought under cultivation. In regional development programs, agro-industries have provided the economic justification for rural infrastructure such as penetration roads that provide access to raw materials, electrical installations for plant operation, or irrigation facilities. Agro-industries can also function as an economic focal point for cooperatives for small farmers and related community-development activities. It is important to note that the process by which rural industrialization occurs, can greatly affect the significance and permanence of the developmental stimulus agro-industries give to rural communities. When backward linkages occur, they generally increase farm employment. This is significant because agriculture remains the primary employer in our country, whereas manufacturing employ less of the labor force. A final point on the employment benefits of agro-industries is that they frequently provide major employment opportunities for women. In India, for example, 25 percent of the workers in the food and beverage industry are women, as are 60 percent in the similar other type of food industry. A large percentage of the commercial sector is engaged in distributing agro-industrial products. Agro-industries similarly contribute to the financial sector and other service industries. Finally, enterprises manufacturing materials for agro-industry, such as agrochemicals and farm machinery, depend on the demand for agricultural produce, and this demand in turn depends on a viable food- and fiber-processing industry.

The most important natural resource of most developing countries is agriculture. Agricultural produce has an international demand and, because production capacity frequently exceeds local consumption, there is an opportunity for export. A nation must process the raw material, however, into a form suitable for export. Even minimal processing, such as drying grain or ginning cotton, adds economic value to the produce and generates foreign exchange. The value added in agro-industrial products tends to exceed that of other manufactured exports because other exports frequently rely on imported components, and export agro-industries tend over time to increase the domestic percentage of value added by increasing the degree of raw material processing. The viability of an agro-industrial project requires soundness in each of the project's three basic component activities -procurement, processing, and marketing. Although this is the operational sequence of the components from the standpoint of the external environment, the marketing factor is the logical starting point for agro based project.

Marketing of Horticultural Produce

Eating the right amount of fruits and vegetables as part of a low fat, high-fiber diet may lower the risk of serious health problems like obesity, type 2 diabetes, heart disease, stroke, and certain types of cancer. For this reason, fruit and vegetable growers, packers, shippers, wholesale distributors, retailers, and commodity boards need to educate its customers about the healthy food items that they should choose. It will be not only a great service to the community, but the best way to increase your fresh produce sales. As a part of marketing plan we need to be sure about items you sell by piece, package, or weight? Selling by the piece is easy for customers because they know exactly what they are getting and for how much.

Selling by the package is also convenient, but requires additional work. Packaged produce also has special handling considerations. Selling by weight is common, but it requires weighing scale and customer pick their fruit as per their choice.

Packaged fruits and vegetables offer a convenience to the consumer, but they require special handling, storage, and display considerations. Damage to one apple within a one kilo bag due to improper handling, storage, or display can affect the others, resulting in faster spoilage of the whole bag of apples.

Quality Is the Key to Marketing Success

It is important to scan bags or packages as they are delivered or before pick-up and reject those that have rotten pieces.

Follow this general, seven-step process to properly prepare for, receive, and handle an incoming produce delivery.

1. Prepare the backroom. Get rid of trash, stack empty boxes, and condense merchandise to make room for the load.
2. A place for everything, and everything in its place. You can create maps of your refrigerator space to find out where the coldest (usually near the fan) and warmest (usually near the door) spots are located to help you store your produce at the right

Figure 2: Demonstration cum hands on training being imparted to the progressive horticulture growers in packaging and handling of fresh produce for marketing.

temperature for the best flavor and the least spoilage. Keep items in the same place each day so you can quickly find needed product. When unloading the truck, try to park items in set areas to minimize handling them multiple times.

3. Know your temperature zones. When picking up or receiving a produce delivery, accept only produce items that are within their recommended temperature ranges Otherwise, they may not last as long in storage or on display. Maintain the "cold chain." Packaged salads lose a day's shelf life for every hour kept out of refrigeration. Bananas and pineapples sustain chill damage easily, and stone fruit (peaches, plums, and nectarines) has "kill zones" if kept too cold or too warm. Basic knowledge about storage will help minimize waste and maximize profits.
4. Handle with care! Never throw or drop produce. This can cause damage. Be careful not to subject fragile items, such as berries or mushrooms, to crushing. Dropping a box of apples as little as three inches can drastically decrease their shelf life and increase waste.
5. Rotate items using the First-In-First-Out (FIFO) method. Place newer items below or behind older items so that you can be sure to rotate all of your produce inventory out onto the sales floor before it goes bad. When stacking cases, make sure the printing on the outside of boxes is visible so you know what is being stacked where.
6. Dating keeps track of aged inventory. So by marking cases with a received-on date (either with a marking pen or price sticker) you can see at a glance which items must be moved first.
7. Stack away empty pallets, dump the trash, sweep, and mop the floor.

Mapping Your Storage

There is a lot to remember when it comes to storing fresh produce. One way to keep track of it all is to make a storage map for your refrigeration and dry storage areas. The diagram below is an example of how a store owner might map out his storage space to prepare for new produce items.

Some produce items go bad because they dry out too quickly. These items would benefit from regular misting while on display. Misting can help double the

Figure 3: Pictures of common fruit packaging machines and road side fruit selling kiosk

Cling film wrapping machine

Shrink packaging machine

Poor road side kinnow fruit retail kiosk

Acceptable road side fruit retail kiosk

shelf life of certain produce items and give produce a fresh, crisp look. Be careful not to soak these items with water. Produce items that benefit from regular misting are: Broccoli, Cabbage, Carrots, Cauliflower, Celery, Lettuce, Spinach etc

Figure 4: A view of retail fruit and vegetable shop at Chandigarh

Growing Importance of Agro-Industry

The importance of agro-industries in a nation's development is being increasingly recognized, and financing for agro-industrial projects has grown significantly in recent years. The corporate sector can add a unique dimension, given the power of private entrepreneurship, its capacity to innovate, its wide variety of skill as well as its ability to reach markets more efficiently. Today's consumer is seeking superior nutritional and taste benefits, better hygiene and convenience. Increasing awareness of health and well-being is also generating demand for wider variety of grains. This calls for a change in farming system from selling whatever is produced to producing what the consumer wants. Increasing crop production alone is not

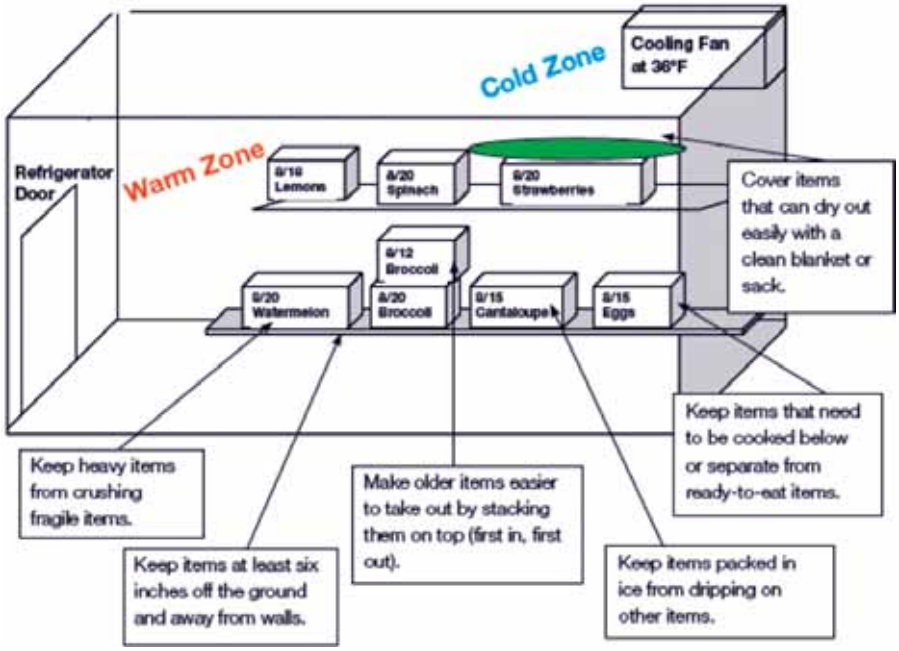

Figure 5: Mapping Your Storage

sufficient to raise farmer income if markets do not support such production. India's agri waste is estimated to be ` 92000/- crore. A big fraction of this wastage is in perishables. A higher level of food processing can create quality agri commodities, thereby, reducing farm wastages. Harvesting is once in a year whereas consumption of farm produce is all the year round thus, necessitating interventions such as cold chain and processing to increase shelf life of farm produce An integrated network of refrigerated buildings and vehicles to transport produce from farm to shop quickly and in good condition is must. Growing middle class in big cities is hungry for high quality fresh and processed food products. If India develops a nationwide cool cold chain, It would connect farmers with these premium markets and raise their income. As per International Institute of Refrigeration if developing countries had same level of refrigeration infrastructure as developed, they would save 200 million tonnes of food or around 14% of their food supply. In India, NCCD estimated that country has meagre (15%) control temperature transportation facility and less 1% of pack houses that pre-condition the produce for onward transportation. This lack of infrastructure means just 4% of country's food is moved through cold chain. So, main missing link is seamless control environment supply chain, comprising on farm pack houses, pre-cooling, distribution hubs, refrigerated transport and marketing vital to move the fresh produce swiftly from farm gate to consumption centers. The country needs to focus adapt the solution that worked and delivered throughout the world. Cold chain does not just reduce the post-harvest losses but also allows the farmers to earn more by maintaining the quality of their produce by marketing it to distant cities. Recently Sh. Surinder Kumar of Abohar has successfully marketed his kinnows from Punjab to the city in Bangalore using the cold chain like waxing, grading, pre-cooling, packaging and transportation in reefer vans. This has not only reduced the wastage but also raised his profits tenfold. So, entrepreneurial farmers or farmer cooperatives can move right up the value chain by developing its own processing activities and products that serve the society as a whole.

Agribusiness is a very common word and many a time it ties to cascade farming with manufacturing without realizing that the manufacturing sector is not the same as farming sector and high tech manufacturer cannot go to the field and grow the raw material. However farmer, the first entrant has to be supported with all that he needs in farming to get the highest production and productivity and must to be ensured profit sharing as much from the chain. Currently we have one way movement of raw materials and one way movement of the finished good and it must change to two way movements of commerce and money between farmer and consumer.

New ideas of constructive change such as market to cultivation are met with three attacks: Futility, Perversity and Jeopardy, an unholy trinity. Course of reform can not work because the problem is unsolvable, any attempt at solution will actually make matters worse and attempting to solve the problem will take attention and resources away from something more important! Processing is the focal point in adopting market to cultivation strategy. ■

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"We are evaluating the possibilities to manufacture products locally"

Sekisui Foam International is the leading Japanese manufacturer of physically cross-linked closed cell polyolefin foam. Sekisui has been developing and manufacturing cross-linked polyolefin foam products and solutions to Australasia, Asia Pacific, Middle East and India. **Rajesh Baliga, National Sales & Mktg Manager, Sekesui Foam International** takes through the journey of the company in India, products and services during an interaction with **Cooling India**...

Please take us through your company's journey in India.

Sekisui Foam International, the foam division of Sekisui Chemicals Co Ltd, Japan started operating in India in the year 2003 and has been in the Indian market for more than a decade now. SFI has two representative offices, one in Bengaluru and one in Mumbai and operates through its distributors network in Indian market.

What are the products and services offered by the company?

SFI offers thermal and acoustical insulation products for HVAC industry, which include duct thermal insulation, duct acoustic insulation, chilled water pipe insulation, insulation for AC units, floor and under deck insulation under various brands such as Thermobreak, Thermobreak Tube, Thermobreak Acoustiplus, Thermobreak No Clad and Softlon.

Please tell us about cross-linked polyolefin technology & its applications.

There are various ways of crosslinking the polyolefin foams and physical crosslinking is the most superior form of crosslinking the cells using the electron beam bombardment generated through high voltage current transformer which results in excellent cell size control resulting in skin finish to the product and good insulation properties. This technology was developed by Sekisui, Japan way back in the year 1967. This technology doesn't use any peroxides or any chemicals for crosslinking and hence is very clean in its operation.

What are the growth drivers of your business? Which sector does generate the maximum demand?

Construction and HVAC manufacturing segments are the two main growth sectors for our business. These segments are the ones which generate maximum demand for our product range.

What kind of technological innovations would you like to incorporate in your products considering rising global temperature? Do you have R&D hub in India?

SFI offers latest products in line with the industrial and environmental requirement, which includes product with low thermal conductivity and higher life. Fire and environmental safety concerns are major parameters, which decide our offering to the global market as well as in India. Our R&D hub for the segments which we are addressing in India is located in Australia. This R&D centre caters to the Sekisui Group's Insulation markets globally.

How would you differentiate Indian HVAC markets from the Global markets, while offering your services and products?

Indian HVAC market is fully aware of the latest happenings in the global scene and always looking for the latest of the product offerings with higher thermal efficiency, better fire, smoke and environmental safety standards, however, the regulations are the one which is missing in the Indian market due to which, pricing of the product is given more importance than any other parameter.

What opportunities would you envisage for your company with the Indian Government's focus on development of infrastructure like smart cities, urban transportation projects?

With the Indian Government's initiative, HVAC industry as a whole and we as insulation manufacturers are definitely going to have the opportunity to grow.

The Government of India launched 'Make in India' campaign in order to make the country manufacturing hub. Do you have any expansion plans?

The product line that we offer in the country is bulky in nature and attracts good amount of freight cost. With this scenario, SFI is continuously looking out for opportunity and are evaluating the possibilities to manufacture the same locally. ■

Efficient Mist Cooling System

There is an urgent demand from the industry for a water cooling system, which will operate with high efficiency even in adverse climatic conditions, and maintain cold water temperature in closed vicinity to WBT...

In process or chemical plants, product vapour generated in the process is condensed in a heat exchanger and is recovered back. The condensation of steam or vapour requires a cooling medium. In early days, this was achieved by using water from a river, a basin or seawater. The cold water is pumped through a heat exchanger and the warm water is discharged back to the water source. This is called once through cooling system.

A once through system is an open loop system. The necessity to reduce the huge amount of water gave birth to the idea of closed loop system. Thus the Wet Cooling system came into effect.

In a wet cooling system, water is circulated to condense the steam in the same type of heat exchanger that is used in the once through cooling. The warm water, instead of being returned to the water source, is cooled in a cooling tower using air as the cooling medium. Only the water carried away due to evaporation, drift and blow-down needs to be replenished by make-up water. Thus, requirement of water quantity is vastly reduced.

Wet Cooling Systems

Wet Cooling Tower System

We will first consider the Wet Cooling Tower System. The wet cooling tower system is based on the principle of evaporation. The heated water coming out of the surface condenser is cooled as it flows through a cooling tower, where air is forced through the tower by either mechanical or natural draft. Now-a-days, mostly, all wet cooling towers are mechanical draft cooling towers, where the air flow is accomplished by fans.

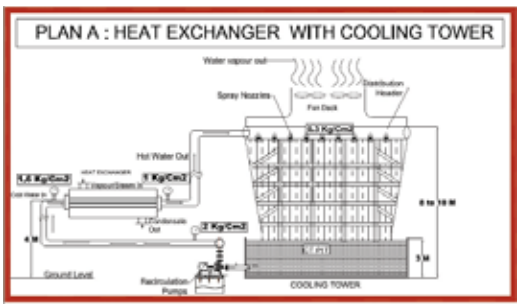
The principle cooling devices used in an induced or forced draft cooling tower are fans which run at the top of Cooling Tower (CT). Air enters through side louvers and escapes from the top. Water enters at the top and trickles down while getting cooled by air draft. A correctly designed induced draft CT can give an approach of 4 to 6°C to wet bulb temperature with a temperature drop of 10°C. Even a very highly efficient CT can not give an approach less than 4°C to WBT. Moreover, if ambient temperature or humidity levels rise, efficiency of CT reduces.

Let's Consider This Through In Example

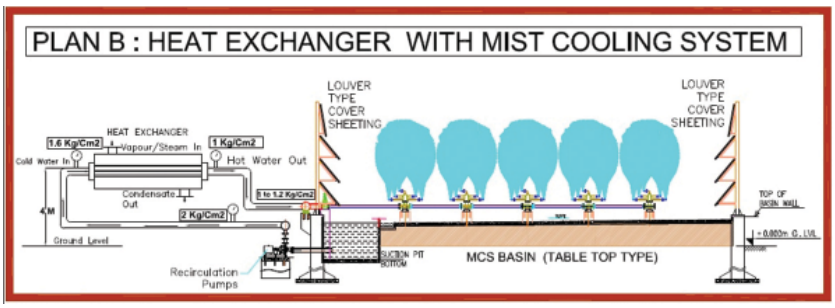
For a Chemical Plant, an induced draft cooling tower is designed to maintain Cold water temperature of 32°C at a WBT of 28°C with an approach of 4°C. Cooling Tower performs as desired during winter, early summer months. But during peak summer / Monsoon, efficiency of cooling tower reduces as humidity rises & its approach to WBT reaches beyond 6°C from design 4°C. Thus due to this rise in Cold Water temperature, these industries always experience loss in production by at least 5 to 7%. These losses do not occur in winter months. This means that the plant will operate at a reduced efficiency for almost 5 to 6 months in a year.

Also due to use of Fans, CT consumes a lot of power. It is observed that the efficiency of CT reduces over a period of time due to ware and tear of moving parts, Fills, Fins etc. which invites heavy maintenance.

Hence, there is an urgent demand from the industry for a water-cooling system, which will operate with high efficiency even in adverse climatic conditions and maintain cold water temperature in closed vicinity to WBT.



Circulation Water Cycle in Cooling Tower Plan A



Circulation Water Cycle in MCS Plan B

Mist Cooling System

MREPL has come out with a solution by designing Mist Cooling System which is a high efficiency system, which ensures an approach of 1°C to prevailing wet bulb temperature with a temperature drop of 12 to 15°C even in adverse climatic conditions.

In tropical conditions, worst wet bulb temperature even at coastal applications is maximum 30.5°C. Hence MCS will always maintain Cold Water of around 31°C+1°C throughout the year. No other cooling system can operate with such efficiency and it makes cooling tower/spray pond systems obsolete.

Salient Features of Mist Cooling System (MCS)

Cold Water Temperature

Mist Cooling System ensures an approach of 1°C to WBT with a temperature drop of 12°C to 15°C.

Energy Savings (Please refer diagrams Plan A & B)

Due to such high temperature drop obtained, water quantity required at the process side is much less. MCS requires water pressure equivalent to the height of cooling tower as shown in the following diagrams. Hence, considerable amount of energy is saved on circulation water pumping. Also, MCS does not require any fans for cooling. Thus, a huge amount of energy is saved on circulation and cooling.

Process Benefits

Mist Cooling System will supply cold water at a temperature very close to WBT (Approach of 1°C) as against an approach of 4 to 5°C in cooling tower. This will reduce the product vapour losses in shell & tube heat exchangers. This will ensure that your plant operates at an enhanced yield in summer and monsoon, also giving stable throughout the year.

Maintenance

MCS has no moving parts. It does not require any fills or fins for cooling. Also material used in the MCS is special grade saran polymer, a highly non-corrosive material having a life of more than 10-15 years.

Choke less Design of Nozzles

MCS operates with a choke less design. Size of smallest opening in MCS is more than one inch (25 MM) in diameter. Hence, chances of particles choking the system are remote. This makes MCS absolutely maintenance free.

Various Designs of MCS to Suit Site Conditions

Open Type MCS: Here, MCS ensures an approach of 1°C to WBT with a ΔT of 12 to 15°C. Water loss due to drift is 0.1 to 0.25% depending on wind load.

Louver Type MCS: Here MCS basin is closed from all sides, up to a height of 6 mtrs. by louver type cover sheeting. MCS ensures an approach of 2°C to WBT with a ΔT of 12 to 15°C. Drift loss can be limited up to 0.002% and also space requirement reduces considerably.

Table Top Design to Prevent Algae Formation: Latest table top design does not allow formation of water level inside the basin and all water passes to suction pit which is covered from top thus minimizing chances of algae formation.

MCS Design For Working in Dusty Environment: Unique suction pit design does not allow dust to pass to the inlet of circulation pumps. Dust is drained from drain valve, while only clear water passes to circulation water pumps.

System Flexibility (Capacity Turn Down Ratio)

MCS is offered with individual line isolation valve. MCS is the only system, which gives such a high flexibility in operation.

Hydro- Balance Valve

Hydro-Balance Valve (HBV) is provided to take care of sub-cooling, which may happen in winter & also is helpful to release excess pressure, which may develop on system at times.

Chemical Treatment

Chemical dosing requirements are similar to that of cooling tower as same hold up of water is maintained in suction pit of table top MCS.

Make-Up Water Requirement

Due to latest 'Louver Type' design, drift loss through MCS can be limited to less than 0.002%. Hence, overall make-up water quantity required is approximately same as compared to cooling towers.

Pay Back Period

The Pay Back period of the MCS in most of the cases, will be obtained in less than ONE year only.

Case Study of Installation of LTMCS at a Data Centre in Pune

History

Client runs a large data centre at Pune. They have server rooms which dissipate huge amount of heat. To meet the air conditioning & cooling requirement, they are using water cooling chillers of Trane Company at their plant. To service the requirement of cooling water induced draft cooling towers were installed to operate at an approach of 4˚C, at a terrace top of utility building

Under the drive of energy saving, client

contacted us for implementing our Mist Cooling System under energy conservation scheme in the year 2015. MREPL team visited the site & after thorough study, The Detailed Case Study Follows –

techno-commercial offer was submitted. MCS was implemented in the year 2016 which is now working at their data centre successfully since last one year. MCS is maintaining an approach of 2 to 3˚C to design WBT thus, saving huge amount of power on compressor & fans.

Comparison Table Between MCS V/S IDCT Specific Comparison For 1200 Tr.

Annexure A: Circulation & Fan Power Saving Due to Installation of LTMCS

Sr. No.	Parameter	Cooling Tower (Induced Draft)	LOUVER TYPE MIST COOLING SYSTEM
1	Temperature Drop (ΔT]	3.4°C	3.4°C
2	Approach to design Wet Bulb Temperature (WBT)	3.9°C	3°C
3	Circulation Water Quantity Required	1100 M^3/Hr.	1100 M^3/Hr.
4	Make up water (Drift +Evaporation)	171.6 M^3/Hr.	150.71 M^3/Hr.
4a	Energy Required (Power Consumed on Pumps)	Recirculation Pumps : Capacity : 1100 M^3/Hr Head : 30 Mtr Total Power :106 KW on Pumps.	Recirculation Pumps : Capacity : 1100 M^3/Hr Head : 30 Mtr Total Power: 106 KW on Pumps.
4b	ENERGY REQUIRED (POWER CONSUMED ON FANS)	Fans : 74 KW/ HR (37KWH/Cell X 2 No's)	Fans : NIL MCS Does not require Any Fans
5	TOTAL POWER REQUIRED FOR COOLING [4A + 4B]	180 KW/ HR	106 KW/ HR
6	TOTAL ENERGY SAVED ON CIRCULATION & COOLING	NIL	74 KW/Hr (PART-A)
7	MAINTENANCE	Very high Due to replacement of fills/ fins/ fan blades etc.	NEGLIGIBLE Due to choke less operation and No moving parts.
8	BREAK DOWN	Very prone to Break down	NO Break down
9	STAND BY	Required	NOT Required
10	MAINTENANCE COST	Rs. Three Lakhs Per Year (Average)	NEGLIGIBLE

Annexure B: Saving on Compressor Motor of 1200Tr Chiller Due to LTMCS

Sr. No.	Parameter	Cooling Tower (Induced Draft)	LOUVER TYPE MIST COOLING SYSTEM
1	Wet Bulb Temperature	27.7°C	27.7°C
2	Chilled water Temp in °C (Assumed)	5°C	5°C
3	Supply Temperature from Cooling Tower/LTMCS	31.6°C	30.7°C
4	Close temperature approach in °C	3.9°C	3°C
5	Delta Temperature of chilled water compressor	26.6°C	25.7°C
6	Chilled water compressor motor KW for 1200 TR (0.6 KW/TR)	720	
7	Saved KW due to LTMCS in %	Nil	3.4 %
8	Energy saved to get water temperature in KW	Nil	24 KW/Hr (PART-B)
9	Total running hours per year	8760	
10	Total Power saving in chilled water compressor Kwh	Nil	2,10,240 Kwh

Energy conservation
(Part-A + Part-B) 98 kw/hr.

It can be clearly seen from above charts that 98 KW per hour are saved by MCS on circulation & cooling. Hence, considering a unit electric rate of ` 7/KW, around `. 16,464/- per day are saved only on power.

Thus considering 365 days of operation per year, total saving only on power by installation of MCS will be around ` 60 Lakhs Per Annum, year after year.

Hence, payback period obtained in less than one year. ■

Makarand A Chitale
Director (Technical)
Mist Ressonance
Engineering Pvt Ltd.

Johnson Controls Introduces YORK® YZ Magnetic Bearing Centrifugal Chiller

New chiller delivers up to 35 percent annual energy savings, reduced maintenance costs and widest operating envelope in industry...

The YORK® YZ Magnetic Bearing Centrifugal Chiller is the first chiller fully optimized for ultimate performance with a next generation low-global warming potential (GWP) refrigerant—R-1233zd(E).

Johnson Controls introduces the YORK® YZ Magnetic Bearing Centrifugal Chiller, the first chiller fully optimized for ultimate performance with a next generation low global warming potential (GWP) refrigerant—R-1233zd(E). Chosen for its efficiency, safety, availability, low environmental impact and cost, nonflammable R-1233zd(E) has an ultra-low GWP of 1 and is readily available from refrigerant manufacturers.

"We have long led the industry in delivering chiller innovations," said Laura Wand, Vice President, Chiller Solutions, Building Technologies & Solutions at Johnson Controls. "With the new YORK® YZ, we have engineered the world's most efficient low-GWP line of centrifugal chillers. Our broad range cooling capacity will serve our customers' many diverse application needs."

Johnson Controls used a holistic approach to system design and engineering, optimizing every component around a carefully selected next generation refrigerant for ultimate performance. The YORK® YZ chiller uses an integral, variable speed drive and advanced magnetic bearing technology that features a single moving assembly suspended in a magnetic field that does not require lubrication. This technology requires 80 percent fewer moving parts than traditional oil- or refrigerant-lubricated drivelines. The result is enhanced reliability, reduced maintenance and improved efficiency. Compared to traditional fixed-speed oil-bearing chillers, the YZ delivers up to 35 percent annual energy savings.

The YZ chiller can deliver significant energy savings and lower operating costs by taking advantage of the off-design conditions where chillers operate 99 percent of the time. The YZ operates with entering condenser water temperature as low as 40°F (4.5°C), providing enhanced performance in every operating condition and the widest operating envelope in the industry. The YORK® YZ uses an optimized single stage design to provide industry-leading real-world energy efficiency. The chiller can also operate with condenser temperatures below the evaporator temperatures, eliminating the need for a water-side economizer, which simplifies the system, requires less mechanical room space and saves money on components, piping, controls and maintenance.

"We continue to deliver industry-leading chiller options that best meet the needs of our current and continually expanding customer base around the world," said Bill Jackson, president, Global Products, Building Technologies & Solutions at Johnson Controls. "The YZ is another fantastic platform system that equips our customers with environmentally friendly performance in an optimized solution. Thank you to our YORK® Chiller team for leading the way."

The YZ chiller brings together groundbreaking YORK® innovations refined over decades of real- world use to create a revolution in chiller design and optimization. It represents a solution from the chiller experts, who like to think of the YORK® YZ chiller as tomorrow's chiller, available today. ■

For more details, visit www.YORK.com/Next.

India as an Engine of Green Growth

Buildings, after all, directly contribute to the challenges created by rapid urbanization. They are responsible for an enormous amount of energy use, resource consumption and greenhouse gas emissions. According to the UNEP Buildings and Climate Change Report, buildings account for more than 40 percent of global energy use and one-third of global greenhouse gas emissions...

Over the last two decades, India has made great accomplishments as a nation and has positioned itself as one of the four great world powers. We have developed robust infrastructure with supportive amenities in rural areas. We have also scaled our technological infrastructure to promote education in rural areas and global innovation in our cities.

Yet, there is still much work to be done if we want to create a sustainable future where all Indians can participate. India is rapidly urbanizing on a breathtaking scale. In the last 20 years, our urban population has nearly doubled. By 2030, it is expected that the world will have 8.6 billion people and 1.5 billion of them will reside in India.

While the continued migration of people into cities and urbanization have driven a tremendous amount of economic development, this also poses serious challenges and questions. How do we manage waste and water use? How do we provide clean and reliable energy for all? How do we source sustainable materials? How do we improve air quality in our cities? How do we prevent chronic illness?

If we want to sustain current economic growth and development levels, while developing healthy, green buildings, there is a critical need to transform our built environment. All of the issues associated with urbanization can be addressed by building more sustainable, resource-efficient buildings and communities, providing a gateway to a more sustainable future for India. Furthermore, buildings with healthy, indoor spaces are paramount

to securing the health and wellbeing of India and further accelerating our position as a global leader.

Buildings, after all, directly contribute to the challenges created by rapid urbanization. They are responsible for an enormous amount of energy use, resource consumption and greenhouse gas emissions. According to the UNEP Buildings and Climate Change Report, buildings account for more than 40 percent of global energy use and one-third of global greenhouse gas emissions.

Therefore, the building sector in India holds the largest potential for significantly mitigating climate change, reducing resource depletion and improving human health. Urbanization has created a huge demand for new construction. To accommodate our massive population shift, many new buildings will need to be constructed— homes, offices, factories, schools, hospitals, retail outlets, data centers and more. India is expected to double its building stock by 2030, and 70 percent of those buildings needed still have yet to be built. How these buildings are developed will compound and not only impact our society, but also India's economy and environment.

Engine of Green Growth

Fortunately, sustainable development is no longer a new concept in India and, in recent years, the nation has continued to take on a greater leadership role in the global green building movement. This is in large part due to strong leadership from our national government. At the historic COP 21 conference in Paris where the international climate agreement was signed, India made a bold commitment to reduce its emissions by 33 to 35 percent by 2030 compared to 2005 levels. To achieve this, the government has set high targets on renewable energy, efficiency and carbon reduction, committing to increasing our non-fossil based power capacity from 30 to 40 percent and reducing carbon by almost three billion tons by 2030. In addition, the government has promised to provide reliable power to everyone, and India is becoming a leader in the production and manufacturing of renewable energy technology. The national government has also shown tremendous leadership in the smart cities movement with efforts such as the 100 Smart Cities Project.

This will be India's Century

In addition to strong leadership from our national government, over the last several years, green building has seen a dramatic increase, as India has become an engine of green growth. Green building is a trillion-dollar industry worldwide, with the market for green building materials alone expected to reach nearly $250 billion by 2019. Our nation now stands at the edge of the transformational economic and social growth we have sought for decades. We are poised to reap the benefits if we commit to continuing to promote sustainable development and green building. If we can accomplish this, then there is no doubt in my mind that this will be India's century.

At the US Green Building Council (USGBC), we have a strong vision of a sustainable built environment within a generation and we work towards achieving our vision of market transformation for the built environment through our LEED, or Leadership in Energy and Environmental Design, green building program. LEED is a global, regional and local certification program for buildings, communities and cities that guides their design, construction, operations and maintenance towards sustainability.

In 2000, USGBC certified the first LEED building, and over the last two decades, LEED certification has become an international symbol of leadership and a mark of high-quality, sustainable buildings that are saving energy, resources and water and are healthier for occupants and their communities. LEED also works for all building types – from homes to corporate headquarters to entire neighborhood developments and cities – at all phases of development.

Today, LEED is the most widely used and trusted green building programs in the world. Currently, there are more than 92,000 registered and certified projects, totaling more than 19.5 billion square feet across 167 countries and territories. Every day, more than 2.2 million square feet of building spaces certifies to LEED and millions of people experience LEED certified buildings. There are also more than 1.5 billion registered and certified LEED residential units.

LEED has become one of the single most powerful economic development tools for revitalizing and scaling sustainable buildings. For example, in the United States alone, it supports nearly 8 million jobs and contributes $554 billion to the economy annually. LEED works by enhancing a company's triple bottom line of people, planet and profit. LEED-certified buildings save money, consume less energy, use less water and fewer resources, provide better indoor air quality and improve occupant comfort and satisfaction.

LEED-certified buildings, on average, have 34 percent lower CO_2 emissions, consume 25 percent less energy and 11 percent less water and have diverted more than 80 million tons of waste from landfills. They also enjoy a lifetime of returns and cost less to operate, reducing water bills as much as 40 percent. Buildings and organizations around the globe use LEED to increase the efficiency of their buildings, freeing up valuable resources that can be used to create new jobs, attract and retain top talent, expand operations and investment in emerging technologies. LEED building owners report reduced operating costs, lower employee absenteeism and turnover, higher resale value, less time on the market, faster lease up rates and reduced risks compared to traditional buildings.

LEED-certified buildings also truly perform. From 2015-2018, it is estimated that LEED-certified buildings in the United States will have more than $2.1 billion in combined energy, water, maintenance and waste savings. This is why so many companies—from Fortune 500s to small businesses—are using LEED to validate investments and outcomes in their real estate.

All of this presents much promise for India, since green growth in the nation is accelerating rapidly and India is now the third-largest market for LEED outside of

the United States. As of December 2017, there are more than 2,600 projects in India participating in LEED, totaling more than 1.2 billion square feet. From housing to hotels to hospitals, from schools to office buildings to transit systems, India is embracing LEED.

Finally, the rate of green building in India is also only expected to grow over the coming years. According to the Dodge Data & Analytics World Green Building Trends 2016 SmartMarket report, global green building is expected to double every three years and emerging economies like China, India and Brazil will be engines of green growth, with development in those countries varying from two-fold to six-fold over current green building levels.

Partnership is the New Leadership

The future of green building in India is extremely bright. The progress we've witnessed over the last two decades is credit to the many advocates and organizations that have helped to build momentum for green building here. One of our core beliefs at USGBC is "partnership is the new leadership." We know that our global success is only due to the partnership and support of the leaders who have been relentless in the pursuit of market transformation of the built environment.

We also know that the greening of the built environment in India will require widespread cooperation. The amount of work we need to accomplish is not going to be done by one organization. We need the combined power of USGBC, and other local Indian leaders like the India Green Building Council (IGBC) and The Energy and Resources Institute (TERI), if we are going to truly realize a sustainable future for all Indians.

Our planet is desperately trying to tell us something and the challenges we face are serious. Global temperatures are only continuing to rise. Sixteen of the 17 warmest years on record all have occurred since 2001, 2016 ranks as the warmest of all, and in May of 2016 we recorded the highest-ever temperature at 51 degrees Celsius in Phalodi. Meanwhile, the last decade has also seen an epidemic of devastating natural disasters like the Mumbai, Chennai and Uttarkhand floods, which disrupted and destroyed countless lives.

Imagine an India that has accomplished the lofty goal of a sustainable future for all.

Green building presents India with enormous opportunities: to be innovative, to be inclusive, to become a global leader on initiatives ranging from solar energy to efficient lighting to grid management to health and wellbeing and beyond. It also offers India an opportunity to achieve broad, durable economic growth that can help lift millions out of poverty, improve their quality of life and set our country on a more prosperous path for generations to come.

Imagine – an India that is performing at the highest levels possible and is a global model for others around the world. An India whose buildings, neighborhoods, communities are cities are as sustainable as possible. An India that prioritizes human health and that saves energy, water and waste. An India powered by the cleanest and most reliable energy that is accessible to all. An India where every child learns in a green school and that is affordable for even the poorest. An India that has accomplished the lofty goal of a sustainable future for all. ■

Mahesh Ramanujan
President & Chief Executive Officer
US Green Building Council

This is what I imagine for our future.

BITZER Introduces Warranty Extension Packages

The specialist in refrigeration compressors offers warranty extension for IQ products as well as warranty extension packages of up to five years for other selected products...

Compressor specialist BITZER introduces complimentary one-year individual warranty extension for IQ products, which is extendable up to an overall guarantee of five years. For non-IQ products, specific warranty extension packages are now available in the 2018 official price list. BITZER stands for quality and customer-oriented solutions. This is why the long-standing company is now introducing warranty extension packages exceeding the legally required warranty of 12 months for most of its products with additional benefits for IQ products.

As of 1 January 2018, customers benefit from a complimentary one-year extra warranty on all BITZER IQ products bought starting from this date – exceeding the legal one-year warranty. Activation of the free extended warranty is to be carried out by scanning the QR code on the product. Then, customers will be led through the self-explanatory activation process.

BITZER IQ products like the IQ MODULE CM-RC-01 increase the efficiency and reliability of any system

The activation process for the BITZER warranty extension is quick and simple

Intelligence Pays Off

BITZER IQ products include intelligent compressors and condensing units as well as certain components like frequency inverters and operating modules. Philippe Maratuech, Director of Services and After-Sales at BITZER, confirms: "We are confident in our abilities and therefore, know just how reliable our products with IQ technology are. We want our customers to benefit from this confidence and to strengthen their trust in our intelligent solutions, which is why we decided to grant them one extra year of warranty with the purchase of an IQ product."

This additional service is available in numerous sales regions on an annual basis and can be extended to an overall warranty of five years: on top of the one-year free warranty on IQ products, customers can extend their warranty if they buy the warranty extension package.

Purely Flexible

With the warranty extension, most BITZER products' warranties can now be extended to duration of up to five years, for a fraction of the product's price. Product and time span are freely selectable by the customer, which makes the warranty extremely flexible and easy to manage. BITZER partners get the opportunity to further protect their BITZER compressors and condensing units, offering their most demanding customers an optimal way of safekeeping their investments. ■

Aspects of Refrigerators, Heat Exchangers, & Fans (Part 2)

This study clarifies the background of the study, highlights the potential energy saving that could be achieved through use of ground energy source and describes the objectives, approach and scope of the thesis. It also focuses on the optimisation and improvement of the operation conditions of the heat cycles and performances of the GSHP...

Some emphasis has recently been put on the utilisation of the ambient energy from ground source and other renewable energy sources in order to stimulate alternative energy sources for heating and cooling of buildings. Exploitation of renewable energy sources and particularly, ground heat in buildings can significantly contribute towards reducing dependency on fossil fuels. This section highlights the potential energy saving that could be achieved through use of ground energy source. This study highlights the energy problem and the possible saving that can be achieved through the use of ground sources energy. Also, this study clarifies the background of the study, highlights the potential energy saving that could be achieved through use of ground energy source and describes the objectives, approach and scope of the thesis. It also focuses on the optimisation and improvement of the operation conditions of the heat cycles and performances of the GSHP. It was recommended that GSHPs are extendable to more comprehensive applications combined with the ground heat exchanger in foundation piles and the seasonal thermal energy storage from solar thermal collectors. Therefore, an approach is needed to integrate renewable energies in a way to meet high building performance. However, because renewable energy sources are stochastic and geographically diffuse, their ability to match demand is determined either by the utilisation of a greater capture area than that occupied by the community to be supplied or the reduction of the community's energy demands to a level commensuratable with the locally available renewable resources.

The earth's surface acts as a huge solar collector, absorbing radiation from the sun. In the UK, the ground maintains a constant temperature of 11-13oC several metres below the surface all the year around. Among many other alternative energy resources and new potential technologies, the ground source heat pumps (GSHPs) are receiving increasing interest because of their potential to decrease primary energy consumption and thus, reduce emissions of greenhouse gases.

Direct expansion GSHPs are well suited to space heating and cooling and can produce significant reduction in carbon emissions. In the vast majority of systems, space cooling has not been normally considered, and this leaves ground-source heat pumps with some economic constraints, as they are not fully utilised throughout the year. The tools that are currently available for design of a GSHP system require the use of key site-specific parameters such as temperature gradient and the thermal and geotechnical properties of the local area. A main core with several channels will be able to handle heating and cooling simultaneously, provided that the channels are thermally insulated to some extent and can be operated independently as single units, but at the same time function as integral parts of the entire core. Loading of the core is done by diverting warm and cold air from the heat pump through the core during periods of excess capacity compared to the current needs of the building. The cold section of the core can also be loaded directly with air during the night, especially, in spring and fall when night times are cooler and daytimes are warmer. The shapes and numbers of the internal channels and the optimum configuration will obviously depend on the operating characteristics of each installation. Efficiency of a GSHP system is generally much greater than that of the conventional air-source heat pump systems. Higher COP (coefficient of performance) is achieved by a GSHP because the source/sink earth temperature is relatively constant as compared to air temperatures. Additionally, heat is absorbed and rejected through water, which is a more desirable heat transfer medium due to its relatively high heat capacity.

The GSHPs in some homes also provide:

- Radiant floor heating.
- Heating tubes in roads or footbaths to melt snow in the winter.
- Hot water for outside hot tubs and
- Energy to heat hot water.

With the improvement of people's living standards and the development of economies, heat pumps have become widely used for air conditioning. The driver

Table 1. Thermodynamic property values

State	Temperature (°C)	Pressure (kPa)	Specific volume (m3/kg)	Specific enthalpy (kJ/kg)	Specific entropy (kJ/(kg K)
1	-20.0	132.73	0.14739	386.55	1.7413
2	2.8	292.80	0.07097	401.51	1.7413
3	0.0	292.80	0.06931	398.60	1.7282
4	33.6	770.20	0.02726	418.68	1.7282
5	30.0	770.20	0.00084	241.72	1.1435
6	0.0	292.80	0.01517	241.72	1.15297
7	0.0	292.80	0.000772	200.00	1.0000
8	-20.0	132.73	0.01889	200.00	1.00434

Table 2. Measured and computed thermodynamic properties of R-22

State	Measured		Computed		
	Temperature (°C)	Pressure (kPa)	Specific volume (m3/kg)	Specific enthalpy (kJ/kg)	Specific entropy (kJ/(kg K)
1	-10.0	310.0	0.07558	402.08	1.7810
2	-4.0	304.0	0.07946	406.25	1.7984
3	82.0	1450.0	0.02057	454.20	1.8165
4	70.0	1435.0	0.01970	444.31	1.7891
5	34.0	1410.0	0.00086	241.40	1.1400
6	33.0	1405.0	0.00086	240.13	1.1359
7	-12.8	320.0	0.019010	240.13	1.1561

to this was that environmental problems associated with the use of refrigeration equipment, the ozone layer depletion and global warming are increasingly becoming the main concerns in developed and developing countries alike. With development and enlargement of the cities in cold regions, the conventional heating methods can severely pollute the environment. In order to clean the cities, the governments drew many measures to restrict citizen heating by burning coal and oil and encourage them to use electric or gas-burning heating. New approaches are being studied and solar-assisted reversible absorption heat pump for small power applications using water-ammonia is under development.

An air-source heat pump is convenient to use and so it is a better method for electric heating. The ambient temperature in winter is comparatively high in most regions, so heat pumps with high efficiency can satisfy their heating requirement. On the other hand, a conventional heat pump is unable to meet the heating requirement in severely cold regions anyway, because its heating capacity decreases rapidly when ambient temperature is below -10°C. According to the weather data in cold regions, the air source heat pump for heating applications must operate for long times with high efficiency and reliability when ambient temperature is as low as -15°C. Hence, a great deal of research and development has been conducted to enable heat pumps to operate steadily with high efficiency and reliability in low temperature environments. For example,

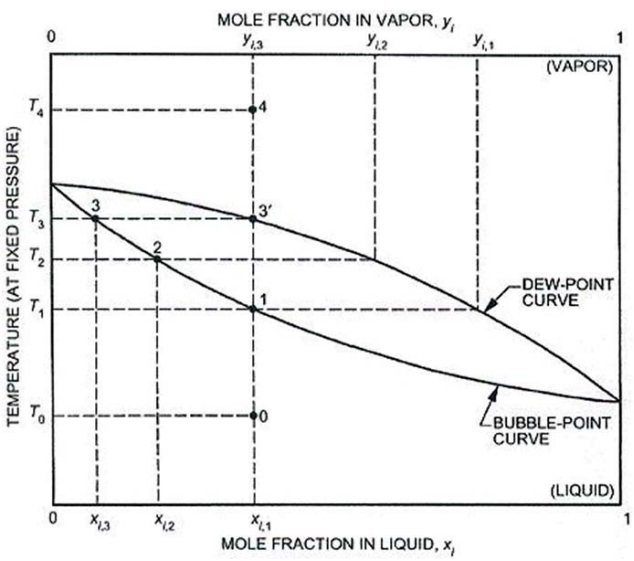


Figure 1: Temperature –concentration (T-x) diagram zerotropic mixture

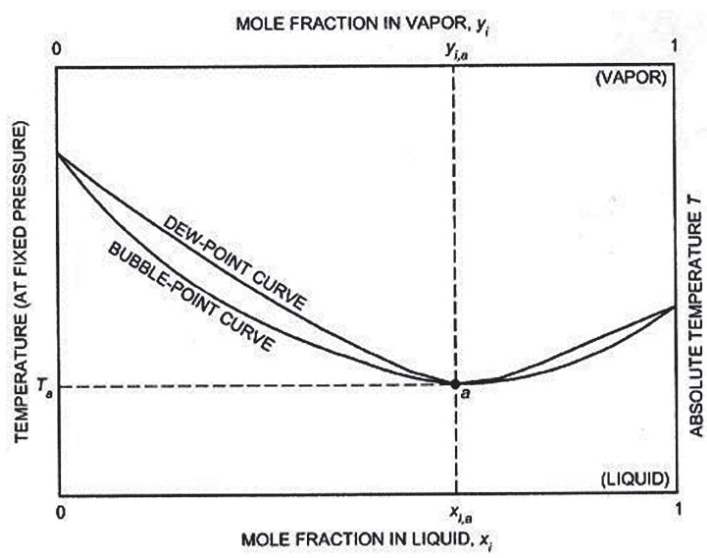


Figure 2: Azerotropic behaviour shown on T-x diagram

Table 3. Thermodynamic property data

State	t, (oC)	p, (kPa)	v, (m3/kg)	h, (kJ/kg)	s, (kJ/(kg K)
1	-20.0	132.73	0.14739	386.55	1.7413
2	37.8	770.20	0.02798	423.07	1.7413
3	30.0	770.20	0.000842	241.72	1.1435
4	-20.0	132.73	0.047636	241.72	1.1692

Table 4. Energy transfers and irreversibility rates for refrigeration system

Component	q, kW	W, kW	I, W/K	I/Itotal (%)
Evaporator	7.000	0	0.4074	9
Suction line	0.1802	0	0.1575	3
Compressor	-0.4276	2.5	2.1928	46
Discharge line	-0.4274	0	0.2258	5
Condenser	-8.7698	0	0.8747	18
Liquid line	-0.0549	0	0.0039	≈0
Expansion device	0	0	0.8730	18
Total	-2.4995	2.5	4.7351	

the burner of a room air conditioner, which uses kerosene, was developed to improve the performance in low outside temperature. Similarly, the packaged heat pump with variable frequency scroll compressor was developed to achieve high temperature air supply and high capacity even under the low ambient temperature of –10 to –20°C. Such heat pump systems can be conveniently used for heating in cold regions. However, the importance of targeting the low capacity range is clear if one has in mind that the air conditioning units below 10 kW cooling account for more than 90% of the total number of units installed in the EU.

Direct Expansion Heat Pump Installation

The undertaken experimental work consists of three parts. The first step dealt with drilling three boreholes each 30 meter deep, digging out the pit and connection of the manifolds and preparation of coils. Holes were grouted with bentonite and sand. The pipes were laid and tested with nitrogen. Then, the pit was backfilled and the heat pump was installed. The second step was concerned with the setting up of the main experimental rig: construction and installation of the heat injection fan, water pump, expansion valve, flow meter, electricity supply, heat exchanger and heat pump. The third step was an installation of refrigerator and measurements.

Thermodynamic property data are summarised in Table 1. Table 2 lists the measured and computed thermodynamic properties of the refrigerant, neglecting the dissolved oil. The property data are tabulated in Table 3.

This result is within computational error of the measured power input to the compressor of 2.5 kW. The analysis demonstrated in Table 4 can be applied to any actual Vapour compression refrigeration system. The only required information for second law analysis is the refrigerant thermodynamic state points and mass flow rates and the temperatures in which the system is exchanging heat.

Figure 1 is a typical T-x diagram valid at a fixed pressure. Most mixtures have T-x diagrams that behave in this fashion, but some have a markedly different feature. If the dew-point and bubble-

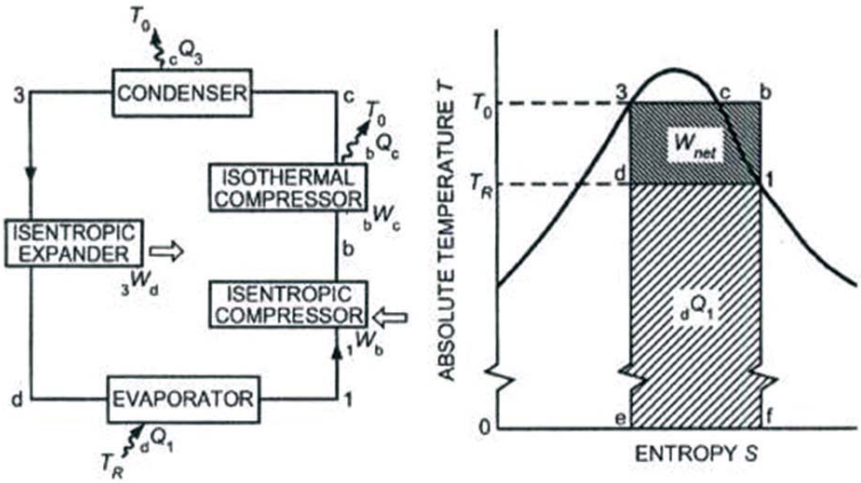


Figure 3: Carnot vapours compression cycle

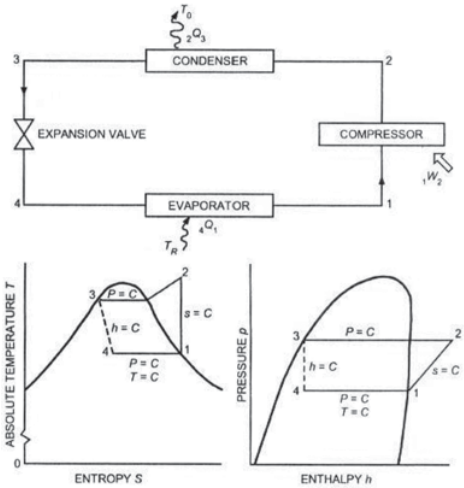


Figure 4: Theoretical single-stage vapours compression refrigeration cycle.

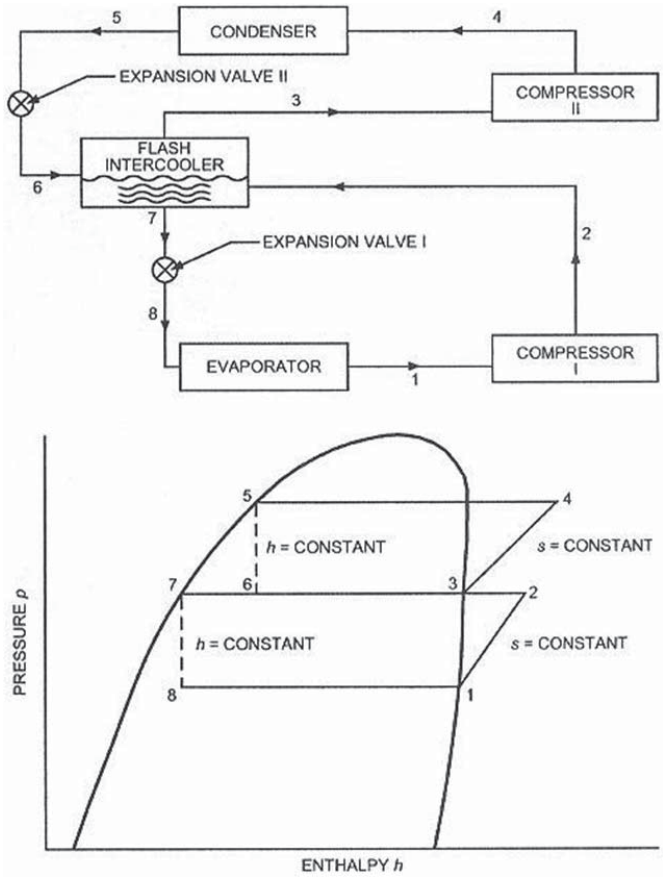


Figure 5: Schematic and pressure-enthalpy diagram for dual-compression, dual-expansion cycles

point curves intersect at any point other than at their ends, the mixture exhibits azeotropic behaviour at that composition. This case is shown as position in the T-x diagram of Figure 2. A system designed to approach the ideal model shown in Figure 3 is desirable. Figure 4 shows the theoretical single-stage cycle used as a model for actual systems.

The need for alternative low-cost energy resources has given rise to the development of the DX-GSHPs for space cooling and heating. The performance of the heat pump depends on the performance of the ground loop and vice versa. It is, therefore, essential to design them together. Closed-loop GSHP systems will not normally require permissions/authorisations from the environment agencies. However, the agency can provide comment on proposed schemes with a view to reducing the risk of groundwater pollution or derogation that might result. The main concerns are:

- Risk of the underground pipes/boreholes creating undesirable hydraulic connections between different water bearing strata.
- Undesirable temperature changes in the aquifer that may result from the operation of a GSHP.
- Pollution of groundwater that might occur from leakage of additive chemicals used in the system.

When compressors are connected in series, the vapour between stages should be cooled to bring the vapour to saturated conditions before proceeding to the next stage of compression. Intercooling usually minimises the displacement of the compressors, reduces the work requirement, and increases the COP of the cycle. If the temperature is below ambient, which is the usual case, the refrigerant itself must be used to cool the vapour. This is accomplished with a flash intercooler. Figure 5 shows a cycle with a flash intercooler installed.

A pressure-enthalpy diagram of cycle is shown in Figure 6. The following performance data are obtained:

- Ambient air temperature $t_o = 30^oC$
- Refrigerated space temperature $t_g = -10^oC$
- Refrigeration load $Q_{evap} = 7.0$ kW
- Compressor power input $W_{comp} = 2.5$ kW
- Condenser fan input $W_{CF} + 0.15$ kW
- Evaporator fan input $W_{EV} = 0.11$ kW

A heat pump is a device for removing heat from one place - the 'source' - and transferring it at a higher temperature to another place. The heat pumps consist of a compressor, a pressure release valve, a circuit containing fluid (refrigerant), and a pump to drive the fluid around the circuit. When the fluid passes through the compressor it increases in temperature. This heat is then given off by the circuit while the pressure is maintained. When the

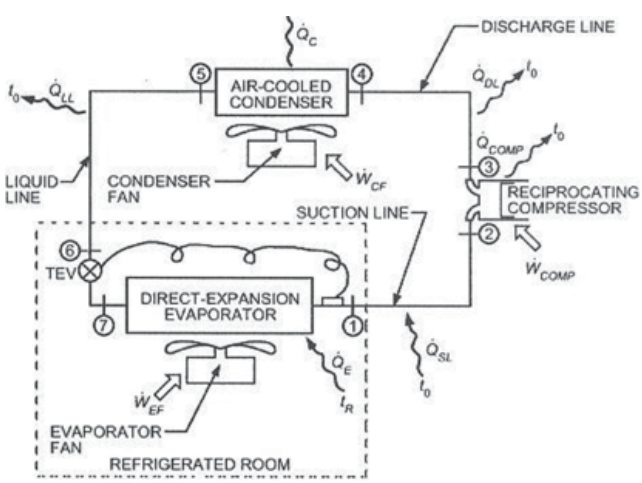


Figure 6: Schematic of real, direct-expansion, single-stage mechanical vapour-compression refrigeration system

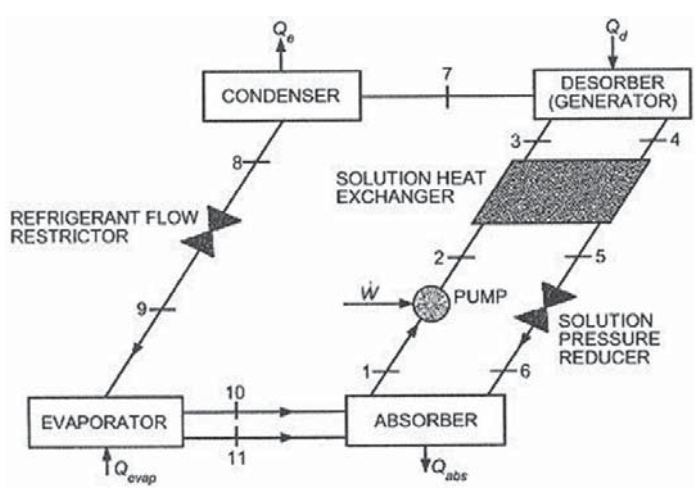


Figure 7: Single-effect absorption cycle

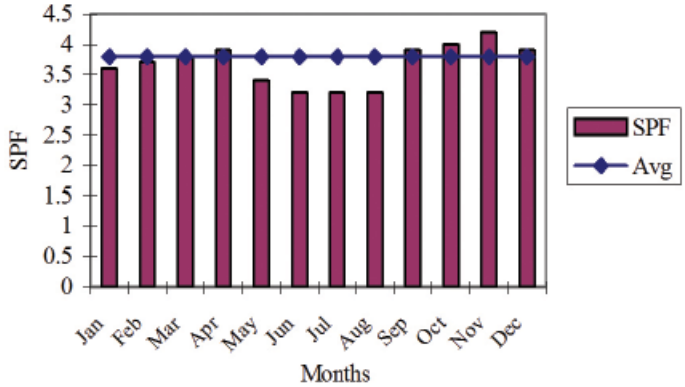


Figure 9: Seasonal performance for individual months and average for 2012

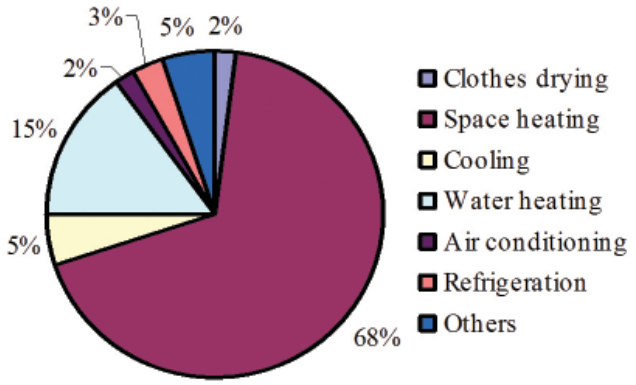


Figure 10: Residential energy consumptions according to end use

fluid passes through the relief valve, the rapid drop in pressure will result in the cooling of the fluid. The fluid then absorbs heat from the surroundings before being re-compressed. In the case of domestic heating, the pressurized circuit provides the heating within the dwelling. The depressurised component is external and, in the case of ground source heat pumps, is buried in the ground. Heat pump efficiencies improve as the temperature differential between 'source' and demand temperature decreases, and when the system can be 'optimised' for a particular situation. The relatively stable ground temperatures moderate the differential at times of peak heat demand and provide a good basis for optimisation.

Absorption cycles require at least two working substances: a sorbent and a fluid refrigerant, these substances undergo phase changes. As illustrated in Figure 7, the refrigerant phase changes occur in an evaporator and a condenser and the sorbent phase changes in an absorber and desorber (generator). For the forward absorption cycle, the highest-temperature heat is always supplied to the generator.

There are two primary factors to describe the efficiency of heat pumps. First, the coefficient pf performance (COP) is determined in the test stand with standard conditions for a certain operating point and/or for a number of typical operating points. Second, the seasonal performance factor (SPF), describes the efficiency of the heat pump system under real conditions during a certain period, for example for one year. The SPFs in this case are the ratio of the heat energy produced by the heat pump and the back-up heater and the corresponding energy required of the heat pump. The SPF for individual months and an average value for the year 2008 for the DX GSHP are shown in Figure 9. The assessment of the 2008 measurement data for the GSHP in the buildings providing both heating and cooling reveals a seasonal performance factor (SPF) of 3.8. The SPF of the individual system was in the range of 3.0-4.6.

Under these conditions, it is predicted that there would only be a small variation in the efficiency of the heat pump system between summer and winter. This is explained by the fact that although the output temperature required for domestic water heating is higher than that required for space heating, the ground temperatures are significantly higher in the summer than in the winter.

There is clearly a lot more that must be done to support distribution GSHPs in general especially from the perspective of buildings in the planning and operation, and distribution GSHP systems (Figures 10-12).

Conclusion

The direct expansion (DX) ground source heat pump (GSHP)

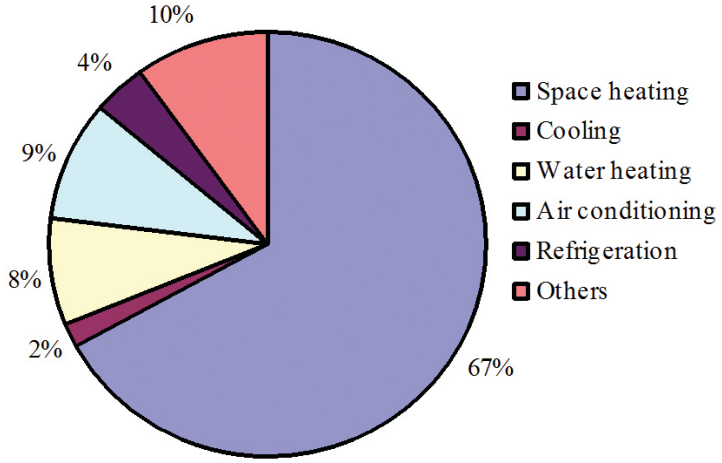


Figure 11: Commercial energy consumptions according to end use

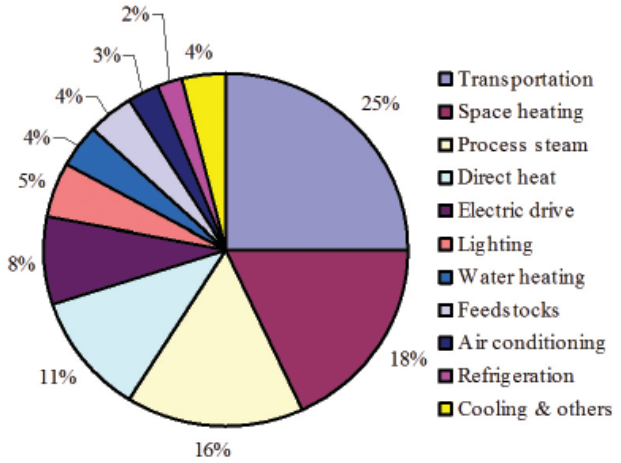


Figure 12: Energy consumptions according to end use

systems have been identified as one of the best sustainable energy technologies for space heating and cooling in residential and commercial buildings. The GSHPs for building heating and cooling are extendable to more comprehensive applications and can be combined with the ground heat exchanger in foundation piles as well as seasonal thermal energy storage from solar thermal collectors. Heat pump technology can be used for heating only, or for cooling only, or be 'reversible' and used for heating and cooling depending on the demand. Reversible heat pumps generally have lower COPs than heating only heat pumps. They will, therefore, result in higher running costs and emissions and are not recommended as an energy-efficient heating option. The GSHP system can provide 91.7% of the total heating requirement of the building and 55.3% of the domestic water-heating requirement, although only sized to meet half the design-heating load. The heat pump can operate reliably and its performance appears to be at least as good as its specification. The system has a measured annual performance factor of 3.16. The heat pump system for domestic applications could be mounted in a cupboard under the stairs and does not reduce the useful space in the house, and there are no visible signs of the installation externally (no flue, vents, etc.).

The performance of the heat pump system could also be improved by eliminating unnecessary running of the integral distribution pump. It is estimated that reducing the running time of the pump, which currently runs virtually continuously, would increase the overall performance factor to 3.43. This would improve both the economic and the environmental performance of the system. More generally, there is still potential for improvement in the performance of heat pumps, and seasonal efficiencies for ground source heat pumps of 4.0 are being achieved. It is also likely that the unit costs will fall as production volumes increase. By comparison, there is little scope to further improve the efficiency of gas- or oil-fired boilers. ■

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World Bank's Aid for Climate Action Programs

Today, at the One Planet Summit in Paris, the Global Covenant of Mayors for Climate & Energy and World Bank Group, the world's largest multilateral development bank, announced a new partnership to provide technical and financial assistance to 150 cities across the world undertaking aggressive climate action programs.

The World Bank's investment of $4.5 billion USD will ensure cities battling the increasing threats of climate change have the funding necessary to implement sustainable initiatives and climate resilience programs.

The partnership will help countries leverage the private sector by developing bankable business plans, structuring public-private partnerships to crowd in private sector investment, monetizing increases in land values, and designing and implementing credit enhancement mechanisms to allow commercial financing to cities. The partnership brings together the largest global alliance of cities committed to tackling climate change with the world's leading development institution to design and structure climate resilient investments and to catalyze new sources of capital to finance them in cities across the globe.

The lending will occur over the next three years under the umbrella of the World Bank's City Resilience Program (CRP), and will draw on resources from IFC and MIGA to provide financial and technical assistance to 150 cities, including current and future Global Covenant cities, to drive climate ambitions forward and upwards and build greater resilience to climate and disaster risks.

The partnership will be inclusive and open to the full spectrum of investors, from multilateral development banks and international financial institutions, to institutional investors, private investors, and local commercial banks.

Ultimately, this collaboration between the Global Covenant of Mayors and the World Bank will help ensure cities realize the investment potential of their climate action commitments, and will have the ability to contribute to their government's NDC investment plans in order to meet their Paris Agreement targets. "Cities are preparing today for the risks of climate change by increasing their resiliency and sustainability - and the World Bank's financing will help them do more of this work," said Michael R Bloomberg, UN Secretary-General's Special Envoy for Cities & Climate Change and Co-Chair of the Global Covenant of Mayors. "The fight against climate change is being led by cities and communities and it's essential they have the funds to continue it."

"As the force of natural disasters intensifies, we need to better plan and build more resilient cities," said Jim Yong Kim, President of the World Bank Group. "We are proud to partner with the Global Covenant of Mayors to do just that. With the World Bank's investment of $4.5 billion in cities, we can support local leaders to protect people from the impacts of climate change." ■

Trends in Household Air Handling Appliances

Use of air handling units has become a necessary for every individual during all his activities throughout the day and this need becomes more severe whenever there are pollution times. People need air not only clean and fresh but free of all types of pollutants which are harmful for health...

The basic requirements of earthly living creatures like air, water and food which were bestowed by nature in their purest form are day by day getting polluted and unbecoming fit for use. Times are gone when air and that also clean air was an integral part to everyone everywhere. With rising industrialization, air handling is not a concept or need limited to industries but due to rising pollution levels all around and throughout the year due to various unwanted and unsustainable lifestyles and activities of mankind, use of air handling units has become a necessary for every individual during all his activities throughout the day and this need becomes more severe whenever there are pollution times. People need air not only clean and fresh but free of all types of pollutants which are harmful for health. Not only indoor air pollutants but outside generated pollutants are unwanted and are harmful. Along with the air pollution from outside like: smog, ozone, or haze hanging in the air, the air inside homes, offices, and other buildings can be polluted other than the air from outside. The air inside the home may be polluted by lead (in house dust), formaldehyde, fire-retardants, radon, even volatile chemicals from fragrances used in conventional cleaners. Some pollutants are tracked into the home. Some arrive via a new mattress or furniture, carpet cleaners, or a coat of paint on the walls. Children, people with asthma, and the elderly may be especially sensitive to indoor pollutants, but other effects on health may appear years later, after repeated exposure. Indoor allergens and irritants have become much more important in recent decades because we're spending more time indoors. And because modern homes are airtight, these irritants can't easily escape.

Air Handling Units

An air handler, or air handling unit (often abbreviated to AHU), is a device used to regulate and circulate air as part of a heating, ventilating, and air-conditioning (HVAC) system. An air handler is usually a large metal box containing a blower, heating or cooling elements filter racks or chambers, sound attenuators, and dampers. Air handlers usually connect to a ductwork ventilation system that distributes the conditioned air through the building and returns it to the AHU. Sometimes AHUs discharge (supply) and admit (return) air directly to and from the space served without ductwork. Small air handlers, for local use, are called terminal units, and may only include an air filter, coil, and blower; these simple terminal units are called blower coils or fan coil units. A larger air handler that conditions 100% outside air, and not circulated air, is known as a makeup air unit (MAU). An air handler designed for outdoor use, typically on roofs, is known as a packaged unit (PU) or rooftop unit (RTU). HVAC technology and terminology can be confusing, and you may be trying to make sense of the components included in your system. If you are researching new equipment options, you might wonder what an air handling unit is, especially if you have heard the phrase and can't find it in the related literature. The unit is the portion of your system responsible for moving air

throughout your home. Your home's heating and cooling system provides temperature moderation, but conditioned air is of no use if it isn't moved throughout your structure. An air handler in a residence is an indoor unit that houses your blower along with relevant heating and cooling elements. The unit connects to your ductwork so that air can move through the system to reach various parts of your home. An air filter is used to prevent dirt and debris from infiltrating the handler, an important measure for ensuring safe and efficient system performance. An air handler coordinates with both heating and cooling equipment. Whether you use an air conditioner and furnace for seasonal home comfort needs or whether you have a split system heat pump, the air handler will facilitate the movement of air into the temperature moderation area and through the ducts. In some homes, the air handling equipment will be installed in a walled area, visible only when your access panel is opened and your filter removed. In other settings, an air handler may be completely visible, housed in a basement or garage space.

Use of household air handling appliance like the vacuum pump, fan, air cleaners, ACs etc has almost stagnated for the last few years. Application of these air handling appliances is limited because currently available catalysts are ineffective in destroying gaseous pollutants from indoor air. Sold as air cleaners, they are not always safe and effective in removing pollutants. By design, they produce ozone, a lung irritant. Usually the best way to address this risk is to control or eliminate the sources of pollutants, and to ventilate a home with clean outdoor air. The ventilation method may, however, be limited by weather conditions or undesirable levels of contaminants contained in outdoor air. If these measures are insufficient, an air cleaning device may be useful. Air cleaning devices are intended to remove pollutants from indoor air. To take charge of the air we and our loved ones breathe, clean and optimally humidified air is an important part of good health for which air has to be free from ultrafine particles as small as 20 nanometers (0.00002 mm) in size, including bacteria, dust, allergens and viruses. Air handling units (AHUs) are no more limited to their specific applications in heating, ventilation and refrigeration systems. The need of air handling appliances to get fresh and clean air is thus increasing day by day and people are looking for such appliances with many particulars like cost effective, portable and effective air cleaners. This article briefly presents the need of air handling units and their development status with respect to an individual. Some air cleaning devices are designed to be installed in the ductwork of a home's central heating, ventilating and air-conditioning (HVAC) system to clean the air in the whole house. Portable room air cleaners can be used to clean the air in a single room or specific areas, but they are not intended for whole-house filtration.

Air Purifier

The thick layer of fog has left people looking for measures to fight the severe conditions. Topping the list for these measure, apart from wearing masks, is to get air purifiers. While consumers choose their air purifiers based on the desired price range, the type of air purifier one must buy also plays an important role. Air purifier is one of the technological innovations which act as a saviour in times of pollution. Air purifiers are of various types and sizes and cater to different needs. To select an air purifier for use, firstly, we have to determine the size of room, noise levels, electricity consumption, filter replacement price, and certifications. It is a technology that absorbs particulate matter present in the air of room. Here are ways we can use technology to tackle air pollution inside home and outside. Air pollution is as big a problem indoors as it is outdoors. It comes as no surprise that manufacturers of home air purifiers started focusing on the market over the past couple of years, with new brands. Most manufacturers claim that their air purifiers can eliminate dust, pollen, allergens, particulate matter, and odor from the air to make it cleaner and more breathable. Here are a few types of air purifiers:

Filters: High efficiency particulate air, is a system of high standard air purification that is believed to remove 99.97 per cent of particles that are .3 microns or larger. (.3 micron to .9 micron are mid-range particles pose have high levels of health concerns and is small enough to get past our body's breathing passages and too large to be exhaled easily). HEPA filters can therefore retrieve almost any harmful particle found in the air. Though HEPA filters have high efficiency, they are known to consume higher energy.

Carbon purifiers: Carbon filtering uses activated carbon as an absorbent and takes in impurities. A carbon filter has

small pores that chemically react to particles that pass through them. They are known to be effective in capturing particles such as gas, smoke and bad odour and do not work for purification of allergens or types of micro-organisms.

Ionic air purifiers: Ionic purifiers work based on ionization of air particles. They have purifying plates that have a charge that is opposite to that of the charge that air particles possess. Though the Ionic purifiers help remove very fine particles from the air, they are sometimes known to re-circulate the same impure particles that they draw into them.

Ozone purifiers: An ozone purifier oxidizes the chemical matter present in the air. They primarily take in the oxygen that is present in the giving it a strong electrical charge. This charge then allows the oxygen molecules to rearrange themselves to form ozone. Though this is believed to be a fast way of air purification, it is known to be harmful as ozone, by itself, is considered harmful.

UV purifiers: UV purifiers or ultraviolet light air purifiers use ultraviolet light to sanitize particles that pass through them including germs, viruses and bacteria by making sure they do not multiple or grow. They do not help purify smoke or allergens.

Small & Portable Air Purifiers

Whether it's a dorm room, small office, hotel room, or car, compact and portable air purifiers can be a handy way to reduce allergens no matter where we are. Just slip one of these pint sized, portable air purifiers into suitcase or place it on cubicle desktop. Portable air purifiers have all met testing standards for filtration effectiveness, even among the least expensive. For some spaces using a full-size air purifier is over kill at best and simply not physically possible at worst. Ideally, a compact air purifier is relatively inexpensive, lightweight, and small in size but still provides quality filtration of a variety of airborne pollutants, like pollen and dander, or chemical vapors/fumes, like VOCs and smoke. There are some problems with the air purifiers that they are bulky, and thus hard to move inhouse - so we'll need to buy multiple units - and they are pretty expensive too. If spending Rs 10,000 or more on home air purifiers seems expensive, then we can opt for portable air purifiers. The small size of portable air purifiers ensures that we can tuck them in the suitcase when we go on a trip or move them between your house, cubicle, and car effortlessly. Portable air cleaners generally contain a fan to circulate the air and use one or more of the air cleaning devices. Portable air cleaners may be moved from room to room and used when continuous and localized air cleaning is needed. They may be an option if a home is not equipped with a central HVAC system or forced air heating system. Portable air cleaners can be evaluated by their effectiveness in reducing airborne pollutants. This effectiveness is measured by the clean air delivery rate (CDAR). The CADR is a measure of a portable air cleaner's delivery of contaminant-free air, expressed in cubic feet per minute. For example, if an air cleaner has a CADR of 250 for dust particles, it may reduce dust particle levels to the same concentration as would be achieved by adding 250 cubic feet of clean air each minute. While a portable air cleaner may not achieve its rated CADR under all circumstances, the CADR value does allow comparison across different portable air cleaners. Many of the portable air cleaners have moderate to large CADR ratings for small particles. However, for typical room sizes, most portable air cleaners currently on the market do not have high enough CADR values to effectively remove large particles such as pollen, dust mite and cockroach allergens. Some portable air cleaners using electronic air cleaners might produce ozone, which is a lung irritant.

Future of Personal Air Handling

Air pollution in general and in urban cities has reached its alarming levels. Hospitals and doctors have reportedly warned about the possible health hazards of the pre-winter smog in the national capital. In future, we have to create a bubble of clean air around us by removing dust, allergens, smoke, and pollution from our personal space which can filter harmful particles out of the air around so that we can breathe clean air and feel refreshed. We need an intelligent personal air quality system which can monitor our environment and cleans as needed. It should be of small size, portable, cost effective, so that it can be easily used anywhere any time-in offices, hotels, cars, public transportation, and more. If looking for an alternative to air purifiers, we can bring home a purifying plant that could do the job. There are a number of air purifying plants available that are known to absorb gases through its pores on the surface of its leaves and their roots. Apart from absorbing carbon dioxide, these plants can absorb a range of indoor air pollutants. Air purifying plants include ferns, aloe vera plants, ivy, peace lilies and many others.■

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Fujian Snowman Launches Refcomp

Refcomp screw compressor Rack Systems

Refcomp Screw Compressor

Fujian Snowman has recently launched 'Italian brand REFCOMP', 'Swedish brand SRM Tec' & 'SNOWKEY from China' in India. Refcomp, a brand from Italy established in 1991, pioneer in energy efficient semi-hermetic screw compressors for AC & refrigeration application. Refcomp products include semi-hermetic reciprocating compressors, semi-hermetic screw compressors, condensing units, parallel compressor rack system, screw skids etc. Having state-of –the-art plants in Lonigo, Italy and in Fujian, China. Company has recently appointed dealers or distributors for Refcomp products in Delhi, Mumbai & Bangalore.

To cater the aftersales & service requirements, Fujian Snowman Co Ltd has also established the service franchise in Delhi, Mumbai. Chennai and Bangalore. Company intends to serve the OEM, system integrators and project market segment whereas promoting the products for open market through its dealer network.

SRM Tec Open type Screw Package

'Swedish SRM tec' is established in 1908, In 1946 SRM tec authorised British Howden to be the first screw compressor manufacturer, which was followed by many other companies from Europe, America & Japan in 1957. In year 1994, Swedish SRM invented natural gas screw compressor with discharge pressure upto 80bar and utilized new rotor material and water lubrication system along with other patented technology.

In 2000, Swedish SRM invented the first oil-free refrigeration screw compressor in the world. In 2010, Swedish SRM joint by Snowman Corporation to develop the new generation refrigeration screw compressor. In 2013, Snowman invested in SRM's parent company (Swedish OPCON AB) and became the second largest shareholder. SRM tec offers you following products range:

- Open type Single stage Screw compressor [Displacement from 215-10850 CMH]
- Open type Double stage compound Screw compressor [Displacement from 544-5084 CMH]
- Semi-hermetic Single stage Screw compressor package
- Semi-hermetic Double stage compound Screw compressor package

It offers Ammonia open and semi-hermetic type screw compressors packages & compressors. Initially SRM Tec is promoting its compressor packages in India. It has secured many orders for it in India by now.

'Snowkey' is one of the largest manufacturing brands for Ice machines in the world. Types: Tube ice machines, Flake ice machines, Slurry Ice machines, Block Ice machines & containerized Ice machines. ■

Indoor Air Quality : Introduction & Solution

IAQ does not have a specific measure of its own as of now. The standards are still being considered by the Indoor Air Quality Organization. When talking about IAQ, not only do we need to consider the average AIQ at the location but also some common pollutants that are of even more concern in an indoor environment...

Impact of Air Pollution

As per a 2017 report by World Health Organization (WHO), environmental pollution can be held responsible for more than 1 in 4 deaths in children under the age of five years. This is something each of us should be thinking about very seriously. Talking specifically about air pollution, the WHO report mentions that **"Every year 570,000 children under the age of 5 years die from respiratory infections, such as pneumonia, attributable to indoor and outdoor air pollution, and second hand smoke."**

Air quality is of particular concern to those of us living and working in the Delhi NCR region. Every winter brings with it many days of particularly, toxic smog. This is especially worrying since even a casual short term exposure to air pollution results in aggravated respiratory and

Table 1: AQI Category, Pollutants and Health Breakpoints

AQI Category (Range)	PM_{10} (24hr)	$PM_{2.5}$ (24hr)	NO_2 (24hr)	O_3 (8hr)	CO (8hr)	SO_2 (24hr)	NH_3 (24hr)	Pb (24hr)
Good (0–50)	0–50	0–30	0–40	0–50	0–1.0	0–40	0–200	0–0.5
Satisfactory (51–100)	51–100	31–60	41–80	51–100	1.1–2.0	41–80	201–400	0.5–1.0
Moderately polluted (101–200)	101–250	61–90	81–180	101–168	2.1–10	81–380	401–800	1.1–2.0
Poor (201–300)	251–350	91–120	181–280	169–208	10–17	381–800	801–1200	2.1–3.0
Very poor (301–400)	351–430	121–250	281–400	209–748	17–34	801–1600	1200–1800	3.1–3.5
Severe (401–500)	430+	250+	400+	748+	34+	1600+	1800+	3.5+

AQI levels for India

AQI	Associated Health Impacts
Good (0–50)	Minimal impact
Satisfactory (51–100)	May cause minor breathing discomfort to sensitive people.
Moderately polluted (101–200)	May cause breathing discomfort to people with lung disease such as asthma, and discomfort to people with heart disease, children and older adults.
Poor (201–300)	May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease.
Very poor (301–400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.
Severe (401–500)	May cause respiratory impact even on healthy people, and serious health impacts on people with lung/heart disease. The health impacts may be experienced even during light physical activity.

cardiovascular stress and illness. Long term exposure can have permanent health effects like:

- Accelerated aging of the lungs
- Loss of lung capacity and decreased lung function
- Development of diseases such as asthma, bronchitis, emphysema, and possibly cancer
- Shortened life span

Apart from the typically vulnerable sections like the elderly, children and pregnant women, air pollution also particularly affects

- Those with pre-existing heart and respiratory conditions like asthma, coronary heart disease etc
- All outdoor workers
- Athletes who exercise vigorously outdoors

What is Air Quality?

Air quality is a measure of the level of air pollution. This can be measured via either passive or active sampling methods. Essentially, a sample of polluted air is analysed for various pollutants like nitrogen oxides, sulphur oxides, benzene, carbon monoxide, particulates etc. The concentration of pollutants by volume is then aggregated and typically, expressed in parts per million by volume.

The particulate matter (PM) pollution is measured in terms of concentrations of particulates falling in different size ranges. Generally, two variations of these are used:

- PM^{10} : inhalable particles, with diameters that are generally 10 micrometers and smaller; and
- $PM^{2.5}$: fine inhalable particles, with diameters that are generally 2.5 micrometers and smaller.

For reference, the average human hair is about 70 micrometer thick, which makes it roughly 30 times a PM2.5 particle.

There are two standard ways of measuring air quality.

Air Quality Index (AQI)

This tells us about the level of pollution in the outdoor air. AQI is measured into six range categories. A more in depth interpretation may be found here with India specific info directly shown in the table 1.

As a side note, the AQI for Delhi ranged between 500 to 900 for days between 7 Nov 2017 and 14 Nov 2017.

Indoor Air Quality (IAQ)

IAQ does not have a specific measure of its own as of now. The standards are still being considered by the Indoor Air Quality Organization. When talking about IAQ, not only do we need to consider the average AIQ at the location but also some common pollutants that are of even more concern in an indoor environment. A major source of indoor air pollution in the developing countries is burning of biomass like wood, charcoal, animal dung etc for cooking and heating purposes.

Some of the common pollutants that affect the indoor air quality are second hand smoke, radon (a radioactive gas found in the soil of many areas), carbon monoxide, molds and other allergen, asbestos fibers, volatile organic compounds (VOCs), other microbes, carbon dioxide, ozone and particulate matters.

Mitigating Approaches

Air pollution is certainly a matter of concern whether it is outdoors or indoors. However, mitigating the outside air pollution is not entirely in the hands of an individual. So, without any intention of minimising the need to improve the outdoor air quality, we'll be focusing on approaches that can be taken to improve the indoor air quality.

Homes and Apartments

Homes in India can be divided into two main categories from the point of view of indoor air quality. First, we have the typical traditional homes which are essentially

Houseplants

open to the environment, both in terms of ventilation and temperature control. Second, we have homes whose design allows sealing of most of the home areas for the purposes of cooling via air conditioners. There are some actions which you can take to improve the indoor air quality of your home irrespective of the category it falls under.

Cooking and Indoor Heating

This is one of the biggest sources of indoor pollution. Make sure that the fuel you use (if any) is as clean burning as possible and that there is minimal possibility of carbon monoxide concentrations building up. This caution also applies to homes that use gas heaters. There are currently many initiatives from the government and NGOs relating to clean burning stoves for rural and low income households. Also having an exhaust chimney is a great help in reducing any harmful effects.

Washrooms and Basements

Spaces that tend to get damp like washrooms, basements etc are more prone to mold and other microbial growth. This should be discouraged by using appropriate coatings and flooring options. Most importantly, there should be a good level of ventilation and air circulation to promote quick drying and reduce general humidity. Thus, having the right exhaust system in these places is quite important.

Other sources

- Do not smoke inside a closed area. The smoke and the harmful chemicals take a lot longer to dissipate in an indoor area as compared to outside.
- If the climate allows, avoid having rugs and carpets. They collect mites, dust, dander and allergens, thus, reducing the quality of air and increasing allergy cases.
- Keep surfaces clean and avoid having a lot of stuff pile up over time.

Sealable Spaces

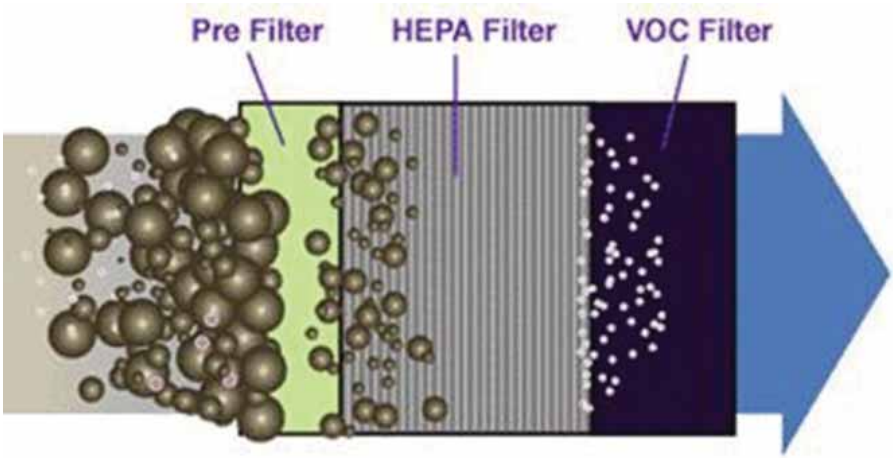
In the last decade or so, homes and apartments have started featuring windows and doors that seal well to make the spaces easier to cool via air conditioners. Though this arrangement provides a good degree of thermal comfort in the hot summer months, there remains a few points of concern from the air quality perspective.

The good news is that such spaces are less affected in times when the AQI outside is very high. So, they are in general better than outside. However, over 99% of the ACs in use in homes in India, do not have any provision for fresh air intake. Correspondingly the air inside the home keeps getting cooled and recirculated. This does nothing to remove the accumulating carbon dioxide in the air, not to mention other indoor pollutants like VOCs etc.

The solution is for this is to make sure that outside air is allowed to circulate in the rooms at least once a day and any time it feels a bit stuffy. A stuffy feeling could be due to higher than safe levels of carbon dioxide and other pollutants in the room's air. Early morning can be a good time to open the doors and windows since typically outside pollution is low at this time.

Indoor Plants

Certain indoor plants are good in removing certain indoor pollutants. The NASA Clean Air study did show that certain common plants are good at removing certain toxic pollutants from



HEPA working

Delhi Smog

indoor air like benzene, formaldehyde and trichloroethylene. The NASA researchers suggest at least one healthy plant every 100 square feet of indoor space for noticeable effect. The list here provides further information about the plants and which pollutants they are effective for.

Buildings Requiring HVAC Systems

Buildings like commercial complexes, hospitals, hotels etc typically need HVAC systems to maintain thermal comfort. Maintaining a good level of air quality requires that the HVAC system also be integrated with good air filtration systems. Typically, these filters are HEPA compliant.

HEPA (High Efficiency Particulate Arrestance) filtration

The HEPA standard, first set forth in 1983 in the US, mandates that a HEPA compliant filter must capture at least 99.97 percent of particles larger than 0.3 μm (micrometers, or microns) in size, while only impeding the flow of air by a relatively small amount.

The filters are typically made from a fabric which aims to have lots of tangled and warped threads. As air passes through the filter, the particles get trapped in the filter. There are a few additional factors that are of concern (depending on the requirements) when choosing a filter.

- Airflow - The volume of air that passes through the filter per second.
- Temperature - The temperature range of air/gas stream the filter is rated to be effective and safe for.
- Pollutant Loading - This is related to the dust/ pollutant holding capacity of the filter. Thus it depends on the rate of gain of weight of the filter as compared with the loss in its ability to process a volume of air (airflow)
- Other considerations - Examples of other considerations could be high moisture or corrosive content in the air being filtered. Concerns like in the case of nuclear reactors where radioactive particles are the issue or in hospital units where microbes could be the issue are also covered under this.

In Conclusion

In conclusion, improving the air quality inside and outside the spaces we live and work in is both important and urgent. The Delhi Government has focused on reducing air pollution by monitoring and reducing the pollution caused due to private transport. Correspondingly a mass transit system (metro) has been built and is continually being expanded on. Other urban initiatives like increasing a city's green cover, regulating polluting industries like thermal power plants etc also need to be followed up. China can be a big inspiration in this area since they've managed to get huge results in the area of managing pollution across the country.

Over time, better alternatives to certain common problems will also become generally available due to advances in science, technology and manufacturing industry. Electric vehicles for example are on the cusp of changing the pollution due to transport narrative.

Yet, in the meantime we should not remain complacent. The simple steps like including indoor plants, upgrading the means of cooking and heating etc should be undertaken by everyone on a priority basis. Additionally, the air quality should be periodically checked and monitored. In case of any deterioration, the root cause must be found out and an appropriate solution implemented. All is certainly not lost yet. ■

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HVAC Aspects of WELL Building Standard

Occupants spend a majority of their time indoors in the conditioned environment and hence, the quality of the ambient space has to be of a high order to not only ensure no negative impact on the human body but also provide a positive impact on the productivity of the people working in the conditioned space...

The modern workspace is complex environment as the internal space is required to have a very different set of ambient parameters than what exists outside and the requirements are getting more and more stringent due to concerns on occupant's health and wellbeing. Occupants spend a majority of their time indoors in the conditioned environment and hence, the quality of the ambient space has to be of a high order to not only ensure no negative impact on the human body but also provide a positive impact on the productivity of the people working in the conditioned space. The World Green Building Council (WGBC) IAQ report emphasis that "there is overwhelming evidence that office design significantly impacts the health, wellbeing and productivity of staff" which further reiterates the importance of a healthy workspace.

Traditionally, building rating systems focused on the physical design aspects, with improved air quality as a byproduct. The focus on occupant health was not specifically a rating parameter. With increasing focus on how workspaces can be more productive and have minimal impact on the occupant, the WELL building standard has been developed by the International Well Building Initiate (IWBI) in the US. This standard is a holistic approach to occupant wellbeing in a workspace and covers a number of key aspects that impact occupants in a building than the traditional physical design elements. Since air conditioning is an integral part of the occupant workspace, there are enhanced requirements for conditioning of the workspace in this standard.

Overview of The WELL Building Standard

The WELL building standard essentially covers 7 aspects that effect or impact the

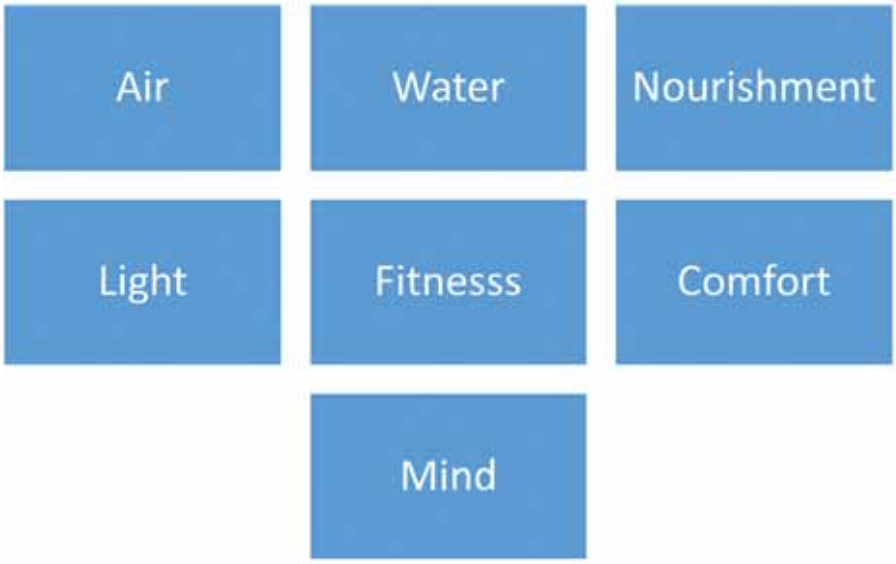

Figure 1: 7 Concepts of WELL Building Rating

health and comfort of the occupant. These seven areas are referred to as "concept" and each concept has linking "features" which have corresponding "parts" and "requirements". The Features standard's compliments the existing popular building standard LEED (Leadership in Environmental and Energy Design) developed by the USGBC (US Green Building Council) and also references industry preferred ASHRAE standards. Figure 1 lists the 7 areas that the Well Building Standard addresses for occupant wellbeing. The standard is performance based in that a large number of requirements have specific performance parameters that have to be achieved for certification. The standard also address the standard also caters for individual occupant comfort which is a significant deviation from current rating systems.

The standard is divided into features, with each feature having parts that consist of requirements. Depending on the type of building, certain parts of a feature would be applicable. Thus, the standard is customizable and addresses a range of buildings. The initial version of the WELL building standard is primarily for commercial and institutional buildings, with sub categories of new constructing/ major renovations, tenant improvements and core & shell developments.

The most significant aspect of the WELL rating system is the interlinkage of the standards "features" with various body systems. Thus, body systems such as nervous system, respiratory system, Digestive, Endocrine etc. are linked to comfort features, light features etc. For example, the nervous system is connected with the light feature as it impacts the internal circadian rhythm. Figure 2 shows the various body systems and the WELL building rating system features.

Another key differentiator from current building ratings systems is the need in WELL building rating process for a recertification after three years. This is a mandatory requirement as the possibilities of the occupant's space conditions changing from the original design conditions is high after three years. The changes occur due to internal changes in use patterns, higher seating capacities that are created etc. and hence, there is a need for a re assessment of the occupant health and wellbeing features and requirements.

The standard has pre conditions which are mandatory for applying for the certification. The rating is on a scale of 1-10 and a score of 4 is a pre-condition. A score of 5 – 6 archive's a silver rating and is compulsory. Scores of 7 -8 achieve gold and 9 – 10 give the building a Platinum rating but these are optional. Figure 3 is an example of a WELL building score card.

HVAC Aspects Covered In The WELL Building Standard

The Indoor Air Quality (IAQ) of a workspace is dependent to a large extent on the air conditioning and ventilation arrangements deployed. Thermal comfort

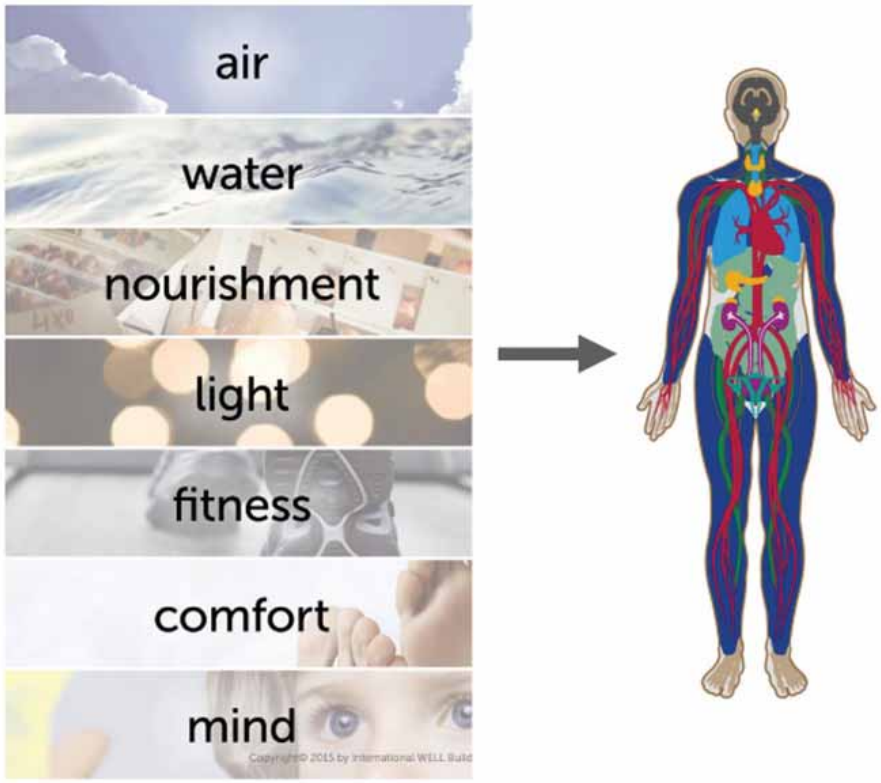

Figure 2: Various body systems and the WELL building rating system features.

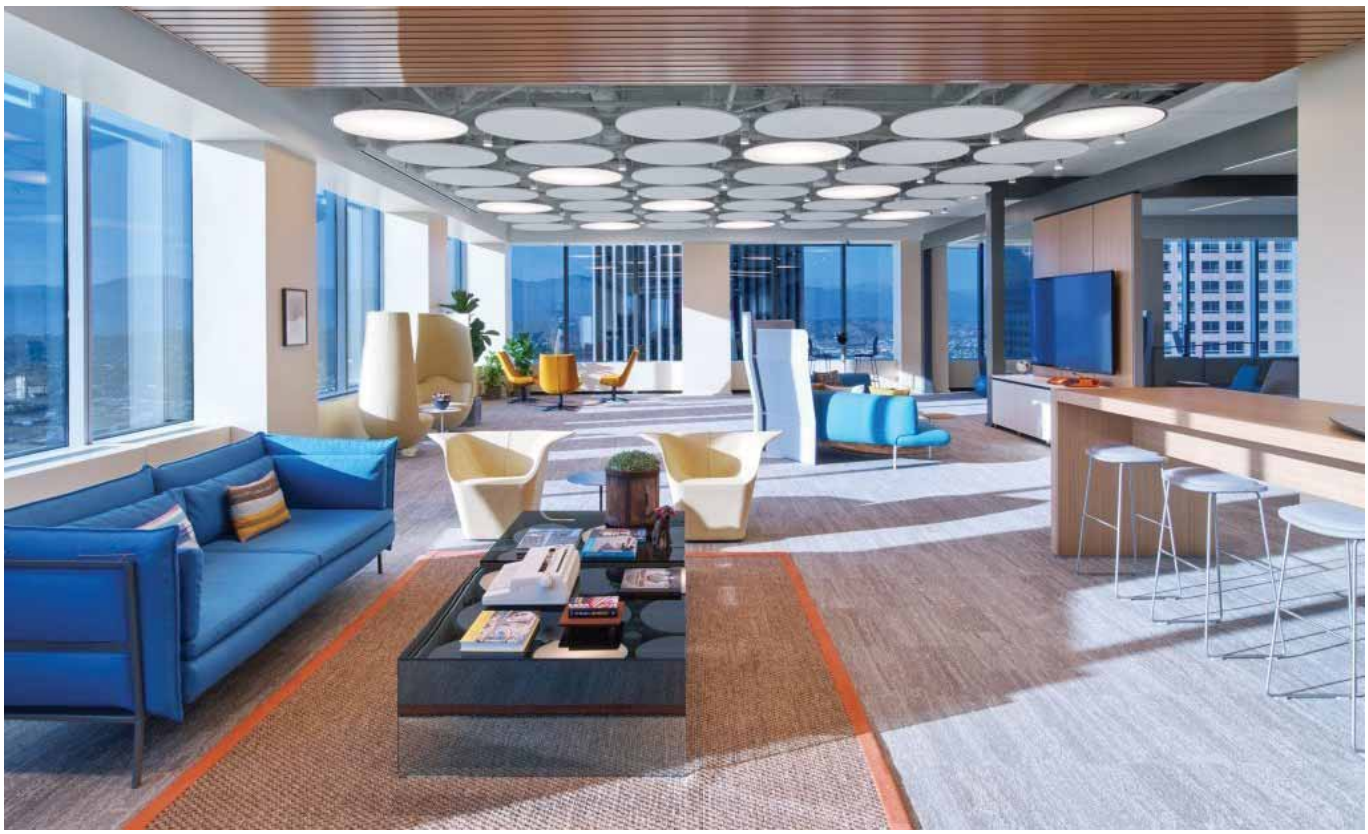

Figure 3: Example of a WELL building score card.

through air conditioning and air quality through ventilation contributes to the ambient air quality. The WELL building rating standard lists a total of 120 features that address different aspects of occupant health. The key features that relate to HVAC in the WELL standard are part of the 'air' and 'comfort' concepts. These are listed as follows:

Features Related to AIR

01 – *Air Quality Standards:* This feature covers the volatile and non-volatile particles as well as Radon levels. This section lists prescriptive values for various pollutants found in indoor air such as PM 2.5, PM 10, CO and Ozone.

13 – *Air Flush:* This deals with the air changes required for maintaining the desired air parameters. Since a lot of contaminants settle into the building before occupancy, the standard specifies the minimum amount of air flush that has to be undertaken prior to the occupancy separately.

03 – *Ventilation Effectiveness:* The standard specifies alignment to AHSRAE 62.1 2013 Ventilation procedure and also requires air quality to acceptable up to 1.6 Km around the building. Demand controlled ventilation requirements are listed and the maximum CO2 levels specified are 800 ppm. The requirement of balancing the HVAC system post operations is also required as per the standard.

05 – *Air Filtration:* To cater for future requirements, the standard specifies air systems to be designed to cater for additional filters. For outdoor air, the minimum filtration efficiency specified is MERV 13. One of the main causes of poor air quality is the lack of focus on maintenance in buildings. The WELL building

standard addresses this by requiring the owner to share annually with IWBI details of filter maintenance.

Features related to COMFORT

75 – *Internally generated Noise:* Radiated and transmitted noise in the workspace is a source of great discomfort but usually goes un noticed due to the other factors that impact air quality that are more prominent such as air borne pollutants. However, the higher levels of noise are linked to lower productivity and hence, the standard requires designation of loud and quite zones, as well as an inventory of noise generating assets. The noise levels of equipment in the workspace are required to adhere to specified Noise Criteria levels as per the use of the space – open office, conference/meeting rooms, breakout areas etc.

76 – *Thermal Comfort:* The WELL building rating system covers both the mechanically ventilated spaces as well as natural ventilated spaces and refers to ASHRAE standard 55 – 2013 Section 5.3/5.4 respectively.

83 – *Radiant Thermal Comfort:* To specifically cater for common areas of buildings, the standard enquires these spaces to meet the ASHRAE standard 55 – 2013 through either hydronic radiant heating/cooling or electric radiant systems

82 – *Individual Thermal Comfort:* A common problem in modern offices is some employees feeling too cold and other feeling too hot. While this could be due to system inefficiencies of faults, many of these complaints are due to the personal choice of the users. The WELL rating system addresses this issue by requiring "free addresses" or open, non-assigned seating for a specified number of staff. This allows the staff to sit at places that are thermally comfortable to their preferences. The standard also makes provisions for personal thermal comfort devises such as fans when a specified number of staff are sitting in a single controlled zone.

Conclusion

Organizations are looking at ways to engage with their employees and a safe and pollutant free work environment is becoming nasality rather than a 'good to have'. Employee retention in workplaces with higher percentage of millennials is linked to their perceived quality of their workspace. Thus, the WELL building standard is a way of assessing, monitoring and managing the workspace not only from the view point of the environment but also the employee health. The 120 features are an exhaustive list of good practices and organist ions can leverage the WELL standard to develop a health workspace of their employees. HVAC plays a major role in keeping the air quality conditions inside to the highest levels both from an air filtration perspective as well as thermal comfort. While there is an additional cost to incorporate the various WELL building requirements, the positive impact on the health of the occupants will more than offset the cost through higher productivity. ■

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Raising the Bar Again!

India Cold Chain Show 2017 went ahead of the industry curve and attracted over 4,759 high profile trade visitors and over 187 premium exhibitors from the cold chain industry. The show welcomed these visitors and exhibitors from 17 and 15 countries respectively....

Dignitaries inaugurating India Cold Chain Show 2017 at Mumbai.

India's most renowned event on Cold Chain, **India Cold Chain Show 2017** successfully concluded its sixth edition on a high note. The show took place from December 12-13-14, 2017 at Bombay Exhibition Centre in Mumbai, Maharashtra. The show went ahead of the industry curve and attracted over 4,759 high profile trade visitors and over 187 premium exhibitors from the cold chain industry. The show welcomed these visitors and exhibitors from 17 and 15 countries respectively.

India Cold Chain Show 2017 demonstrated a stirring range of both national and international companies from various sectors of the industry such as horticulture, material-handling, humidifier & dehumidifiers, freezing and chilling systems, air curtains, cold storage doors, compressors, packaging and others. The new companies include Agritech Equipment & Services Pvt Ltd., Arimpoor Enterprises, Bernhard Upmann Verpackungsmaschinen Gmbh & Co.KG, Blue Star Limited, Hindustan Chemicals and much more. In addition to this, Turkey pioneered in the 2017 edition and had a pavilion.

There was also a Dutch distribution center comprising 12 companies across the country offering best cold chain solutions all under one roof. "I am elated to see how the India Cold Chain Tour has turned up this time. With new visitors joining in, it is really overwhelming to see how the Tour is shaping up. Our endeavours to make India Cold Chain Tour meaningful and fruitful for the participants are surely seeing results," shares Anuj Mathur, Managing Director, Reed Manch Exhibitions.

Unveiling Unique Products & Technologies

India Cold Chain Show takes pride in always bringing to its visitors and exhibitors, nothing but the best. The show every year promises to tap every nerve of the industry and bring together latest cold chain solutions, new and innovative technology solutions, live demonstrations and new product launches. This year, some 47 leading companies including Arctic Refrigeration (p) Ltd, Brianza Plastica, Hindustan Chemicals, Middleby Celfrost Innovations Pvt Ltd, Gandhi Automations and many others unveiled their new and innovative products.

Think-Tankers Galore

India Cold Chain Show 2017 keeping up to its promise of always bringing more

Show attracted over 4,759 high profile trade visitors

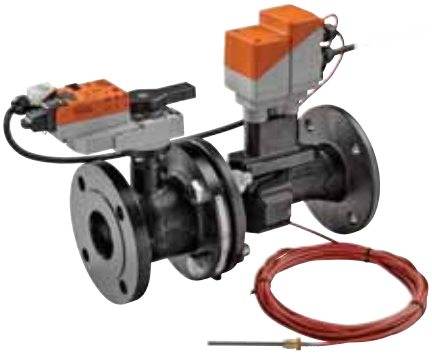
Cooling India team interacting with vicitors and exhibitors

for its participants successfully held its India Cold Chain Conference 2017 from December 12-13, 2017. The conference revolved around the theme- 'Tapping the unexplored opportunity in cold chain business in India'. It was inaugurated by R.R. Jadhav, Dairy Commissioner, Maharashtra, Mandkini Eknathrao Khadse, Honarary Chairperson, MRSDMM, Dilip Shinde, Chairman and Managing Director, MRSDMM, Ashish Guru, Senior Vice President, Federation of Cold Storage Association of India and President, Gujarat Cold Storage Association, Gujarat, Anil D. Gulanikar, President, AAR. Leading speakers from Hindustan Unilever, Burger King, Allanasons, PescaFresh, Tessol, Amul Dairy, Mondelez India, CRISIL, MACCIA, etc., were also present during the conference.

The conference emphasised on the underlying trends of the cold chain industry and brought together many thoughts, ideas and well-debated solutions on one dais. The conference saw more than 121 conference delegates, marking another record. We at India Cold Chain, wish to extend a big thank you to all our supporting associations, media partners, exhibitors and visitors in making this show bigger and better every year. We hope to seek your continuous support next year as well. See you all in our next volume – India Cold Chain Show 2018 from 13-14-15 December, which will once again take place at Bombay Exhibition Centre, Mumbai, Maharashtra. ■

Belimo Energy Valve™ Sets New Standards

With its unique functionality and intelligent cloud services, the Belimo Energy Valve™ sets new standards for automatic optimization and offers an all-round care-free package. Belimo created a new product category with its introduction of the Belimo Energy Valve™. This control valve continuously optimizes the water flow, automatically adjusts it to current climatic conditions and eliminates the so called Delta-T syndrome. Since its market launch in 2012, the Belimo Energy Valve™ has won 20 awards from industry organizations worldwide. Today, thousands of these smart valves help to reduce the operating costs in buildings and CO_2 emissions. Now, the third



generation of the Belimo Energy Valve™ is being launched.

Cloud for Enhanced Comfort

Upon request, the new version can be connected over the Internet to the Belimo Cloud. The operation of the valve is then continuously monitored and compared against other valves operating under similar conditions. Customers receive regular energy reports that include data on trends, energy, and performance. Technical support from Belimo can likewise give customers better and faster advice thanks to the available data.

Innovative Flow Measurement

Belimo supplemented the ultrasonic flow measurement with its patented glycol meter. Many systems require a mixture of water and glycol as a heat transfer fluid. The new Belimo Energy Valve™ monitors this glycol concentration and protects the plants against frost. ■

Website: www.belimo.com

Building Management System from Johnsons & Controls

The new Metasys® Enterprise Management is a comprehensive analytical platform with cloud-based versatility. One that proactively analyzes building data across your enterprise. Helps find opportunities for improved performance. Pinpoint inefficiencies to reduce energy costs. Quickly identify and diagnose equipment problems. And, more importantly, help take corrective action to fix them. Meet sustainability goals, stay compliant, and demonstrate how the investments you make in your building generously pay you back.

Powerful Software, Optimized

Performance.

The Metasys® Energy Management feature set gives you the power to optimize energy consumption and reduce demand. It consists of features that collect, analyze and display information for monitored physical and virtual meters in your facility. This includes Energy Fault Detection and Diagnostics for energy consumption monitoring, meter fault detection and performance monitoring.

Equipment Fault Detection and Diagnostics allows users to easily pinpoint the root cause of equipment issues. And then provide recommended actions so users can issue work orders to correct them. Then the Asset Maintenance features provide specific dashboards that can be easily configured to assist with these work orders, service reports and maintenance KPIs. ■

Website: www.johnsoncontrols.com

Greenheck Introduces Model EQD Direct Drive Mixed Flow Inline Fan

Greenheck's new Model EQD direct drive mixed flow inline fan features an energy-saving Vari-Green® motor mounted inside a patent pending octagonal housing. The Vari-Green motor's variable speed control allows the fan performance to match facility demand and requires virtually no maintenance.

The unique octagonal housing coupled with the aluminum mixed flow wheel's straightening vanes improves fan efficiency and helps reduce sound levels by converting swirling airflow into straight laminar flow. The compact housing is manufactured of formed

galvanized steel panels coupled with a heavy-gauge steel drive frame for exceptional strength and durability. Standard universal mounting supports, field-rotatable housing, and removable duct collars allow for easy installation.

Model EQD offers a performance range up to 4,250 cfm and static pressure up to 2.5 in. wg. Model EQD is ideal for indoor, commercial clean air applications where quiet, economical operation is desired such as office buildings, educational facilities, hospitals, manufacturing facilities and multifamily housing. Greenheck is the worldwide leader in manufacturing and distributing air movement, conditioning and control equipment. ■

Email: www.greenheck.com

MAC 10® RFAC Fan Filter Unit

ENVIRCO® developed the MAC 10® RFAC for applications requiring negative pressure reverse flow FFUs. The RFAC is designed to pull contaminated air from the intake side of the filter, filter the air, and then exhaust it outside of the area required. The most common negative pressure applications are for modular cleanrooms, cleanroom garmenting rooms, healthcare contamination control, cleanroom workstations, clean workbench enclosures, and associated air hoods.

The RFAC is a versatile FFU capable of being used in ceiling grids, installed inside equipment, or wall-mounted. Alternatively, the RFAC can be designed into an AC-powered mobile cart to function as a portable negative pressure FFU.

RFAC FFUs are available in Standard or RSR style configurations. To support increased HEPA filter life, RSR RFACs come standard with MERV 8 20"x20"x1" pleated roomside pre-filters. The 2x4 RSR RFAC has two pre-filters, and the 2x2 RSR RFAC has a single pre-filter. The pre-filter is intended to capture larger airborne particles and dust to filter them ahead of the more expensive

HEPA filter media, which targets removal of much finer particulate matter. Pre-filters are accessible through a latching perforated door that swings open for easy roomside filter replacement.

The RFAC comes standard with an ON/OFF switch and a variable solid state speed control. Optionally, the RFAC can be equipped with an ENVIRCO TPC control card that enables support for serial MODBUS network control or external analog control input.

Standard Features

- Mill-finished aluminum exterior is available in a 2'x2' or 2'x4' Standard or RSR (roomside replaceable) configuration
- Reliable internal knife edge/gel seal gasket filter mounting (RSR model only)
- Type J HEPA filter (99.99% collection efficiency @ 0.3 μm)
- Supports more than 700 CFM airflow, higher than competitive models
- 5" x 14" output is redirectable to support any one of four directions
- Protective face screen: expanded steel, powder coated white
- Latching easy open/close pre-filter perforated door provides roomside access for replaceable low cost MERV 8 20"x20"x1" pre-filters (2x4 has two pre-filters, 2x2 has one pre-filter)
- Aluminum filter diffuser screen on RSR filter
- Highest quality, reliable, high efficiency motorized impeller assembly includes a PSC motor and backward-inclined impeller
- ON/OFF switch and turn adjustable solid state speed control
- Walkable plenum rated to 250 lbs. (excluding air output box)
- Models available supporting: 115V or 277V
- UL listed with standard UL 900 filter, file number E152685 (UL507) ■

Website: www.climaveneta.com

Horticulture

Export of Horticulture Produce in India

Quanity: in MT; Value in Lacs

Products	2007-08		2008-09		2009-10		2010-11	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value
I. Floriculture & Seed								
Floriculture	36240.71	34014.42	30798.34	36881.41	26814.52	29446.36	28906.76	29604.04
Fruit & Vegetables Seeds	10157.13	14212.29	8535.53	11999.09	8883.86	14507.51	11622.33	18491.77
Total	46397.84	48226.71	39333.87	48880.50	35698.38	43953.87	40529.09	48095.81
II. Fresh Fruits & Vegetables								
Fresh Onions	1008606.48	103577.89	1670186.29	182752.21	1664922.39	231942.98	1182324.20	177928.62
Other Fresh Vegetables	350235.47	48949.01	505285.46	68020.32	419241.35	73185.90	499320.05	92138.76
Dried Nuts (Walnuts)	6716.48	16207.80	5696.34	14123.63	9073.38	19789.51	5762.34	16629.25
Fresh Mangoes	54350.80	12741.76	83703.18	17071.25	74460.61	20053.98	58863.41	16483.60
Fresh Grapes	96963.57	31782.51	124627.97	40861.28	131153.61	54533.89	98005.12	42830.28
Other Fresh Fruits	207700.78	30452.60	256768.53	43086.84	260675.43	52283.32	255024.83	51175.27
Total	1724573.58	243711.57	2646267.77	365915.53	2559526.77	451789.58	2099299.95	397185.78
III.Processed Fruits & Vegetables								
Cucumber & Gherkins							209231.83	51525.79
Dried and Preserved Vegetables	125726.28	42993.81	147861.22	49641.51	124613.50	53207.48	49009.12	37333.50
Mango Pulp	166752.17	50968.51	173013.60	75298.90	186197.85	74460.77	170219.72	81893.27
Other Processed Fruits and Vegetables	311756.29	96281.65	387126.42	137179.00	397978.17	143550.63	199868.41	99704.05
Total	604234.74	190243.97	708001.24	262119.41	708789.52	271218.88	628329.08	270456.61
Grand Total (I+II+III)	**2375206.16**	**482182.25**	**3393602.88**	**676915.44**	**3304014.67**	**766962.33**	**2768158.12**	**715738.20**

Products	2011-12		2012-13		2013-14	
	Qty	Value	Qty	Value	Qty	Value
I. Floriculture & Seed						
Floriculture	30926.02	36532.15	27121.86	42344.60	22485.21	45590.62
Fruit and Vegetables Seeds	15205.81	28776.35	17168.00	34772.39	17816.70	41053.76
Total	46131.83	65308.50	44289.86	77116.99	40301.91	86644.38
II. Fresh Fruits & Vegetables						
Fresh Onions	1309924.82	172299.80	1666872.60	196662.66	1482498.58	316961.25
Other Fresh Vegetables	734178.80	131048.20	768627.20	151633.56	953731.22	229332.27
Dried Nuts (Walnuts)	5841.56	23108.40	5295.47	19983.57	6726.36	32453.50
Fresh Mangoes	63441.29	20974.30	55584.99	26471.78	41279.97	28542.85
Fresh Grapes	108584.56	60288.15	172744.42	125942.78	192616.91	166647.45
Other Fresh Fruits	270437.20	75541.11	263970.29	77975.78	240552.45	102159.21
Total	2492408.27	483259.96	2933094.97	598670.13	2917405.49	876096.53
III.Processed Fruits and Vegetables						
Cucumber & Gherkins	258603.00	74503.45	238624.89	85659.18	218749.79	95520.18
Dried and Preserved Vegetables	64794.09	52678.47	68520.25	63795.76	56158.38	74271.74
Mango Pulp	150499.06	62082.91	147815.69	60855.73	174860.33	77294.76
Other Processed Fruits and Vegetables	274807.05	157759.82	269217.26	173305.54	287384.61	226660.26
Total	748703.20	347024.65	724178.09	383616.21	737153.11	473746.94
Grand Total (I+II+III)	**3287243.30**	**895593.11**	**3701562.92**	**1059403.33**	**3694860.51**	**1436487.85**

Source : Indian Horticulture Database, Various Issues, National Horticulture Board, Ministry of Agriculture

Forthcoming Events At A Glance

ACREX 2018
Venue: BIEC, Bengaluru
Date: 22nd to 24th February 2018
Website: www.acrex.in

FoodTech Pune 2018
Venue: Pune
Date: 23rd to 25th February 2018
Website: http://foodtechpune.com

Global Logistics show
Venue: Bombay Exhibition Centre, Mumbai
Date: 22nd to 24th February 2018
Website: http://globallogisticsshow.com

Indoor Air 2018
Venue: The Pennsylvania Convention Center, Philadelphia
Date: 22nd to 27th July 2018
Website: http://mms.isiaq.org

ISK-SODEX Istanbul
Venue: TÜYAP Fair Convention and Congress Cente
Date: 7th to 10th February 2018
Website: http://www.sodex.com.tr

DairyTech India 2018
Venue: Bangalore International Exhibition Centre (BIEC)
Date: 31st to 2nd September 2018
Website: www.dairytechindia.in

index to advertisers

Indira Gandhi International Airport is Smartest Building

Honeywell a global leader in Connected Buildings, announced Indira Gandhi International (IGI) Airport as India's smartest building, at the Network 18 and Honeywell Smart Building Awards for 2017.

IGI Airport has consistently improved upon its commitment to be India's smartest building, winning this same award for three consecutive years. The airport also captured the awards for being the smartest airport building, and as the greenest, the safest, and the most productive building in India. Chhatrapati Shivaji International Airport shared the awards for being the Smartest Airport Building, and as the Greenest, and the Most Productive Building in India. The Infosys Software Development Building 11 shared the award for being the country's Safest Building and also the award for the Smartest Single Occupant Private Office Building in India. "We are fulfilling India's long-term sustainability and

urban development goals, and will continue to do so in line with the 100 Smart Cities Mission," said Vikas Chadha, president, Honeywell India. "We are encouraged by the increased interest and participation from the commercial building and facility management community. The awards strengthen our commitment to making buildings green, safe, and productive." ■

Ten Hudson Yards Designated LEED Platinum

Hudson Yards developers Related Companies and Oxford Properties Group today announced that 10 Hudson Yards, its first commercial office building to open, has received a LEED Platinum certification, making it the first commercial office building in New York to receive such a rating since the LEED v2009 rating system went into effect. The certification from the United States Green Building Council is an important early milestone in the development's ambition to become the most connected, sustainable, responsive and efficient neighborhood in the US, and a world model for the city of the future. Since opening in May 2016, 10 Hudson Yards has been home to the global headquarters of Tapestry (Coach Inc., Kate

Spade, Stuart Weitzman), L'Oréal USA, SAP, The Boston Consulting Group, Vayner Media, Intersection and Sidewalk Labs. More recently, Crescent Capital Group, Ardea Partners, Chain Bridge Asset Management and Intercept Pharmaceuticals have moved their offices to the West Side tower, making 10 Hudson Yards home to more than 6,000 employees.

The 52-story tower, designed by acclaimed global architects Kohn Pedersen Fox Associates (KPF), offers state-of-the-art commercial offices, ground-floor retail space and a direct connection to the Shops & Restaurants at Hudson Yards. The building features panoramic views and is uniquely interwoven with the High Line, making 10 Hudson Yards one of the most distinct buildings in the city. ■

Efficient Colorado Residence Hall

Construction is well underway on a new energy-efficient residence hall at the University of Colorado in Boulder. The 178,000-square-foot Williams Village East facility is being built according to LEED gold standards, with such renewable energy features as solar panels, LED lighting, recycling areas, occupancy sensor lighting, green outlets, thermostats in each room, low-flow toilets and urinals, door closers and a VRF HVAC system, according to a release.

The projected move-in date for the $96.7 million residence hall is August 2019. Construction on Williams Village East began in August. The building will sit just east of the Williams Village North residence hall on a site currently occupied by a parking lot and four tennis courts that are no longer in use. The 700-bed, seven-story Williams Village East was designed to match the architectural style and exterior finish of Williams Village North, which opened in August 2011.

"A lot of the energy efficient features we designed into the building focus not only on saving energy, but also encourage students to get into the habit of being energy conscious," said Meghan Bogener, project architect and interior designer at KWK Architects. "When designing these types of projects, we often ask our clients, 'Do you want to look green, or do you want to be green?' We find that the best design solutions incorporate both aspects." ■

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Typical case study data of a 1200 TR Chiller

Sr. No.	Parameter	Cooling Tower (Induced Draft)	**LTMCS**
1	Wet Bulb Temperature	29°C	29°C
2	Chilled Water Temp in °C (Assumed)	5°C	5°C
3	Supply Temp. from CT / LTMCS	33°C	30°C
4	Approach to WBT	4°C	1°C
5	**ΔT for Chiller**	**28°C**	**25°C**
6	Chilled Water Compressor Motor Kw for 1200 TR	720	643
7	Energy Saved in %	-	10.7%
8	**Energy Saved in Kw**	**-**	**77 Kw/Hr**
9	Total Running Hours per Annum	8640	8640
10	**TOTAL POWER SAVED PER ANNUM**	**-**	**6,65,280 Kw**

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