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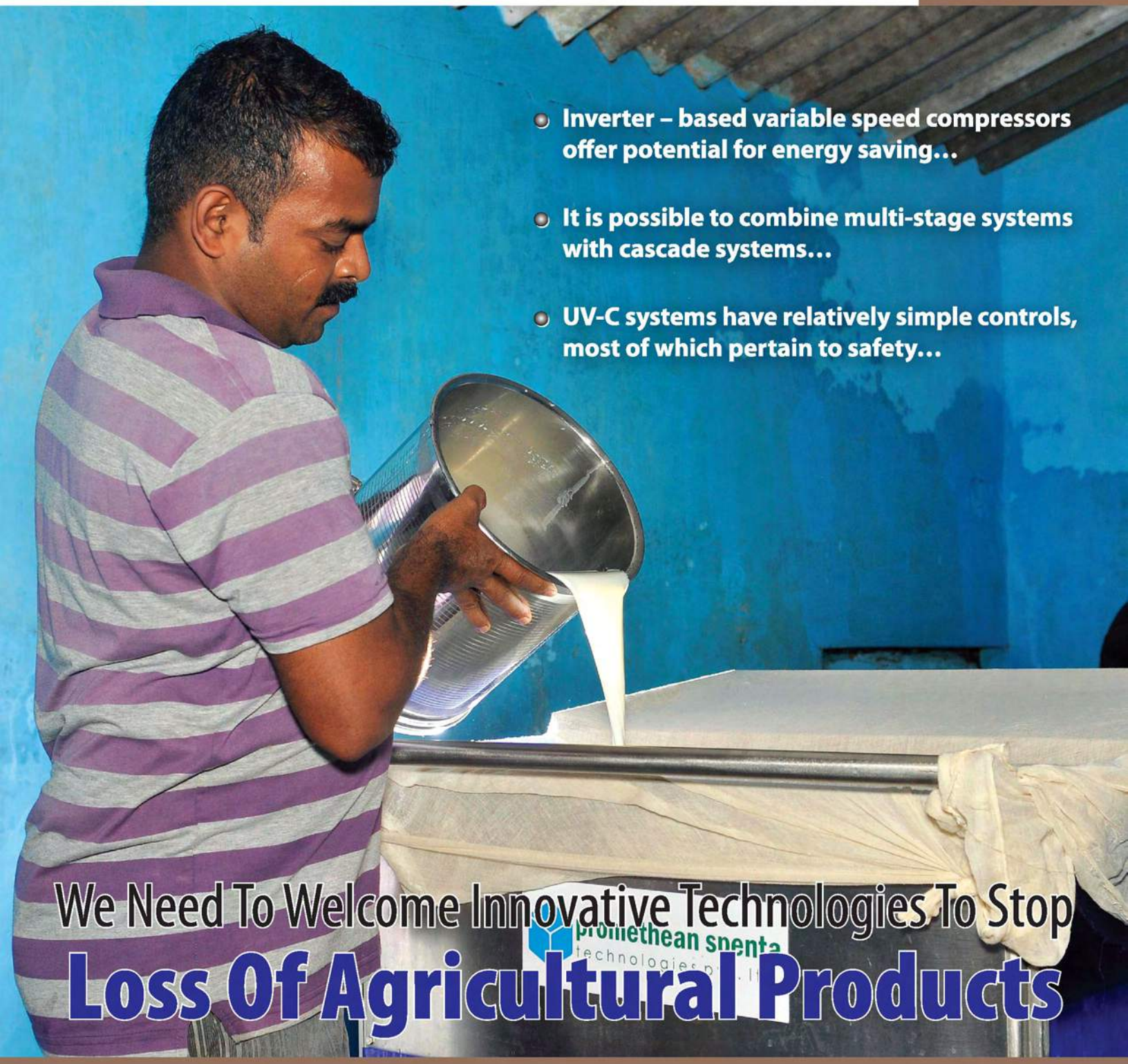

- Inverter – based variable speed compressors offer potential for energy saving...
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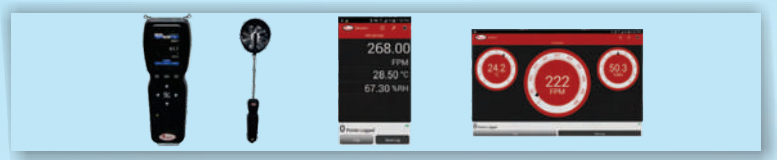

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Publisher's Letter

Collaboration and Co-ordination Are Essential

With the economic growth, the food habit and the demand thereon are changing in urban India. Along with that the widespread growth of branded food retailing companies is making us rethink on the design of the food supply chain (cold chain). Besides cost, safety, presentation etc., quality and taste of the food are two major factors that demand meticulous attention.

A fairly large number of members of the young Indian generation prefer readymade solutions to fill their stomach and quench their thirst. Thus, the quality issue of the food items that are served through retailing has been much more prominent now than it was ever before.

Those who are connected to the Indian food industry and handling the day-to-day activities – need not be especially informed about the set of challenges, which are growing every day. However, unless we efficiently and effectively address these challenges with immediate effect, a time may come soon – when the entire cold chain system will be in standstill condition, and that will affect our flourishing economy with multiple prongs.

Although, many of the food manufacturers have already started implementing their own strategic plans to overcome these challenges, a little consideration shows that, beyond a certain area the challenges are of combined nature, where the steps for improvement have to be taken as a combined effort with everyone's agreement and co-operation.

Thus, at this juncture, it is very important that the users of cold chain and the service providers (logistics, refrigeration, IT and others) work together to design new solutions. As today's challenges are of highly complex nature, no individual professional or group can offer an all round remedy. Appropriate collaboration and effective co-ordination are absolutely essential today to succeed in running any food chain business.

Please send your comments at pravita@charypublications.in

Pravita Iyer
Publisher & Director

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Cover Image Courtesy: Promethean Power Systems

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V5 X Series

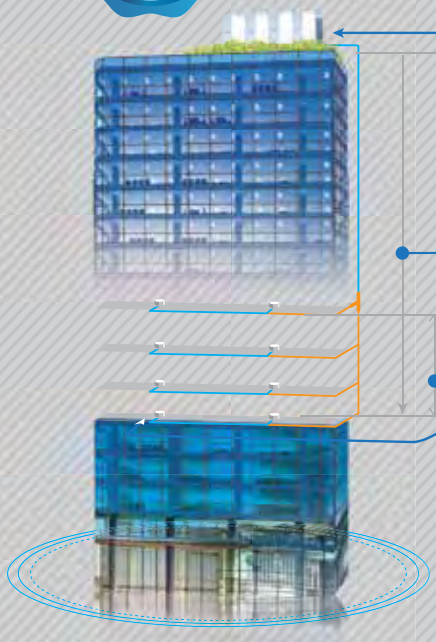
ALL DC INVERTER VRF

88HP

R410A

Diamond Shaped Design

1000m The solution offers a piping length of 1,000m and level difference of 110m, making it perfect for large projects.



110m
Max.110m level difference between IDU~ODU

175m
Max.175m actual piping length

30m
Max.30m level difference between IDU~IDU

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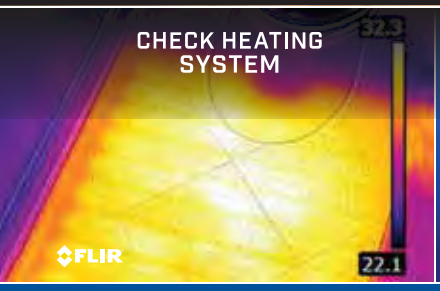

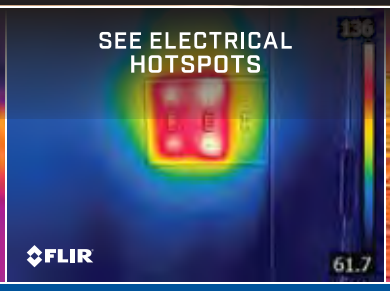

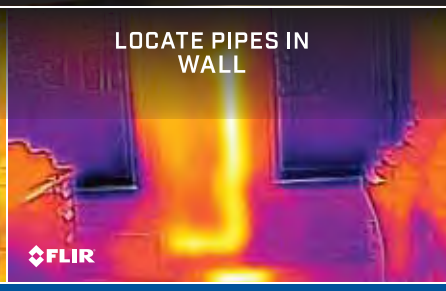

For further information, please contact us at:

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FROM THE EDITOR

Look Before You Leap

When you buy a new appliance, your focus often concentrates on the central function or the main deliverable from that, and obviously your buying decision depends on that. However, at times during use, you realise that the accessories or the secondary attachments with the main product are also equally important. To be more clear, let me put a real-life example. When you buy some split AC system, you concentrate on the star-rating, look, noise level and so on. How many of you truly verify the soundness of the remote control device that has enough possibility of getting damaged because of a fall (from hand) or someone sitting on it by mistake (say when it is left on your sofa) during use?

Unfortunately, when it happens, you get highly irritated, even in some cases you may get deprived of enjoying the comfort for which the gadget has been devised. Just think a little, what is the root cause behind your irritation and who is responsible for this?

All the fingers point at you. The buyer did not check the accessory when decided to buy the product. All other criteria that you scanned are important, however, (as in the above example) the remote control device is the most essential thing – without which you cannot run the system easily or comfortably.

Although from the cost-angle such accessories are not of very high value, yet from the utility-angle they occupy a prime position. If your comfort device is slightly old, you may also find it little difficult to buy a spare from the market close to your home. You may get a spare from the company but that takes time. Also, as per today's prevalent practice, for many spare parts, you have to register a request through the company's website. Then that will be addressed. So, the matter is time-consuming. Thus, better take your own time, and check all your devices minutely before you make the final buying decision.

Pl. send your views at pkchatterjee@charypublications.in

P. K. Chatterjee

"It's better to take your own time, and check all your devices minutely before you make the final buying decision..."

Directors
Mahadevan Iyer
Pravita Iyer

Publisher
Pravita Iyer

Editor
P K Chatterjee
pkchatterjee@charypublications.in

Editorial Coordinator
Bharti Solanki
mktg@charypublications.in

Advertising Department
Jigar Padachh
advt@coolingindia.in

Design
Rakesh Sutar

Subscription Department
Hemant Yelave
Nafisa Khan
sub@charypublications.in

Accounts
Dattakumar Barge
accounts@charypublications.in

Chary Publications Pvt Ltd

Editorial, Subscription & Advt. Office:
201, Premalaya, Next to Cafe Coffee Day,
Opp. Telecom Factory, Deonar, Mumbai - 400 088.
Tel.: (022) 2507 3300 / 01

₹ 100/- Per Copy
₹ 1000/- Annual Subscription

Printed by Pravita Iyer and Published by Pravita Iyer on behalf of Chary Publications Pvt Ltd., and Printed at PRINT TECH, C-18, Royal Ind. Est., Naigaum Cross Road, Wadala, Mumbai 400031 and Published at 201, Premalaya, Opp. Telecom Factory, Deonar, Mumbai 400088.

Editor: P K Chatterjee

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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**
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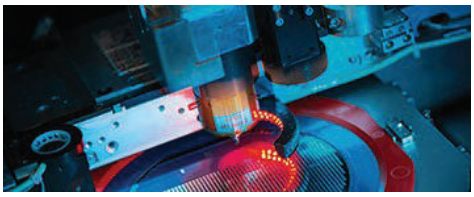
CTI MEMBER

Danfoss to set up a refrigeration and cooling lab soon



Danfoss is a well known brand in India...

Danfoss Industries, a leading conglomerate in the climate and energy space, has entered into an agreement with the Government Industrial Training Institute (ITI), Guindy to set up a Refrigeration and Cooling (RAC) lab at the institute's premises for over 130 students pursuing RAC course over the next three years. The initiative will enhance the learning atmosphere and knowledge levels of the RAC students and trainers in government ITIs and rural community colleges in India.

ITI Guindy, the only government-owned ITI have 45 students being enrolled every year. The current infra-structure, learning materials, curriculum and learning resources in government ITI require refinement, and hence this lab will benefit students on acquiring hands-on industry training. "It is imperative though, that India's infrastructure story is sustainable. Energy efficient HVAC solutions are the need of the hour and for this, skilled labour trained in the nuances of energy efficiency is required. We are happy to announce this initiative that is set to benefit a lot of students who want to pursue a career in the refrigeration sector. It will play a dual role of bridging the gap for skill in the refrigeration and air-conditioning industry and providing industry ready skilled manpower trained in modern RAC technologies," said Ravichandran Purushothaman, President, Danfoss India.

Danfoss, the leader in the Climate and Energy Solutions is known for its expertise and experience in the sector for over 90 years. With specialised solutions in the RAC sector, it will help students and faculty gain knowledge and experience on new innovations – that are being introduced in the market. The agreement will provide for industrial visits to Danfoss facilities, technical sessions, special training programs, frequent visits of Danfoss representatives and experts to ITI to exchange ideas, internships, scholarships and other reward programmes. ■

LG Electronics receives excellence in design awards

LG Electronics has received four Appliance design 2015 'excellence in design awards'; two gold and two silver awards, across multiple home appliance and air conditioning categories.

Appliance design's 'excellence in design awards' recognise outstanding achievements in innovation, design and functionality. A prestigious panel of judges from respected industry associations selects entries from 10 categories for innovation, simplicity, functionality and other considerations including optimised capabilities, environmental footprint, energy and cost-savings. "We found LG's impressive technologies coupled with sophisticated, streamlined aesthetics across its product lineup to be clear winners for both LG and our readers," said Darryl Seland, editorial director of Appliance Design.

LG got distinctions in the major appliances, small appliances and HVAC categories. ■

Tado launches smart AC control

A recent research report titled, "Global Thermal Energy Storage Market 2015-2019," states that revenue-wise this industry will cross US$1300 million by 2019. Europe, Middle East and Africa (EMEA) are expected to witness high growth followed by the APAC region.

The new tado Smart AC Control connects smart phone to air conditioner...

This research also recognises some companies as the key players in the market from 2015-2019, namely: Baltimore Aircoil Company (BAC), Caldwell Energy, CALMAC and Chicago Bridge & Iron Co. Other prominent vendors in the market are: NEST and Sunwell Technologies.

One of the trends for this market is the increased investment in storage tech. Rapid advances in storage technology like electric vehicles or solar-powered storage will pave the way for the growth of the market in the future. ■

Toshiba gears to double sales of air conditioning by 2020

David Dunn
General Manager, Toshiba Air Conditioning, UK

Toshiba air-conditioning, a division of Toshiba Carrier UK Limited, plans to double sales by 2020. This follows five years of double-digit growth by Toshiba, despite challenging market conditions. It has introduced new products, increased stock levels, new appointments, a major expansion in production capacity, and the roll out of a global training initiative. The company is increasing stocking capacity at its Plymouth facility with an extension and addition of a further 44,000 sq ft of racking space in phase 1, ensuring immediate product availability across its most popular ranges of Toshiba split and VRF air conditioning.

On the R&D front, the Toshiba factories are employing some 350 additional design engineers, to fast-track the development and introduction of innovative AC technologies. Work is already under way on a major extension to the state-of-the-art Toshiba Thailand factory, including expansion of its world-class R&D facilities due for completion this year. This includes a new global technical training centre with capacity to train 150 delegates simultaneously equipped with Toshiba's full range of air conditioning and control technology.

The planned growth is supported by the recent creation of the Building and Industrial System (BIS) group within United Technologies, bringing together Toshiba Air Conditioning, Carrier Air Conditioning, Chubb security and fire systems and Otis, the lift specialists.

David Dunn, General Manager, Toshiba Air Conditioning UK, said, "It is obviously a challenging target, particularly given that the base year for the growth target was a very strong year for Toshiba. It will require significant investment across the business, in new products, manufacturing facilities and logistics. But this is now in place, and we are well on the way to creating the new infrastructure required." ■

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Quality conscious Indian OEMs offer 100% copper advantage ACs

International Copper Association India (ICA India), a part of Copper Alliance, had recently organised an extensive consumer awareness campaign on room air conditioners in Mumbai and Delhi. The campaign was intended to help consumers make informed decision while buying air conditioners. The campaign educated more than 25 lakh consumers on the advantages of having 100% copper tubes in indoor, outdoor units and connecting tube of air conditioners.

Most areas in India have ambient conditions, which are dusty, prone to pollution, fumes from sewerages and salty sea-breeze. In such areas, the condenser is heavily clogged leading to gas leakages, indoor unit filter choking, corrosion and drop in energy efficiency. The condensers, which are made of copper tube can be easily and effectively cleaned when exposed to such harsh conditions, thus lowering the risk of gas leakages, corrosion and drop in energy efficiency. Copper tube condensers are more efficient at transferring heat, low on maintenance and highly reliable and durable.

While most buyers check for star ratings, tonnage, key features, brands and price range at the time of selecting a perfect air-conditioner, it is important to note that the efficiency, performance, running cost and life span of the room air conditioner is always highly dependent on two basic factors, i.e., star ratings and the choice of metal used in the condenser coil, evaporate coil and connecting tubes. Air conditioners made from other metals involve high maintenance cost, prone to corrosion and are also less durable in the long run. Copper on account of high strength and proven technology leads to high durability, the maintenance becomes less expensive with AMC and brings in overall high reliability. Most of the Japanese OEMs, which are known for their quality products, continue to use 100% copper in their ACs.■

FiltersUSA.com offers a wide variety of replacement filters

Pleated furnace filters...

When the house air conditioner is running more frequently, changing the filter becomes more important. There are simple steps that you can take to improve the indoor air quality. During the cooling season, we tend to overlook replacing the filters. When the air conditioner runs, it also cleans the air. Clogged or inefficient filters do not clean the air effectively. They also produce greater stress on the blower motor and the restricted airflow can cause your system's temperature to drop below optimal levels. This causes your air conditioner to freeze up. The restricted airflow combined with the stress on the motor will cost you more in energy bills plus the possibility of the costs associated with a service call. Replacing the filter is cheap and simple. To meet your need, FiltersUSA.com offers a wide variety of replacement filters. ■

Yanmar releases new air-conditioning systems series

Yanmar has unleashed a series of energy efficient Gas Heat Pump (GHP) *1 air-conditioning sytems, the GHP XAIR II K. The series is the successor of the GHP XAIR series developed earlier, and which at the time received high acclaim in the market for its energy-saving features and high performance.

With the amendment of the energy saving act in Japan, increased use of gas air-conditioning systems has been assertively promoted, with policies for saving of energy.

This brings opportunity for Yanmar to provide the market with energy-saving products, and contribute to the popularisation of gas powered equipment with decreased impact on the environment. ■

Camfil introduces energy-efficient HVAC air filters

Camfil, the world leader in air filtration technology, has recently unveiled the energy efficient bag filter, Hi-Flo F7 50+. The new Hi-Flo II is a new and enhanced version of Camfil's award winning Hi-Flo low energy air filter. Featuring aerodynamic pockets for optimised performance, the new low energy air filters have been rated A+ by Eurovent. It saves up to £30 per year for every installed filter. FMs, Energy Managers and building owners will be able to meet the much tougher requirements for energy savings specified in Eurovent's 2015 energy efficiency classification system for air filters.

Bill Wilkinson, Managing Director, Camfil UK, said, "The new energy saver 'Hi-Flo' filter from Camfil is a major 'quick win' for switched on Energy Managers and FMs. The pay backs within revenue budgets are typically less than three months and air filters are designed to be changed, unlike other components within the ventilation system, so consequently do not put any pressure on capital budgets when upgrading to low energy air filters."

Eurovent - for air filters: Eurovent's new objective energy efficiency classification has been implemented. All air filters can be graded from A+ to E. The grade A+ stands for the lowest energy consumption and E for the highest.

Hi-Flo II: The top model, M7 in filter class F7, has received the highest rating from Eurovent (A+) for its outstandingly low energy consumption. In addition to saving more energy, the filtration efficiency of the new Hi-Flo II M7 is significantly higher than the performance demands for equivalent filters in EN779:2012, the European standard for general ventilation filters.

HVAC systems heat cool and clean the air distribution within some 200,000 buildings in the UK. That's approximately 7,300 organisations consuming 35% of the UK's energy consumption. The Federation of European Heating, Ventilating and Air-Conditioning Associations have estimated that within the EU there is a potential annual saving of 5TWh available by switching to low energy air filters. This would equate to £500 million of energy savings in the UK. ■

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Godrej rolls out next generation refrigerators

A view of the rolling out ceremony...

Godrej Appliances, while keeping in line with its core philosophy of 'Brighter Living', has unveiled 'NXW - the next generation refrigerator'. Just like different foods require different temperatures, with the new JTRT technology (Just The Right Temperature), the NXW allows users to customise their refrigerator the way they want by storing food in three flexible temperature zones - Chiller (-1 to 3°C), Fridge (1 to 5°C) and Pantry (4 to 8°C). To add to the consumers' delight, this refrigerator is packed with advanced features such as digital touch screen panel, motion sensing zone light, stay cool technology and smart air lock technology among others. This marks the entry of Godrej Appliances into the premium segment.

Commenting on the launch, Kamal Nandi, Business Head and EVP – Godrej Appliances, said, "As an organisation, Godrej has always been on its toes to keep pace with the times. We are constantly turning, exploring, innovating and evolving. The organisation is rapidly changing. We're embracing new technology and innovations, creating a culture of strategic and innovative thinking across the organisation. Our philosophy of innovation is human-centric design. The Godrej NXW refrigerator is a leap in that direction and promises to be a revolution by bringing never seen before technology. We designed this refrigerator not just as a cooling device but as something that can bring people closer through food."

Ramesh Chembath, VP – Marketing, Godrej Appliances, added, "With the launch of NXW, we have transformed the refrigerator from a 'just another appliance' into a 'smart and interactive gadget' in your kitchen. This launch marks the beginning of a new era in the refrigerator category for Godrej Appliances and will set new benchmarks in the Indian consumer durables industry." ■

Air compressor launched for multiple applications

Powered by a tier 4 final-compliant Doosan engine, the P185WDO portable air compressor meets the needs of a variety of applications, from powering handheld air tools, to sand blasting, sprinkler and irrigation line blow-out, cable laying and pipeline testing.

Doosan portable power introduces the P185WDO-T4F; The legendary P185 is now powered by the rugged and reliable Doosan D24 engine.

The P185WDO maintains Doosan portable power's renowned features and reliability while incorporating over fifty years of engine experience with the Doosan D24.

With this new engine comes quieter sound emissions, proving that improved power does not have to mean increased noise.

This unit also offers enhanced fuel efficiency over previous models and is more economical. ■

ICA identifies environmentally friendly ways for refrigeration

Heat exchangers made with cu tubes are 'highly compatible' with most low-GWP refrigerants for RACHP systems, as per the International Copper Association (ICA).

Nigel Cotton, Microgroove team leader for the International Copper Association (ICA), said, "In both laboratory and manufacturing environments, smaller-diameter copper tubes are proving to be a good match for eco-friendly refrigerants."The ICA identified refrigerants such as R-32 (GWP 675) and low-GWP HFOs such as HFO-1234yf and HFO-1234-ze, which have GWPs of four and six, respectively.

He added, "Many more refrigerants that are blends of HFCs/ HFOs are also under consideration for various applications. When makers use smaller-dia cu tube, they can save on materials and raise performance in more ways than one.■

UAE air conditioners market to grow at 8% until 2020

According to TechSci research report, "UAE Air Conditioners market forecast and opportunities, 2020", air conditioners market in the UAE is projected to grow at a CAGR of 8% during 2015-20. Growth in the market is anticipated on account of growing population, increasing purchasing power, high temperatures and upcoming construction projects in the country.

Various technological advancements such as development of air conditioners with built-in air purifiers, coupled with introduction of energy-efficient air conditioners are also propelling growth in UAE air conditioners market. UAE has the seventh highest per capita income in the world. Increasing purchasing power of consumers in the country is consequently resulting in higher urbanisation. To cater to increasing housing demand of the growing urban population and large number of expatriates in the country, various construction projects are anticipated to start over the next few years, which will bring a noteworthy addition to the demand for air conditioners in the UAE. Moreover, on account of upcoming events such as World Expo 2020, and growth in the hospitality and tourism sector, the demand for air conditioners is expected to increase during the forecast period.

There are two types of air conditioners available in the market, namely, central air conditioners (VRF, chillers & others), and room air conditioners (split & window). UAE air conditioners market is dominated by central air conditioners, which held the majority revenue share in the market in 2014. On account of increasing construction activities in the country, this segment is expected to maintain its dominance over the next five years as well. Presently, residential sector accounts for the largest market share in the country's air conditioners market, followed by commercial and industrial sectors. "Owing to the enforcement of various energy efficiency labeling standards by the government, the demand for energy efficient air conditioners in the UAE is growing at a significant pace, which will help the country in making significant savings in the overall electricity consumption over the next five years.", claimed Karan Chechi, Research Director with TechSci Research. ■

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The system removes the efficiency losses associated with power conversion, boosting the system's efficiency and cost-effectiveness...

Gree's pioneering direct-drive photovoltaic-powered VRF system is a hybrid solar-electric technology that can save end users up to 30% of their cooling energy costs. According to the company, this is the first commercially available system of its kind in the world.

The units can be used in heat-pump mode to produce heating or hot water – a typical application being to fill a residential storage tank with hot water during the day ready for consumption in the evening.

Conventional PV-powered VRF systems collect solar energy and produce electrical power, feeding it to a DC-AC converter for use by the VRF. Gree's system uses an advanced power management system to overcome the need for a DC-AC converter, feeding electricity from the PV array directly to the air conditioning system.

This removes the efficiency losses associated with power conversion, boosting the system's efficiency and cost-effectiveness. When conditions allow, surplus electricity not required for air conditioning can be fed back into the grid, giving end users an income from feed-in tariff, further tilting the economics in favour of PV-powered air conditioning. Klima-Therm, the expanding chiller and air conditioning specialist, has been appointed a distributor for the Chinese manufacturer Gree's pioneering photovoltaic-powered VRF air conditioning and split systems in the UK.

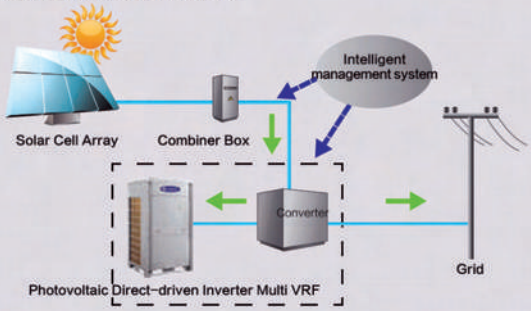
Roberto Mallozzi, Managing Director, Klima-Therm, says, "This latest agreement with Gree means that Klima-Therm is now the only supplier in the UK offering the manufacturer's full range of industry-leading products.

Gree operates nine manufacturing plants, seven in China plus facilities in Brazil and Asia. It has capacity to produce some 60m residential air conditioners and 5.5m commercial systems a year. The company spent over £410million on research and development in 2013 alone, and holds CE, UL and TUV certification.

Tim Mitchell, Sales Director, says, "The market for air conditioning in the UK is changing. We believe that demand for sustainable solutions, which harness renewable energy such as solar power and other sources, is set to increase significantly – not least because of the mandatory requirement to include renewable energy in planning proposals. ■

Photovoltaic Air Conditioning & Power Generation Mode

When photovoltaic generated power is more than air conditioner consumption demand, photovoltaic power will give priority to the air conditioner, and then the residual power will be sent to the grid.



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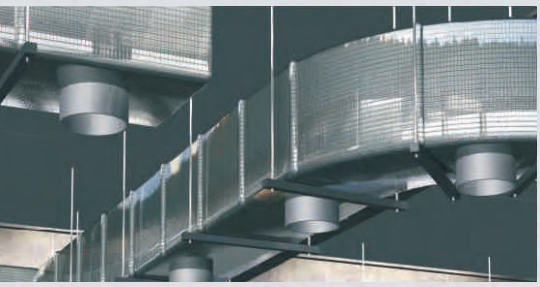
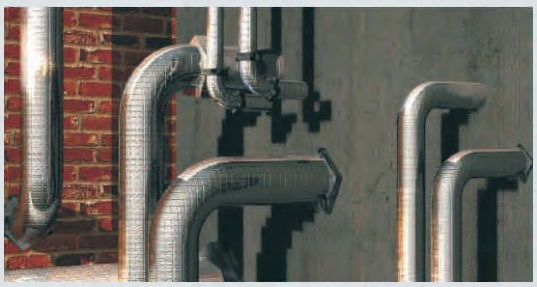


Ducting Insulation



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Amsterdam Zoo Renovation Project

Mechanical Room Design Avoids Welding And Solves Space Shortage At Historic Site

The historic nature of the buildings, the fine architecture, extreme space and access constraints, and the need to keep the zoo open for visitors presented contractor Imtech with a challenging set of circumstances. What did they do?

The Natura Artis Magistra Zoo (known as Artis) in Amsterdam, the Netherlands, is one of the oldest zoos in Europe. Founded in 1838, Artis contains 27 historic buildings, making it a unique cultural heritage of the 19th century.

When two of these buildings – 'het Groote Museum', previously used to house several television studios, and 'de Ledenlokalen', previously closed to the public, – were renovated, a new mechanical room was needed for their heating and cooling systems.

The initial plan was to replace the existing mechanical room within the main building, but the owner's decision to use that space for a different purpose led to a small basement area underneath the Artis Square being allocated for a new mechanical room.

This needed to accommodate a second heat pump to serve Micropia, a museum dedicated to micro-organisms in a newly constructed floor on top of the 'Ledenlokalen'.

The historic nature of the buildings, the fine architecture, extreme space and access constraints and the need to keep the zoo open for visitors presented contractor Imtech with a challenging set of circumstances. Feeling confident in their previous experience with Victaulic, they chose to use the company again to help solve the challenges ahead of them.

Engineering input

Imtech project leader, Ronald van

Use of grooved components and couplings avoided welding...

Haasteren, was able to outline the general requirements of the system, but rather than have the basic drawings produced inhouse, as usual, he called on the Victaulic Construction Piping Services (CPS) team for engineering assistance at the outset.

The Victaulic CPS experts set about positioning the essential equipment and designing the piping system from scratch within the allocated space.

Measuring just 8m square and approximately 2m high, the space proved too small to house the mechanical room: either a rethink on requirements or more space was necessary. Artis then gave approval for a second adjacent basement to be dug out so that the components and piping could be divided into two.

"Although working in two separate areas added complications to an already complex project, it was now feasible. We produced new drawings to create a model where everything fitted and then split the job into four sections: two in each basement. The originally designated basement became the site for the first phase of the installation, where production could start while the new area was being prepared as the second-phase site," said CPS Piping Coordinator Lieven Luypaert.

Space constraints

Tightness of space made the mechanical room not only difficult to design but also to install. Restricted access to the job site was anadditional complication.

The basements could only be accessed by a space of around 1m square. It was quite impossible for all materials to be delivered at once and the above-ground area set aside for deliveries had to be reduced to allow for further ongoing construction of the Artis Square where the basements were located.

A highly efficient just-in-time delivery arrangement was essential for the installation to progress. CPS met this requirement by producing a bill of materials designed per zone with items bagged and tagged for delivery to the correct area when needed, keeping as much of the site as possible free for the installers to work in. As the installation grew and working space became smaller, this 'bag and tag' system became evenmore vital.

> *"The originally designated basement became the site for the first phase of the installation, where production could start while the new area was being prepared as the second-phase site...*

Overcoming delays

Engineering work started in summer 2013, but altered decisions and a series of necessary changes to engineering drawings meant that first drawings for the mechanical room were not submitted until November 2013. The final design was approved in March 2014 and construction started in late July 2014.

Earlier delays significantly compressed the schedule for the installation that had a one-year timeline for completion, yet the project was delivered at the end of November 2014, exactly one year from when the first drawings were completed.

Additionally ground-water problems due to flooding which would have made welding impossible did not stop sub-contractor Random Installatietechniek from installing grooved-end products. Peter Van Mol, Victaulic sales engineer for the Netherlands and Belgium, supported the installation on site and ensured everything went smoothly.

Using Installation–Ready couplings reduced the time needed to connect pipework, as there were no loose parts and no need to disassemble the coupling before installation.

Prefabrication also helped claw back lost time. The provision of cut-length sheets for the pipe enabled 90% of the pipe to be prefabricated offsite and delivered ready for installation at the right time and place.

Artis Zoo, Amsterdam, the Netherlands...

The mechanical room was designed to fit into a very small space...

A new basement area had to be created to house the mechanical room...

Customer's view

"There was no alternative to get this job completed than installing Victaulic products. Welding in such confined space and access constraints was impossible and we wouldn't have been able to meet the tight deadline," said van Haasteren.

Hans Bongers, Lead Engineer at Imtech, added, "It was a very complex project and we knew from previous jobs that Victaulic could add value. The biggest benefit was their extra input on the engineering side which gave us a workable design and helped us deliver the project on time." ■

Pankaj Soni
Country Manager
Victaulic
India

Cost Effective Refrigeration Is Needed

Literally, Agricultural Cold Chain has a wide gamut, and challenges are present at every stage. This article focuses on some of the good practices that are helping in reducing cost of refrigeration of the perishable agri-products as long as they are within four walls…

When we talk about refrigeration, naturally, it occurs to any Indian, in a power-starved country like India, how we should provide the extra power that will be required to run the refrigerated plants that are essential components for any cold environment or facility (my focus is not only on cold stores, but also malls and other places where agri-products are kept long time, in its true sense). However, if we consider the fact that 40% of our agricultural produce is lost because of lack of appropriate refrigeration facilities in the country, when we look into the fact that the farmer's suicide has increased 26% in 2014 over 2013 – definitely we all realise the need for a robust agri-cold-chain in our country. The cold chain is literally a long one that (in some cases) originates from the corn field and ends at our dining table. However, here I am going to focus on the beneficial provisions for refrigeration within four walls only.

Now, coming back to the question of power supply: many of us already know that soon our entire country is going to enter a new phase of metering, which is called ToD (Time of Day) metering. A ToD meter is a device that records the time of using energy along with the amount of energy used. In many countries around the world, the power tariff is designed based on the time of the day when the power is consumed.

Thus, using more power during peak load hours will cost more than using that during the off-peak hours. Also, if a consumer can produce some power at his premises – that also he may exchange during peak hours with the grid. For all these to be a reality an Advanced Metering Infrastructure (AMI) is required. In India, the first

Image Courtesy: Promethean Power Systems

A farmer pouring milk into Rapid Milk Chiller (RMC) hopper for milk chilling…

pilot AMI was installed at a small town near Chennai called Puducherry. The result is good, and by now everyone knows – it works.

Next comes up the question: the refrigeration plant/system in a cold facility runs during 24 hours and its active hours mostly coincide with those of the peak load hours, then how to reduce the power bill?

Well, as the purpose of this article is to disseminate some of the good developments that are reality today, in the later portion of this article, I will focus on a few examples of best practices (developments) that are being followed in some countries (including India), which will address the above question.

Contextually, I would like to mention that although application of solar energy in refrigeration is no longer a new concept, it's a pity that even being one of the most blessed countries of the world with plenty of sunlight, we are yet to exploit the full potential of the same in our country. Just to draw a reference of international progress in this field: way back in September 2011, SunDanzer Refrigeration Inc. obtained a non-exclusive license from NASA to patented battery-free solar powered refrigeration systems technology. It was originally developed by innovators at NASA's Johnson Space Center who were investigating solar alternatives for cooling lunar bases. (Source: www.nasa.gov)

The technology can be used for a variety of purposes, including off-grid, battery-free refrigeration for food and drinks, air conditioning systems in remote locations such as field hospitals, and refrigeration of milk tankers and other transportation vehicles. By that time, SunDanzer was already using the technology to develop a battery-free solar powered refrigerator for storing vaccines and a refrigerated container for transporting food and beverages to remote military personnel.

Image Courtesy: www.coca-colacompany.com

Such provisions are very useful for our country's rural areas, and although at a slow pace, the area of technology is drawing attention here too. Several Indian universities and research centres are also working on it.

By 2013, as part of their 'eKOCool' project, Coca-Cola India installed more than 1,000 solar coolers at shops in rural parts of India, where an estimated 60% of the population lacked electricity (and where those with access to the grid only had power a few hours each day). Rooftop solar panels were linked to the chest-style coolers installed inside the stores. (Source: http://www.coca-colacompany.com)

As per the company, the idea of the solar cooler was borne out of the realities of the Indian marketplace but chiefly a couple of factors (1) the need for safe hydration and packaged beverages as a safe, hydration option, when it is served chilled, and (2) the practical reality that most rural pockets in the country either have no or intermittent supply of electricity. The logistics for procuring ice, which the retailers use to chill the product, is cumbersome. Sometimes, the retailers have to fetch the ice from places as distant as 5 kms away and that too, the supply chain for ice is not reliable. Solar coolers, by harnessing sunlight, was a good solution to all this.

Describing the win-win outcome of the programme, Coca-Cola company states, the eKOCool solar cooler programme targeted expansion in rural markets. The capacity of the solar cooler was initially restricted to two cases keeping in mind the cost, available space at retail outlets and the potential for sales. The increase in sales has been such that retailers are demanding a cooler with higher capacity. The solar cooler is bringing in

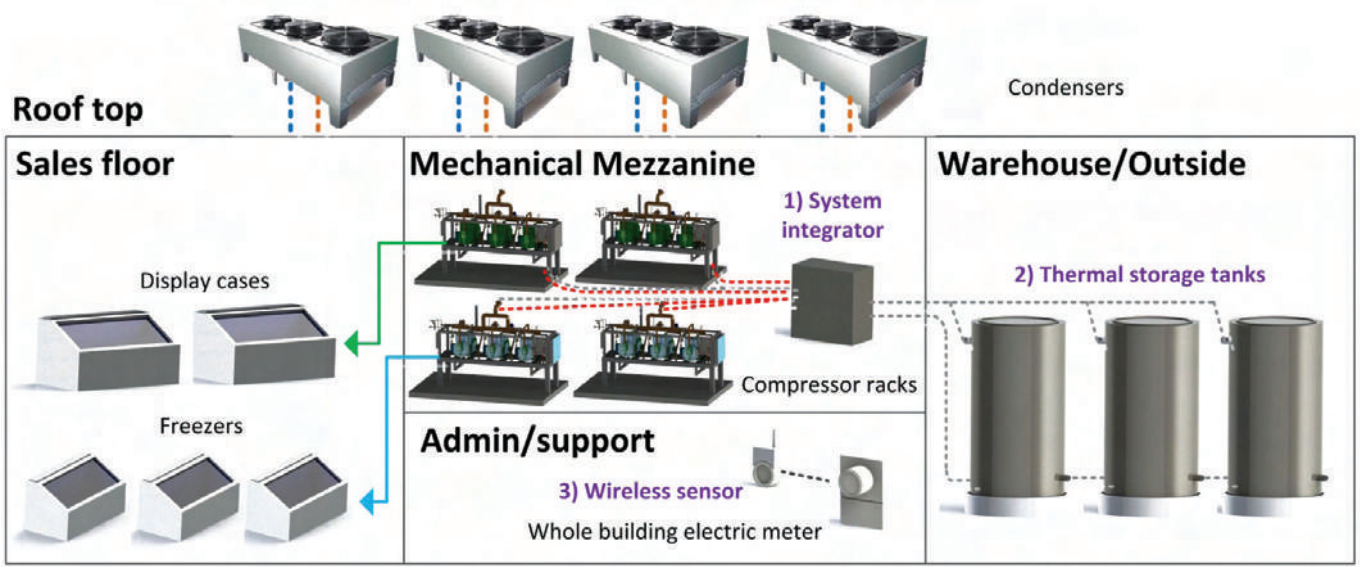


Image Courtesy: www.axiomexergy.com

A schematic diagram of the application of the refrigeration battery...

first time retailers who were not selling Coca-Cola products before – as well as first time consumers who have never consumed Coca-Cola products due to unavailability of chilled beverages. The programme has thus been able to tap new rural markets for Coca-Cola. As the programme expands, the increase in sales from existing retailers and emergence of demand from rural markets will encourage new retailers to crop up and thus benefitting both – retailers as well as Coca-Cola.

There are many references of good practices in this field, many companies are doing excellent projects throughout the world. As everything cannot be included in this small article, let me hereafter highlight a few projects from the journalistic angle, and obviously I will not go into the details of the technical sides of those – as my purpose is just creating awareness among my community.

Refrigeration battery

Axiom Exergy Inc. is based in Berkeley, California. It is a firm equipped to deliver a cost-effective energy storage solution that meets the unique needs of individuals and organisations. Let us now see a bit of their system that is working for super stores.

In the USA, an average supermarket runs on a profit of 1.38% of total sales. But many items there need to remain cool throughout 24 hours. So, every supermarket needs a way to reduce consumption during afternoon which is the peak load time for them.

According to Axiom Energy, the refrigeration battery is a thermal energy storage retrofit for central refrigeration systems in supermarkets and other refrigerated facilities. The technology is very simple. They say, "Charge by freezing a tank of water with common additives at night, when electricity is cheap. Discharge by using the frozen tanks to provide refrigeration during peak hours, when electricity is expensive."

The Refrigeration Battery System Integrator plugs into the central compressor racks as if it were a new refrigerated display case. It does not require physical changes or controls programming modifications to central refrigeration systems. The refrigeration battery's thermal storage tanks are located in the warehouse or outside on a concrete pad. Their wireless sensors connect to the building's existing electricity meter.

Image Courtesy: www.powergridindia.com

A view of the new meter installation for grid connection...

Rapid milk chiller

According to a case study from Promethean Power Systems – which designs and manufactures refrigeration systems for cold-storage applications in off-grid and partially electrified areas of developing countries, the collection centre in the village of Chetawala (Rajasthan, India) started operations in 1997 with 50 L of milk per day. It used to collect milk every morning and evening and dispatch it in cans to the nearest chilling point.

Over the years, milk procurement increased to 500 L per day, but that brought along many operational issues. High ambient temperatures in Rajasthan and large distances between villages, resulted in 5% milk spoilage. When the milk spoiled, collection centre had to bear the penalty.

In addition, collection vehicles had fixed time of arriving at the centre and only a few minutes to collect the milk and depart for the next centre. Such rigid schedule often led to losing out on milk delivered by distant farmers – who could not reach in time. Moreover, erratic grid supply led to high dependence on diesel generators pushing up chilling costs. Such issues made 1000 L collection centres economically unviable to operate and less commitment of milk producers towards Jaipur Dairy. (Source: www.promethean-power.com)

Promethean installed a Rapid Milk Chiller (RMC) at Chetawala. The milk chiller can cool milk without a diesel generator at village collection centres. It can chill 1000 litres of milk per day – even when there is no power during milk collection – by using only 4 to 5 hours of intermittent grid power between each milking shift. By eliminating diesel, Promethean Milk Chiller (PMC) provides the most cost effective way of collecting top quality chilled milk from village milk collection centres where grid power is erratic.

Apartment building creates energy surplus

One of the six winners of the INTERSOLAR AWARD 2015 is an apartment owners building at Frankfurt's Gutleutviertel. Their achievement shows that everything is possible through effort. If it is possible in Germany, why not in our motherland India?

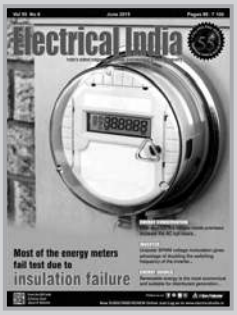
The 'Aktiv-Stadthaus' (active house) (realised with the help of Solarnova Deutschland GmbH) generates more energy that the residents of the 75 apartments consume. Passive efficiency achieved by insulation and active electricity generation are optimally combined in this Effizienzhaus Plus (an efficient building pilot project initiated by the German government).

What makes this concept revolutionary is the fact that both the users' energy requirements and urban integration were taken into account in the planning process. "The Aktiv-Stadthaus is a proof that the EU can achieve its 2020 energy efficiency target," said the (Intersolar 2015) panel, explaining its reasons for presenting the project with the Intersolar AWARD 2015. (Source: http://www.intersolar.de)

Conclusion

I started with the challenge that how we can make best cold facilities (within four walls) in our power-starved country. The product and project references cited above are of self-explanatory type, and show how some good projects or schemes are working in India and abroad. To stop loss of agri-products in our country, to increase the shelf-life of the perishable food items, to feed the nation at reasonable cost, we need to ponder on such innovative technologies and techniques. ■

P K Chatterjee
Editor
Cooling India



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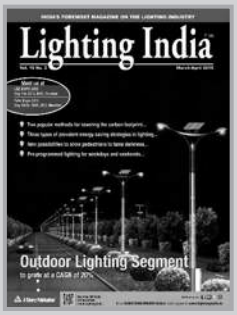

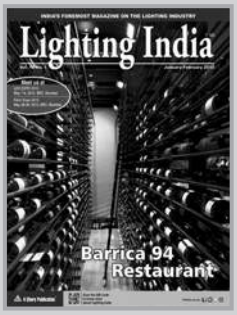

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Inverter Compressors vs Conventional Compressors

Variable speed drives, based on inverters, have been applied successfully to control the capacity of positive displacement machines – such as compressors. Inverter – based variable speed compressor technology offers the potential for energy savings...

The compressor is the 'heart' of any refrigerator or air conditioner and most of the research revolves around the compressor to make it more efficient to improve overall performance of these two types of products. Technology changes on a daily basis, and inverter compressors have started replacing conventional compressors in appliances like refrigerators and air conditioners.

The inefficient use of electricity to drive the compressors of refrigeration and air-conditioning systems is considered as an indirect contributor to the emission of greenhouse gases to the atmosphere. This emission can be reduced by improving the energy conversion efficiency of refrigeration systems.

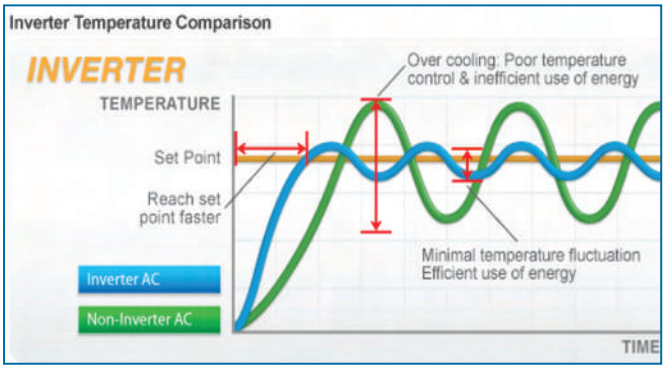
One of the methods of achieving this is through capacity control, which matches the system capacity to the load. Capacity control reduces the on/off cycling losses of the equipment and improves the steady-state efficiency of an appliance due to a lower pressure differential across the compressor at part-load conditions.

This article explains the basics of conventional versus inverter compressors.

Working of conventional compressors

The conventional compressor works on a principle of 'Single Speed'. They are either 'ON' or 'OFF' based on the loading/temperature setting of a thermostat in a refrigerator or air conditioner. Here most compressors are designed to handle the peak load condition (e.g., high temperature in summer), which indicates they will run in peak load even if the ambient temperature is less during the winters. This ultimately results in high power consumption and with the user paying a high electricity bill. Moreover, conventional compressors are designed to take care of heat ingress due to the frequent door openings and closings for refrigerator or to the outdoors for air conditioners.

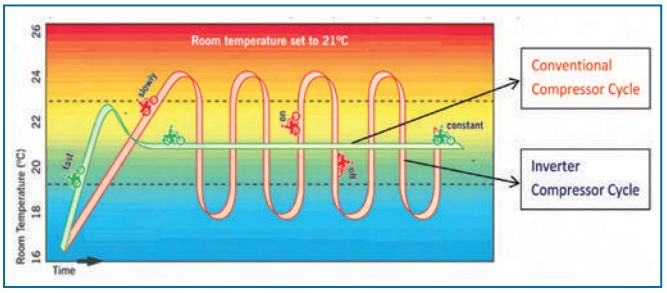
Working of the inverter compressor



Unlike the conventional compressor, here the inverter compressor works on a principle of Variable Frequency Drive (VFD) to cause the speed of the compressor to vary – as a result of varying load conditions. The change in speed of the compressor, in turn, causes the refrigerant flow to change.

The inverter technology is the latest evolution of technology concerning the compressor motor. An inverter is used to control the speed of the compressor motor, so as to continuously regulate the temperature. The inverter units have a variable-frequency drive that comprises an adjustable electrical inverter to control the speed of the compressor motor, which in turn adjusts the compressor output. The drive converts the incoming alternating power (A.C.) source to direct current power – and then through a modulation in an electrical inverter produces current of desired frequency.

A microcontroller samples the ambient air temperature and adjusts the speed of the compressor accordingly. A compressor with inverter technology helps ensure that during summer months when cooling load is high, the compressor works at high capacity. At other times when cooling load is less, the compressor works at a lower capacity setting.

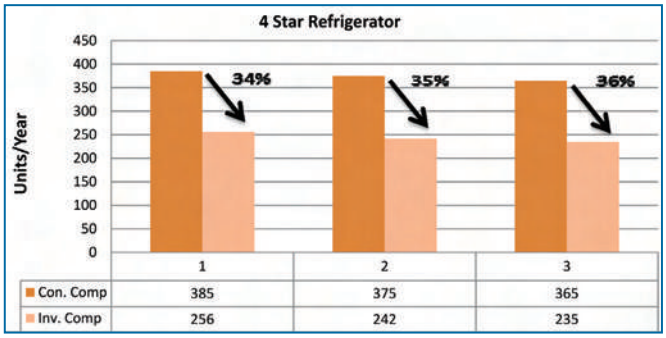


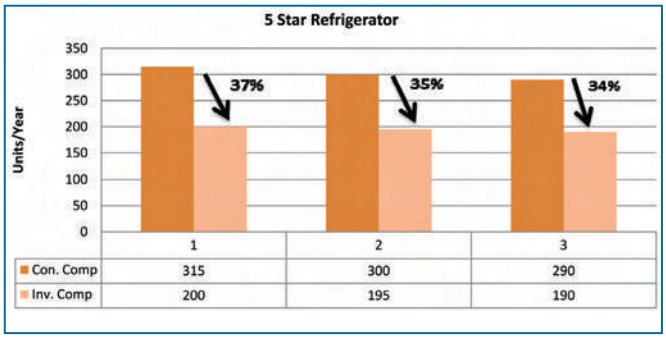
Comparative data between conventional & inverter compressor

Refrigerator

Displayed below, few of the actual tested data of four star and five star refrigerators of various gross capacity for their energy consumption:

Gross Capacity (Liters)	Energy consumption (kWh/year)				Energy Saved (%)	
	Conventional Compressor		Inverter Compressor			
	4 star	5 star	4 star	5 star #	4 star	5 star
310	385	315	256	200	34	37
285	375	300	242	195	35	35
258	365	290	235	190	36	34





It is clearly seen that inverter compressor is consuming less power compared to the conventional compressor in a range of 34% to 37%, which is a very high percentage.

Note: Few refrigerators were tested at UL Manesar lab and based on the result, percentage of saving has been calculated and highlighted. Refrigerant (134 a) was used in a conventional compressor while (600-a) was used in inverter compressor. The outcome compressor isn't the only factor.

Advantages of inverter compressor

Inverter compressor technology is highly responsive, efficient, compact and allows flexibility of placement. The inverter air conditioning units have increased efficiency when compared to traditional air conditioners. Sharp fluctuations in the load are eliminated. This makes the inverter units quieter, with lower operating cost and more reliability. The inverter units are more expensive than the constant speed air conditioners, but this initial expense can be offset by lower energy bills.

Conclusions

The subject is entirely focused on the 'consumers of India', to spread the awareness for better energy efficient products available in the market. With greater awareness, it will help in saving energy and contribute in 'India's growth story.'

In recent years, compressors with variable speed drives have gained an increased market share in air conditioners and household refrigerators, due to improved efficiency and reliability brought about by advancements in material, manufacturing technology and optimised design.

Over the past few years, the price of inverters had been steadily decreasing. This trend is attributed generally to improved design, increased production and the decrease in price of electronic devices. The reliability of inverters is constantly improving, due to improved technology and availability of better components. Space is also decreasing, due to improved packaging, higher efficiency, more effective heat sinks and improved circuitry. ■

Development Analysis And Application Of **Cascade Refrigeration System**

The cascade refrigeration system that consists of multi number of different refrigeration cycles was introduced in the 1930s to meet the demand for low temperature refrigeration that is required in the temperature range from -100^{0}C to -30^{0}C...

Cascade refrigeration cycles are employed in industrial cooling units where high temperature lift between the heat source and sink is desired. Single stage vapour compression refrigeration systems are inefficient due to their high losses due to irreversibility and very high compression ratio that further leads to high discharge problem and low volumetric efficiencies. Although multi-stage vapour compression refrigeration system with single refrigerant can overcome the problem, due to the use of a single refrigerant, high critical temperature and low freezing point of the refrigerant are needed. Also, the operating pressures with a single refrigerant may become too high or too low. The cascade system can overcome several problems coming from the high pressure ratio in low temperature refrigeration systems.

The cascade refrigeration system that consists of multi number of different refrigeration cycles was introduced in the 1930s to meet the demand for low temperature refrigeration that is required in the temperature range from -100^{0}C to -30^{0}C.

In the process of designing a cascade system, one of the most important issues is to find an optimal intermediate temperature of the cascade condenser, which is the evaporating temperature of a high temperature cycle or the condensing temperature of a low temperature cycle, to obtain the best efficiency of the system. The optimisation research on an intermediate temperature of cascade system has been performed by many researchers with various cascade systems. Bhattacharyya et al.

considered a two-stage cascade cycle for optimisation of intermediate temperature to yield maximum exergy and refrigeration effect. Based on the mathematical modelling, they calculated the performance of the system according to various parameters and established some correlations to find the optimal intermediate temperature and maximum COP. Lee et al. optimised a CO_2/NH_3 cascade system taking into consideration of the compressor efficiency and exergy losses in their analysis. They also found that the optimal condensing temperature of a cascade-condenser is -18^{0}C at a condensing temperature of 35^{0}C and an evaporating temperature of -50^{0}C. Getu et al. also analysed thermodynamically with the help of numerical methods to obtain the optimal condensing temperature of the cascade condenser. Their final results were correlations for optimal conditions.

It is clear that on the performance of a cascade system the determination of the optimum condensing temp. of the cascade condenser is a very important factor and that can be treated as the major performance factor along with the COP of the system.

Basics of cascade refrigeration system

Multi-stage vapour compression refrigeration system is very useful to obtain refrigeration effect using one single refrigerant, when the temperature difference between the evaporator and condenser is high. It is observed that in a multi-stage vapour compression refrigeration system, different temperature limits can be obtained. However, the losses due to irreversibility is less compared to a single stage vapour compression refrigeration system.

Although multi-stage systems have been very successful in many cases, they have certain limitations.

These are:

- Since only one refrigerant is used throughout the system, the refrigerant used should have high critical temperature and low freezing point
- The working pressure with a single refrigerant may become too high or too low. Generally only R12, R22 and NH_3 systems have been used in multi-stage systems as other conventional working fluids may operate in vacuum at very low evaporator temperatures. Operation in vacuum leads to leakages into the system, and large compressor displacement due to high specific volume.
- Possibility of migration of lubrication oil from one compressor to other, leads to compressor break-down.

> *"It is possible to use more than two cascade stages, and it is also possible to combine multi-stage systems with cascade systems..."*

The above limitations can be overcome by using cascade systems. A cascade refrigeration system can be considered to be equivalent to two independent vapour-compression systems linked together in such a way that the evaporator of the high-temperature system becomes the condenser of the low-temperature system. The condenser of lower stage system is coupled to the evaporator of the next higher stage system and so on. The component where heat of condensation of lower stage refrigerant is supplied for vaporisation of next level refrigerant is called cascade condenser. However, the working media of the two systems are separated from each other. This therefore, allows the use of different refrigerants working at different temperature ranges to achieve the desired effect, which would otherwise, need to be achieved by a single refrigerant – working at a bigger operating pressure range. Thus, one can make use of suitable refrigerants at the higher and lower pressure ranges to derive maximum benefit. It is possible to use more than two cascade stages, and it is also possible to combine multi-stage systems with cascade systems.

Figures 1, 2 & 3 show the schematic, P-h and T-s diagrams respectively of a two-stage cascade refrigeration system, which consists of two single stage refrigeration systems with two different refrigerants. The high temperature cycle employs one refrigerant and the low temperature cycle uses another one as a refrigerant and two cycles are

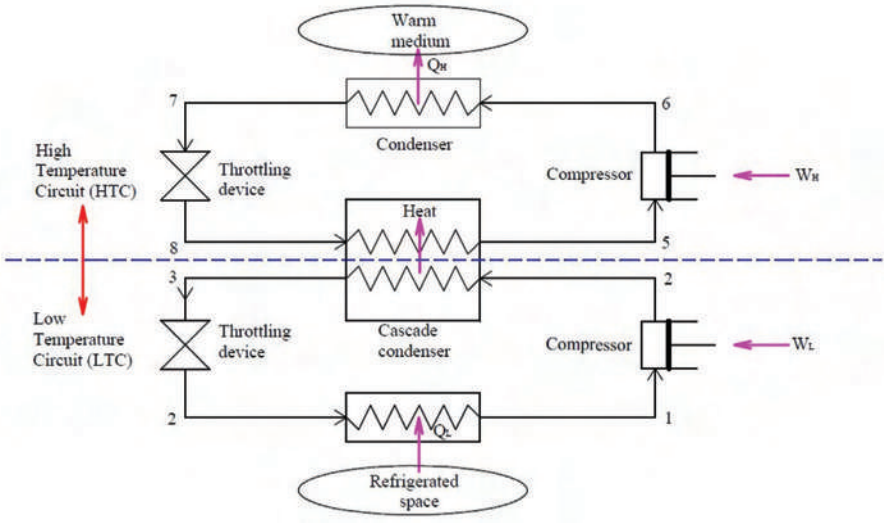


Fig. 1: System description of cascade refrigeration system...

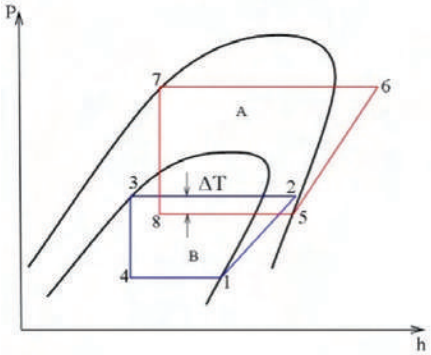


Fig. 2: P-h diagram of a cascade refrigeration system...

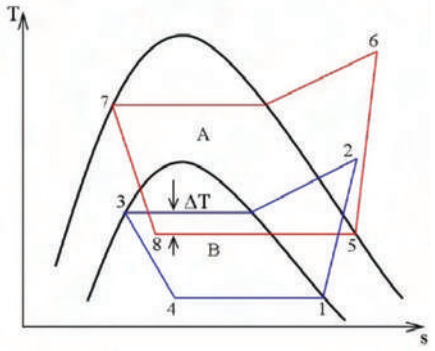


Fig. 3: T-s diagram of a cascade refrigeration system...

connected by a cascade heat exchanger i.e., cascade condenser, and it is called Low Temperature Circuit (LTC). In the cascade condenser, the refrigerant of LTC evaporates and the heat of evaporation is transferred to the refrigerant of the other circuit and it condenses, and this circuit is called High Temperature Circuit (HTC).

The condenser in this cascade refrigeration system rejects a heat of $\dot{Q}_H$ from the condenser at condensing temperature of T_C, to its warm coolant or environment at temperature of T_O. The evaporator of this cascade system absorbs a refrigerated load $\dot{Q}_L$ from the cold refrigerated space at T_{CL} to the evaporating temperature T_E. The heat absorbed by the evaporator of the Low Temperature Compressor (LTC) plus the work input to the LTC compressor equals the heat absorbed by the evaporator of the High Temperature Compressor (HTC). T_{MC} and T_{ME} represent the condensing and evaporating temperatures of the cascade condenser, respectively. ΔT ($=T_{MC} - T_{ME}$) represents the difference between the condensing temp. of LTC and the evaporating temperature of HTC. The evaporating temperature T_E, the condensing temperature T_C, and the temperature difference in the cascade-condenser are three important design parameters of a cascade refrigeration system.

Advantages of cascade refrigeration system

As a result of environmental problems related to global warming and ozone-depleting effects caused by the use of synthetic refrigerants over the last decades, the return to use of natural substance for refrigeration purposes seems to be the best long-term alternative. Therefore, natural fluid has attracted renewed interest during the last years. However, it is to be kept in mind that they must not be less energy efficient, than the fluids that they replace. They must be proven to be safe, both for local neighbourhood and global environment. They must be simple to use and cost-effective, immediately available and ideally, should not require any significantly new technology. In low-temperature applications, including rapid freezing and the storage of frozen food, the required evaporating temperature of the refrigeration system ranges from -40^0C to -55^0C, so a single-stage vapour-compression refrigeration system is insufficient, while two-stage or cascade refrigeration systems are used for low-temperature applications. The advantages of cascade refrigeration system are listed below:

- It is very efficient both energetically and economically for low temperature refrigeration especially in the range bellow -35^0C. Dopazo et al. has compared the cascade system with others and their analysis shows that at -40^0C or lower the evaporating temperature, the choice of the cascade system is the most advantageous with a COP value of up to 19.5% higher. Thus, it has a huge demand in rapid freezing, storage of frozen food, liquefaction of gases and dry ice production industries
- As the temperature range is high in case of cascade refrigeration, we can employ a large variety of refrigerants according to the property of the individual refrigerants
- As in cascade refrigeration system, the individual single stage vapour compression cycles are separated, so here the possibility of migration of lubricating oil from one compressor to other can be ceased, which reduces the compressor discharge problem
- One can employ a large variety of natural or unconventional refrigerants like ammonia, carbon-di-oxide, R290, R1270 etc., which are environment friendly and possesses less pollution
- Cascade refrigeration systems are simple in construction, and cost effective.

Disadvantages of cascade refrigeration system

Despite its advantages, cascade refrigeration systems have few disadvantages. It requires the use of a proprietary blend refrigerant. These characteristic results in three of the problems connected with:

- A leak in the system can easily lead to the loss of only some of the refrigerant components of the refrigerant mixture, which consists of different types of refrigerants with different boiling points, as a result of an imbalance in the ratio of the remaining refrigerants. To return the system to function, all the other refrigerants should be replaced with new and potentially expensive refrigerants ensuring the correct combination of attitude
- The mixture is proprietary and may not be readily available from traditional refrigerant power sources, and therefore may be difficult and expensive
- These types of cascade systems are not widely used. So, it is difficult to find highly skilled field service staff being familiar with repair and maintenance procedures
- These and other issues may cause unwanted costs and downtime.

Thermodynamic analysis

Since the original cascade system is too complex to establish analytic expressions, a few assumptions are necessary to simplify the analysis.

Hence, the analysis is conducted based on the following suppositions that are often used in thermodynamic analysis of cascade cycles.

- All components are assumed to be at steady-state and the processes occurring in it are steady-flow processes. The changes in the potential and the kinetic energy terms of the components are assumed to be negligible
- The high and low-temperature circuit compressors are either isentropic or their isentropic efficiency can be expressed as a function of the pressure ratio. Combined motor and mechanical efficiency of each compressor is assumed to be 0.93
- The heat loss and pressure drop in the pipe connecting the components are assumed to be negligible
- All throttling devices are assumed to be isenthalpic
- The state of the refrigerants at the outlet of the condenser and cascade condenser are at saturated liquid state and that of the evaporator is at saturated vapour state
- The dead state temperature of the cascade refrigeration system is at ambient temperature of 25^0C.

Based on the assumptions described above, the four conservation equations are applied to find the mass flow rate of each cycle, the work input to the compressor, the heat transfer rates of condenser and cascade-condenser, the entropy generation rate and the exergy destruction rate.

The corresponding equations connecting different thermodynamic properties are given below:

Mass balance

$$\sum_{in} \dot{m} = \sum_{out} \dot{m}\,(kg/s) \qquad (1)$$

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Energy balance

$$\dot{Q} - \dot{W} + \sum_{in} \dot{m}h - \sum_{out} \dot{m}h = 0\,(kW) \quad (2)$$

Entropy balance

$$\dot{S}_{gen} = \sum_{out} \dot{m}s - \sum_{in} \dot{m}s - \sum \frac{\dot{Q}}{T}\,(kW/K) \quad (3)$$

Exergy balance

$$\dot{X}_{des} = \sum_{j} \left(1 - \frac{T_0}{T_j}\right)\dot{Q}j - \dot{w}_{cv} + \sum_{i} \dot{m}x - \sum_{e} \dot{m}x\,(kW) \quad (4)$$

The exergy destruction can also be determined by using the Gouy-Stodola theorem as:

$$\dot{X}_{des} = T_0\,\dot{S}_{gen} \quad (5)$$

The thermodynamic properties (like specific volume, enthalpy and entropy) of the refrigerants can be determined using the software developed by IIR.

System performance

The overall coefficient of performance or the first-law efficiency of the cascade refrigeration system can be written as:

$$COP = \frac{\dot{Q}_L}{\dot{W}_H + \dot{W}_L} = \frac{(COP_{LTC})(COP_{HTC})}{1 + COP_{LTC} + COP_{HTC}} \quad (6)$$

where,

$$COP_{LTC} = \frac{\dot{Q}_L}{\dot{W}_L} \text{ and } COP_{HTC} = \frac{\dot{Q}_M}{\dot{W}_H} \quad (7)\ \&\ (8)$$

The refrigerated capacity $\dot{Q}_L$, the heat transfer rate in the cascade-condenser $\dot{Q}_M$, the work input to the HTC compressor $\dot{W}_H$, and the work input to the LTC compressor $\dot{W}_L$, can all be determined using properties of the refrigerants at different state points.

The second-law efficiency of the whole system is defined as the ratio of actual COP to ideal COP_{carnot}, which is given by

$$n_H = \frac{COP}{COP_{carnot}} \quad (9)$$

Where,

$$COP_{carnot} = \frac{T_E}{T_C - T_E} \quad (10)$$

Effect of different controlling parameters

The performance of cascade refrigeration system in terms of system COP and exergy destruction, and the optimal intermediate temperature of the cascade condenser depends on different parameters under which the system works. The most important parameters include condensing temperature, evaporating temperature, temperature difference in cascade condenser, sub-cooling, superheating, isentropic efficiencies of compressors. The effects of these parameters on the system performance can be summarised as follows:.

- Increase in condensing temperature leads to a decrease in COP and an increase in refrigerant mass flow ratio of HTC and LTC
- Increase in evaporating temperature increases COP of the system and decreases mass flow ratio of HTC and LTC
- Increase in temperature difference in cascade condenser reduces both COP and mass flow ratio of HTC and LTC
- An increase in the degree of superheat reduces COP of the system and reduces the mass flow rate of the system
- An increase in sub-cooling increases both COP and mass flow rate of the system
- An increase in isentropic efficiency of compressors increases COP linearly
- The exergy destruction rate is minimum when the intermediate temp. of the cascade condenser lies in between -10 to -20^{0}C.

Application of cascade refrigerant sys.

There are many applications of cascade refrigeration system in industrial cooling below -40^{0}C. The applications in different industrial plants are given. One of the most important applications is the liquefaction of petroleum vapours. The insulation, whatever efficient it may be, will not keep LNG cold enough by itself. Inevitably, heat leakage will warm and vaporise the LNG. Industry practice is to store LNG as a boiling cryogen. That is, the liquid is stored at its boiling point for the pressure at which it is stored (atmospheric pressure). As the vapour boils off, heat for the phase change cools the remaining liquid. Because the insulation is very efficient, only a relatively small amount of boil off is necessary to maintain temperature. This phenomenon is also called auto-refrigeration. Other applications include liquefaction of industrial gases, manufacturing of dry ice and deep freezing.

Recent use of cascade systems

In recent time, British distribution centre is using CO_2/NH_3 cascade plant combined with CO_2 secondary system. The photographic view of the plant is shown in Fig. 4. In 2006, British supermarket chain ASDA was looking for a new refrigeration system to replace an existing R22 plant and meet increased operational demands at its distribution centre in Lutterworth near Leicester, United-Kingdom. Independent industrial refrigeration engineering company 'Star Refrigeration', completed an innovative cooling plant installation using a carbon dioxide (CO_2) and ammonia cascade system combined with a CO_2 secondary system, a technology type that the chain had installed since 2002 in the context of its long-term modernisation programme to replace all HCFC-22-based systems.

Fig. 4: Inside the machinery room of ASDA's Lutterworth Distribution Centre... Source: Star Refrigeration (2007)

Conclusion

Based on the above, the Coefficient of Performance (COP) and the optimal intermediate temperature of the cascade condenser are the main design aspects of the performance of this system. The optimal condensing temperature of a cascade condenser increases with TC, TE and ΔT. The maximum COP increases with only TE, but decreases as TC or ΔT increases. Besides this, increase of superheat reduces COP of the system, and an increase in sub-cooling increases COP. An increase in isentropic efficiency of compressors also increases COP linearly. Finally, it can be stated that cascade systems are highly reliable, simple in construction, and can be applied to a wide range of refrigerants. ■

Dr Bijan Kumar Mandal
Professor
Indian Institute of Engineering Science Technology
Shibpur, Howrah, India

Saikat Haldar
Mechanical Engineering Student
Indian Institute of Engineering Science and Technology,
Shibpur, Howrah, India

Subham Shit
An active member of the research group, Refrigeration and AC at Indian Institute of Engineering Science and Technology, Shibpur, Howrah

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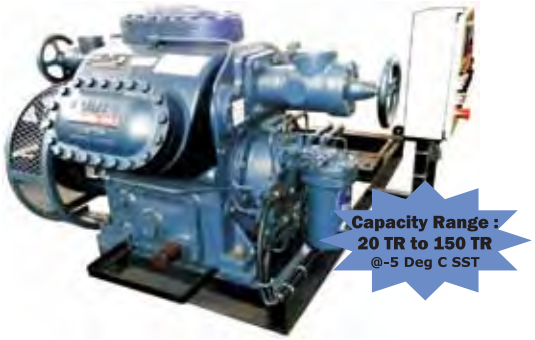

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How UV-C Energy Works In HVAC Applications

The similarities between UV-C lamps and fluorescent lamps provide many benefits. They can be constructed in the same form factors, reducing manufacturing, packing, and shipping costs to offset much higher material costs of UV-C lamps...

Light energy in the ultraviolet-C (UV-C) wavelength has been used extensively in HVAC equipment since the mid-1990s to improve Indoor Air Quality (IAQ) by eliminating the buildup of biofilms and other organic contaminants on the surfaces of system components, including cooling coils, plenum interiors, drain pans, and air filters1, 2. UV-C works by disassociating elemental bonds, which in turn disinfects and disintegrates organic materials.

In new systems, such buildups are avoided by the continuous cleaning of equipment with UV-C energy. In retrofit applications, UV-C eradicates organic matter that has accumulated and grown over time, and then prevents it from returning.

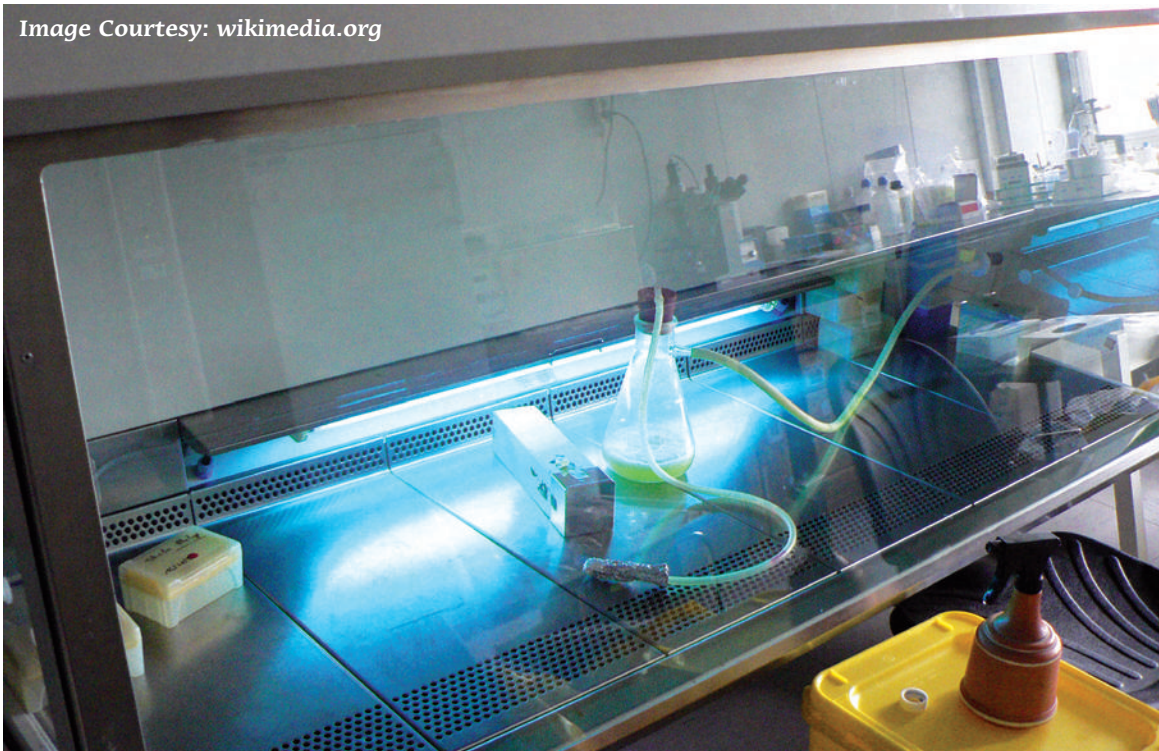
The nature of UV-C

UV light comprises a segment of the electromagnetic spectrum between 400 and 100 nm, corresponding to photon energies from 3 to 124 eV. The UV segment has four sections, labeled UV-A (400 to 315 nm), UV-B (315 to 280 nm), very high energy and destructive UV-C (280 to 200 nm) and vacuum UV. Fig. 1

We all are familiar with the deleterious effects of UV transmitted by sunlight in the UV-A and UV-B wavelengths, giving rise to UV inhibitors, or blocking agents, which are found in glass(es) and lotions. We are also familiar with products engineered to withstand the effects of UV radiation, such as plastics, paints, and rubbers.

However, unlike UV-A and B, the UV-C wavelength has much more electron volt energy (eV) as UV-A, and it is well absorbed (not reflected) by organic substances, adding to its destructiveness.UV-C's germicidal effects are well

Image Courtesy: wikimedia.org



A low-pressure mercury-vapour discharge tube floods the inside of a biosafety cabinet with shortwave UV light when not in use, sterilising microbiological contaminants from irradiated surfaces...

proven. It owes these effects to the biocidal features of ionizing radiation, that is, UV-C does far more damage to molecules in biological systems than other methods.

Sunburn is one example of that damage. Sunburn is caused by sun striking living cells in the epidermis and killing them; the redness is the increased capillary action and blood flow enabling white blood cells to remove the dead cells.

> *"Aluminium is among the best inorganic reflectors of the UV-C wavelength, UV-C energy is easily directed deep into and throughout a cooling coil...*

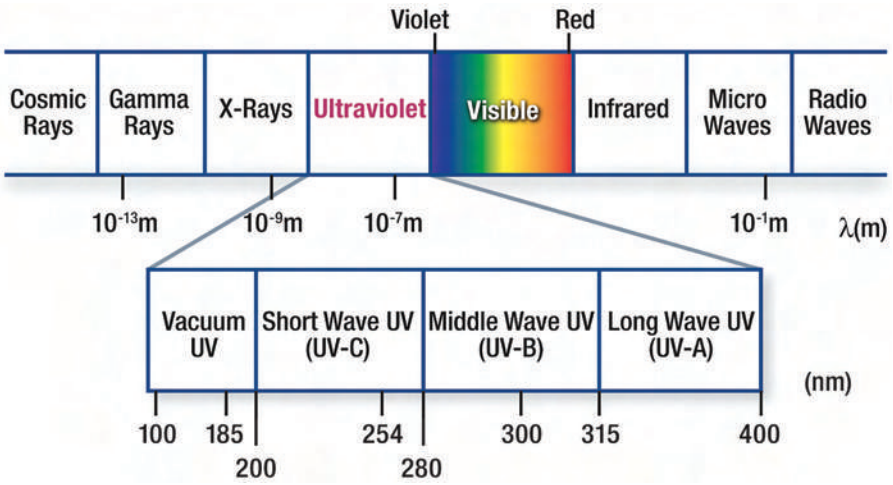


Fig. 1: This diagram shows the electromagnetic spectrum, with a breakout of visible light segments—colors. The UV spectrum ranges from 100 to 400 nm and is invisible... Courtesy: UV Resources

Ionization drives UV-C's power to alter chemical bonds. It carries enough energy to excite molecules into a permanent chemical separation, causing lasting damage to DNA, and ultimately killing the cell. Even a very brief exposure can render microbial replication impossible. After being killed, organic remnants are subject to photo-degradation (disintegration), a key feature of UV-C energy.

UV-C is absorbed by the earth's ozone layer and much of its atmosphere, and does not make it to the earth's surface; vacuum UV resides principally outside of the atmosphere.

Exposure and consequent dosage is the quantity of UV-C light absorbed over a specific period of time. A 2010 study commissioned by ASHRAE and the Air Conditioning, Heating, and Refrigeration Institute (AHRI) found that even the most sophisticated organic compounds suffer from exposure to small dosages of UV-C energy. And because UV-C lamp installations in HVAC applications operate 24/7, time is infinite, so organic surface materials are both disinfected and fully disintegrated. Once gone, they won't re-form as long as the lamps are on and maintained.

Unlike manufactured compounds, the mostly simple organic debris as found on coil surfaces are fairly easy to degrade. And because aluminium is among the best inorganic reflectors of the UV-C wavelength, UV-C energy is easily directed deep into and throughout a cooling coil.

UV-C lamps and lamp replacements

Modern UV-C lamps are very similar to fluorescent lamps typically found in ceiling fixtures. Both types of lamps are manufactured on fluorescent lamp machines in similar form factors (lengths and diameters), and they operate using identical electrochemical processes: an electric discharge through argon gas strikes mercury vapour to generate a photon with a wavelength of 253.7 nm (typically called UV-C), which is invisible to the eye.

UV-C lamps differ slightly from their fluorescent counterparts in that the UV-C lamp's glass envelope is a highly engineered, UV-C transparent glass. This allows the 253.7nm wavelength to transmit through the lamp envelope unfiltered. Fluorescent lamps, however, use ordinary glass that is coated with phosphors on its interior surface. The UV-C energy is contained to excite the phosphors to glow (fluoresce) in the visible light range.

That being said, what gives UV-C lamps their characteristic blue hue, as shown in Fig. 2?

Fig. 2: Example of the 'blue hue' of a UV-C lamp installation. The intensity of the blue does not indicate the efficacy of the light. Modeling is the most accurate and efficient method to determine UV-C energy levels... Courtesy: UV Resources

A typical UV-C lamp produces about 90% of its energy in the UV-C wavelength. About 4% of its energy is given up as heat, and the rest (~5%) is in the visible light range that is medium blue in colour. This blue color results from the argon gas in the enveolpe.

The similarities between UV-C lamps and fluorescent lamps provide many benefits. They can be constructed in the same form factors, reducing manufacturing, packing, and shipping costs to offset much higher material costs of UV-C lamps. They can also be stored and recycled in the same manner. UV-C lamps are typically warranted to provide more than 80% of their initial output over a 9,000-hour period. Because UV-C lamps should be operated continuously, the corresponding 8,760 hours of a 24/7 schedule also fits conveniently into annual re-lamping schedules.

Attempting to run UV-C lamps longer than 9,000 hours can produce individual lamp outages, so maintenance staff must monitor them routinely to know what to replace.

Replacing lamps as they burn out also requires a larger inventory of replacement lamps for when the lamps begin to fail in larger numbers.

Like fluorescent lamps, UV-C lamps come in a variety of types and sizes, including single-ended and double-ended lamps. The single-ended lamps have all of the starting and ending terminals (pins) contained in the lamp base. They are used in several lamp systems, some of which allow the lamps to be inserted through a plenum or duct into the airstream, typically downstream of the cooling coil.

Double-ended lamps have pins at both ends, come in many varieties, and are installed into specific-length-fixtures usually containing the ballast like a fluorescent fixture. Typically, all lamp types are available in High Output (HO) and Standard Output (SO) varieties. The difference between them is their watt rating and ballast size. HO lamps are recommended because they are less expensive on a per-lamp-watt basis.

Another consideration is opting for encapsulated lamps, which have a transparent poly tetra fluoro ethylene (PTFE) coating over the glass envelope. Encapsulated lamps hermetically seal UV-C lamps in case of breakage. Should an accident occur, broken glass and mercury will remain within the lamp encapsulated.

Three tiers of benefits

UV-C systems provide three levels of benefits when applied to HVAC systems.

Level 1- HVAC system efficiency: UV-C eliminates and/or prevents the build-up of organic material on the surfaces of cooling coils, drain pans, and interior duct surfaces. This improves airflow, returns and maintains the heat-transfer levels of cooling coils to 'as-built' capacity, and reduces maintenance.

Level 2- IAQ: UV-C improves airflow levels and eliminates organic material on surfaces, which helps improve Indoor Air Quality (IAQ) by reducing pathogens and odours. This improves occupant productivity, boosts comfort levels, and reduces sick time.

Level 3- economic impact: The impact that UV-C has on mechanical systems and occupants translates into substantial economic benefits, including reductions in energy consumption, energy cost and carbon footprint; reductions in hot/cold complaints and maintenance actions associated with complaints; reductions in system downtime and staff time needed for chemical or mechanical cleaning; and increases in occupant satisfaction and productivity. On an average, UV-C can slash 10 to 25% of HVAC energy use.

UV-C life cycle

To receive these benefits, engineers need to apply simple methods of sizing, selection, and specifying a UV-C system during installation design. Contractors must correctly install the UV-C system, and facility staff must change the lamps annually. These activities can be grouped into the life cycle phases of system design, installation, activation/commissioning, and operations and maintenance.

Sizing, selection and specification

For a complete design solution, engineers need to simply determine:

- How much UV-C energy is needed to 'do the job'
- The lamp/ballast characteristics required to meet the intended operating conditions
- The required quantity and configuration of lamps needed.

In its 2011 ASHRAE handbook, applications, Chapter 60.8, ASHRAE technical committee, TC2.9, established minimum irradiation levels of 50-100 μW/cm^2 (microwatts per square centimeter) for cooling coil applications. This requirement is considered the 'minimum' across the entire coil surface, including plenum ends and corners.

These engineering units, however, are unfamiliar to most practitioners. In lighting applications, sizing will generally resolve to lamp watts.

An accurate way to convert microwatts to lamp watts is to use a form-factor translation consisting of a 1 sq metre surface with a 1-meter-long lamp located midway up the surface on a horizontal plane.

The average lamp watts and output of lamp manufacturers' published data shows that a 1 metre, High-Output (HO) lamp is rated at 80 lamp watts with an output of 245 μW/cm^2, at 1 metre distance (i.e.,lamp surface to coil surface). UV-C lamps are usually installed at 12 in. from the coil surface, so the irradiance needs to be interpolated for that distance. Using the industry-accepted 'cylindrical view factor model,' 5 the resulting irradiance at 12inch is 1375 μW/cm^2.

While this number seems to be more than enough to meet the 100 μW/cm^2 recommended by ASHRAE, all operating conditions must first be taken into account.

Certain conditions effectively lessen or 'de-rate' the performance of the lamps, such as air temperature and velocity. In fact, changes in these variables can positively affect design performance.

In typical conditions of 500 fpm velocity and 55 F air temperature, lamps are de-rated by about 50%. Hence, the 1375μW/cm^{2}generated from a conventional high-output 80 lamp watt bulb would now yield a dose irradiance of closer to 688 μW/cm^2—at 12in. from the coil surface.

The next consideration factor is distance of the UV-C lamp to the plenum corners. The view factor on the 1-metre example (Fig. 3) shows – this to be 25% of the highest mean value.

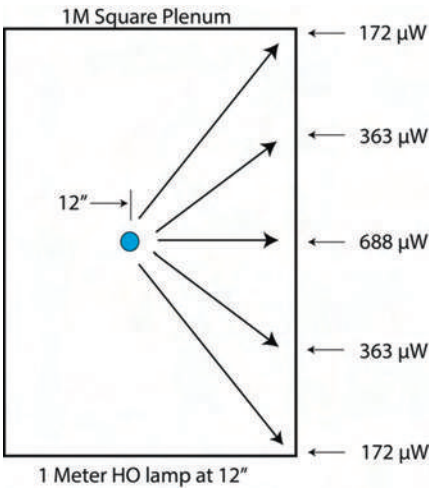


Fig. 3: An illustration of the view factor model... Courtesy: UV Resources

Following through our earlier example, 688 μW/cm^2 is multiplied by 0.25, which then results in 172 μW/cm^2 at the farthest points, or corners of the plenum.

The good news? UV-C dosage is 'increased' based on reflectivity from the plenum's surfaces, or the amount of UV-C energy bouncing off of the top, bottom, and sides of a plenum toward the coil and elsewhere.

Reflectivity sends UV energy everywhere to assure 'all' surfaces are clean and disinfected. Different materials have different reflectance multipliers, as shown in Table 1.

Using a galvanized steel plenum, as an example, the multiplier is 1.50 (a 50% increase in UV-C energy); hence 172 μW/cm^2 x 1.50 = 258 μW/cm^2.

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Metal	UV-C multiplier
Stainless steel	1.40
Galvanized steel	1.50
Aluminium	1.75

Table 1: Approximate UV-C dosage multipliers for different materials typically used in HVAC equipment... Courtesy: UV Resources

Even without reflectivity, the ASHRAE minimum UV-C dosage levels would be achieved at the farthest distance from the lamp to the coil. Should less light be used? Because more light positively affects the airborne kill of microbes – and because there is no significant cost savings for trying to use fewer or less-intense UV-C lamps, the 80-watt HO lamps are always recommended.

By working through the 1-metre example, the results can be used for future UV-C lamp installations as follows. The lamp was a 1-meter-long, 80-Watt HO lamp, irradiating a 1-sq-meter surface, or 10.76 sq ft. If the lamp wattage is divided by the square footage of the surface, it becomes (80/10.76) = 7.43Watts/sqft of coil surface area. This simpler method exceeds ASHRAE's recommendations of 100 $\mu W/cm^2$ at the farthest point, under typical operating conditions, when the lamp is located 12in.from the coil surface!

After determining how much light is needed, engineers need to select the types of lamps that will provide the necessary light energy. Among the considerations are single-ended (Fig. 4) and double-ended lamps (Fig. 5). Double-ended lamps are used in specific length configurations and usually confine the design in certain Air Handling Units (AHUs). Single-ended lamps provide a lot of flexibility relative to a given plenum's width because they can be overlapped (Fig.6). Single-ended lamp fixtures can also be used in hard-to-access plenums and smaller rooftop units, as they are installed and serviced from outside the plenum (Fig. 5).

Another consideration is whether to use PTFE encapsulation for safety. Encapsulated lamps trap the glass and mercury within a protective envelope should the lamp break. In most applications there is a risk of lamp breakage. Encapsulation is recommended because the clean-up procedures for broken lamps can be extensive as found in the 2011 ASHRAE handbook–applications, Chapter 60.

Courtesy: UV Resources

Fig. 4: Single-ended UV-C lamps are easily installed in commercial and residential air conditioning units...

Courtesy: UV Resources

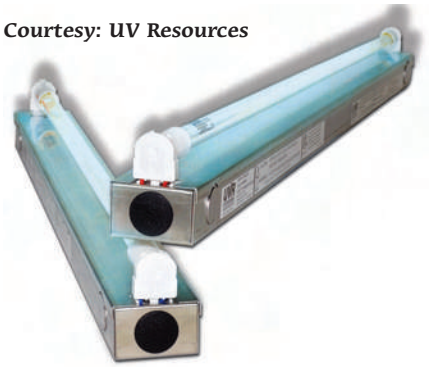

Fig. 5: Double-ended lamps are used in specific length configurations...

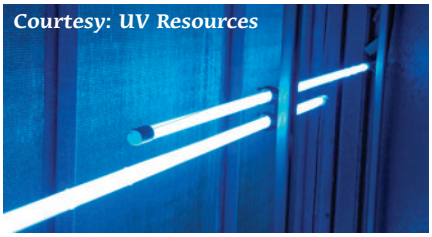

Fig. 6: Single-ended lamps can be overlapped...

When using single-ended lamps, lamps of a single length can often be selected for the entire facility. This minimises the number of spare lamps that must be kept on site, and it increases the purchasing power for buying in bulk when re-lamping on an annual schedule.

As mentioned, this approach simply overlaps lamps, and eliminates having to have combinations of sizes to get a perfect fit from one end of the coil bank to the other.

Installation design

For a complete UV-C installation design, engineers may want to specify certain other aspects of their design. This could include the calculated distance of 12 imch from the coil, and a lamp holder that will assure that the lamps are properly held and can be easily replaced. The installation design should also specify the required electrical power. Ballasts today are typically offered in 120-277 Vac designs for flexibility.

Controls

UV-C systems have relatively simple controls, most of which pertain to safety. A typical control package includes a cut-off switch located just outside the UV light installation's plenum door. Also included in that control circuit are the door interlock switches that turn off the lights when an access door is opened. Access doors can also be equipped with a view port to facilitate lamp inspections.

Another traditional control option is the radiometer, which can display lamp operating hours and a relative indication of UV-C output. However, radiometers only monitor one lamp, and if that lamp is on while others have failed, the option may be meaningless.

Also, lamps are much more reliable today and only lose as little as 15% of their initial output after 9,000 hours of operation, so the radiometer has lost favour.

Simple, self-powered current sensors show whether a particular lamp/ballast combination is on or out are in greater demand today. Multiple lamp/ballast sensors can be fed into a replicator that allows one signal to the Building Management System (BMS) to represent up to eight lamp/ballast combinations. They also can be chained together to represent an infinite number of lamp/ballast combinations with one signal. Additional programming can be added to alert operators – if a lamp or ballast is out, which eliminates the need to visit each AHU to check for failures.

When controls are designed into the UV-C system, commissioning providers need to check that they are documented appropriately and functioning properly.

UV-C light is an incredibly effective and affordable technology for keeping critical components of commercial HVAC systems clean and operating to 'as-built' specifications. Benefits of applying UV-C lamps in HVAC systems include greater energy efficiency, lower operating expenses, fewer occupant complaints and better IAQ. ■

Forrest Fencl
President
UV Resources
Writer or co-writer of 15 patents
A member of the International Ultraviolet Association and the Illuminating Eng. Society

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E: mansi.chawla@nm-india.com
mehak.mamtani@nm-india.com

Mumbai Office:
T: +91-9665161147
E: satyendra.mehra@nm-india.com
sujoy.gomes@nm-india.com

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Measure To Manage Your AC Load

Energy measurement is the first step towards the energy management. Whether logging of consumption should be done on daily or weekly or monthly basis that depends on the usage of AC…

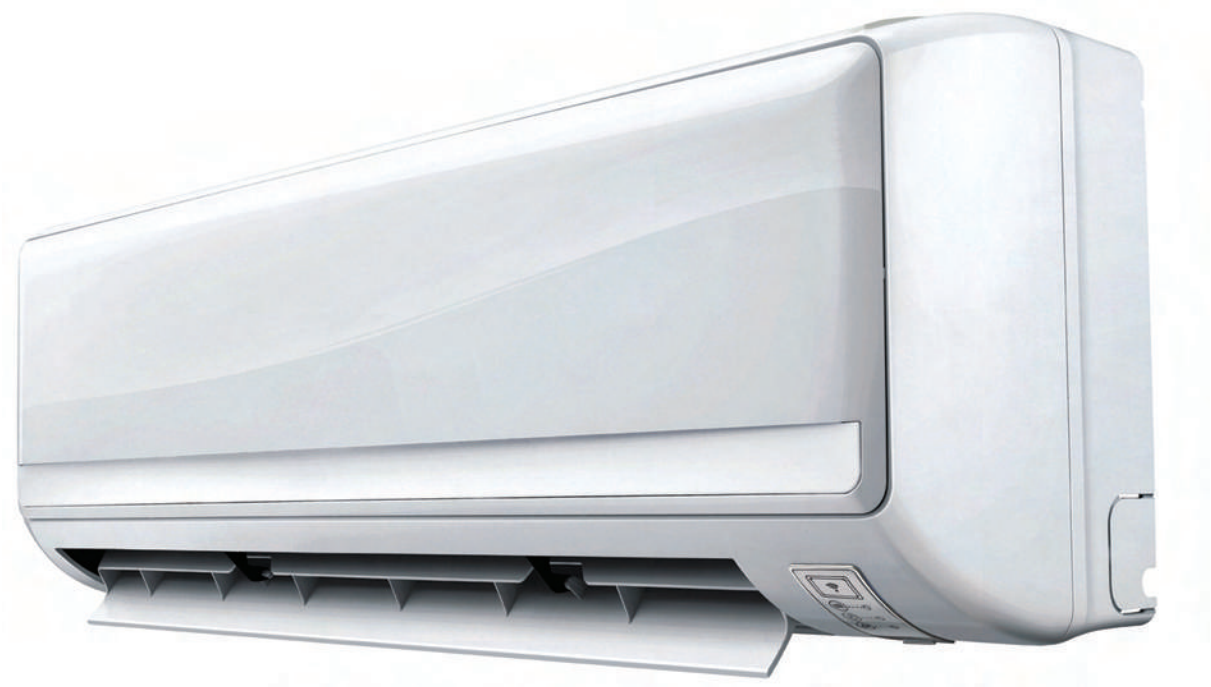
In the domestic electricity consumption, out of the total (say) 20 units per day consumption, more than 10 units are consumed by the Air Conditioning System (AC). If the same is monitored by just retrofitting a single phase static watt-hour meter costing around ₹ 400, then we can have day to day control on consumption of electricity for the purpose of air conditioning in domestic and commercial segments. That will prevent us from receiving annoying over inflated electricity bill after each month.

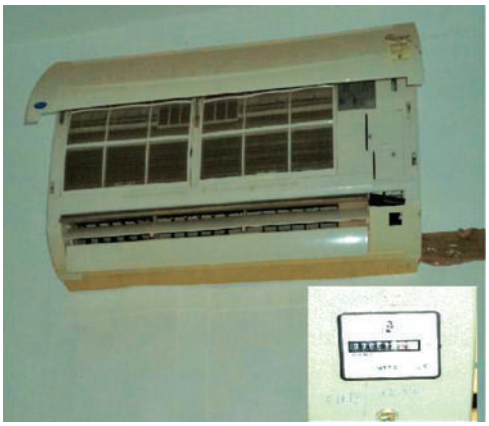
Need for monitoring AC systems

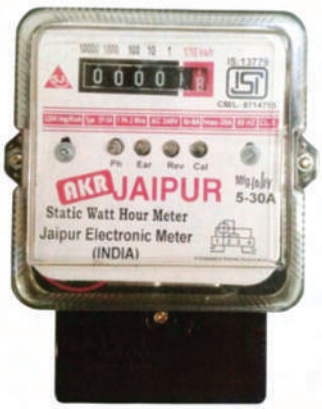
Energy measurement is the first step towards the energy management. Whether logging of consumption should be done on daily or weekly or monthly basis that depends on the usage of AC, as well as how an individual responds proactively. While using an AC, we must know the energy consumption for running it daily. Also, we should compare that with the total consumption per day in the domestic or commercial environment.

If more than one AC system is running in the premises, 'relative condition monitoring' of daily kWH of each of them will make the consumer think why the daily kWH difference is occurring among the AC systems operating in the same premises? The difference in kWH in daily readings will promptly draw attention of the energy conscious consumer to conserve energy.

Earlier, I advocated that each existing AC system should be fitted externally with an hour meter costing ₹ 400/. But addition of hour meter inside the new generation (already installed) AC systems is cumbersome. But for old window and







Word of caution: This kWH meter image does not promote or canvass its brand. Because of the price affordability at ₹ 400/- and availability through e-commerce site, its image is displayed here...

split AC, this hour meter can be easily added on to the compressor thermostat circuit indoor.

Also, I suggest that AC OEMs can add this hour meter as an integral part of the indoor AC system. This will show an AC machine's total run-hours, and the AC compressor's cut-in/cut-out hours – to indicate the AC user how effectively he uses his AC system in his premises.

When we buy star-rated AC systems for ₹ 20,000 or more, they (AC system manufacturers) must integrate this hour meter in their indoor units. In AC usage, everyone is accountable to local and global warming. As the energy-inefficient AC users contribute to reduce energy consumption and global warming potential, the government should offer tax reduction on the 5-star-rated AC systems and similar other electrical gadgets.

Because of the fall in price of the kWH meters from ~ ₹ 1000 to ₹ 400, these days it is much more easy for the AC consumer to assess his AC system's health by monitoring its daily consumption for the same given run hours. However, it is always better to assess an AC system's health by knowing the parameters like AC compressor's run-hours, AC machine's run-hours and the total consumption in the run-hours. This will give the clear picture of the AC machine's efficiency.

Reasons behind day-to-day varying power consumptions of the AC machines

Even if the same AC machine runs for nearly the fixed hours each day, its power consumption varies each day due to many factors. Following is a list of some of them:

- AC indoor temperature settings are generally set from 20 to 26^{0}C. But it varies depending on every individual's need
- Clogging in the AC evaporator filter goes unnoticed (it needs to be cleaned once in two weeks)
- Condenser coils getting choked over a period of few months to years
- AC outdoor unit can be torched under the sun or we can comfort the same by weather roofing
- The refrigerant leaks minutely over a period when not noticed; AC runs more hours to cool
- The AC compressor run-hours vary due to operating for more hours or more people inside
- The conditioned air when leaking out of premises, forces the AC compressor run fully
- When heat sources like fridge, deep freezer come inside premises, they increase the AC run hours
- Higher ambient outside and solar heat ingress from the roof increase the AC run hours.

Practical way of daily monitoring

Please find below, the technical details of ₹ 400 rated Static Watt-hour Meter as taken from www.snapdeal.com. The consumer can choose any similar branded meter of this type near this price to suit to his needs.

- 1 phase, 2 wire, Accuracy Class: 1.0
- Conformation with IS:13779, original ISI rated
- Current: 5 to 30 Ampere AC as load current
- Reference voltage: 240 Volts, Reference frequency: 50 Hz
- Display: Electromechanical counter with one decimal
- Surge resistant and tamper proof with magnetic shielding
- Sustained accuracy over long period of time
- Low power consumption
- High insulation and dielectric strength
- LED indication for current reversal tampering and phase availability
- Durable polycarbonate enclosure, which is UV protected, flame retardant.

How is this meter hooked up?

This kWH meter needs to be fixed between the MCB isolator to the AC stabiliser inside the conditioned area. Or, if the user has only one AC, the same can be fixed near the EB mains distribution board from where, the user has run a heavy conductor cable to match the AC load. In offices, IT, ITES work spaces where individual machines are working, this can be fixed near the indoor unit at a readable level from the floor.

Applications of relative monitoring

- Relative condition monitoring of air conditioners (if more than one fixed) inside premises
- When the AC is serviced, the daily kWH reduction before and after the service done
- When ACs are serviced, to give more attention to service to excess power consuming AC system
- Same area cabins and same size AC why still the varying kWH consumption can be studied
- KWH reduction can be noticed instantly on every AC: in-house efficiency improvement
- In case of overcharging, kWH consumption increases first to show impending breakdown
- If the stabiliser malfunctions or due to heavy voltage variations, the kWH varies

- If two AC systems at the same premises are of 3-star and 5-star respectively, the 5-star savings can be confirmed by monitoring.

Govt to mandate the 'monitor to target energy reduction' programme

- The govt has taken the initiatives to the AC system conservation. Through the 'star labelling programme,' it has spread the AC energy consumption awareness. But the govt gave the carrot only till now to the consumer and not the carrot & stick to them. It has promoted 5-Star ratings in AC; and year after year, BEE is changing the AC star ratings now, improving the 5-Star efficiency ratings
- Showcasing the energy conservation is the first thing. But prompting the AC user with kWH meter is more of 'DO IT YOURSELF TO CONFIRM YOUR ACHIEVED SAVINGS.' We have to catalyse the energy efficiency practices by forcing the consumer to practice
- The proof of pudding is in the eating. The govt has showcased the AC efficiency norms. But same govt must mandate each of the AC consumers to verify with this type of affordable kWH meter to his existing AC. On condition monitoring his AC daily, weekly and monthly, each consumer will start saving electricity in his AC. The same consumer will showcase his savings to his neighbours, friends around him; this attitude will multiply and improve the energy efficient people culture
- So, to cultivate the energy efficient people culture among AC users, the govt has to make it compulsory to fix kWH meter in each and every existing AC system. Then each AC user will monitor his AC consumption to target reduction in his existing AC first. Later he will automatically switch over to 5-star rated AC
- The energy experts in BEE and in the ministry said in 2012, that energy-efficient electrical appliances (majority is AC only) used in household and commercial establishments can save about 20,000 MW (Mega Watt) of power per year, resulting in savings of ₹ 1.2 lakh crore in capital investment on new power plants. India spent ₹ 23,000 crore in clean energy programmes till 2011. BEE says in 2012, that around 1.15 crore labeled air conditioners have been sold across the country during the past five years
- When the new AC consumer is buying his AC system, he must be mandated to buy this kWH meter along with AC to fix during installation. It is similar to the agriculture segment, the farmer is mandated to buy capacitor along with his new purchase of motor. This gives saving to him and reduction in T & D loss in rural sector
- When the consumer has decided to spend ₹ 20,000 + towards his new AC; over the counter, he can be convinced to buy this static kWH low cost meter for the sake of monitoring
- What will happen to the AC system user after installing this retrofit kWH meter to his AC after a few months /years of run?

a. He'll be 1st shocked to find his AC's guzzling power use all these years
b. Next, he will find relief in implementing in his AC, the zero cost energy efficient running practices
c. Next, he will be delighted to see more savings after implementing low cost ECON measures to his AC
d. Later, the consumer will be happy to share and showcase his kWH savings achieved in his AC to others.

All the above govt suggestions will become a reality practically today, if this one step is enforced by the govt to promote consumer's existing and new AC efficiency in domestic and commercial segments. ■

Ashok Sethuraman
A BEE Accredited Energy Auditor
Website: www.energymeasuretosave.com

Compressor Technology Helps Improve Efficiency

The demand for energy saving appliances is on the rise, while businesses in India strive to achieve smaller carbon foot prints. Energy saving HVAC systems of the future promise better bang for the buck in the long run…

Air-conditioner manufacturers today are deploying technologies which are focused not only on achieving a desired level of climate control – but also sipping less power while doing so. Energy efficiency with emerging technologies will undoubtedly play a dominant role in influencing air-conditioning research, design and development in the near future.

Variable Refrigerant Flow (VRF) systems

Specifically engineered for mixed-use real estate properties and the hospitality industry, HVAC systems like the CITY MULTI VRF (Variable Refrigerant Flow) divides the entire space in a building into individual cooling or heating zones, while providing each individual zone with a personalised comfort system. This ensures total comfort for the occupants of offices, schools, hospitals, assisted-living facilities, hotels operating in the building.

Zoning offers maximum individual comfort and energy savings, because each zone receives air-conditioning only when it needs it. Each zone of the CITY MULTI VRF system has its own indoor unit or group of indoor units that precisely controls the indoor temperature, while operating with minimal energy usage. One has to only set the comfort level and then sit back while the technology takes over. VRF saves 40 to 50% less power than conventional HVAC systems.

Zero OPD refrigerants: Newly developed cooling agents like the R410A refrigerant are chlorine-free, non-flammable, environment friendly. The R410A is labelled as zero ODP (ozone depletion potential) – and is about 20% more energy efficient compared to conventional air-conditioners.

Inverters

Inverter technology systems developed in Japan, produce the right amount of output to match the exact requirements in any commercial or residential space.

In this system, the compressor remains on, but will consume only that much power required to keep the temperature stable at a desired level. It automatically adjusts itself based on the requirement of the room, thus drawing much less power and consuming lesser units of electricity. These systems work so efficiently that they don't waste valuable energy by over heating or over cooling; resulting in greatly reduced running cost. Inverter technology can save up to 30 to 50% of electricity over a regular air conditioner.

Econo-cool smart save systems

The Econo-cool smart save system is a one touch operation (system), which automatically adjusts the direction of airflow based on the temperature at the air outlet. The set temperature can therefore be two degree Celsius above the conventional temperature settings without the loss of comfort and with 20% increase in energy efficiency.

Advanced compressors and DC motors

The latest innovation in compressor technology helps improve efficiency by using a DC brushless motor. This reduces standby power consumption by a heating compressor instead of a crankcase heater. The Re-engineered shape of the bell-mouth hood has improved static pressure at the exhaust air outlet facilitating a reduction in fan input power.

Environment temperature control technology has also reduced the energy consumption by controlling the refrigerant temperature according to the operational load and raising evaporating temperatures. This product engineering gives an edge over conventional HVAC units in the market.

With the HVAC market in India pegged at around ₹ 7500 to ₹ 8000 crore and poised to grow at 13.6% over next five years, manufacturers are wooing customers with the promise of long-term cost saving. Some companies like Mitsubishi Electric have managed to strike a fine balance in offering performance, reliability, low power consumption and a long operational life.

The Environmental Vision 2021 is an initiative that was launched by Mitsubishi Electric way back in 1991 as a 30-year effort to build a greener planet. It sets dramatic goals for reducing green house gas emissions (reducing carbon dioxide emissions from product usage by 30%), recycling resources and raising environmental awareness by 2021. ■

Neeraj Gupta
General Manager - Sales & Marketing
Living Environment Division
Mitsubishi Electric India

Air Conditioning Options For Buildings

This article explores the various air conditioning options for multi storied, multi room cooling spaces like hotels, hostels and training centres. In these types of buildings the ratio of the living room spaces to the common spaces is around 70-80% of the total conditioned space...

Central air conditioning (AC) systems using refrigerant R410A can be classified on the basis of mode of transfer of cooling effect as:

- Chilled air
- Chilled water
- Refrigerant (variable refrigerant flow)

The oldest AC plants are the chilled air systems where the air is chilled through direct expansion of refrigerant and the chilled air is distributed across the cooling spaces. The advantage of this system is that it handles only air in the secondary cooling side and involves low risk of loss of refrigerant. The major disadvantage of this system is that air has low density and handling air involves large ducts which occupy space, results in operational noise and vibrations due to fan operation, consumes high electrical power for transfer of air to the conditioned spaces and there are losses of both air and cooling effect during the transfer.

To overcome this deficiency of handling large volume of chilled air circulation, large volume of space occupied by the ducting, chilled water circulation systems were introduced. The chilled water is pressurised demineralised water is circulated between the evaporator (chiller) and the load. Further down, the cooling effect is transferred through the air cooling systems. The chilled water system reduces the volume occupied by the AC system considerably and is transferrable between buildings, across multiple storeys. The cooling effect is transferred from the chilled water lines to the conditioned spaces through air handling units (AHUs) or fan coil units (FCUs) for individual rooms.

The most modern system is to have a large condenser consisting of high pressure liquid refrigerant, transfer it to the vicinity of the required conditioned spaces and then expand the liquid to vapour in an evaporator located in the conditioned space as a split system. The compressor, condenser and the cooling system like cooling tower, are all located in a single outdoor location and can be called as an outdoor unit. The evaporator is located indoor very near the area required to be air conditioned. This system is called as VRF system.

In VRF systems, since the high pressure from the condenser is being transferred, there is no requirement for insulation of the piping and the cooling effect is realised only on expansion after the expansion valve in the evaporator. This system will avoid the energy losses (cooling energy loss) due to insulation of the chilled water pipelines between the chillers and the AHUs. Also, the AHU losses are avoided. Therefore from the angle of energy efficiency this system is more efficient than the other two systems described above.

Typical advantages of VRF systems are zoning flexibility implying that independent temperature control for different rooms/spaces. Capacity controllability, ease of retrofitting, low installation cost, minimization of ducting space. It is possible to have refrigerant piping of as much as 100 m with multi-splits in ceiling cassette configurations and concealed ducting adding to the aesthetics of the building design. In zones which are inadequately cooled by conventional AC systems, the VRFs come in handy.

New design advances like the use of variable frequency drives for compressors and cooling tower fans of condensers for energy saving capacity modulation can be usefully employed for capacity control of VRF systems.

The main disadvantage of the VRF systems are a large condenser volume, large volume of refrigerant (refrigerant charge is more than double that of conventional systems), large ducting of refrigerant piping which can be potential sources of refrigerant leaks from the system. Another major disadvantage of the system is the requirement of a separate ventilation system for air change as this system provides only cooling effect and ventilation has to be separately taken care of.

Energy efficiency of AC plants

The indices are both inherent (machine dependent) and installed dependent on both machine and its operating environment).

Three inherent indices of energy efficiency are:

- SP (Specific electric power) (kW of electric power input per tonne of refrigeration = kW/TR) [1 TR=3.516 kW]
- EER (energy efficiency ratio) = cooling load (kW)/ electric input (kW) which is expressed on the basis of p.u., it is generally in the range of 2.3 to 3.1.
- COP (coefficient of performance) is given by the ratio 3.516/SP

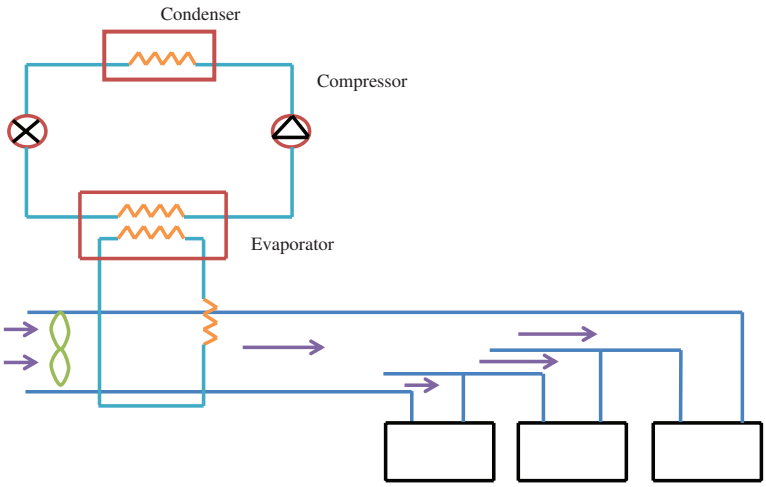


Fig. 1: A Conventional AC with chilled air circulation through AHU...

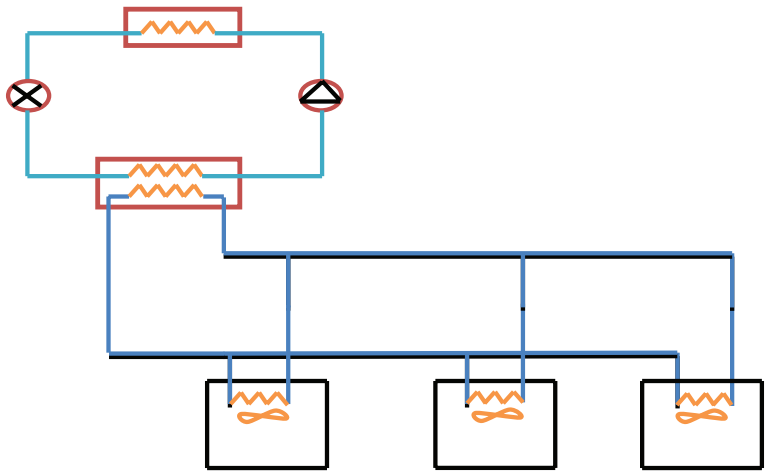


Fig. 2: A conventional AC system with chilled water circulation through fan coil unit systems...

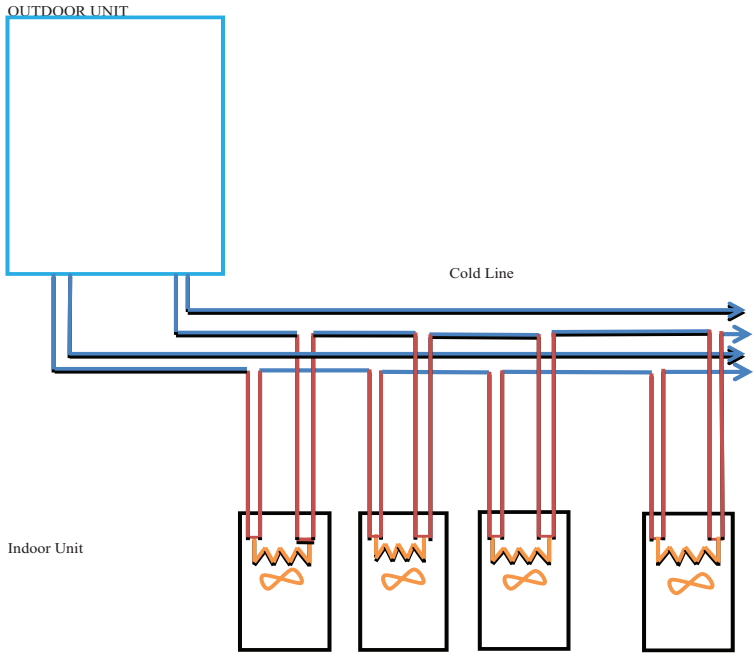


Fig. 3: View of a variable refrigerant flow air conditioning system...

> *The high cost of the central and VRV systems is because of the ducting required to be drawn whereas for split systems only electrical supply needs to be provided...*

The above three are interrelated. The installed energy efficiency index is the SEC (specific energy consumption) in kWh/m^2/year or in kWh/TR/year. As per the Energy Conservation Building Code of India, the energy efficiency of buildings must be within 120 kWh/m^2/year for AC buildings and 25-40 kWh/m^2/year for non AC buildings. The AC contribution can be taken as 80-90 kWh/m^2/year. The AC power is benchmarked at 25 W/m^2. To compute the specific energy (kWh/TR/year) from specific power rating (kW/TR), the on time to total time ratio is ratio of the period under which the AC plant is in operation and drawing full active power to the total time period under consideration (24 hours/day; 720 hours/month or 8760 hours/year). This is a temperature dependent factor and is designed to be around 0.1 to 0.3 for the ambient temperature of 33-34ºC and is reduced to zero when the ambient temperature coincides with conditioned air temperature.

Table 1 shows the cooling load per unit area for different sizes of AC systems. Table 2 indicates Electrical load for cooling per unit area (floor space) for conventional compression air conditioning and Table 3 shows the annual energy consumption for cooling per unit area (floor space) for conventional compression air conditioning. In the case of variable refrigerant flow systems (VRF or VRV) and energy saving of around 10% can be expected to account for reduced energy losses of cooling systems (cold air ducts or cold chilled water pipelines) since liquid refrigerant at high pressure is transferred and expanded to low pressure at the load end. Beside the reduced losses due to dispersion losses of the cold air and water piping, the energy savings are resulting from capacity control. Most ACs do not operate at 100% of the load but at 30-70% load for which efficient capacity control is called for. The VRF systems are able to modulate their refrigerant output to suit the load requirement and with VFDs energy savings can be achieved at part loads.

Sl. No.	Particulars of floor area with a height of 3.1 m	Specific cooling capacity range (TR/m^2)	Specific cooling capacity (average value) (TR/m^2)
1.	Individual rooms	0.110-0.140	0.114
2.	Medium sized cooling spaces	0.060-0.075	0.065
3.	Large sized cooling spaces	0.040-0.050	0.045

Table 1: Cooling load per unit area (floor space)...

Sl. No.	Particulars of floor area with a height of 3.1 m	Specific electric input range (kW/m^2)	Specific electric input range (average value) (W/m^2)
1.	Individual rooms	0.143-0.182	150
2.	Medium sized cooling spaces	0.110-0.390	120
3.	Large sized cooling spaces	0.075-0.090	85

Table 2: Electrical load for cooling per unit area (floor space) for conventional compression air conditioning...

Sl. No.	Particulars of floor area with a height of 3.1 m	Specific electric energy range (kWh/m^2/year)	Specific electric energy range (average value) (kWh/m^2/year)
1.	Individual rooms	125-160	130
2.	Medium sized cooling spaces	145-178	160
3.	Large sized cooling spaces	131-158	150

Table 3: Annual energy consumption for cooling per unit area (floor space) for conventional compression air conditioning...

Sl. No.	Particulars of floor area with a height of 3.1 m	Capital cost (range) (₹ Lakhs/TR)	Capital cost (average) (₹ Lakhs/TR)	Capital cost (average) (₹ Lakhs/m^2)
1.	Split air conditioners (1.5 TR)	0.35-0.45	0.40	0.045
2.	Central air conditioners of conventional type of chilled water line, air ducting and air fans (100 TR)	0.70-.090	0.75	0.048
3.	Central air conditioning with variable refrigerant flow system (100 TR)	1.1-1.3	1.2	0.054

Table 4: Capital cost for different types of air conditioning systems...

Economics of AC plants

Table 4 gives the capital cost for different systems. The high cost of the central and VRV systems is because of the ducting required to be drawn whereas for split systems only electrical supply needs to be provided and the ducting lengths are quite small for each individual unit. Though the cost on cooling load basis (TR) are significantly different the cost per m^2 of floor space cooled are showing less variations. The pay back period per m^2 of floor space cooled is around 6-7 years for VRV systems as compared to central ACs and 9-11 years as compared to split ACs.

Applicability of VRFs for multi room cooling spaces (hotels, hostels and training centres)

Typically in multi storeyed, multi room cooling spaces (hostels, hotels and training centres) contain the following types of spaces to be air conditioned:

- Common spaces like:
- Lounges

- Dining Halls
- Lecture/Meeting halls
- Banquet halls
- Double rooms

The ratio of the living room spaces to the common spaces is around 70-80% of the total conditioned space. For central areas, central ACs or VRF central systems can be considered. For individual rooms split ACs can be considered. In multi storeyed systems with several elevations, the space occupied by chilled air ducting becomes quite considerable and it is better to go in for fan coil units installed in individual rooms with chilled water circulation to the rooms. An alternative to the conventional chilled water system is the VRF system where the refrigerant can be conveyed at high pressure to the cooling area and expanded therein.

The choice between (a) central systems for the whole building, (b) split systems for individual rooms and conventional central systems for common cooling spaces, and (c) VRFs for the entire building, in most cases depends on the capital cost made available at the time of building construction. Where there are capital cost constraints, users tend to go in for option (b) in two phases. Where aesthetics are not compromised, then VRFs are ideally suited. In the case of retrofitting of old buildings which do not have provision for duct work or ducts, VRFs are the ideal choice. VRFs also address the cases where conventional ACs are unable to provide the required level of cooling in the rooms or areas where cooling is required. VRFs overcome the poor controllability of AHUs of conventional ACs. By coupling the VRFs with heat recovery wheels for recovery of cooling effect, there could be good energy saving up to 70%.

Concluding remarks

- For multi storeyed, multi room cooling spaces (hostels, hotels and training centres) the air conditioning choice is between (a) central systems for the whole building, (b) split systems for individual rooms and conventional central systems for common cooling spaces, or (c) VRFs for the entire building.
- In most cases the choice depends on the capital cost made available at the time of building construction. High capital cost is one of the main deterrents to this technology as a result of which the market penetration is hardly 1 in India and 2-3 % in Europe and Japan.
- Energy wise VRFs give a saving of around 10 % but the savings are offset by high capital cost which is ₹ 1.2 lakhs/TR as compared to ₹ 0.40 lakhs/TR for split systems and ₹ 0.75 lakhs/TR. However, if one goes by the cost per unit floor space the costs are almost comparable (₹ 0.045 to 0.054 lakhs/m^2). ■

M Siddhartha Bhatt
Additional Director &
Divisional Head of the
Energy Efficiency &
Renewable Energy Division
of CPRI, Bangalore

Winning Customer Engagement

By installing two HMX-Ambiators, D B Corp Limited managed to maintain the inside temperature at their printing facility in Indore in the range of 26 to 27^{0}C, when outside was as hot as at 45^{0}C...

HMX-Ambiator in application...

D B Corp Limited, informally known as the Dainik Bhaskar Group, is the largest print media company in India. It is well known for its flagship Hindi daily newspaper Dainik Bhaskar, its Gujarati daily newspaper Divya Bhaskar, and its Marathi daily newspaper, Dainik Divya Marathi, as well as other publications such as Business Bhaskar, Saurashtra Samachar, DB Star and DNA.

The challenge

The group set up a new newspaper printing facility in Indore, Madhya Pradesh, to publish the popular English daily, DNA.

The new facility was built on an area of approximately 4,000 ft^2 with a height of 40 feet. Indore is a hot and dry city where the temperature soars up to 45^{0}C in summer.

To add to the woes of the staff working there, the sensible heat load inside the newly constructed facility was a staggering 1,700,000 BTU/h.

In spite of these conditions, the management wanted to maintain a maximum temperature of 30^{0}C inside the facility during the peak summer season. This was an extremely difficult condition to achieve keeping in mind the searing heat outside and the heat load inside the facility.

Outcome of simulation

On the basis of the heat load calculation, an air conditioning system of 142 tonnes was required to maintain a temperature lower than 30^{0}C inside the facility. This solution was rejected because of the high capital as well as operational expenditure involved.

Action and result

Two HMX-Ambiators were installed and commissioned – and the temperature readings recorded inside the facility showed that it could be maintained in the range of 26 to 27^{0}C.

D B Corp was already using HMX-Ambiators at their printing facility at Mhape in Navi Mumbai, which is an installation of close to 0.3 million CFM. The company was highly satisfied with the performance of the units even during the peak summer season.

HMX-Ambiator 40000 CFM (Unit 1)					
Sr. No	Time	Ambient		Room	
		DBT (^{0}C)	WBT (^{0}C)	DBT (^{0}C)	WBT (^{0}C)
1	10.00 am	38.00	20.70	26.00	23.00
2	01.00 pm	41.10	20.50	27.20	34.90

HMX-Ambiator 40000 CFM (Unit 2)					
Sr. No	Time	Ambient		Room	
		DBT (^{0}C)	WBT (^{0}C)	DBT (^{0}C)	WBT (^{0}C)
1	10.30 am	38.40	20.90	26.20	23.10
2	01.30 pm	41.50	20.50	27.00	24.50

Keeping the high internal heat load and the high ambient temperatures in mind – and the satisfactory experience with the HMX-Ambiators, the management decided to go for the HMX solutions to provide comfortable working conditions inside the facility at Indore.

HMX suggested that a total of 80,000 CFM would be required to maintain the desired condition inside. Accordingly, 2 x 40000 CFM HMX-Ambiators were installed at the facility.

The management of DNA, Indore, was happy with the performance of the HMX-Ambiators. According to Sharad Patil, General Manager – Maintenance and Facilities, this solution has proved to be perfect for them as they got what they were looking for from a cooling solution with an excellent price-performance ratio.

Mutual benefits

Impressed by the performance of the HMX-Ambiators at Indore, the management of DNA went ahead and replaced their existing air washer units at Ahmadabad and Jaipur with these systems. ■

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A Hot Day With Cold Chain Professionals

The time has come when we should start looking at cold chains as a different sector all together, and work on further developing this sector through continuous innovation and absoption of new technologies…

It was June 9, when around 150 top level professionals from the user community (FMCG, Pharma, Quick Service Restaurants and Hardline Retail Stores), service providers, consultants, IT solution providers and financial institutes connected to Indian Cold Chain, assembled in Mumbai to evaluate the present challenges, trends and potentials of the Indian Cold Chain.

The 4th Cold Chain Strategy Summit, which was organised by KamiKaze B2B Media, turned into an excellent knowledge sharing platform. There, more than 20 speakers shared their knowledge and expertise on various topics. The vendors noted the emerging challenges in the field, and the users explored some new solutions that they were looking for. Representatives from the field of finance exposed everyone with the potential growth areas, where profitable ventures can be set up.

(L2R) Sandeep Anand, Head Merchandise Planning (FMCG & Staples), Bharti Retail; Rajeev Bhanawat, Head Liquid Milk Business, Parag Milk Foods; (Moderator) Devdip Purkayastha, President, CHEP India; Saravana Gughan S D, Executive Vice President – India and International, &Samhoud Food B.V.; Ritesh Manchanda, National Distribution – Manager, Yum Restaurant; Harpreet Singh Malhotra, CMD, Tiger Logistics India and Ritesh Bhatia, Business Head, FSC Cold Chain are in a panel discussion on the last mile distribution…

Glimpses from the thought waves

Atul Patil, Regional Manager (West), Bry-Air (Asia) Pvt. Ltd.

Atul Patil, Regional Manager (West), Bry-Air (Asia) Pvt. Ltd., delivered his presentation on the requirement of dehumidification in cold storages. According to him some of our cold storages need defrosting even in every 5 to 6 hours, so better the technology used more effective is the result obtained. Also, it leads to cost saving.

Rouble Kataria, VP - R&D and Training, Haldiram Snacks Pvt. Ltd.

Rouble Kataria, VP - R&D and Training, Haldiram Snacks Pvt. Ltd., focused on the supply change challenges during new product development. Kataria feels that continuous monitoring of the temperature during food transit is very essential as we need to deliver the right quality to the consumer. She also stressed on training of the field personnel in this regard.

Lloyd Sanford, Executive Director/Founder, Top Blue Supply Chains Pvt. Ltd.

Lloyd Sanford, Executive Director/ Founder, Top Blue Supply Chains Pvt. Ltd., highlighted different aspects of a smart cold chain. He holds that understanding objectives, qualifying project needs, validating raw material sourcing, end-product demand and local people's affordability etc., are very important for building a robust cold chain.

Prasad Deshpande, Head - Procurement, Global Supply Chain & Contract Management, Biocon Ltd.

Prasad Deshpande, Head - Procurement, Global Supply Chain & Contract Management, Biocon Ltd., drew attention on the requirement of fixed temperature range during distribution of complex biologics. He feels, as the entire medicine system is changing globally, to send certain formulations to foreign buyers, Indian pharmaceutical companies need very efficient, reliable and visible cold chains. It's a big challenge today.

Saravana Gughan S D, Executive Vice President – India and International, &Samhoud Food B.V.

Saravana Gughan S D, Executive Vice President – India and International, &Samhoud Food B.V., pointed at the evolution of the milk supply chain. With the growth of the domestic market, the old practice of maintaining a filling plant near the market is no longer enough. Also, collecting milk from the villages is a big challenge. Thus, new generation cold chain has to sort out these challenges.

Glimpses from the thought waves

S. Venkatraman, Partner & Head (Mumbai), Rabo Equity Advisors Pvt. Ltd.

S. Venkatraman, Partner & Head (Mumbai), Rabo Equity Advisors Pvt. Ltd., highlighted the opportunities for cold chain solutions across various food sub-sectors. In the organised segment, dairy, meat, seafood and imported fruits are driving demand for cold storage infrastructure. Controlled Atmosphere (CA) storage for apples has been picking up. Also, there has been a steady shift towards palletised storage as well as multi chamber storage. There is an emerging opportunity in managing backend storage and logistics, especially in case of perishables as well as handling of frozen foods and ingredients for organised food service. Also, there is an opportunity to augment cold chain facilities and container handling facilities at major ports as well as at air cargo complexes for targeting global markets.

> *"As the entire medicine system is changing globally, to send certain formulations to foreign buyers, Indian pharmaceutical companies need very efficient, reliable and visible cold chains…*

The event enlisted three panel discussions with different themes, namely – A systematic view of the supply chain: How to increase potential of end-to-end supply chain visibility, design business strategies and achieve logistics excellence; Last mile distribution: Re-engineering your supply chain whilst maintaining compliance and operational excellence; and Ensuring quality throughout the product supply chain: From manufacturer to customer quality control in emerging markets and global supply chains. Also, there were six presentations by individuals.

Simultaneously, with the conference, a small exhibition was arranged to demonstrate the latest developments in the cold chain sector. Experts from Gandhi Automations, Maini Materials Movement, Koolex, Future Supply Chains, TCI and CHEP had interacted with the visitors through their stalls. The much awaited Cold Chain Industry Awards, which were presented by Future Supply Chains recognised the leaders in the cold chain industry. The winners included TESSOL, Jubilant Foodworks Ltd., Mondelez India Foods Ltd., GUBBA Cold Storage, ITC Ltd., HUL, TCI Supply Chain Solutions, Emerson Climate Technologies and others.

The entire event was highly interactive, several questions were asked by the enthusiast audience. Also, the roles of the moderators in the panel discussions were praiseworthy.

A few points that the day-long session kindled in the minds of the attendees

- Dehumidification of the cold stores is very important, especially in India, where three sides of the country have water sources.
- Before developing a new food item, cooked food manufacturers should examine their logistics capability – as unlike other supply chains, here an additional target finds utmost importance – that is to be able to reach the food item to the customer with the right quality.
- Protection of maximum product value and improvement of cold storage's ROI are two important aspects that should be assessed before developing a new cold storage.
- For pharma-logistics simple cold environment is not enough. The logistics process should ensure that the specific temperature range is maintained throughout the handling process.
- In milk logistics too temperature range is important. As dairy logistics is growing in the country, stringent focus should be put on this segment. We have to gear up for seasons of non-availability.
- For protein, fruit and other perishable food items also, we have to build more strategic cold stores, depending on local (domestic) people's availability and foreign demand, especially, at a point when Indian grapes and prawns are catching up global attention.

Communication from an attendee

Anil Sabharwal, Director, Sabharwal Food Ind. Pvt. Ltd. (Roshan Frozen & Cold Storage)

Anil Sabharwal, Director, Sabharwal Food Ind. Pvt. Ltd. (Roshan Frozen & Cold Storage), who was present in the event informed, "I found the 4th Cold Chain Strategy Summit a good experience to attend. The event was well organised and efficiently managed. The speakers and attendees were diverse – but almost everyone was involved in the cold chain and logistics function in their companies and organisations. Thus, the discussions were practical."

"I also had the opportunity to meet up with some new people and companies – and that was a good takeaway that provided me the opportunity to create awareness about our new cold chain project set up with Danfoss."

Conclusion

In the last one decade or so, we have focused on developing robust supply chains in the country. So far cold chains have been treated as an integral part of the supply chain sector. However, India being a tropical country, now the time has come when we should start looking at cold chains as a different sector all together, and start working on further developing this sector through continuous innovation and absorption of new technologies. ■

P K Chatterjee
Editor
Cooling India

Building Insulation With Thermal Imaging

Building inspectors have been using FLIR thermal imaging cameras for energy audits for decades, but the investment cost prevented many building and installation companies from buying one. In recent years increasingly affordable models have entered the market…

One of the building professionals that leaped at the opportunity is Björn Blomgren of the Nybro, Sweden, based service company Hammarstedts. He expresses, "When I bought the camera I was afraid that I would not use it often enough to justify the investment, but it soon became clear that this was not a problem. As I went along I found more ways of using the FLIR thermal imaging camera. It really is a very versatile tool."

"I already had some experience with thermal imaging cameras because I worked as an industrial maintenance technician in the past, but the thermal imaging cameras I used back then were large, cumbersome and too expensive for a building professional", Blomgren recollects. "That's why I never bought a thermal imaging camera, even though I knew that it would be a great asset." But a few years ago Blomgren heard about the FLIR i5 thermal imaging camera, an affordable entry model that fell within his budget. "There simply was no reason left for me not to purchase a thermal imaging camera. I am very glad that I did it, for it is a very useful and versatile tool."

With a resolution of 80x80 pixels and a thermal sensitivity of 0.10 °C the FLIR i5 provides professionals with a thermal imaging solution that is adequate for a large number of applications. Together with its similar counterparts the i3 and the i7 it is one of the smallest, lightest and most affordable thermal imaging camera on the market. Designed to be easy to use, it requires but basic training to obtain thermal images that will immediately give you the thermal information you need.

Björn Blomgren demonstrates the use of the FLIR i5 thermal imaging camera…

This versatile tool can be used for a wide variety of applications, including HVAC system and building insulation inspections…

Quick guide to sell houses

Blomgren uses his FLIR i5 thermal imaging camera mostly for building inspections. "In Sweden it is required by law to provide documentation of the energy consumption of a house before it is sold to the new owner. This does not necessarily include an energy audit, so in some cases this is just a list of figures that show the energy consumption by the previous owner. But I think it is a good selling point for the house if a proper energy audit is included as well. That is why I started offering that service. And apparently I'm not the only one who thought that such an energy audit would be a good selling point, for many house owners who want to sell their house have already hired me and the amount of requests keeps rising."

According to Blomgren the energy audit service for house sellers is also good promotion. "If you deliver a good service with accurate and reliable results then both the seller and the buyer of the house will be inclined to contact you if there is a building related issue. But that is only if the service you deliver is good. If a house has defects I have not detected during the survey, then that is not good for my reputation, so I always make sure that every survey is thorough and accurate."

Variety of applications

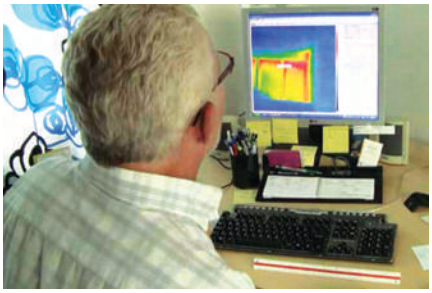
Building inspections are mostly done in the winter because a sufficient temperature difference is necessary between the inside and outside temperatures to be able to spot insulation failures. Blomgren therefore worried that the FLIR i5 camera would be idle half of the year. Looking back he is glad to see that this was not the case. "There's a wide variety of applications you can use this camera for. It can do much more than building inspections alone." The most obvious use of the camera for a company that specialises in building and heating ventilation air conditioning (HVAC) systems is for HVAC maintenance. "With every HVAC system we install we perform a thermographic survey before delivery, to confirm that everything is working properly. Being able to show the customer this report is a great advantage."

Validating complaints and finding faults

Sometimes Blomgren is also called in when there are complaints. "With the thermal imaging camera you can immediately see

whether there is some truth to the complaint. A recent example of this use of the FLIR i5 thermal imaging camera was a university building nearby. “A new HVAC was installed by another company, but there were complaints about rooms being too warm or too cold, so the university called me for help. I performed a thermographic survey of the premises and I found that there were problems with air circulation causing certain areas to warm up while others remained cold. Based on my survey the problem could be solved.”

Another very obvious example of the use of the thermal imaging camera is with under-floor heating. “If there is a leak in the under-floor heating it is very easy to find with the thermal imaging camera, without having to open up the entire floor, for instance. Not only does this save time and effort, but money as well.” But it’s not just leaks in under-floor heating that can be found with the FLIR i5 thermal imaging camera, according to Blomgren. “There have also been cases where plumbing had started to leak, causing water damage. With the thermal imaging camera I was able to find the leak faster and without opening up the walls. This allowed the plumber to more accurately coordinate the repairs.”



Blomgren uses FLIR QuickReport software to analyze thermal images & to generate reports for his clients...

Solutions for refrigeration and cold storage

Hammarstedts is the leading service company in the south-east part of Sweden delivering innovative solutions within heating, ventilation, energy and process automation. Blomgren's colleagues also deliver complete solutions for the refrigeration and cold storage rooms in supermarkets. If they have problems with their installation Blomgren's colleagues often call in his help. "With the FLIR i5 thermal imaging camera you can quickly spot whether there is a problem with the insulation. This is something that you can do all year round, since there is usually a large temperature difference between the inside of the refrigeration unit and the temperature in the room outside the refrigeration unit.”

All in all Blomgren is very happy with his FLIR i5 thermal imaging camera. “The i5 thermal imaging camera definitely has an adequate image quality for these applications. I use this camera so much in the field that I am considering to buy a new thermal imaging camera from FLIR Systems. Perhaps a FLIR E-series or a B-Series thermal imaging camera, I’m not sure yet. But it will definitely be a FLIR camera. That much is certain. No other supplier provides the same combination of user friendly design, thermal imaging performance and affordable price tags that is offered by FLIR Systems.” ■

For more information about thermal imaging cameras or about this application, please contact: www.flir.com

Reduction Of Radiant Heat

Most insulation materials work on the principle of trapped air gas being a good insulator...

The radiant heat is invisible and has no temperature, just energy. When this energy strikes another surface, it increases the temperature of that surface. In summer, radiation from the sun strikes the outer surfaces of walls and ceilings and is absorbed causing the surface to heat up. This heat flows from the outer wall to the inner wall through conduction which is then radiated through the air spaces in the building to other surfaces within the building. Radiation between surfaces is through invisible infra-red heat rays. Different types of insulation products reduce the heat transferred by conduction, convection and radiation to varying degrees. As a result, each provides different thermal performance and corresponding 'R' values. The primary function of reflective insulation is to reduce radiant heat transfer across open spaces, which is a significant contributor to heat gain in summer and heat loss in winter.

There are many types of materials that reduce heat gain and heat loss. Some materials provide greater resistance than others, depending on the mode of heat transfer: convection, conduction or radiation. Most insulation materials work on the principle of trapped air gas being a good insulator. Mass insulation like, 'INSU shield'- closed cell, FR cross linked polyethylene foam, use cellular walls of plastics, fibre glass wool uses glass fibres to reduce convection thereby decreasing the transfer of heat. These materials also reduce heat transfer by conduction due to the presence of trapped air. (These products, like most building materials, have very high radiant transfer rates). Most building materials, including fiberglass, foam and cellulose have 'E' values in excess of 0.70.

Reflective insulation typically have 'E' values of 0.03 (again, the lower the better). Therefore, reflective insulation is superior to other types of insulating materials in reducing heat flow by radiation. When reflective insulation is installed in building cavities, it traps air (like other insulation materials) and therefore reduces heat flow by convection thus addressing all three modes of heat transfer. In all cases, the reflective material must be adjacent to an air space. Aluminium, when sandwiched between two pieces of plywood or between two concrete layers for example, will conduct heat at a high rate. The conductive insulation material should always be in contact with the substrate for better insulation.

Reflective insulation reduces radiant heat transfer across open spaces...

Understanding a Reflective Insulation System (RIS)

A reflective insulation system is typically formed by layers of aluminium or a low emittance material and enclosed air spaces, which in turn provides highly reflective or low emittance cavities (air bubble film) adjacent to a heated region.

The performance of the system is determined by the emittance of the material(s), the lower the better, and the size of the enclosed air spaces. The smaller the air space, the less heat will transfer by convection. Therefore, to lessen heat flow by convection, a reflective insulation, with its multiple layers of aluminium and enclosed air space (INSU reflector), is positioned in a building cavity (stud wall, furred-out masonry wall, floor joist, ceiling joist, etc.) to divide the larger cavity (3/4" furring, 2" x 4", 2" x 6", etc.) into smaller air spaces. These smaller trapped air spaces reduce convective heat flow.

Reflective insulation differs from conventional mass insulation in the following:

- Reflective insulation has very low emittance values 'E-values' (typically 0.03 compared to 0.90 for most insulation), thus it significantly reduces heat transfer by radiation
- A reflective insulation does not have significant mass to absorb and retain heat
- Reflective insulation has lower moisture transfer and absorption rates, in most cases
- Reflective insulation traps air with layers of aluminium and air bubble film plastic as opposed to mass insulation, which uses fibres of glass, particles of foam, or ground up paper
- Reflective insulation does not irritate the skin, eyes, or throat and contain no substances, which will give out gas
- The change in thermal performance due to compaction or moisture absorption, a common concern with mass insulation, is not an issue with reflective insulation.

Supreme's thermal insulation division offers solutions in the following areas:

- Ducting insulation in hospitals, shopping malls, airports, PEBs, IT/BPO etc.
- Pipe insulation for split AC tubings, chiller piping, drain pipes, chilled water lines etc.
- Floor insulation in server rooms, data centres, medical and diagnostic centres, and control rooms for petrochemicals
- Underdeck insulation in PEBs, textile units, malls, airports etc.
- Overdeck and wall insulation in commercial buildings, residential buildings, cold storages etc.

'INSU reflector' offered by Supreme is made of polyethylene Air Bubble Film (ABF) laminated with aluminium foil on one or both sides. The bright surface of the aluminium foil reflects 96 to 99% infra-red radiation received by the surface of a heated slate roof. It protects the building from undesirable heat gain. The thin reflective foil having low emissivity, and high reflectivity when installed with an air space restricts the transfer of far-infrared radiation making it an ideal material to be used for under deck application.

'INSU shield' is a non-fibrous, fire retardant, closed cell, tri dimensional chemically cross linked polyethylene foam XLPE. An ideal environment friendly insulation material, with a perfect solution for all the insulation needs for ducts, roofs, pipes, vessels etc. The divergent advantages of 'INSU shield' are, ease of installation, low thermal conductivity and good moisture and vapours resistance preventing microbial growth – and optimum condensation protection. ■

A reflective insulation system is typically formed by layers of aluminium or a low emittance material...

Atul Khanna
General Manager - Thermal Insulation Division
The Supreme Industries Ltd.

Feasibility Analysis Of **Solar Air Dehumidifier**

The experimental results show that, Calcium Chloride solution with 30% concentration can be regenerated up to 48% using solar energy...

In this communication, performance solar air dehumidifier has been studied for Kota, Rajasthan. The experimental set up was built in laboratory at UCE RTU Kota. The parametric study has been carried out in the year of 2014-15, in which desiccant inlet temperature, air inlet temperature, air flow rate, desiccant flow rate are studied. The experimental results expressed in terms of graphical method and found that by increasing regeneration temperature of desiccant improves the moisture absorption capacity of air, which decreases the cooling load of air conditioner. This concept is working on solar energy and it is found a feasible solution to reduce the cooling load.

Refrigeration is a process of removing heat from a substance under controlled conditions. Air conditioning means maintaining the internal atmospheric conditions for Human Comfort. Mainly two cycles are generally used for Refrigeration and Air Conditioning processes, these are – Vapour Compression Refrigeration (VCR) Cycle and Vapour Absorption Refrigeration (VAR) Cycle. In Vapour Compression Cycle, a working substance, refrigerant is used for heat transfer between Evaporator and Condenser. In evaporator, the refrigerant absorbs its latent heat from chamber which is to be cooled. It is required to change the condition of refrigerant for the refrigeration process – and with the help of latent heat we change the condition of refrigerant. Condenser is used for taking latent heat of refrigerant that was gained from evaporator and reduce the temperature of the refrigerant.

In Vapour Absorption Cycle, we replace the compressor by a absorber, a pump, a generator and pressure reducing valves. The function of these

Image Courtesy: www.heatwithsolar.com.au

components and compressor is same. Compressor is used as mechanical energy in order to change the condition of refrigerant in Vapour Compression Cycle. In Vapour Absorption Cycle, we use heat energy to change the condition of refrigerant. At small scale, we use evaporative coolers for the space cooling. These coolers use water as a refrigerant, which is used for cooling of the air, and cold air is transferred to the space which is to be conditioned. The droplets of water sometimes go with the air and increase the humidity of air and this is not desirable.

In Vapour Compression System, it is required that air is to be cooled below its dew point temperature for dehumidification. This is the main disadvantage of the Vapour Compression System because, the cooling of air below its dew point temperature for dehumidification results the temperature of air very low to required temperature. The combination of Conventional Air Conditioning System, which operates on closed cycle using electricity with a desiccant system can controls both the temperature and humidity within human comfort range.

In desiccant system, we use desiccant for the dehumidification of the air for human comfort. The dehumidification is achieved by passing the air over the solid desiccant or through the spray of liquid desiccant. The desiccant absorbs the moisture from the air and makes it dry. Thus, the desiccant quantity is increased and this excess quantity of air is removed by the regeneration process – and is done by the help of Solar Energy. Solar collector is used for providing the heat energy for regeneration process. The pressure drop in Solid desiccant is high as compared to that of liquid desiccant. Silica Gel is a good example of solid desiccant. In solid desiccant system, the air is passed over the desiccant wheel where it is dried. The desiccant wheel absorbs moisture from the air and becomes wet. This absorbed moisture is removed by other fan. This system requires large wheel surface area, this results the desiccant wheel bulky. Thus, this system is expensive. Liquid desiccant have many advantages over the solid desiccant mainly the pressure drop is low as compared to that of solid desiccant. The regeneration temperature required for liquid desiccant is lower as compared to that of solid desiccant. We can do pre-cooling and pre-heating of desiccant in liquid desiccant system in the heat exchanger.

Combination of conventional AC system, which operates on closed cycle using electricity with a desiccant system can controls both the temperature and humidity...

Types of liquid desiccant are Calcium Chloride, Lithium Chloride, Lithium Bromide, etc.

Lithium Chloride works with low pressure and requires large surface area of heat exchanger. This results the system expensive. Calcium Chloride has many advantages over the Lithium Chloride Desiccant. It is inexpensive, non-toxic, non-flammable, etc. Mostly it doesn't freeze easily and has strong affinity of water. The Solar Air Dehumidifier (Liquid Desiccant) Consists of a absorber and a regenerator. In absorber the outside air is passes through a spray of cold desiccant where it is dried and a weak solution is generated. This weak solution is pumped to the regenerator through the indirect-contact counter-flow heat exchanger with the help of pump. In regenerator, the weak solution of desiccant is changed into strong solution by removing excess amount of moisture by the Solar Energy and Air.

Experimental studies have been carried out on liquid-desiccant air conditioner by Lowenstein et al., in which Lithium Chloride and water solution was used as desiccant. It was found that, the minimum pressure drop was obtained for liquid-desiccant conditioner compared to other two conditioners and the temperature of air delivered was lower for the same conditioner. Madhukeswaran and Parkash experimentally investigated the effect of different coatings on performance of flat plate solar collector. It was found that, the maximum temperature was obtained for black chrome coating compared to other two coatings and the thermal efficiency of collector was highest for the same coating. They optimized the tilt angle of the flat plate collector. Anmim et al. studied the Liquid Desiccant Dehumidifier with cooling capacity using compression heat pump system, in which Lithium Chloride was selected as refrigerant. It was found that, the water condensation rate increases with increasing desiccant flow rate, air inlet humidity ratio and desiccant inlet concentration. It changes very little with air inlet temperature and desiccant inlet temperature. Experimental studies have been carried out on Evaporative Air Coolers coupled with Solar Water Heater by Alosaimy, in which Calcium Chloride and water solution was used as desiccant. It was found that, desiccant minimum temperature was proportional to the humidity potential between the indoor and outdoor conditions (temperature and humidity). The experimental results show that, Calcium Chloride solution with 30% concentration can be regenerated up to 48% using solar energy. Bakhtiar et al. experimentally studied liquid-desiccant air dehumidifier, in which Lithium Chloride was used as refrigerant. It was found that, the higher air velocity obtained faster air dehumidification and the higher desiccant flow obtained larger effectiveness but effectiveness was slowly come down after some time of their experiment.

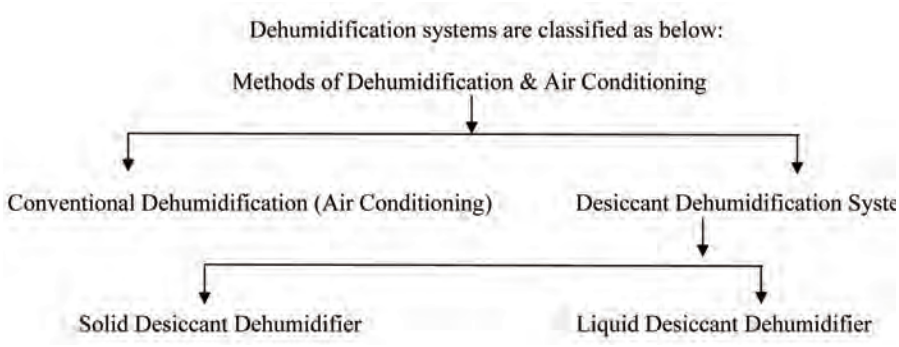
Kishore and Dilip experimentally analyzed the liquid desiccant dehumidifier, in which Calcium Chloride was used as refrigerant. It was found that, as the regeneration temperature was increased, moisture absorbing capacity of air was increased and dehumidification rate in the absorber was increased. It was found that moisture removal rate was increased with increasing in regeneration. The whole study is clarified that the relative humidity have not been controlled with solar regeneration system by any researcher and this factor is very important for comfort cooling of buildings.

In this communication we experimentally studied the effect of various parameters that affect the relative humidity of air for cooling applications. In this manner we analyzed the Solar Air Dehumidifier experimentally with the solar energy, used for regeneration process, and compare the outcomes of the results with the standard results.

Classification of Dehumidification Systems

Conventional Dehumidification System

In conventional dehumidification system, the air is cooled below its dew point temperature for removal the moisture from the air. The air is dehumidified by cooling and condensation. The moisture removal rate depends upon the temperature of cooling coil. Lower the temperature, the air will be drier. This system consists of evaporator, condenser, compressor and expansion valve.



Desiccant Dehumidification System

The working principle of desiccant dehumidification system is different from the Conventional Systems. In the desiccant dehumidification system, the moisture is absorbed with the help of desiccant. When the vapour pressure is low at the surface of the surface of the desiccant, they attract the moisture. At that time the vapor pressure exerted by molecules of water is higher, so the water molecules enter into the desiccant & thus air becomes dry (this is known as dehumidification process). In the regeneration process, the moisture is removed to the air when the vapour pressure of desiccant is higher than the air. This system also improves the quality of conditioned air because we can use fresh air instead of used air as in conventional air conditioning.

Solid Desiccant Dehumidifier

In this system, the air is passing over the desiccant wheel and the wheel adsorbs the moisture from the air. After adsorption the wheels becomes wet and the adsorbed moisture is removed by the help of other fan as shown in Fig. 1.

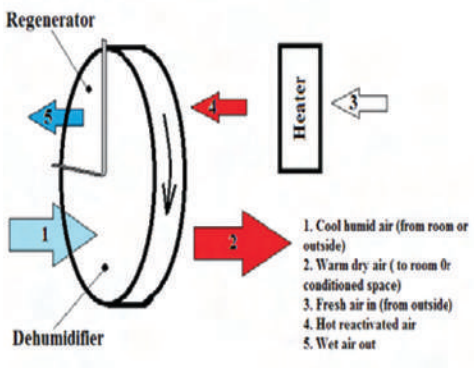


Fig. 1: Solid Desiccant Dehumidifier...

Liquid Desiccant Dehumidifier

Working of the liquid desiccant dehumidifier is almost same to the Solid Desiccant Dehumidifier which extracts moisture from the air and rejects to the atmosphere with the help of regenerator. Outside humid air or return air is supplied to the dehumidifier where it loses its moisture to the cool concentrated desiccant solution and it becomes hot & dry, which is supplied to the conditioned space. Then this diluted or weak desiccant is heated up with heater (low grade heat/waste heat can be used) & sprayed in the regenerator. Where its concentration increases (it becomes strong solution) after giving its water to the air. And this air is then exhausted to the atmosphere.

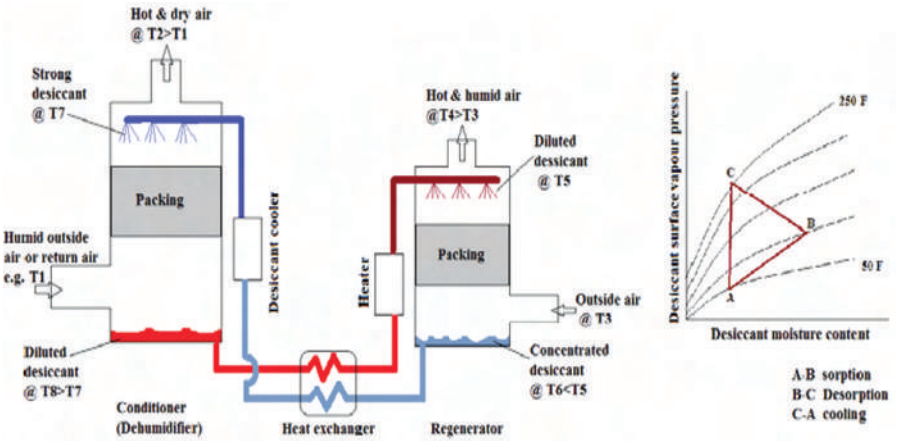
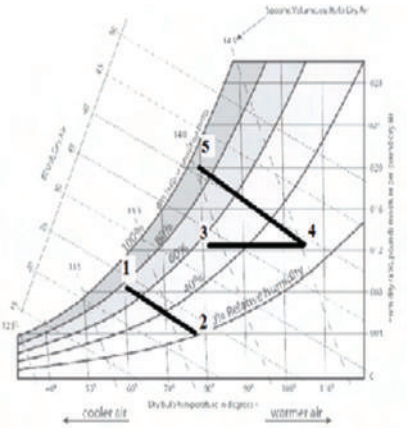


Fig. 2: Liquid Desiccant Dehumidifier...



Advantage of Liquid Desiccants over Solid Desiccants

- Pressure drop is higher in Solid Desiccant System as compared to the Liquid Desiccant System.
- The desiccant wheel has large surface and is bulky too.
- Liquid desiccant can be heated up to dry off moisture; significant heat may remain in hot and dried solution. In the case of solid desiccant system, it is hard to recover this heat.

Material And Methods

Problem Description

For good air conditioning the air should not be more humid. Dry air is required for corrosion protection at military storages, electronic protection, condensation prevention, ice rinks, injection mouldings, surface preparations & coatings, comfort cooling in buildings. Our objective is to minimize the power consumption and make the air dehumidified for human comfort. We can use solar energy instead of electrical energy for regeneration of desiccant. The heat energy for regeneration is given by the Flat Plate Solar Collector. Calcium Chloride is used as a desiccant. It is the cheapest and best choice for desiccant system. Other advantages are that it has strong affinity for water and it doesn't freeze easily unlike the Magnesium Chloride brine.

Experimental Setup

An experimental setup is developed in department of mechanical engineering, Rajasthan Technical University Kota under project work. A schematic diagram of experimental setup is shown in Figure 1. Where, two identical towers are used as direct contact type heat exchanger for regeneration and absorber. The material of tower is fibre reinforced plastic and height of tower is 120cm. Packing material is used as

Sl No	Conventional Dehumidification	Desiccant Dehumidification
1.	Conventional systems are best when used for higher temperature and moisture levels.	Desiccant systems are suitable for low temperature required (8^{O}C or below).
2.	The moisture removal rate decreases below 8^{O}C dew point temperature.	Moisture removal rate doesn't decrease.
3.	Suitable for region, where electricity is cheaper and thermal energy is expensive.	Preferably used where thermal energy is cheaper.
4.	Conventional system is used where 100% RH is required.	Desiccant dehumidification is used for applications below 45% RH down to less than 1% RH.

Table 1: Comparison between Conventional Dehumidification and Desiccant Dehumidification...

Devices	Operating Range	Fluid	Uncertainty
Thermocouple Type Thermometers	-200 to 350^{O}C	Air and Liquid	±0.1732
Capacitive Probe Type Hygrometer	0 to 100% RH	Air	±0.1732
Vane Type Anemometer	0 to 10 m/s	Air	±0.1732
Electronic Weighting Machine	0 to 1000 gm	Liquid	±0.1732

Table 2: Specifications of Measuring Device...

polypropylene intalox saddle for a height of 30cm. At the bottom collection tank is provided for each heat exchanger (tower) which is used as storage of desiccant. Two centrifugal pumps are used for pumping the desiccant, having a maximum discharge of 1000litre/hour. Desiccant is sprayed in the towers with the help of nozzle with very fine droplets. For circulation of desiccant, PVC pipes are used. Demister pads are used for elimination of desiccant which is carry over through air stream. Glass wool is used as insulation material. The specifications of measuring devices are given in the above Table 1.

Procedure: In the absorber cooled desiccant is sprayed on the packing and the moisture is absorbed from the incoming air stream. Form the absorber the desiccant is transfer to the collection tank through the counter flow indirect contact type heat exchanger after that it is collected in storage tank and pumped to the regenerator with the help of pump. In the regenerator, the excess moisture is removed by the air and heat energy. For the heat energy we use solar energy instead of mechanical energy. The flat plate solar collector is used for converting solar energy into thermal energy. It consists of six copper tubes of 1inch diameter for flow of fluid and copper plate as absorbing plate. The dimension of Solar Collector is 3x1x1 feet. At steady state conditions we measured different measurements from measuring devices. Thermometer is used for measuring temperature; humidity is measured using the hygrometer.

For measurement of concentration of desiccant, we take samples of desiccant of 100ml. At that temperature its density is calculated with the help of weighting machine and the concentration is calculated using the correlation developed by R Manuel. After taking the readings for absorber, we take the readings for regenerator. On the basis of these readings, moisture removal rate and moisture absorption rate for absorber and regenerator is calculated respectively. The effect of different parameters namely air inlet temperature, desiccant inlet temperature are studied.

Results and Discussion

The objective of the study is to experimentally analyze the effect of various performance parameters of Solar Desiccant System. In this experiment, Calcium Chloride is used as desiccant which is non toxic, non flammable and easily available in market. The parameters are studied as follows: Desiccant inlet temperature, Air inlet temperature, Air and desiccant flow rate.

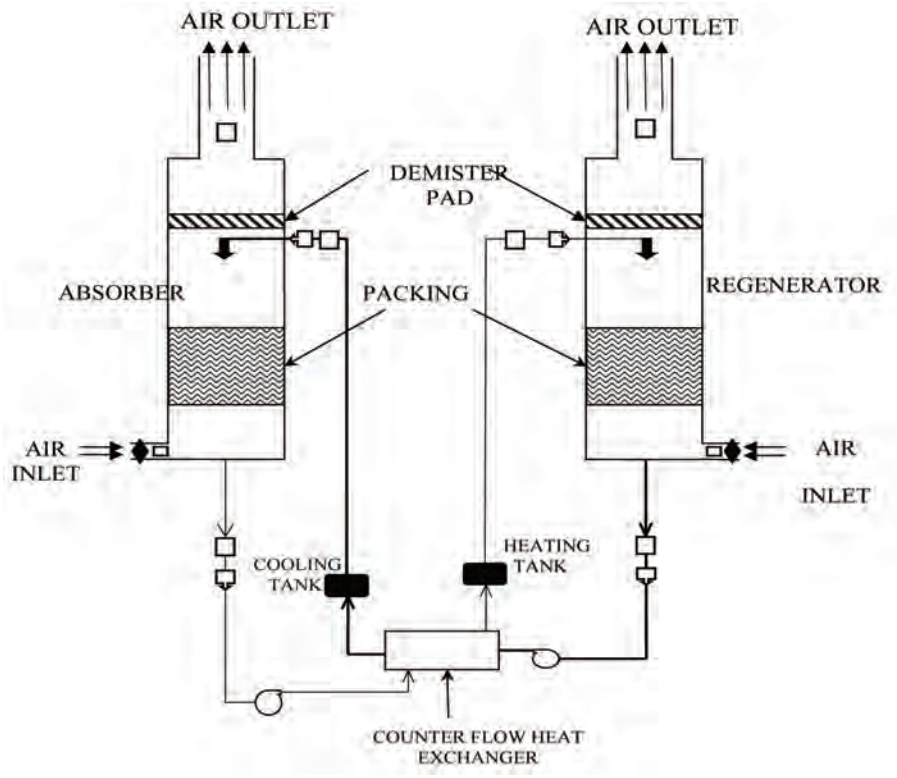


Fig. 3: Schematic Diagram of Experimental Setup...

	WEAK SOLUTION
	STRONG SOLUTION
	DESICCANT SAMPLING
	HYGROMETER
	THERMOCOUPLE

Effect of regeneration temperature on humidity reduction

The figure shows the effect of the air regenerator temperature on the humidification on air in the regenerator. The moisture absorbing capacity of the air increases as the air regeneration temperature increases. As we decrease the air mass flow rate decreases, humidification rate increases by keeping desiccant flow constant.

Effect of Regeneration Temperature on Temperature Increase

The influence of regeneration temperature on the air exit temperature is given in the Figures 5 shown below. As we increase the regeneration temperature, more heat is utilized to regenerate the solution and resulting, the exit temperature also increases. The moisture absorbing capacity

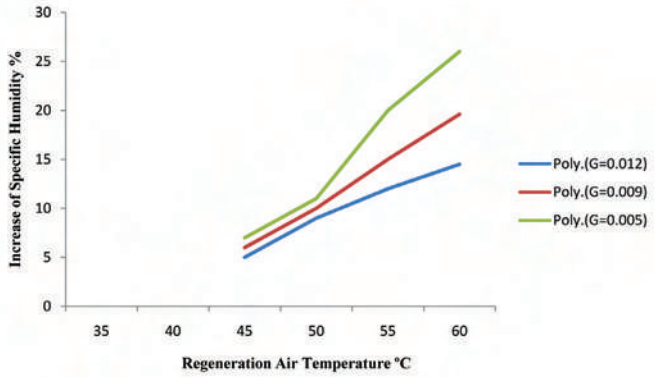


Fig. 4: Effect of regeneration temperature on humidity reduction...

increases as the air regenerator temperature increases. By decreasing air flow rate keeping desiccant flow constant, the moisture absorbing capacity of air decreases.

Effect of Desiccant Inlet Temperature

Figure 6 shows the influence of desiccant inlet temperature on the moisture removal capacity in absorber with different air mass flow rates. It is also shows the relationship between the air flow rate and the moisture removal rate. For analyze the effect of desiccant inlet temperature

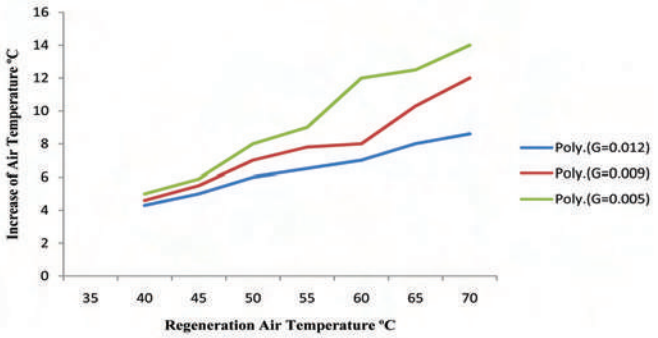


Fig. 5: Effect of regeneration temperature on temperature increase...

on dehumidification process, we kept the desiccant flow rate constant. As the desiccant inlet temperature increase in absorber, the moisture

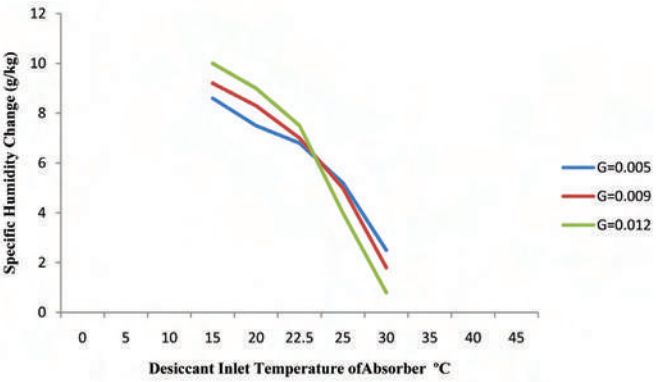


Fig. 6: Effect of Desiccant inlet temperature on humidity decrease in absorber...

removal capacity decreases. As shown in Fig 6 the moisture removal increases as the air flow rate increases.

Effect of Humidity Ratio with Time with Desiccant Flow Variations

The experimental results show that higher air velocity will obtain the faster air dehumidification, but it has low effectiveness. Refer Figure 7.

Conclusion

It is seen from the above discussions, the moisture removal rate increases with the regeneration of desiccant. The moisture removal decreases when the inlet temperature of desiccant in absorber increases. The maximum temperature for the regeneration is obtained for black

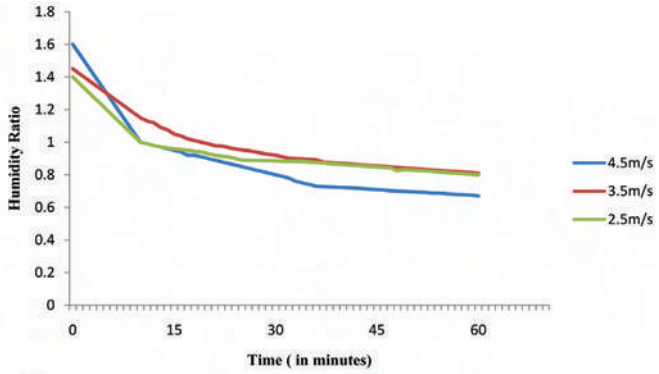


Fig. 7: Effect of humidity ratio with time & desiccant flow...

chrome coating in solar plate. These results are compared with the existing standard results and found that they are approximately same. The water condensation rate doesn't change much with the air inlet temperature and desiccant temperature. It almost remains constant. The water condensation rate increases with increasing desiccant inlet concentration.

The use of solar energy reduces the cost of operation of the system. The demand of the energy is increasing day by day and it is more sense to use solar driven systems which are very economical as compared to the conventionally electrically driven systems. In solar driven dehumidifier we use solar energy for the regeneration of the desiccant instead of electrical energy and Calcium Chloride is used as desiccant. Resulting, this system can be used as Air Conditioning systems and it is not expensive. ■

Dr Shiv Lal
Assistant Professor Dept. of Mechanical Engineering at University College of Engineering, Rajasthan Technical University, Kota

Vishal Sharma
Student of Mechanical Engineering at University College of Engineering, Rajasthan Technical University, Kota

Suresh Kumar
Student of Mechanical Engineering at University College of Engineering, Rajasthan Technical University, Kota

Sunil Kumar
Student of Mechanical Engineering at University College of Engineering, Rajasthan Technical University, Kota

Mahesh Kumar Soni
Student of Mechanical Engineering at University College of Engineering, Rajasthan Technical University, Kota

Bry-Air unveils adsorption chiller

First of its kind in India, Bry-Air (Asia), recently launched its 'adsorption chiller' (35 to 1180 kW). Based on an innovative green technology, it will be manufactured in India under license from Power Partners, Inc., USA. It provides energy-smart cooling using waste heat, and is the first ever product being launched in India to tap the abundant low grade waste heat available in process industries – and use that for process cooling or air-conditioning (HVAC). A lot of low grade process heat (50 to 100°C) generally goes waste, which now can be used for cooling. This eco-friendly solution also cuts down CO_2 emission and reduces energy expenses. "Adsorption chillers use energy from waste heat with negligible electricity consumption to provide chilled water for process cooling and air conditioning. They do this with 'green' refrigerant (water) and desiccant (silica gel). We are excited about the opportunities this technology provides," said Deepak Pahwa, Managing Director, Bry-Air (Asia). The adsorption chiller has unbeatable advantages like ultra-low electricity consumption, negligible noise and vibration, life expectancy of over 20 years and negligible maintenance. ■

Website: www.bryair.com

Electronic Expansion Valves Available from Colmac Coil

Electronic Expansion Valves (EEVs) are becoming more and more popular due to the efficiency increase they offer for Direct Expansion systems. Their quick response time and precise flow metering allow for tight superheat control and minimize the risk of liquid refrigerant reaching the compressor. The result is increased evaporator capacity, reduced energy costs and less air temperature fluctuation.

Colmac provides both motorized and pulse width modulating valve types for use with all standard refrigerants, along with the sensors and controllers required to operate them. Components can be shipped loose or factory installed to reduce field install time and expense.

For those wishing to install their own valve and controls, Colmac can build sensor ports into the evaporator's suction header (sensors not included). ■

Website: www.colmaccoil.com

Daikin releases floor-mount indoor unit

Daikin has released their FVXS floor mounted indoor unit for use with Daikin's MXS 2-, 3-, 4- and 8-port multi-split system. These floor-mount units offer the installer greater installation flexibility and are suitable for use in rooms that have sparse vertical wall height like glass-walled sunrooms or attic room additions.

Available in 9, 12, and 18 MBH capacities, the FVXS can be installed free-standing or partially recessed, and includes top and bottom discharge that adjusts air flow based upon use in heating or cooling mode. "The FVXS units, new to North America, are a very proven technology for Daikin elsewhere in the world. They extend the connectivity of multi-split systems and are excellent for use in new constructions and retrofit applications where radiant systems have been used," said John Clements, Director, Ductless Products. ■

Website: www.daikinac.com

Humisonic - a complete hygienic and energy-saving system

HumiSonic, manufactured in-house, is a compact ultrasonic adiabatic humidifier that exploits CAREL's experience in electronic technology. The built-in electronic board ensures precise control of unit operation and humidity production as well as connectivity to probes control and supervisory systems, using the Modbus and Carel communication protocols. Its features include:

Hygiene

Special care has been paid to hygiene. Periodical washing cycles mean no stagnant water or dust build-up. HumiSonic comes with a drain valve that automatically empties the unit at the end of each working cycle or after a period of inactivity. In addition, the material used to make the tank comprises silver ions for active protection against bacteria proliferation.

Compact system

HumiSonic is a complete system, featuring a miniature humidity probe and activation sensor that detects air flow. Despite its compact size, it comes with a built-in electronic board, making it a complete solution that does not require any external electrical panels.

Performance based

HumiSonic is the ideal solution for comfort applications, being perfect for home fan coils installed on the wall or in false-ceilings and for small air handling units. It also has the right features for industrial and food applications: cold rooms and climate rooms, display cases etc. ■

Website: www.carel.com

MIV Insulating Systems designs refrigerator doors

Based in Avigliana, Italy, MIV Insulating Systems s.r.l. designs, manufactures and installs insulating doors and accessories for customers in Italy and internationally. The doors and accessories are thoroughly tested with an objective to provide best possible performance in all conditions of environment and of use. It offers its products and services through salesmen and technicians.

Doors:

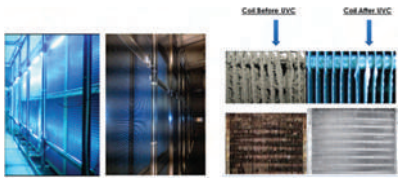
- Wing mm40, Wing mm70, Wing mm90, Wing mm120, Automation, Controlled Atmosphere.

Components

- Aluminium profiles, PVC profiles, Rubber profiles, Sliding doors fittings, Hinged doors fittings, Doors and frames reinforcements, Electric components, Others. ■

Website: www.mivsrl.com

UVGI cost effective system from Ensavior Technologies



Ensavior Technologies brings cost effective equipment to cater to the users' needs. The HVAC cooling coil remains clean on a continuous basis, and it gives a 10 to 15% saving in energy, and pays back period of 12 to 18 months. This lowers the maintenance cost and down-time of the AC system. Ultra Violet Germicidal Irradiation (UVGI) is the use of ultraviolet (UV) energy to kill or inactivate microbes (viral, bacterial, and fungal species). HVAC consumes 60% of energy in a centralised AC system. The condensation of moisture around the cooling coil creates growth of algae, mold, mildew, bacteria and viruses. This reduces the heat transfer efficiency and air flow of the AHU, which in turn increases the power consumption.

Advantages

- 10 to 15% power savings
- Keeps cooling coil clean
- Improves indoor air quality
- Increases HVAC equipment life span
- Reduces maintenance cost
- Short pay back period
- Prevents Sick Building Syndrome. ■

Website: www.ensavior.com

Smart and affordable transmitters

Telaire T5100 series

The Telaire T5100 series ventostat CO_2 and temperature transmitter is a low-cost wall-mounted sensing solution for demand-controlled ventilation. The ventostat provides an optional intuitive VLI (Visual Limit Indicator) display for CO_2 thresholds, a passive temperature output (20k Ω thermistor), and a standard analogue 0 to 10 V or 4 to 20 mA (which is to be chosen while ordering) signal to maintain air quality in enclosed spaces (such as school classrooms, offices, gymnasiums and theatres).

The T5100 series also offers a digital UIP (User Interface Program) to configure internal CO_2 concentration thresholds (optional accessory cable and software not included). The factory defaults are 1000 and 1500 ppm. The low-cost, pre-calibrated and reliable transmitters are maintenance-free and have flexible configurations and an intuitive VLI display. T5100 products have two terminal pins for connecting inside the sensor to a common ground. They have 3-wire or 4-wire type configurations, powered by either AC or DC voltage. ■

Website: www.almontazar.com

Young Mind Working Behind

Though the market is full of a wide range of functional coatings, Hsiung has chosen to focus on thermal insulation paint, with an emphasis on original technology...

Taiwan's long-standing Kou Guang Transportation Company has used Heatax to paint the shells of its buses...

Alan Hsiung is a young entrepreneur in Taipei. Years ago, he noticed that Taiwan is full of 30-to-40-year-old houses. In Taipei, for example, up to 40% of the homes are more than 30 years old. In addition, the current rate of urban renewal will likely never surpass the established existing housing. Therefore, one of the most economic and feasible ways to renovate these old houses is to transform them with paint.

Though the market is full of a wide range of functional coatings, Hsiung has chosen to focus on thermal insulation paint, with an emphasis on original technology, and he continues to challenge himself to produce the highest standard of thermal insulation paint in Taiwan.

In the beginning, Hsiung and his partners specialised in applied materials, and they worked together in the Industrial Technology Research Institute, which isTaiwan's high-tech hub. Unfortunately, the results they produced failed to meet expectations, and they were faced with increased competition from both imported and domestic products.

Even though many of his colleagues around him chose to pursue PhDs instead, for six years Hsiung remained dedicated to one single mission: to make a long-lasting, high-performance thermal insulation paint named Heatax.

Heatax utilises nanotechnology and polymer technology, which deliver stronger molecular cohesion. In specific, Heatax's nanotechnology helps in strengthening intermolecular forces, so the surface tension becomes stronger. This also greatly enhances the degree of weather-coating for higher durability. In addition, the ceramic hollow-thermal break particles deliver excellent insulation coating reflectivity for a better heat reflection rate. These particles also provide thermos-bottle-like characteristics by effectively blocking thermal conduction.

After Heatax was launched, without any commercial publicity, it came to be widely hailed for having the highest 'CP value' (cost-to-performance ratio) of all thermal insulation paints in Taiwan. Within a few short years, many of Taiwan's biggest companies, including the Taiwan Chinese Petroleum Corporation, United Microelectronics Corporation (UMC), Formosa Plastics Corporation, and China Telecom, had become Hsiung's customers. Even Taiwan's long-standing Kou Guang Transportation Company has used Heatax to paint the shells of its buses.

To meet the demands of foreign customers, Heatax has achieved several certifications, including the United States' Intertek, Singapore's GreenLabel, mainland China's CMS, and Taiwan's SGS, among others.

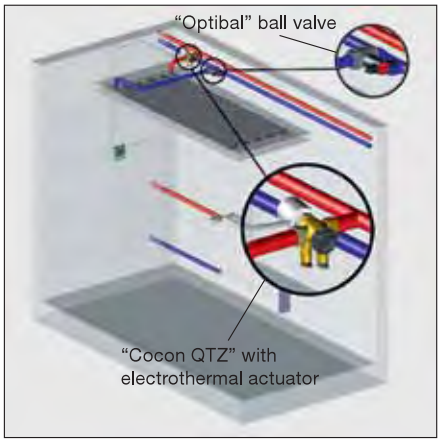
Although many milestones have already been reached and some even surpassed, including making Heatax an affordable option for people to use in improving their own living spaces, Hsiung still has one important goal that he wishes to achieve: to spend a summer weekend at the beach with his friends! ■

MADE IN GERMANY

Pressure independent dynamic balancing valve (PID) “Cocon Q” with automatic flow control: multifunctional and economical

“Cocon QTZ” with electromotive actuator/with pressure test points

“Cocon QFC” with electromotive actuator/with pressure test points



Chilled ceiling system

The Oventrop pressure independent dynamic balancing valve “Cocon Q” combines two hydronic functions in one valve.

Firstly, in connection with standard actuators or thermostats (M 30 x 1,5), the valve controls the flow rate depending upon the room temperature requirements.

Secondly, the maximum flow rate, when the valve is fully open, is automatically controlled, ensuring that the maximum required flow rate in all supply risers is not exceeded.

Your advantage:
- multifunctional applications (e.g. chilled ceilings, fan coil units, air handling units, convector and central heating systems)
- presetting and optical display of the nominal values even with mounted actuator

For further information please contact:

Mr. Sunil Anand
Dehli, India
Phone (+91) 1 20 - 2 59 13 19
Mobile (+91) 99 71 66 46 90
E-Mail s.anand@oventrop.com
or:
Mr. Milind Pawar
Mumbai, India
Mobile (+91) 98 33 83 08 37
E-Mail m.pawar@oventrop.com

RNI Registration No. MAHENG/2005/18432 • Postal Registration No. MNE/345/2015-17
Posted at T F Deonar Post Office, Mumbai - 400088 On 15th of Every Month, Date of Publications 15th of Every Month