Vol. 10 No. 5

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Cooling India

December 2014

India's foremost Monthly dedicated to the growth of HVACR Industry

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T8700
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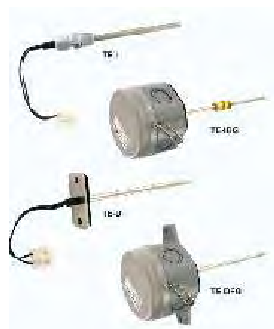
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Publisher's Letter

Synthetic refrigerant or natural refrigerant seems to be the future option

The retail revolution splurged the development of malls and supermarkets since late nineties and the increasing size of retail market led to a increasing demand for optimized air conditioning systems. An overview of 'HVAC systems for Large Retail Facilities' details about malls as well as the large format stores both within and as standalone developments, and also mentions that the HVAC design of retail developments is a complex process, with a large set of variables in play including refrigerants.

The efforts to replace widely used refrigerants with zero Ozone Depletion Potential and virtually zero Global Warming Potential alternative refrigerants has important implications for heat exchangers, air conditioning system and the choice of materials in these designs. An article 'New Copper-based heat exchangers for alternative refrigerants' highlights how several copper-based technologies can enable the transition to these new alternative refrigerants.

Due to significantly higher GWP, presently used refrigerants will be phased out very soon and either synthetic refrigerant or natural refrigerant seems to be the future option for air-conditioning systems. The article 'Carbon dioxide as Refrigerant in Air-Conditioning Systems: Present and Future' discusses the basic technology, environmental safety issues, comparison with existing technologies and commercial status of transcritical CO_2 refrigeration cycle for air-conditioning applications.

Cooling India participated in India Cold Chain Show 2014 held recently at Mumbai. The post event coverage will be carried out in January 2015 special annual issue.

Please send your comments at pravita@charypublications.in

Pravita Iyer
Publisher & Director


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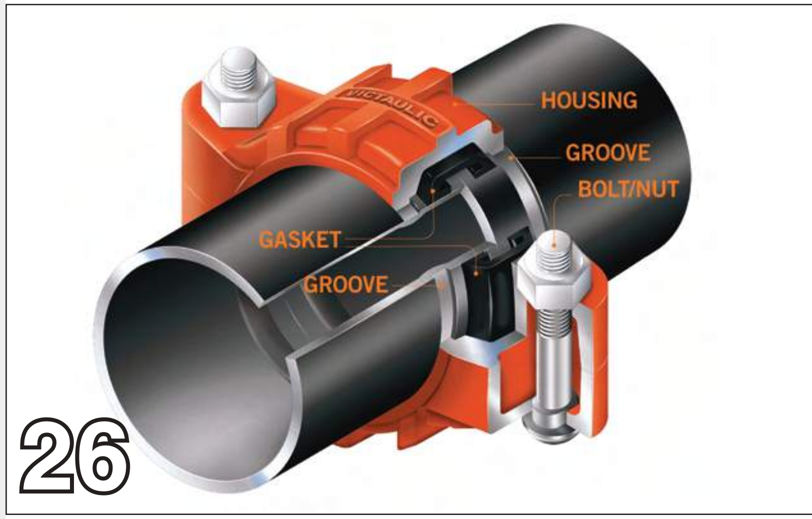

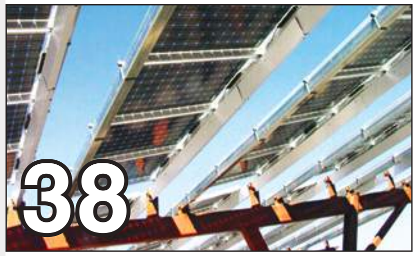

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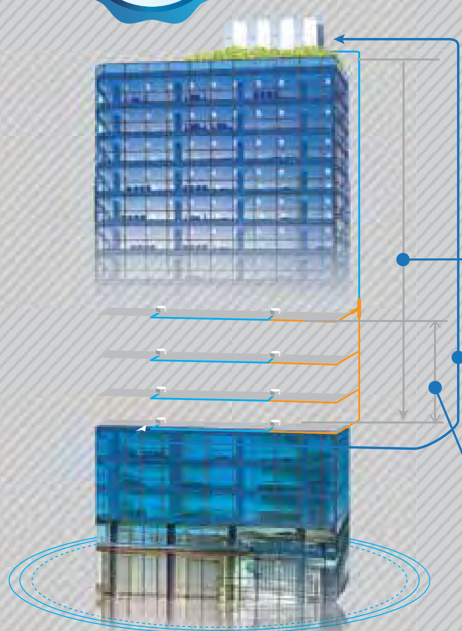

110m
Max.110m level difference between IDU~ODU (outdoor down)

175m
Max.175m actual piping length

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

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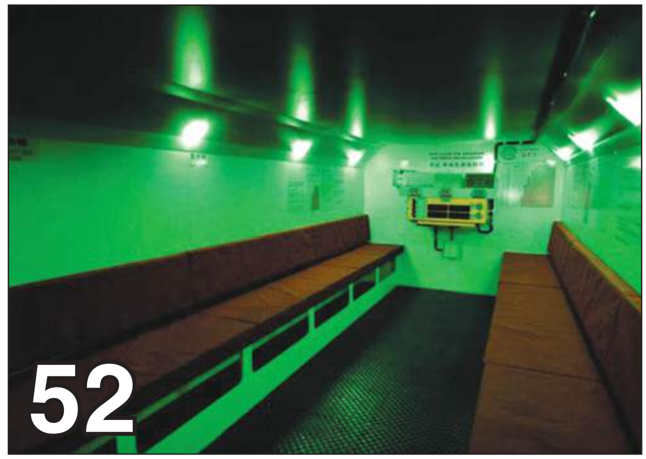

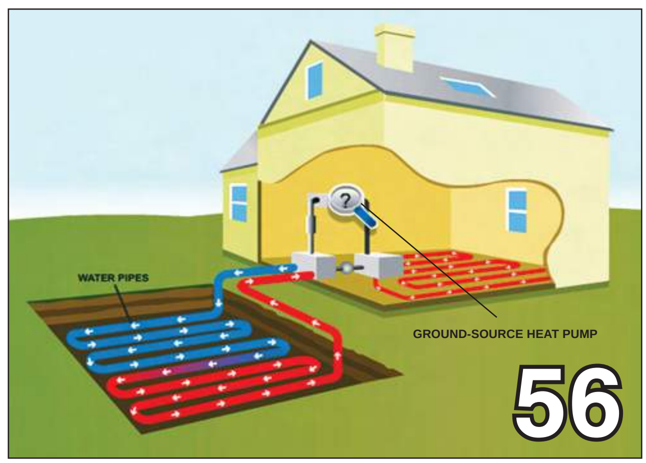

Department

Editorial

New Technologies, Regulations for Refrigerants

Air conditioning and refrigeration industry is propelling the global cause by phasing out chlorinated refrigerants in consonance with Montreal Protocol framework. U.S. Environmental Protection Agency proposed to limit certain potent greenhouse gases from use in ACs, refrigerators, and foams etc, to induce climate-friendly alternatives. This strategy devised is replacing R-12 by R-134a, R-11 by R-123 & R-22 being replaced with R-410A in global HVACR markets & applications. New refrigerants such as HFOs have been developed. However, industry is recognizing value of customized refrigerants. Nowadays, refrigerant mixtures have become more common to an endless range of new refrigerant possibilities. New technologies in heat transfer surfaces and compressors are in the offing to take advantage of newfound flexibility in refrigerants.

HFC refrigerants are chlorine free and though HFCs such as R-410A, are considered global warming gases, they do not damage ozone layer. Chemical manufacturers are introducing a plethora of new medium and low GWP refrigerants to help solve the global warming problem. HVACR industry needs to invest to develop and commercialize low GWP technologies. AHRI said the industry is committing $5 billion over the next decade to research and develop new refrigerants and equipment to help accomplish the phase down and induce new regulations.

The HVAC industry encompasses operation and maintenance, system design, equipment manufacturing, sales and research. The industry was historically regulated by the manufacturers of HVAC equipment, but regulation and standard organizations have been established to support industry, encourage high standards and achievement. At a recent white house event, Barack Obama has created the legal framework for phasing out F-gases with high ODP and GWP, reports Dave Rule, President, International Institute of Ammonia Refrigeration, USA. In the medium term, industry expects a shortage which will make environmentally harmful refrigerants expensive, and so, is the search happening currently for cost viable efficient alternatives too. Altogether, USA reveals a trend toward natural refrigerants, starting from large refrigerated warehouses via smaller commercial applications through to air-conditioning systems. And, the reason behind changes to regulation is to promote a gradual reduction in F-Gases until 2050.

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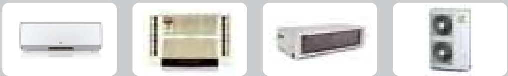

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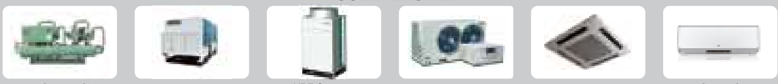

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Danfoss ICE Awards 2014 recognises best practices in cold chain

Danfoss India, the Indian subsidiary of leading Climate & Energy solutions provider Danfoss Global, presented the 2014 Indian Cold chain Excellence (ICE) in the City, recognising cold chain players in Dairy and Food Processing sector who follow best practices of energy efficiency in their facilities. Banas Dairy from Ahmedabad received the Best Food processing Facility Award for using the most updated technology in Bulk Milk Coolers and Condensing Units such as multi-refrigerant scroll compressors which help in achieving high energy efficiency levels for milk refrigeration, processing and storage. "Recognition of profitable yet energy efficient facilities like Banas Dairy is required to encourage stakeholders in this sector to shift to better technologies that enable optimum use of energy. With Gujarat taking the lead in dairy output in the country, better benefits can be reaped by milk cooperatives and processing centres through technology upgradation" said Rajesh Premchandran, VP, Refrigeration and AC Division, Danfoss Industries Pvt Ltd, India. With an annual dairy output worth over Rs 12,500 crore, Gujarat acquired highest share of about 21% in terms of total dairy output worth over Rs 60,000 crore across top 20 states in India, according to an ASSOCHAM study on dairy sector. Danfoss developed customized products for the Indian environment which can improve profitability. A largely adopted Danfoss applications is the Optyma Slim Pack which is the new condensing unit designed to fit into a light and compact housing, has already found great acceptance in the milk capital of India, Gujarat with many milk societies installing these applications in their plants to lower their total life cycle costs. Danfoss offers solutions that can help combat both global warming and meet the energy efficiency requirements of the dairy industry. Awards in other categories include Best Maintained Cold Storage Award for Harshna Ice and Cold Storage, Progressive Manufacturer Award for Suraksha Transport Systems, Progressive Service Provider Award for Brattle Foods, Progressive Development Award for Knids Green Pvt ltd (IIM Sabjiwala), Progressive Association Award for West Bengal Cold Storage Association, Progressive Farmer's Award for Sahyadri Farms and Dynamic Leadership Award for Shrinivasa Ramanujam from Adani Agrifresh. ■

Smart Homes - the Key to a Smarter India

A panel discussion on Smart Homes – A Necessity or an Indulgence was held by ACREX India 2015 on November 21, 2014 in Bangalore. Several noted real estate honchos met to discuss the various facets of Smart Homes including the demand, market, challenges faced and the solutions to overcome these challenges in order to pave the way for a smarter way of living. The industry is expected to grow between 30-40% in India. The session began with panelists – Nirmal Ram, Cerebration Consultants (Consultant) & National president of ISHRAE, Ramakrishnan, Sobha Developers (Developer), Avinash Gautam, Silvan Innovation Labs and Tilak Thomas, Thomas Associates (Architect) discussing the need for Smart Homes and how energy efficiency has become need of the hour. Smart Homes are technology driven spaces that are not only easier to live in but also have the perks of saving on energy. The Smart Homes industry is fast gaining interest among home owners, new home buyers, property developers and housing industries across the world. Smart homes have automated devices installed that can be handled remotely and in the last two years there has been a spurt in demand for these types of homes. ■

Kirloskar Chillers launched TURBOLEV range of chillers

Kirloskar Chillers, announced introduction of its TURBOLEV Series chillers using magnetic bearing centrifugal compressors today. Kirloskar chillers are manufactured and tested in Pune. The TURBOLEV range extends from 95 TR to 375TR, with single and dual compressor configurations. Chillers can easily save 18-20% energy over conventional screw chillers. Periodically introducing innovative products & solutions for comfort cooling, process cooling and heating applications, Kirloskar Chillers has consistently demonstrated its commitment to customer satisfaction. They have introduced TURBOLEV range of water cooled variable speed Centrifugal Chillers using compressors with bearings using the principle of magnetic levitation. Certified in accordance with AHRI500/590 & AHRI 551/591, these chillers are highly energy efficient, reliable and extremely quiet. The company aims to obtain 13 to 15% of business coming in from TURBOLEV chillers in the coming financial year. In future, TURBOLEV chillers would be the logical solution for buildings proposing to opt for Green Building rating in accordance with the US Green Building Council (USGBC), the IGBC or Green Rating for Integrated Habitat Assessment (GRIHA) certification systems. Rahul Kirloskar Chairman said "I am proud that Kirloskar Chillers is today an established player in the chiller industry with a footprint of more 3000 chillers / 500,000 TR. We are proud to have many prestigious names on the list of our customers. We are no longer an India-centric company – our products are exported to Europe, Middle East and South East Asia as well." Dr. Prem C. Jain, Chairman IGBC (Indian Green Building Council) reminisced, "India will jump from 25 Bnat present to 100 Bn sq ft of construction in the next 30 years; a majority of it will be Green, and green means high efficiency. Though majority of these buildings may not need air conditioners, a substantial proportion will need air conditioning systems; they will need chillers. I am sure Kirloskar who today has launched magnetic bearing compressor centrifugal chillers today will prosper and provide India that missing link; we will not need to import from any other country what is available in my own country." ■

Airedale TurboChill chiller (200-1830kW) with low GWP refrigerant R1234ze shortlisted for more awards

The first British Standards Institution (BSI) approved free-cooling chiller with low global warming potential (GWP) refrigerant R1234ze is on a further awards shortlist having recently been selected as a finalist in the National ACR Awards 2015. Nominated for 'Air Conditioning Product of the Year', Airedale International's TurboChill™ and TurboChill™ FreeCool (200-1830kW) with R1234ze delivers industry-leading energy efficiency per footprint available from a centrifugal-based free-cooling chiller. The TurboChill FreeCool offers up to twice as much free-cooling as a thermosiphon free-cooling system and, based on a 24/7 London data centre with a typical room temperature of 24^{O}C, can deliver free-cooling for up to 95% of the year and potential energy savings of up to 50% compared with a conventional chiller. Free-cooling saves vast amounts of energy, particularly when room temperatures are high. In addition, the TurboChill FreeCool design incorporates the ability to supply fully concurrent free-cooling, without break of supply, during the transition from mechanical cooling, unlike equivalent thermosiphon designs. In addition to energy savings through reducing the need for mechanical (DX) cooling, concurrent free-cooling also maximises the part-load efficiencies of components such as EC fans, inverter-driven pumps and centrifugal compressors. The addition of low GWP hydro-fluoro olefin (HFO) based refrigerant R1234ze which has a 100-year GWP lower than 1 (better than CO_2) makes the TurboChill a highly sustainable cooling alternative which automatically receives two BREEAM points in recognition of its low global warming impact. The TurboChill with R1234ze is also a finalist in this year's HVR Awards and Energy Awards and the 2015 CIBSE Building Performance Awards. The National ACR Awards results will be announced on 29 January 2015. ■

Greenheck introduces Energy Recovery Filter System for Kitchen Hoods

Greenheck's new Energy Recovery Filter System incorporates energy recovery technology into kitchen exhaust hoods. The Energy Recovery Filter System captures waste heat produced by the cooking appliances that would otherwise be exhausted from a kitchen hood and uses it to preheat a portion of the incoming water supply that is directed into the patented energy recovery filters. The water flowing through the filters captures waste heat from the exhaust air-stream, preheating the water supply. Preheating water before it enters a conventional water heater saves energy and reduces a restaurant's water heating costs. As an added benefit, the water flowing through the filters naturally lowers the hood temperature, condensing more grease from the air-stream. Independent third party testing shows the highly efficient Energy Recovery Filter System removes 88% of grease particles at 8 microns resulting in reduced hood and duct cleaning costs as well. Greenheck is worldwide leader in manufacturing and distributing air movement and control equipment ■

International Copper Association India organizes Workshop on Microgroove Copper Tube Heat Exchangers

International Copper Association India, a part of Copper Alliance, recently organized a special Workshop on Microgroove Copper Tube Heat Exchangers in Delhi and Chennai. The objective of the workshop was to highlight the advantages of smaller-diameter tube heat exchangers to increase the rate of heat transfer through coils in numerous applications, thereby improving energy efficiency of appliances, including air conditioners. The global ACR industry faces increasing pressure from government regulations to improve energy efficiency, reduce environmental impact of refrigerants, and improve indoor air quality while facing constant pressure from consumers to keep prices low. Use of 5mm Microgroove Copper condensers helps reduce cost, create higher energy efficiency, less refrigerant, comes with higher durability and demands low investments. Coils made with smaller diameter & inner grooved copper tubes enable removing heat resourcefully from the refrigerant in case of the condenser coil or evaporator coil. This higher heat transfer efficiency increases the overall energy efficiency of the system. The use of smaller tubes also improves the air-flow outside the tubes because of the reduced form factor. "With this new era of environmental and energy efficiency requirements, MicroGroove technology handles the higher pressures of new refrigerants while meeting cost reduction goals and sustainability concerns. This technology has a key role to play in design of sustainable ACR products. OEM's are yet to adopt concept of smaller diameter copper tube in heat exchangers. We have been creating awareness on the 5 mm Microgroove Copper Tube heat exchangers globally and work on the technology with various universities, consultants and various OEM's. This technology packs all the advantages of copper into more compact, more efficient, cost-effective heat exchangers" said Ms Bowie Bao, Project Manager for Appliances & Technology, ICA China. ■


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Frigesco gets DECC funding to develop flash defrost for use in air source heat pumps

Frigesco, pioneering ultra-efficient flash defrost technology for refrigeration, is awarded new DECC funding of £102,000 to develop the system for use in air source heat pumps. Flash defrost, which has recently won a string of innovation awards, can reduce supermarket cooling energy costs by up to 20%. Field trials in working supermarkets are currently underway with results expected shortly. The latest grant, conferred under DECC's Energy Entrepreneurs' Fund, will be used to fund joint research by Frigesco and heat pump specialist Glen Dimplex,designed to develop flash defrost technology for application in air source heat pumps (ASHPs). David Walter, managing director of Frigesco, explained: "Coils on ASHPs operating in cool conditions (below 7C) in humid climates quickly ice up, and need to be regularly defrosted to maintain performance and reduce energy use. Existing approaches consume extra power, which can account for a significant component total energy use,reducing their efficiency."Frigesco's system saves all the electrical power normally used for defrost, so applying it to ASHPs should deliver a significant increase in energy efficiency and an associated reduction in grid carbon dioxide emissions. It is a very exciting further application for flash defrost, and we believe it has great potential."The project involves designing and building a flash defrost system which can be built into new ASHP units. It will be trialled with a production version of a Glen Dimplex A16M ASHP, whose performance and energy characteristics have been documented across the climate spectrum. The tests will be repeated and recorded after the unit has been fitted with the Frigesco defrost system, and the effect on annual energy consumption and carbon dioxide emissions established to EN14511:2013 standards. Frigesco received DECC funding of £145,000 in 2012/13 to support its development of a flash defrost for use in refrigerated display cabinets. Field trials have been taking place in supermarkets in the UK, mainland Europe, the US and South Africa, with results expected to be complete by the end of the first quarter of 2015. Its latest project on ASHPs will begin in the New Year, and will last for 12 months. ■

Air Conditioning Market in India 2014-2018

The market is witnessing an increase in the use of green technologies. Market vendors are increasingly adopting green technologies to create energy-efficient and eco-friendly air conditioning systems. Introduction of hybrid systems and non-polluting refrigerants have led to the provision and adoption of green technologies by vendors and end-users, respectively. According to the report, demand for energy-efficient air conditioners has increased significantly Increased need to save energy coupled with an increase in the adoption of green technologies by many countries is driving the growth of the market. Further, the report states that competition among market vendors has intensified and that has accounted to be a major challenge faced by the market. Vendors are experiencing a decline in their margins owing to increased competition and fluctuations in the price of raw materials. The study was conducted using an objective combination of primary and secondary information including inputs from key participants in the industry. The report contains a comprehensive market and vendor landscape in addition to a SWOT analysis of the key vendors. ■

ASHRAE drives Home Residential Guidance in 2015 Winter Conference Technical Program

Guidance to help ensure that homes are energy efficient and have good indoor environmental quality will be featured in several Technical Program sessions at the 2015 ASHRAE Winter Conference, Jan. 24-28, Chicago. "More time and energy is spent in residential environments than any other environment," Max Sherman, who chaired a Presidential Ad Hoc Committee on the Residential Construction Market that developed a report on "ASHRAE and the Residential Construction Market," said. "The ASHRAE Board of Directors recently acknowledged that by creating a Residential Committee and by making residential an initiative in the Society's newly adopted Strategic Plan. Similarly ASHRAE's mission of providing technical information cannot be achieved without consideration of residential information and guidance. Starting in Chicago, we will see an increase in the number of residential programs available for the professional. This residential guidance is not just for the consulting engineer but is intended for broader residential stakeholders as well."Sherman noted that in the past, ASHRAE used to be heavily focused on residential. In 1895, President Edward Bates, first president of the American Society of Heating and Ventilating Engineers, an ASHRAE predecessor society, spent much of his Presidential address talking about the living conditions of the poor and the Society's duty to improve it. ASHRAE's emphasis has shifted more to commercial and institutional occupancies and away from where people spend most of their time. In the last year, given the amount of energy used in residential buildings and issues related to the indoor environmental quality, ASHRAE took a look at how it can contribute most effectively to the improvement of the performance of residential buildings. The Society released a report, "ASHRAE and the Residential Construction Market," which contains a series of recommendations to the Board of Directors. The ASHRAE 2015 Winter Conference takes place at the Palmer House Hilton, while the ASHRAE co-sponsored AHR Expo is held Jan. 26-28, McCormick Place. ■

Natural refrigerants increasingly significant worldwide

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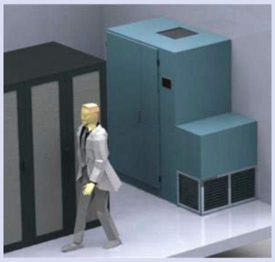
In Europe, the F-Gas Regulation is driving the advance of natural refrigerants "by law". The lecture event entitled "Natural Refrigerants Throughout the World – Country Situation, Applications and Experiences" held by eurammon on October 15 at the Chillventa illuminated the current situation in various international markets. Experts from the individual countries showed how the use of natural refrigerants is developing in Kazakhstan, the Middle East, Turkey and the USA. Kazakhstan still has a long way to go to achieve environmentally friendly standards in refrigeration. Even so, its endorsement of the Kyoto Protocol in 2009 constituted a first important milestone for the Central Asian state when it comes to sustainable technologies. The country now has to implement a national plan to regulate the emissions of climate-damaging greenhouse gases. But a lot still has to be done for natural refrigerants, confirms Yuri Dubodelov from SAKADA Engineering, Almaty. The whole region is suffering from an extreme lack of skilled workers, with scarcely any engineering and development expertise, and there is very little demand for high-performance refrigeration systems that also face strict safety requirements. The situation in the Middle East is much better. Hans Raaymakers, General Manager at ADEAREST, underlines in particular the role played by ammonia in the United Arab Emirates. There has been widespread use of the natural refrigerant throughout the whole region since the 1990s. Many systems are currently being modernized or replaced by new ones, so we expect a continued increase in the spread of ammonia; however, until legislation is in place to urge the use of ammonia, then the cheaper initial costs of adopting conventional refrigeration systems will be seen as an advantage.For decades now, applications with natural refrigerants have been accepted as part of the industrial standard in Turkey. Around 90% of systems use ammonia; only 10% of the systems are operated with fluorinated refrigerants and this is only for cooling areas smaller than 2,000 m^2 in size. There is still relatively little use of CO_2 as a refrigerant. Here increasing impetus is coming from multinational companies that are refurbishing systems with high GWP & high ozone depletion potential. ■

MD Logistics announces extreme Cold Chain Offerings

Leading third-party logistics (3PL) provider MD Logistics now offers -20 degrees Celsius cold chain solutions. As one of the fastest-growing 3PL providers, MD Logistics continues to expand its pharmaceutical and life sciences solutions in response to customer needs. In this case, a new partnership with international biopharmaceutical company, FeF Chemicals, drove MD Logistics to implement this solution.While FeF Chemicals' -20^{O}C cold chain requirements were a new frontier for MD Logistics, the company's constant state of evolution prepared them to seamlessly integrate the necessary equipment, processes and oversight."Developing turnkey solutions allows us to remain responsive to the changing landscape and keep our customers relevant in their respective industries" said Jeff Luthman, vice president of life science solutions for MD Logistics. "We're thrilled to offer FeF Chemicals a customized solution that streamlines its North American operations."The new service offering comes as MD Logistics celebrates several other achievements, including a significant cooler expansion at its Reno, Nevada, facility, pharmaceutical Foreign Trade Zone services, and the successful company-wide integration of a state-of-the-art JDA Red Prairie Warehouse Management System. ■

Direct-Air Evaporative Cooling becomes Mainstream as 200th Installation announced



EcoCooling, the leaders in direct-air evaporative cooling revealed they have completed their 200th data centre cooling installation using the energy saving technology. "Using CRECs (computer room evaporative coolers) instead of the conventional CRAC units (computer room air conditioning units) can save over 90% of the energy needed to cool a data centre," said EcoCooling managing and technical director Alan Beresford, "we are very pleased to announce Serve The World as the 200th data centre to adopt this solution at its 600kW Oslo facility in Norway."Data centre engineers are by nature very cautious and it has taken a number of years for the CREC cooling to be accepted as a safe and reliable alternative to expensive refrigeration-based CRAC cooling. Serve The World now joins a list of highly respected data centre operators able to operate with PUEs (power utilisation effectiveness) of 1.2 or less regardless of the level of occupancy in the data centre. Other data centres which have grasped the power and cost saving EcoCooling CREC cooling technology include Insurance company Unum, UK telecoms companies BT and TalkTalk, public sector organisations Humberside police and Warwickshire County Council plus colocation specialist Capgemini, as well as Cambridge University and RNLI (the Royal Naval Lifeboat Institute).Within the 200 installations there are data centres with power consumptions from 10kW to 1MW. For a 1MW installation the EcoCooling CREC solution would require only around 40kW of power compared to as much as 1000kW with conventional CRAC cooling. This saves the cost and infrastructure for 960 kW of power. Aberdeen University Data Centre – cooled by EcoCooling CRECs has been awarded Data Centre Project of the Year in the BCS & Computing UK IT Industry Awards – covering the UK's entire IT industry. Aberdeen beat off competition from Tesco, Capital One and the NHS. A number of best practices including the deployment of EcoCooling CRECs has led to a PUE of less than 1.1. ■

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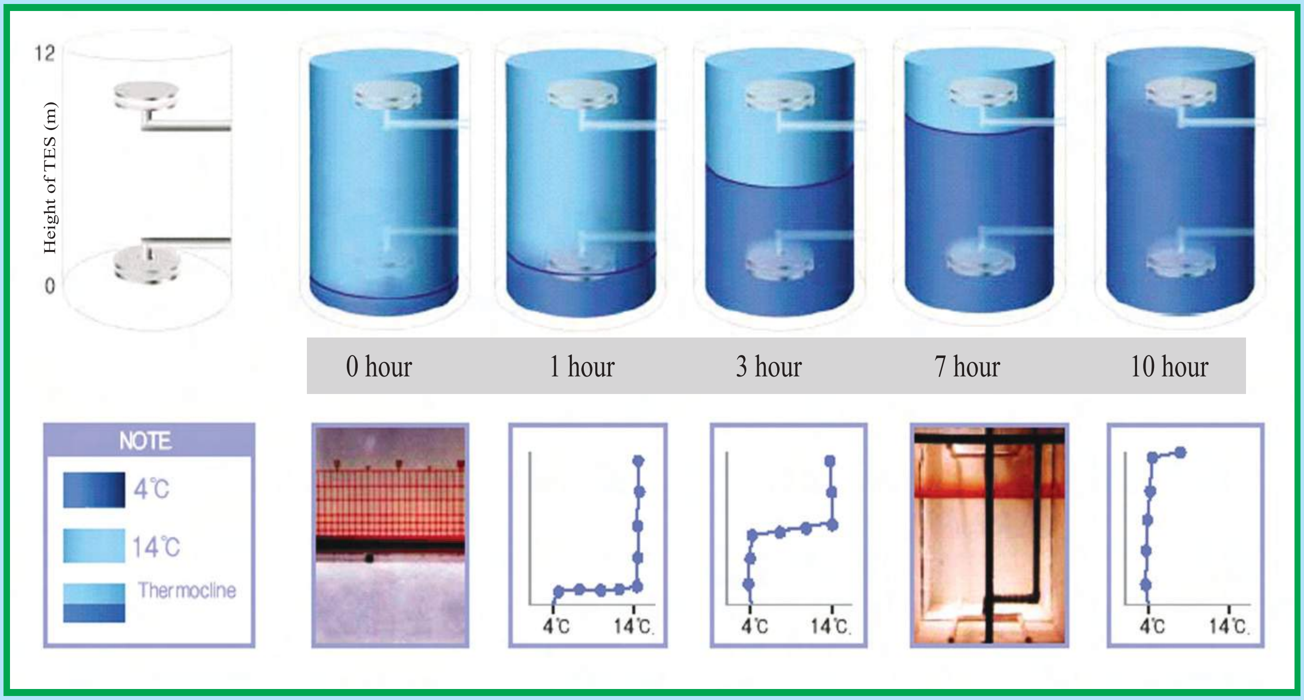

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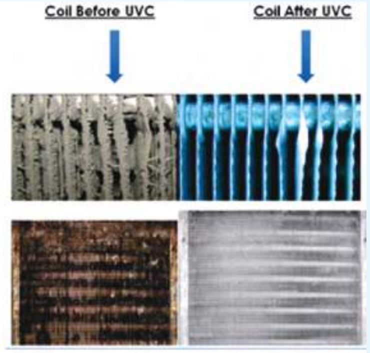

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Heat Pipes for Advanced Cooling Technology

Passive pre-cool and reheat heat pipe technology optimizes building air conditioning and heating system performance with short term return on investment. A heat pipe or heat pin is a heat-transfer device that combines the principles of both thermal conductivity and phase transition to efficiently manage the transfer of heat between two solid interfaces.

At the hot interface of a heat pipe a liquid in contact with a thermally conductive solid surface turns into a vapor by absorbing heat from that surface. The vapor then travels along the heat pipe to the cold interface and condenses back into a liquid - releasing the latent heat. The liquid then returns to the hot interface through capillary action, centrifugal force, or gravity, and the cycle repeats. Due to the very high heat transfer coefficients for boiling and condensation, heat pipes are highly efficient thermal conductors. The effective thermal conductivity varies with heat pipe length, and can approach 100,000 W/m K for long heat pipes, in comparison with approximately 400 W/m K for copper.

All electronic components, from microprocessors to high end power converters, generate heat and rejection of this heat is necessary for their optimum and reliable operation. As electronic design allows higher through put in smaller packages, dissipating the heat load becomes a critical design factor. Many of today's electronic devices require cooling

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beyond the capability of standard metallic heat sinks. The heat pipe is meeting this need and is rapidly becoming a main stream thermal management tool. Heat pipes have been commercially available since the mid 1960's. Only in the past few years, however, has the electronics industry embraced heat pipes as reliable, cost-effective solutions for high end cooling applications. The purpose of this article is to explain basic heat pipe operation, advances, benefits and applications.

Advantages of heat pipe based cooling systems

A heat pipe based cooling solution usually weighs less while moving more heat at a lower delta than traditional cooling solutions, increasing components and product lifetimes and operation reliability. Heat pipes enable passive cooling solutions for high heat load and high temperature equipment, lacking moving parts and boasting extraordinary lifetimes as a result. The benefits of a standard heat pipe include:

- High Thermal Conductivity (10,000 to 100,000 W/m K)
- Isothermal
- Passive
- Low Cost
- Shock/Vibration tolerant.

Heat pipe design

There are many factors to consider when designing a heat pipe: compatibility of materials, operating temperature range, diameter, power limitations, thermal resistances, and operating orientation. However, the design issues are reduced to two major considerations by limiting the selection to copper/water heat pipes for cooling electronics. These considerations are the amount of power the heat pipe is capable of carrying and its effective thermal resistance. The most important heat pipe design consideration is the amount of power the heat pipe is capable of transferring. Heat pipes can be designed to carry a few watts or several kilowatts, depending on the application. Heat pipes can transfer much higher powers for a given temperature gradient than even the best metallic conductors. If driven beyond its capacity, however, the effective thermal conductivity of the heat pipe will be significantly reduced. Therefore, it is important to assure that the heat pipe is designed to safely transport the required heat load. The maximum heat transport capability of the heat pipe is governed by several limiting factors which must be addressed when designing a heat pipe. There are five primary heat pipe heat transport limitations. These heat transport limits, which are a function of the heat pipe operating temperature, include: viscous, sonic, capillary pumping, entrainment or flooding, and boiling.

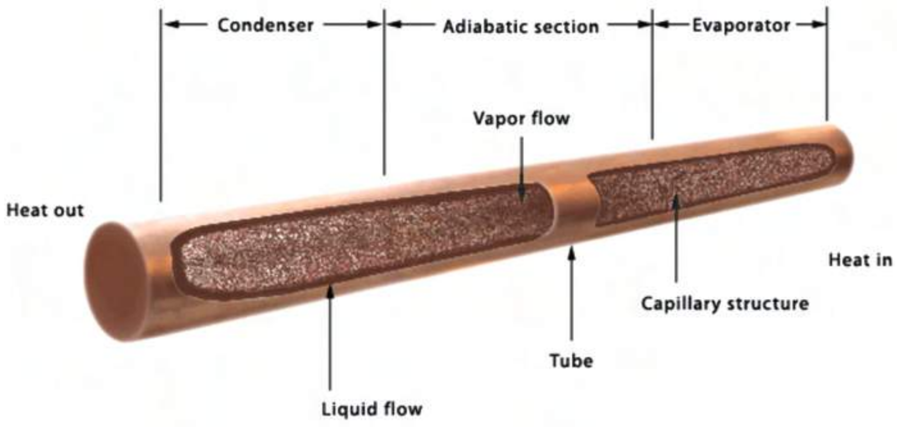
Working of heat pipes

Heat pipes are highly reliable industrial products for cooling applications. Companies are developing new functionality and increased performance with emerging heat pipe technology. Heat pipes are used across a wide range of markets and applications, e.g., terrestrial electronics cooling (copper-water), on orbit satellite thermal management (aluminum-ammonia) and high temperature calibration equipment (liquid metal heat pipes). Heat is transferred by the evaporation and condensation of a working fluid. Heat transfer to the evaporator vaporizes liquid within the wick.

- Vapor pressure drives fluid to the condenser
- Heat transfer from the condenser condenses vapor at the wick.
- Liquid returns to the evaporator by capillary forces generated in the wick.

The lower end of the heat pipe is exposed to heat and the coolant within it starts to evaporate by absorbing heat. As the coolant turns into vapor, it, and its heat load, convect within the heat pipe. The reduced molecular density forces the vaporized coolant upwards, where it is exposed to the cold end of the heat pipe. The coolant then condenses back into a liquid state, releasing the latent heat. Since, the rate of condensation increases with increased delta temperatures between the vapor and heat pipe surface, the gaseous coolant automatically streams towards the coldest spot within the heat pipe. As the coolant condenses, and its molecular density increases once more, gravitational forces pull the coolant towards the lower end of the heat pipe.

A heat pipe is a closed evaporator-condenser system consisting of a sealed, hollow tube whose inside walls



are lined with a capillary structure or wick. Thermodynamic working fluid, with substantial vapor pressure at the desired operating temperature, saturates the pores of the wick in a state of equilibrium between liquid and vapor. When heat is applied to the heat pipe, the liquid in the wick heats and evaporates. As the evaporating fluid fills the heat pipe hollow center, it diffuses throughout its length. Condensation of the vapor occurs wherever the temperature is even slightly below that of the evaporation area.

As it condenses, the vapor gives up the heat it acquired during evaporation. This effective high thermal conductance helps maintain near constant temperatures along the entire length of the pipe. Attaching a heat sink to a portion of the heat pipe makes condensation take place at this point of heat transfer and establishes a vapor flow pattern. Capillary action within the wick returns the condensate to the evaporator (heat source) and completes the operating cycle. This system, proven in aerospace applications, transmits thermal energy at rates hundred of times greater and with a far superior energy-to-weight ratio than can be gained from the most efficient solid conductor.

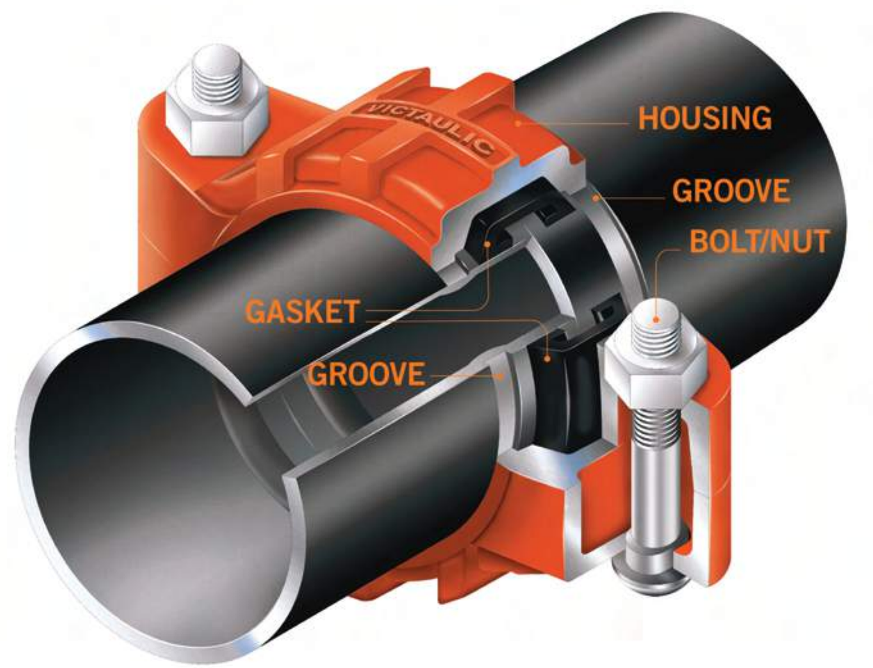
Features of modern heat pipes

Since its beginning in the early 1960s, the heat pipe technology has evolved into many different shapes and forms and has been used in numerous applications from computer cooling to spacecraft thermal control. The following are the various advanced forms of heat pipes:

- Water Heat Pipes
- Intermediate Temp Heat Pipes
- High Temperature Heat Pipes
- Vapor Chambers
- Pressure Controlled Heat Pipes
- Loop Heat Pipes
- Heat Pipe Loops
- Heat Pipe Life Tests

Heat pipes can be designed to operate over a very broad range of temperatures from cryogenic (<-243°C) applications utilizing titanium alloy/nitrogen heat pipes, to high temperature applications (>2000°C) using tungsten/silver heat pipes. In electronic cooling applications where it is desirable to maintain junction temperatures below 125-150°C, copper/water heat pipes are typically used. Copper/methanol heat pipes are used if the application requires heat pipe operation below 0°C.

To aid the coolant cycle, improve its performance, and make it less dependent on the orientation of the heat pipe towards earth gravitational center, modern heat pipes feature inner walls with a fine, capillary structure. The capillary surfaces within the heat pipe break the coolants surface tension, distributing it evenly throughout the structure. As soon as coolant evaporates on one end, the coolants surface tension automatically pulls in fresh coolant from the surrounding area. As a result of the self organizing streams of the coolant in both phases, heat is actively convecting through heat pipes throughout the entire coolant cycle, at a rate unmatched by solid heat spreaders and heat sinks. By adjusting its dimensions, capillary surface structure, coolant formula and internal pressure, heat pipes performance can be fine-tuned for operating range and angle dependence, to match a wide range of operation. ■



Refurbishment & Maintenance of Existing and Historic Buildings with Mechanical Piping Systems

In the refurbishment of existing buildings, a grooved mechanical system offers advantages as it is faster to install than welding or flanging and doesn't require job site preparation.

Work on existing or historical buildings often presents challenges, with structural constraints, limited access, risk of damaging the building and designs that do not incorporate adequate space for modern HVAC systems.

Such buildings also require a fast installation that maintains complex plaster and takes the existing decoration and paint into account without the risk of discolouration. There is also potential fragility as well as vulnerability to fire hazards, often caused by extensive use of welding.

In this article Simon Ouellette, Engineering Services Supervisor at Victaulic, discusses the advantages that mechanical pipe joining systems, also known as grooved systems, bring to the maintenance and refurbishment of these types of buildings, and helps to reduce and avoid the above mentioned risks.

Challenges faced

There are many reasons why a historic or existing building may require a new heating or cooling system; the owners may wish to update an old boiler system with more modern heating pumps or chillers to increase the system's capacity or efficiency, the pipe sizes within a system may need to be altered to increase flow, or the system in place is so worn out that it becomes a threat to the building's integrity.

Other reasons may include a desire to make a building more marketable or when changing its usage. Additionally, to comply with new building codes and regulations, owners may need to retrofit with a modern fire protection system. All of these instances require working with an existing piping system. Compatibility of the two systems is not always guaranteed, posing a real challenge to engineers and installers. Problems caused by confined spaces, working around existing structures and limited site accessibility often result in an even bigger challenge. But more critical is the risk of damage to the building.

Project preparation

Planning and preparation are crucial in retrofit projects where many factors concerning the building's preservation need to be taken into account. Specifying the right pipe joining method from the start can help to overcome most of these challenges and can result in a swift installation and material handling. Using today's modern design technologies, such as 3D modelling and walk-throughs brings along numerous advantages. Not only will the design be more accurate, solving issues like pipe collisions at an early design stage, but it will also enhance onsite material handling. Using modern design technologies allows the output of detailed bill of materials and pipe cut length sheets, resulting in leaner fabrication techniques, improved material handling and less time spent on the job site.

The tight architectural designs of mechanical rooms in historical buildings demand reliable, cost-effective solutions that keep system footprint to a minimum.

Simon Ouellette, is Engineering Services Supervisor at Victaulic, the world's leading producer of grooved mechanical couplings and pipe-joining systems. Victaulic mechanical pipe joining systems can be found in projects as diverse as Tetra Pak in Pune, the Park Hotel Hyderabad and the IOCL Naptha cracker plant at the Panipat Refinery in Haryana.

Right method from the start

Grooved mechanical pipe joining involves cold forming a groove in pipe ends and then joining them with bolted housings around a pressure responsive gasket. This method is considered a standard form of joining fire protection piping systems and is employed in the most demanding industrial markets and critical applications because of its ease of installation and reliability. Also in the refurbishment of existing buildings, a grooved mechanical system has its merits. It is three to four times faster to install than a welded or flanged system and it doesn't require job site preparation, unlike the extensive preparation necessary for welding.

Specifying this flame-free pipe joining method removes the many health and safety concerns associated with welding. It eliminates the risk of fire during installation and also the need for a hot work permit and safety watch.

Unique challenges

When refurbishing old buildings, it is also common to be faced with unforeseen events, such as the discovery of asbestos in the building's structure, causing massive project delays and these can even result in missing the project deadline. Because of the speed of installation a mechanical grooved system provides, installing such a system can help to recover lost time.

Also existing decoration, furniture, paintings and wallpaper need to be taken into account when installing a new system and can be highly damaged by fumes released when welding. Installing a grooved mechanical system takes away all these risks together with the risk of damaging the interior when bringing in welding equipment and the extra costs for fire blankets to protect the interior.

Another factor that has a huge influence in the preservation of a building is humidity. For example, wooden or painted surfaces can crack when humidity in the winter isn't high enough, or when humidity is too high, moisture can migrate through the walls. When installing a new HVAC system it is crucial to keep the downtime as short as possible to reduce the risk of humidity settling in. Therefore it is important to select a pipe joining method that is easy to install and maintain, to keep the system downtime as short as possible.

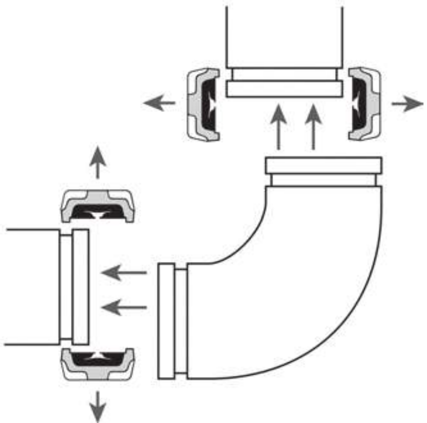
Grooved mechanical pipe joining systems require less labour, provide a smaller footprint, and enable better prefabrication while improving onsite material handling and maintenance. This flame-free joining method enhances safety and minimizes project risk due to the ease and speed of installation it provides, while reducing the total cost of installation.

Easier prefabrication

Time spent on the jobsite is a critical cost and risk factor, leading contractors to prefabricate as much as possible offsite. Prefabrication offers major productivity gains and labour efficiencies – especially when there is limited lay down space on the job site, as is often the case in retrofits.

Within the piping industry, prefabrication is considered to be up to four times more productive than field fabrication. Twice as much work can be completed per man-hour, due to the controlled environment of off-site prefabrication and availability of specific tooling. In addition, twice the productive hours can be achieved due to better materials flow control and improved supervision.

But even prefabrication is not a perfect science, line-up errors can still happen in the field; a small number of such errors can have significant impact



A union at every joint means flexibility and ease of maintenance.

on an installation schedule. To make the field management of such rework easier, using a mechanical joining system, which provides a union at every joint, allows simple field correction of any alignment errors, minimising schedule disruptions onsite. Another advantage of prefabricating a grooved system is that spools are normally kept straight, while welded spools are usually bent. By working with straight spools, onsite risk of damaging the building and its interior is considerably reduced and line-up problems less common.

Piping is an area where front-loading efficiencies and maximising productivity can produce significant savings in man-hours and ultimately can help compress construction schedules. In fact, while piping system materials can account for as little as one per cent of total installed costs on a project, their installation time can eat nearly 30 percent of the entire project schedule. Therefore, when considering the significant schedule and cost advantages achieved by strategic prefabrication, one can begin to see why prefabrication is indeed coming of age.

Without prefabrication and a grooved system, it would have been impossible to meet the tight schedule for the refurbishment of the 'La Scala' theatre in Milan. Using a 'Bag and Tag' system enabled deliveries of prefabricated spool to the jobsite on the day it was required and also kept unloading time and interference with traffic in the city centre as limited as possible.

This was also the case for the refurbishment of the 'Chamber of Deputies' in Rome. Prefabrication was crucial due to the location of the building in the centre of the most crowded city in Italy. Confined spaces, interference with traffic and the tight schedule were important factors when refurbishing the DN200/8" cooling lines. The prefabrication approach minimized incon-veniences and reduced the time they took.

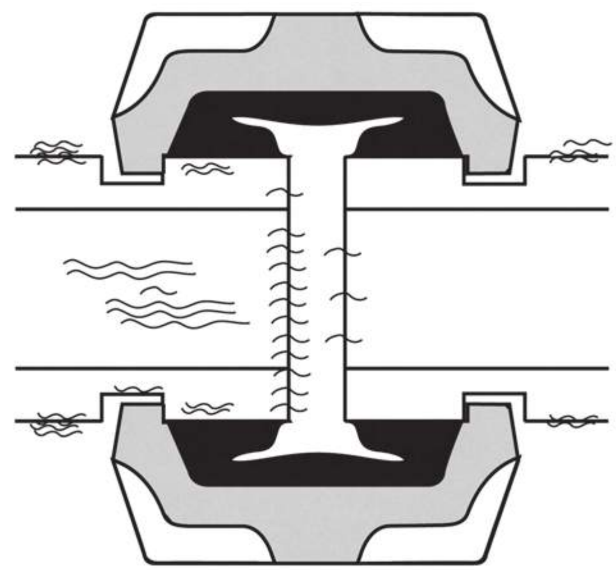
Working around constraints

The tight architectural designs of mechanical rooms in historical buildings puts pressure on consulting engineers and contractors to deliver reliable, cost-effective solutions that fit in the structural constraints and keep the system's footprint to a minimum.

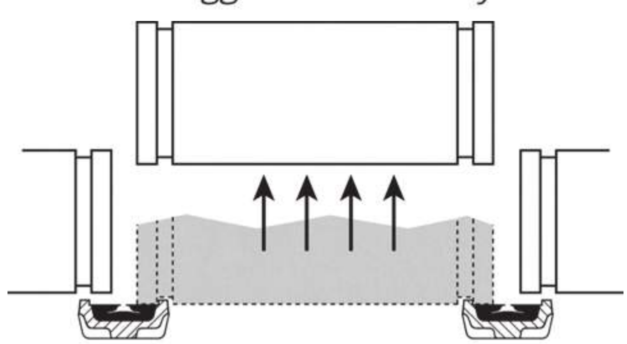
Because of the limited available space, the risk of pump cavitation & lower efficiency is greatly increased. When turbulent water enters a pump chamber and the suction eye of a pump impeller, the degree of turbulence has a direct correlation with lower pump efficiency and greater hydraulic noise within the pump casing. To reduce effects of turbulence before water enters the centrifugal action of the pump impeller, suction pipes are typically kept as long and straight as possible before the connection onto the pump. Yet installing long lengths of pipe may often not be possible. When bends have to be connected directly onto the pump suction side, the result is water flow that may spin in opposite directions within the eye of the impeller. Pump energy then has to be spent correcting this action before producing the expected performance, decreasing flow and pressure.

Grooved end mechanical piping systems address all these issues. They are lighter weight, smaller sized, with higher integral strength compared with welded or flanged systems. And because grooved products are considerably smaller in footprint compared to flanges, pipes can be installed closer to each other. Also the need for having an extra spool piece between flanged check and butterfly valves is eliminated when designing mechanical rooms with grooved valves.

To increase pump efficiency and



Exaggerated for clarity



Exaggerated for clarity

Grooved couplings maintain excellent noise & vibration attenuation qualities, as well as the ability to accommodate deflection, expansion and contraction.

avoid cavitation in confined spaces, a grooved end suction diffuser is a simple alternative - it straightens out the spinning fluid created by the change in direction at bends and enables pipework to be connected closer to the pump at a 90-degree angle. Eliminating long pipe runs, elbows and reducers makes for a smaller mechanical room footprint and optimum pump performance.

Noise and vibration

Excessive vibration and noise caused by a system can be a great challenge for many engineers when designing a system. Not only does it decrease the lifetime of the system but these are also key elements for tenants. But in historical buildings, there are even more crucial factors that need to be taken into account. System vibration can weaken structures, cause serious damage and because insulation in old buildings is often rudimentary, system noise can be easily heard throughout the property.

Grooved couplings maintain excellent noise and vibration attenuation qualities, as well as the ability to accommodate deflection, expansion and contraction throughout the life of the piping system. Sound attenuation depends only on the three flexible couplings being placed near to one another, in close proximity to the source of vibration, so there are still numerous opportunities for design flexibility.

Furthermore, each successive joint in a mechanical grooved system creates an additional reduction in vibration. Independent testing concluded that, for any given pipe diameter, less vibration is transmitted with each additional Victaulic coupling, regardless of whether Victaulic flexible or rigid couplings are used. For a building like the 'La Scala' Theatre, where acoustics are crucial, this was one of the decisive factors in specifying a grooved mechanical system.

Conclusions

Grooved mechanical piping systems are a highly and reliable alternative, compared to welding and flanging for the refurbishment of HVAC systems in existing and historic buildings. They provide a smaller footprint and a greater ease of prefabrication, improving onsite material handling. This flame-free joining method helps to minimise the risks due to the ease and speed of installation, enhances onsite safety and reduces system downtime during unscheduled or day-to-day maintenance.

As the refurbishment of the Scala Theatre in Milan and the Chamber of Deputies in Rome both revealed, grooved mechanical piping systems are faster to install and reduce project costs and exposure to damage compared to other pipe joining methods.

Furthermore, when mechanical pipe joining systems combine with the right project management and design services, such as BIM, software solutions and bag-and-tag, they can provide a complete solution to transform and modernise the process of refurbishing HVAC systems. ■

Commissioning of Fan/Blower Units

Beyond the Scope of Switching ON

Fan Units find their application in HVAC/R facility in all residential as well as commercial buildings. Fan units are commonly used in most of the equipment in a HVAC/R system.

They are used in Cooling Towers, Air Handler Units, Ventilation Units, and Forced Draft Type Heat Exchangers etc. Based on their mode of operation and their basis of construction, they are classified into various categories like Axial Fans, Centrifugal Fans, Aerofoil Fans and Propeller Fans etc.

The philosophy of Commissioning of a Fan/Blower unit as defined and interpreted by different category of lay people differs from one another. According to a Contractor's philosophy, Commissioning of a fan/blower unit is just switching "On" the equipment by pressing its button and making it operational, whereas on the other hand a Client's philosophy is little more extended up to recording of air-flow rate and the technician's philosophy is further stretched up to recording the amperage also. The veracity still supersedes these curtailed philosophies and asserts Commissioning of a fan/blower unit as a vast and unique subject that requires a thorough understanding about its concepts. Although there are numerous points that require ample time to follow and implement, but a few of them are very much essential to be followed stringently. Here are few important procedures which are crucial to complete a faultless commissioning and shall never be ignored or bypassed.

Every fan/blower unit is selected

based on six basic parameters viz. air-flow rate, its potential to overcome the static pressure drop, type of installation/ducting arrangement, density of air it has to handle, noise level and finally its efficiency i.e. Output Power Vs Input Power. There are four basic types of Ducting arrangements for fans/blower (shown in Fig. 1). These ducting arrangement effect the performance of fans/blowers.

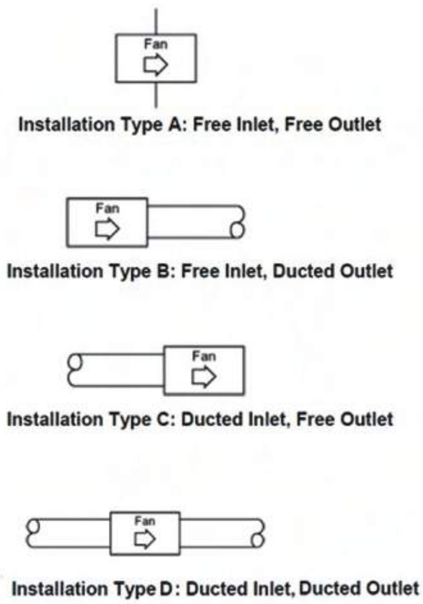


Fig. 1: Four Basic Types of Installation/Ducting Arrangement for Fans/Blowers

Considering all the four basic installation types and ducting arrangement for fan/blower units, this article is structured and furnished.

Vibration Isolators

When mechanical equipments like fan/blower units are bolted or anchored firmly to the building floor or slab, the vibrations produced by them are transmitted directly into the structures. The vibrations travel in solid building structure like columns, beams, floor & slabs and may be transmitted as structural borne noise to certain distance away from the equipments. Sometimes these unwanted vibrations bring about structural damages if the operating weight of the fan/blower unit is too much. To circumvent such situation, vibration isolators are recommended to plant beneath the floor mounted fan/blower units (as shown in Fig. 2) and

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Hanger type vibration isolators are recommended to be provided for hanging type fan/blower units. Vibration isolators are available in various types and in various patterns, but the most commonly used are Spring Type Vibration Isolators and Neoprene Vibration Isolators.

Fig. 2: A Vane Axial Fan Unit Mounted On Spring Vibration Isolators at Four Corners

Prior to commissioning of a fan/blower unit, it must be ensured that vibration isolators of suitable potency designed to with stand the operating weight of the fan/blower unit are provided. It should also be noted that all the vibration isolators provided for a particular fan/blower unit shall be of same size and equal capacity.

Validation of appropriate Motor for the Fan

This is an unavoidable activity which shall be a part of standard procedures involved in the commissioning of a fan/blower unit. Motors employed for fan/blower units are generally available in different speed ranges like 2- Pole Motors, 4- Pole Motors, and 6- Pole Motors etc. The selection of motor for a particular fan/blower model depends on its speed and its capacity to meet the fan/blower size. There should not be a wide difference between the selected fan/blower speed and the selected motor speed. Although manufacturers take enough care while undertaking their design and selection activities but the problem arises whenever a fan/blower assembly is delivered to the site in a dismantled state and that too for a unit with a Belt-Pulley type arrangement. Past experiences convey that there is always a chance of shuffling/interchanging of motors whenever the fan/blower assembly is delivered in a dismantled state to the site. The ill-effects of shuffling or interchanging of fans-motors result in a severe problem during and after commissioning. For instance, if a fan/blower unit is selected to deliver a certain amount of air-flow at 750 rpm and is designed to be coupled with a 4-pole motor of 1450 rpm by means of belt & pulley mechanism. In case if it's compatible motor gets replaced by a 2-pole motor during assembly, then the consequences may not be favourable since the speed of a 2-pole motor is just twice to that of a 4-pole motor. The result will be either increase in fan speed, thereby increasing the air-flow rate of the fan as well as amperage of the motor or else it will make the fan unstable and will start surging. So one of the most obligatory activities in commissioning is to check the technical data sheet of the fan/blower unit and cross verify for the exactness of its motor.

Motor terminal connections

Before switching "On" the fan/blower unit, power rating of the motor must be checked thoroughly. Mostly 3-phase Induction type motors are used for fan application in HVAC/R facility, except in a few cases where 1-phase motors are also used as in case of small sized propeller fans. All the 3-phase induction motors are either electrically connected to work with DOL (Direct On-Line) starters or Star - Delta Starters. In today's modern times, fan-motors are being operated on VFDs i.e. variable frequency drives. 3-Phase Induction motors of capacity up to 5.0 KW are compatible to operate with DOL starter and 3-Phase Induction motors of capacity above 5.0 KW are compatible to operate with Star – Delta starter.

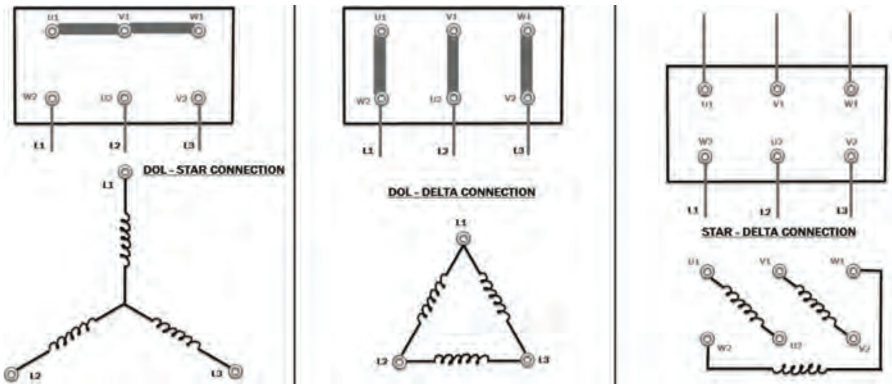


Fig. 3: A Typical DOL Starter Connection and STAR–DELTA Connection for 3-Phase Induction Motor

Fig. 3 represents two types of DOL connections viz. Star DOL & Delta DOL and Star-Delta Connections to a 3-Phase Induction Motor. Commissioning Engineers must thoroughly check the wiring connection prior to commissioning of a fan/blower unit. Any wrong wiring connections to motor terminals may cause the fan-motor to "Tripp Off" frequently or may cause electrical accidents.

For a fan unit with 1-phase motors, dual windings (Main winding and Secondary winding) are the commonest as shown in Fig. 4.

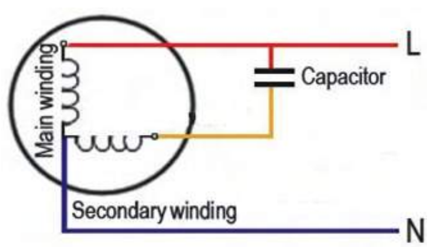


Fig. 4: A Typical Single Phase Motor Wiring Connection

Motor Megger

One of the key activities generally avoided and uncared for, while commissioning is Megging of the fan/blower motor. Megging of a 3-phase motor shall be done in order to validate the insulation resistance among the windings and to verify the strength of the insulation between two power cables. If the Meg value between two power cables is less than the minimum recommended value, then it is strongly recommended to replace the power cables otherwise short circuit will occur between two phases. Similarly, the same is the case with motor windings. If the Meg value between two windings of a motor is less than the minimum recommended value, then it is strongly suggested to warm up the motor by means of some external source. Even after warming up, if no improvement is observed in the Meg value, then the whole motor winding has to be re-varnished. But if the Meg value between the motor body & motor windings fall below the limits then there is no other option left, except to go for re-winding of motor. This action not only saves and protects the motor from getting burnout but also it prevents the occurrence of electrical hazards.

For 1-phase motors Insulation testing shall be done across the motor casing and the winding of the motor but not across the windings. Megging of motor is done by using an Instrument called Insulation Tester (shown in Fig. 5).

Fig. 5: A Digital Insulation Tester

Verification of Electrical Components & their ratings

Prior to commissioning of fan/blower units, a common mistake generally committed is that cable sizes and ratings of electrical components used in the starter panel like contactor rating, MPCB rating & its set point, Fuse rating, MCB rating, Over Load Relay rating & its set points are never focussed on. A skilled Commissioning Engineer is the one who concentrates and focus on this branch and check the cable sizes with their ratings or else he will seek the guidance of an Electrical Engineer for the right path. Under-rated safety components like MPCBs, MCBs or fuses will cause frequent shunting & tripping "Off" the motor. And also under-sized cables & contactors will heat up instantly and will cause burn out. On the other hand, over-rated safety components will never let the motor trip "Off" even in case of high amperage and such a situation will cause damage to the motor.

Proper Earthing/Grounding

Every fan/blower unit is coupled with an electrical motor directly or indirectly. The concept of a motor is very well known to all of us that it is a device which converts electrical energy into mechanical energy. This conversion is achieved by simulating electromagnetic field followed by heating up whenever current flows through its coil/winding. The coil/winding is shielded with insulation material like PVC paper to absorb any stray/leak current inside the motor. If the insulating material becomes week or feeble by continuous rubbing of hot coil winding with the motor casing, then the motor casing will act like a conductor and will cause electric shock to those who ever comes in contact with it, during its course of operation. In such a situation, proper earthing or grounding of the fan/blower unit in union with the motor will protect by redirecting the excess current to the grounding conductor of the building. If any safety device what is called GFCI or Ground Fault Circuit Interrupter is installed in the circuit, the grounding wire will trigger the GFCI to "shut off" the power in case of any short circuit. Commissioning Engineers must thoroughly check and ensure that fan/blower unit in union with the motor is properly connected to the grounded conductor by carrying out continuity test. Also the correct size of earthing/grounding strip or wire to be used must be established to match with the current carrying capacity of the equipment.

No Load Run Test

Every fan-motor must pass through No-Load run test. No-Load run means a fan must be de-coupled from the motor. No-Load run test can be performed on direct coupled fans as well as belt-pulley coupled fans having driver-driven mechanism. No- load run test is performed by running the motor at rated voltage with a de-coupled shaft extension (zero load or nearer to zero torque), and record the following parameters: line voltage, line current, input (absorbed) power and shaft rotational speed. Although, the intent of carrying this test is very significant as it has a broader relevance for determining various losses of the motor. But our main purpose of carrying No-Load run test is to check the free rotation of the motor shaft. Simultaneously the speed of the motor shaft (for 3-Phase Induction motor) shall be checked to confirm whether the fan-motor is of 2-Pole or 4-Pole or 6-Pole etc especially for those motors whose name plates or rating tags are lost or misplaced. For 1-phase motors, No-Load run test shall be carried out to determine the maximum speed of the motor shaft.

Measurement of Air-Flow Rate

Air balancing and Air-flow measurements are essential and vital activities in the commissioning of fan/blower units without which commissioning of fan/blower units are treated to be incomplete. The rarest case ever observed is the precise measurement of air-flow rate of the fan/blower units. For measuring air-flow rate through grills & diffusers, a Digital hood fitted with pitot tube is the best option. But all the contracting companies won't afford to arrange for a digital hood with pitot tube and hence the worthiness of a digital hood is never valued by contracting companies. The option left over with such contracting companies is to go ahead with rotating vane type digital anemometer and get unreliable as well as inconsistent readings of air-flow rate. There are two reasons for getting unstable and unreliable readings of air-flow rate by measuring with a rotating vane type digital anemometer at the air terminals.

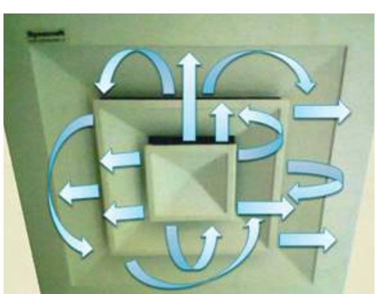


Fig. 6: A Typical Air Diffuser on False Ceiling showing the outflow of air

The first reason is due to turbulence of air. Fig. 6 shows how the air-flow pattern changes and becomes turbulent as soon as it exits out of an air terminal.

Air-flow measurement shall be

carried out at the air terminals in the air network (both at suction side as well as at discharge side). Whenever air discharges out of grills/diffusers, then it becomes turbulent. Due to turbulence of air there will always be inconsistency in the air velocity moving around the terminals.

The second reason for getting unstable and unreliable readings of air-flow rate by measuring with a vane type digital anemometer at the air terminals is only because of unawareness and lack of knowledge of the Engineers. Most of the Engineers working in the arena of HVAC/R are ignorant and unapprised about net effective area. Every air terminal whether grills or diffusers are selected on the basis of free area and net effective area.

Fig. 7: A Typical Air Grill showing the Effective Area

Refer to Fig. 7 for better understanding about Effective area.

Effective area (Ak), is the net area of a grill/diffuser utilized by the air stream in passing through the face openings. The standard equation for calculation is:

Air Flow rate (CFM) = Face Velocity * Effective Area.

(Ak) is a factor which every manufacturer of grills/diffusers specify in their technical data.

Free area is the total minimum area of the openings in the supply air outlet or return air inlet through which air can pass. It is also known as the "see-through area".

Effective Area = Free Area * (Ak)

Since most of the Engineers usually don't bother to check the value of (Ak) / specifications provided by the manufacturers and also it is practically spiky to measure the net effective area of grills/diffusers and hence they calculate the air-flow rate by using a very deplorable formula:

Air Flow rate (CFM) = Face Velocity * Free Area.

The result is unreliable value of air-flow rate. These two practical problems can be surmounted by maintaining laminar air-flow or by creating a condition for laminar air-flow and simultaneously maintaining a free area at the air terminal. This is practically achieved by aligning a straight duct piece at the mouth of grill/diffuser wherever air-flow rate has to be measured. This duct piece creates laminar air-flow and maintains a free area for measurement at the outlet. Refer to Fig. 8.

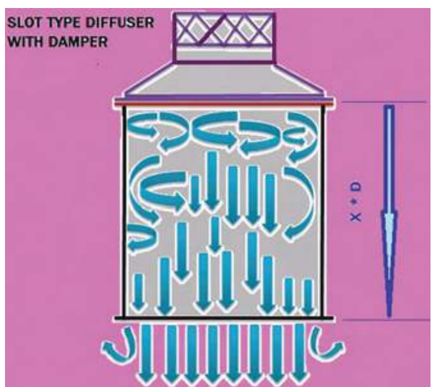


Fig. 8: A Typical Diffuser showing air-flow measurement using duct piece

Under any pathetic or wretched site condition, if at all a small duct piece is not manageable then the best option left up with, is to measure the velocity of air-flow using an anemometer by removing grills or diffusers at air terminals.

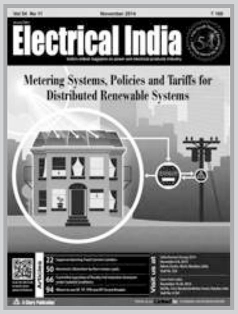
There are certain fans that are installed at site without ducts on either side i.e. with free inlet & free outlet as in case of propeller fans. For such fans, it's difficult to determine the actual area of the medium through which the air will propagate and hence there has to be a definite area through which the rate of air-flow shall be measured. This problem can be wrecked by placing a temporary duct piece on either side of the fan unit as shown in Fig. 9 for measuring air-flow rate.

Fig. 9: A Propeller Fan with Free Inlet and Free Outlet

Measurement of Static Pressure

For a ducted type fan/blower unit, a Design Engineer establishes the required static pressure by calculating the pressure drop offered by ducts, elbows, reducers, dampers etc. and by adding a safety factor to the sum of total calculated pressure drops. But practically at site, due to site constraints changes are incorporated in the ducting layout and thus variation occurs between selected static pressure and the actual static pressure drop. Finally the variation in pressure drop results in the variation of air-flow rate. Hence there will always be a difference in the designed air-flow rate and the actual air-flow rate of the fan/blower unit. To establish the actual static pressure of the fan/blower unit and the static pressure drop offered in the entire air network, a manometer or a Digital magnhelic gauge is used. A manometer or Digital magnhelic gauge shall be fixed across the foremost volume control damper positioned at the mouth of the fan/blower unit. Refer to Fig. 10 for static pressure measurement and its arrangement set-up.

Static Pressure shall be measured in two steps. In the first step the Volume Control Damper shall be 100 % closed (fully). The magnhelic gauge will read the maximum static pressure that the selected fan/blower unit can generate at 0% air-flow (No air-flow). In the second step the Volume Control Damper shall be 100% open (fully). The magnhelic gauge will read the maximum static pressure drop that the selected fan/ blower unit can resist at the 100% air-



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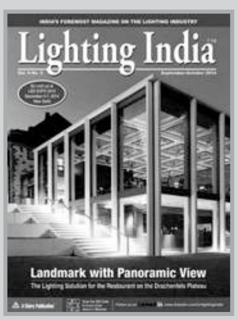

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flow rate fleeting through the existing air network. These two points shall be plotted on the fan curve provided by the manufacturer for any particular fan model and verify the actual potential of the fan/blower unit.

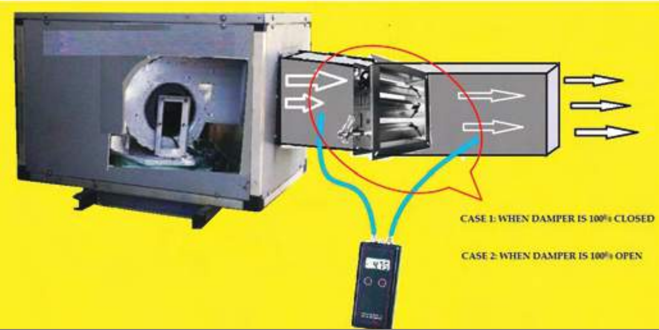


Fig. 10: Digital Magnhelic Gauge fixed across the foremost Volume Control Damper from the mouth of a Fan/Blower unit

Power Measurement

For any equipment, it is very important to establish the power consumption or the electrical power intake by the equipment when it is in use. This will aid to establish the specific power consumption or efficiency of fan/blower unit. The formula for calculating electrical input power to 3-phase motor is

Power (KW) = (Volts x Amps x √3 x Pf)/1000

Where Volts = Mean Voltage

i. e. {(Voltage R-Y) + (Voltage Y-B) + (Voltage B-R)}/3

Amps = Mean Amperage

i. e. {(Amperage@R) + (Amperage@Y) + (Amperage B)}/3

Engineers sooner or later assume an approximate value of pf as 0.9 or 0.95 which is absolutely a wrong ideology. Practically power factor varies with the variation in inductive load. Power factor must always be measured by using a Power factor meter to get exact power intake by the motor. The rated power on the motor indicates the mechanical output power offered by the motor which shall not be treated as the Input Power. Every motor is rated with its efficiency marked on the name plate. Once after calculating the exact Input power, exact output power of the motor shall be calculated by using the formula:

Output Power (motor) = Input Power (motor) x Efficiency

The output power of motor is then transmitted to the fan/blower shaft which shall be considered as input power to the fan/blower. The transmission of mechanical power is carried directly in case of direct coupled fans/blowers or else the transmission of mechanical power is carried out by means of drives. If the fan/blower is directly coupled to the motor then the transmission loss factor shall be 1 and if the fan/blower is belt driven then the transmission loss factor shall be 0.95 (for V-belt only). The Input Power of the fan/blower shall be calculated by the following formula:

Input Power (fan/blower) = Output power (motor) * 0.95

The mechanical output power of the fan/blower shall be calculated by using the formula:

Output Power (fan/blower) = Input Power (fan/blower) x Efficiency

The deviation observed in actual output power of the fan/blower and the rated output power of the fan/blower will indicate about the healthiness of the system.

Plotting actual Fan Operating Point on Fan Performance Curve

There has always been a misconception in the minds of Immature Engineers that the commissioning of a fan unit is limited up to recording the parameters. The main objective of commissioning is to verify the actual operating point of a fan unit with the designed operating point as declared by the manufacturer. The divergence can be either interpolated or extrapolated to match with the designed operating point.

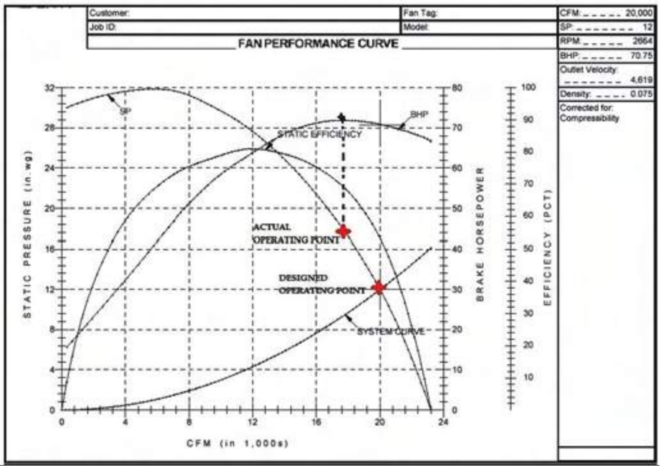


Fig. 11: A Typical Fan Performance Curve denoting the Designed Operating Point & Actual Operating Point

A typical fan performance curve is shown in Fig. 11 as a ready reference. If the actual operating point of the fan unit doesn't fall anywhere on the fan performance curve then it indicates that parameters recorded are incorrect or else the fan has become unstable which is a rarest case. Parameters shall be recorded repeatedly till the actual operating point of the fan is established on the fan performance curve provided by the manufacturer for that particular fan model. Air-flow rate, Static pressure and Fan Power are the three significant parameters required for achieving actual operating point at a defined speed on the fan curve. Plotting of Operating Point and its establishment on Fan Performance Curve is a very indispensable activity without which Commissioning of fan unit shall be treated as incomplete.

Corroboration between Discharge side Air-flow rate & Suction side Air-flow rate

Ideally a fan/blower unit is considered to be constant air volume equipment. But practically there has always been a minor variation in air-flow rate say round about 5% - 10% between the discharge side and the suction side of a fan/blower unit. Since 5% - 10% variation may be due to unstable parameters and thus this much variation can be ignored. There are several cases where the difference between air-flow rate on discharge side and on suction side is quite considerable. The variation may be due to various factors which effects influentially on the performance of a fan/blower unit. Ideally air-flow rate should be measured on both sides i.e. on Discharge side as well as on the Suction side of the fan/blower unit. Many a times, it is experienced that Project Execution Engineer/Supervisor switches "On" the fan/blower unit and tries to measure the air-flow rate without seeking guidance from a Commissioning Engineer. This is a general practice which is experienced mostly where projects that are undertaken by unprofessional contractors and in all such cases system failure has occurred. The interesting scene comes into sight when fan/blower unit operates and the failure is observed in the measurement of air-flow rate. Either the measured air-flow rate is too high than the rated air-flow or else the measured air-flow rate is too low than the rated air-flow. Then such situation calls for a Commissioning Engineer to intervene. Since this is common problem and can be considered as a problem by-default. In such cases air-flow rate shall be measured on both sides so that the lacuna can be traced out. The best ideology to trace out the stumbling block is to check the amperage of the fan-motor and compare the same with the rated amperage as specified on the name plate. This will give an idea about the air-flow rate of the fan unit. The more the air-flow rate, the more amperage it will draw.

The diagnosis for such failure of air-flow rate can be of various types and can differ from case to case.

Case 1: There are various cases especially those for Exhaust Air ventilation fan units, where it is found that the air-flow rate on discharge side is too much higher than on the suction side. This problem may take its birth due to intake of air by infiltration through leakage in the air network. The source of leakage may exist at various locations. Fig. 12 illustrates an exhaust air ventilation fan unit discharging out 6,000 CFM of air and takes in only 3,800 CFM of air. As a matter of fact, a fan never generates extra air volume. So is obvious for the question to arise, that

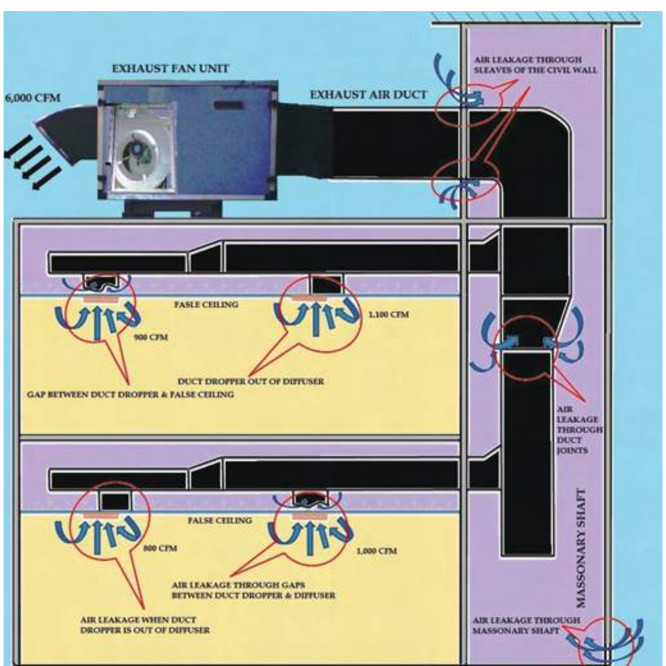


Fig. 12: Exhaust Air System where Air-flow rate at Discharge side > Air-flow rate at Suction side

from where the fan unit is getting this extra air volume of 2,200 CFM. As the question is simple and so the answer is. The fan is taking in 2,200 CFM of air through gaps between the duct droppers and false ceilings, through civil or masonry shaft leakage and through gaps at the duct joints. All these technical hitches point their finger towards a single culprit i.e. Execution Engineer and the site supervisors who have shown irresponsibility in monitoring and checking these snags during the execution of project. A Commissioning Engineer has to first check the entire air network including masonry shaft as well as the position of the droppers and collars above false ceiling.

Case 2: The second case in itself is also quite critical which is observed at most of the places especially in the toilet areas where exhaust air ventilation system is provided considering that the fresh air will be drawn from the adjacent lobby or the passage area via louvers provided on the toilet doors. The doors of the toilet shall be provided with louvers as they will be a part of exhaust air network. Failing to provide louvers or else the size and number of louvers provided are not sufficient enough, in both the cases the effect will be the same i.e. the measured air-flow rate of the fan unit on discharge side and on the suction side will be very much less than the rated air-flow. The immature client and the pitiable Project Execution Engineer assume the fan unit to be of under-rated capacity and declare about its non-performance. The condition will remain the same even if the existing fan unit is replaced by a new fan unit. The fact is that the fan unit is not getting free air which it has to draw through louvers as the intent of design itself is meant for such kind of arrangement. Fig. 13 illustrates such kind of situation.

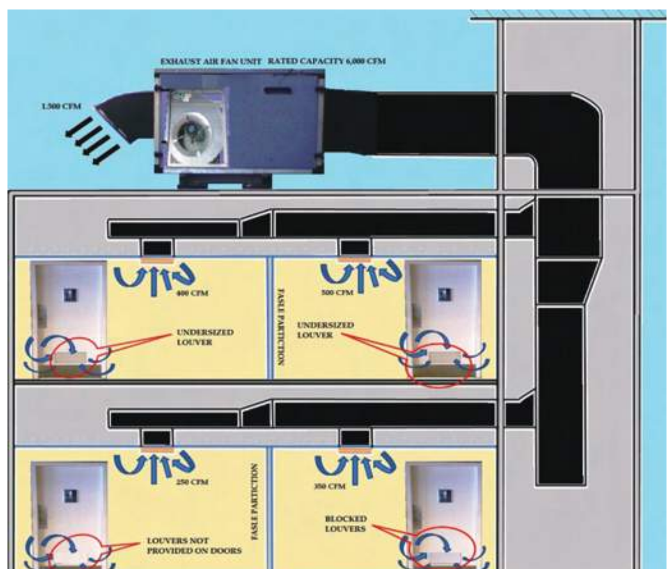


Fig. 13: Exhaust Air System where actual Air-flow rate < rated Air-flow

Case 3: Sometimes it is even observed that the air-flow rate drawn by the fresh air ventilation fan unit is too high but when it is measured at discharge side then the scenario seems to be a nightmare because the measured value on the discharge side is comparably negligible. This is a case of its own kind and so it can be rightly said that this case is vice-versa of case – 1. Fig. 14 illustrate such incidents.

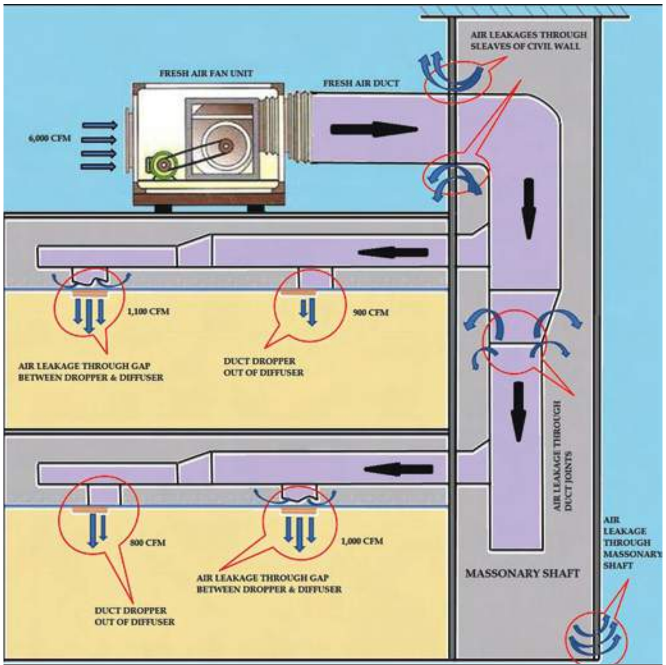


Fig. 14: Fresh Air System where Air-flow rate on Discharge side < Air-flow rate on Suction side

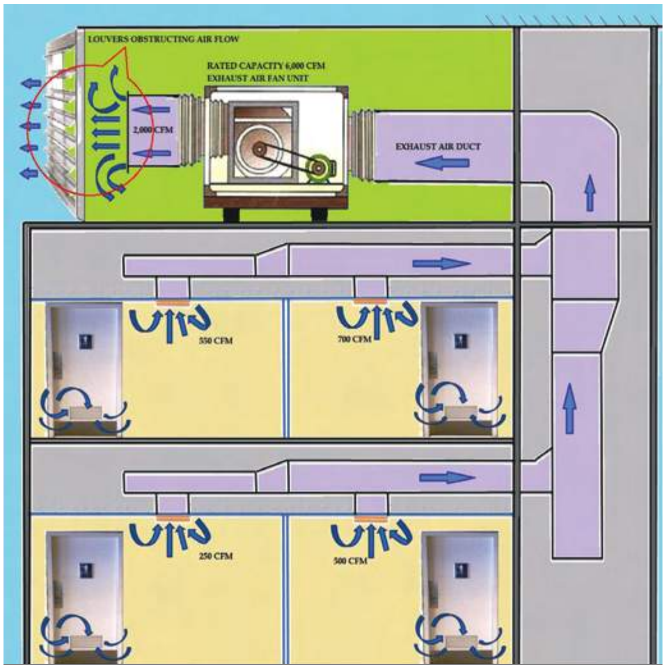


Fig. 15: An Exhaust Air System having Restricted Air-flow on the Discharge side

The same reason is applicable i.e. the leakage through gaps between droppers and the false ceiling, gaps between the duct joints, voids and gaps through masonry/civil shafts etc. Over in all it's merely due to leakage of air only. To trace out the exact location of air leakage, the right persons shall be the Execution Engineer and the site supervisors who are aware of all the In's and Out's of the Project.

Case 4: Quite often there is a remarkable variation in the rated air-flow and the actual air-flow rate. After profound and thorough investigation also it is difficult to trace out the root cause despite of close monitoring while executing the project. But the answer lies there in the problem itself. Insufficient clearance for the fan unit either at suction side or at discharge side is one of the major root causes. Case – 2 revealed how insufficient clearance on the suction side for the free flow of air, have an effect on the fan performance. Same is the problem with insufficient clearance for free flow of air on the discharge side. This is shown very well in Fig. 15.

Every customer has a different perspective about their project. They are more or less inclined towards aesthetic look of the project rather than towards technical part of the project. Generally exhaust/fresh air fan units are placed either on terrace or at such a level where these fan units may be visible to the outsiders. To hide these fan units, customers generally prefer to cover the terrace by louvers and hence the obstruction to free flow of air occurs. Such an approach of customer, sometimes lead to a major system failure which cannot be corrected easily. These problems could be resolved at the installation stage itself if the Execution Engineer has an engineering approach to route the exhaust/fresh air duct to free air zone or else if the Execution Engineer educates the customer about the ill consequences of covering the free area.

Options are always available with the entire Project team to throw ball in each other's court in case of any system failure. Let it be in Design Engineer's court for a wrong selection or Manufacturer for supplying inefficient system or Execution Engineer for applying wrong methodology while installation and sometimes even in Customer's court for demanding inappropriate system which will be unfit to meet his need and requirement or the Architect for designing the structure by focussing primarily on aesthetic look which may not be fit for HVAC/R facility. But an expert Engineer if engaged for commissioning activity shall be reasonable enough to justify and to establish the real and root cause for the failure while system commissioning. What is discouraging is that a poor system commissioning is getting encouragement and approach is towards misinterpretation of standards. This approach always penalizes the HVAC/R system working and its performance. ■

Renewable Energy in HVAC/R

Amid growing concerns about rising energy prices, energy independence, and the impact of climate change, statistics show buildings to be the primary energy consumer. The energy consumption by heating, ventilation, and air conditioning systems accounts for roughly 40 percent of total building energy consumption, and in turn, buildings account for 35 to 40 percent of total worldwide energy consumption.

HVAC energy consumption in commercial buildings is a key contributor to total global energy consumption. Driven by tightening energy efficiency regulations and by demand for higher-efficiency buildings, the technology for efficient HVAC systems is advancing. According to a new report from Navigant Research, annual revenue from energy efficient HVAC systems will grow from $17.2 billion in 2013 to $33.2 billion by 2020.

This fact underscores the importance of targeting building energy use as a key to decreasing the energy consumption. The building sector can significantly reduce energy use by incorporating energy-efficient strategies into the design, construction, and operation of new buildings and undertaking retrofits to improve the efficiency of existing buildings. It can further reduce dependence on fossil fuel derived energy by increasing use of on-site and off-site renewable energy sources.

The concept of a Net Zero Energy Building, one which produces as much energy as it uses over the course of a year, recently has been evolving from research to reality. Currently, there are only a small number of highly efficient

Norman Dsouza, Sales and marketing director actively involved in propagating integral approach to design in construction and maintenance of buildings having direct impact on environment and natural resources.

buildings that meet the criteria to be called "Net Zero". As a result of advances in construction technologies, renewable energy systems, and academic research, creating Net Zero Energy buildings is becoming more and more feasible.

While the exact definitions of metrics for "net zero energy" vary, most agree that Net Zero Energy Buildings combine:

Exemplary building design to minimize energy requirements and Renewable energy systems that meet these reduced energy needs.

As the "zero energy" and "net zero energy" concepts are relatively new, there are not yet definitive, widely accepted zero-energy metrics. The Department of Energy and the National Renewable Energy Laboratory have spearheaded much of the work on net zero energy buildings to date. NREL presents several definitions for "net zero energy", and they encourage building designers, owners, and operators to select the metric that best fits their project. Site Energy refers to the energy consumed and generated at a site e.g. a building, regardless of where or how that energy originated. In a net zero site energy building, for every unit of energy the building consumes over a year, it must generate a unit of energy.

Source Energy refers to primary energy needed to extract and deliver energy to a site, including the energy that may be lost or wasted in the process of generation, transmission and distribution. For example, a coal-burning power plant may generate 1 Joule of electricity for every 3 Joules of energy in the coal consumed. If natural gas is used at a site, for every 20 Joules consumed, 1 Joule may be needed to extract and distribute the gas to the site. Metrics for net zero source energy buildings account for these factors, though exact metrics can vary depending on site and utility factors.

Net Zero Energy Cost is perhaps the simplest metric to use: it means that the building has an energy utility bill of Rs 0 over the course of a year. In some cases, building owners or operators may take advantage of selling Renewable Energy Credits from on-site renewable generation. Many conventional energy sources result in emissions of carbon dioxide, nitrogen oxides, sulfur dioxide, etc. A Net Zero Energy Emissions building either uses no energy which results in emissions or offsets the emissions by exporting emissions-free energy.

Regardless of the definition or metric used for a Net Zero Energy Building, minimizing the energy use through efficient building design should be a fundamental design criterion and the highest priority of all NZEB projects. Energy efficiency is generally the most cost-effective strategy with the highest return on investment, and maximizing efficiency opportunities before developing renewable energy plans will minimize the cost of the renewable energy projects needed. Using advanced energy analysis tools, design teams can optimize efficient designs and technologies. Energy efficiency measures include design strategies and features that reduce the demand-side loads such as high-performance envelopes, air barrier systems, day-lighting, sun control and shading devices, careful selection of windows and glazing, passive solar heating, natural ventilation, and water conservation. Once building loads are reduced, the loads should be met with efficient equipment and systems. This may include energy efficient lighting, electric lighting controls, high-performance HVAC, and geothermal heat pumps. Energy conversion devices such as combined heat and power systems, fuel cells, and microturbines do not generate renewable energy. Instead, they convert fossils fuel energy into heat and electricity and are can be considered energy efficiency strategies.

In the wake of the global recession of 2009, developed markets for efficient HVAC – especially in North America and Europe – remain sluggish. However, the North American market will revive during 2013 and begin to experience more substantial growth during 2014. Europe will follow a similar trend, but recovery will likely not occur until mid to late 2014. The strongest region for energy efficient HVAC expansion, however, will be Asia Pacific, which will account for 55 percent of the world market by 2020. The global HVAC market, according to the report, is led by large suppliers, such as UTC Carrier, Hitachi, Ingersoll-Rand Trane, Daikin, and LG Electronics, many of which also produce various other products, technologies, and services. HVAC-only manufacturers are largely limited to smaller and midsize brands such as Lennox and Uponor. Some larger suppliers, such as Johnson Controls, also provide integrated engineering and operations/ maintenance services, overlapping in part with services more traditionally provided by energy service companies.

Energy Efficient HVAC Systems, analyzes the global market opportunity for energy efficient commercial HVAC systems, including unitary systems, heat pumps, furnaces and boilers, ductless cooling, engineered cooling systems, radiant heating and cooling, and ventilation systems. The comprehensive focus on assessment of the demand drivers, business models, policy and regulatory factors, and technology issues associated with the global market for these systems. Key industry players are profiled in depth, and worldwide revenue forecasts, segmented by application, region, and key major countries, extend through 2020.

Apart from managing energy consumption, a substantial amount of energy is still required to power a building. Thus, the build green industry is inevitably moving towards alternative sources of energy to the traditional burning of oil and gas - renewable energy, predominantly building integrated photovoltaic and the usage of biomass/ biogas. These identified renewable energy sources are sustainable alternative to SE Asia's growing energy needs. Focusing on Singapore (the region's green building leader) primarily, solar photovoltaic is expected to generate approximately 5% of the country's power needs by 2025, and biomass/ biogas will generate another 2%. In time, more building owners, developers and other building professionals will utilise renewable energy sources and systems to generate energy for their buildings, as the economic viability becomes more evident and recognised. According to the Sustainable Energy Association, renewable energy systems can last up to 20 to 25 years, rendering a good 20-year investment return, after the 5-year payback of initial investment.

Additionally, with the trending towards the implementation of zero-net-energy buildings, the increased adoption of solar powered energy for buildings is certain. In the next few years, suppliers of maturely developed building integrated solar panels and systems in the Western region will find a buoyant market for their offerings, in SE Asia and its wider region.

For the past century, okay a decade, LEED certified buildings have been the premier standard in high performance sustainable buildings. Other standards like the Living Building Challenge, Passivhaus, and Zero Net Energy verified buildings were signals of over achieving designers and owners looking to make a statement. These high benchmarks were viewed as complex and expensive goals that design teams were lucky to participate in only rarely. ZNE buildings currently contribute to a small fraction of all green buildings, but if you have read an industry article lately, you know the market is changing.

The New Buildings Institute defines Zero Net Energy buildings as buildings with greatly reduced energy loads such that, averaged over a year, 100% of the buildings' energy use can be met with onsite renewable energy technologies. Project teams achieve highly energy efficient designs through thoughtful material choice, passive energy strategies and intelligent system design and sizing. Then apply renewable power generation to reach ZNE status. In the past, owners were reluctant to invest in what was a costly and time consuming project path to ZNE. Through increased incentives, more aggressive energy codes and policy, less expensive renewable energy systems, and more experienced design teams, ZNE now comes at a much smaller additional cost and is gaining market share. An experienced team will incorporate early energy analysis, and an integrated design approach to manage these costs. According to a report released in early 2014 by NBI, the number of buildings achieving or pursuing ZNE across North America has more than doubled since 2012. With those kinds of numbers if it was a product on the popular show Shark Tank, I would invest in it.

ZNE is achievable in a wide variety of regions and climate zones, working for many building types and sizes. These buildings use only a quarter of the energy of average commercial buildings, repaying incremental costs applied during design and construction as significant operational savings. Much like other sustainable building objectives, ZNE is achieved by careful design, selecting the right technology for the project's specific needs, controls, monitoring and constant feedback and commissioning. In other words, a lot of work! But the benefits in terms of energy savings and building resiliency are worth it. NBI states that 24% of all ZNE verified projects are now renovated existing buildings, once considered a near impossible feat. This bodes well for Americas aging building stock especially in larger cities in the northeast like New York and Boston that have building energy policies, like Boston's Building Energy Reporting & Disclosure Ordinance.

ZNE districts are also a growing trend. Communities and campuses are committing groups of buildings to achieve ZNE, taking advantage of economies of scale. Today there are currently 18 ZNE districts in the US. Community district efforts are organizing everywhere. In December 2013 the city of Cambridge, MA created the Zero Net Energy Task Force that has been charged with advancing the goal of putting Cambridge on the trajectory towards becoming a "net zero community".

In the last few years ZNE buildings have gone from impossible to improbable to finally achievable. ZNE buildings are becoming the new standard for achieving significant energy savings and reducing greenhouse gas emissions in the built environment, a market transformation tool much like LEED. Do you remember when LEED certification was a statement!

The Net Zero Energy Commercial Building Initiative aims to achieve marketable net zero energy buildings by 2025 through an array of public and private partnerships to advance the development and adoption of high-performance buildings. Net Zero Energy Building principles can be applied to most types of projects, including residential, industrial, and commercial buildings in both new construction and existing buildings. A growing number of projects have been designed and constructed across the various market sectors and climate zones. Several links to DOE's Commercial project resources are provided below, including:

The design of this Net Zero source energy Habitat for Humanity home carefully combines envelope efficiency, efficient equipment, appliances and lighting, and passive and active solar features, including photovoltaics, to reach the zero energy goal. The home uses the utility power grid for storage—delivering energy to the grid when the PV system produces more energy than the home uses and draws from the grid when the PV system produces less energy than the house needs. This approach eliminates the need for battery storage and reduces the cost, complexity, and maintenance of the solar electric system.

Regular discussions with Habitat construction staff and volunteers weighed the applicability of the optimized solutions to the special needs and economics of a Habitat house which moved the design toward simple, easily maintained mechanical systems, and volunteer-friendly construction techniques. A data acquisition system was installed in the completed home to monitor its performance.

The question for policymakers, and all other citizens, is no longer whether humans are changing our climate. The question now is how we can stabilize an already-changing climate in a way that promotes economic prosperity? While recently established domestic policies have made strides toward a lower carbon future, such measures are stepping stones. They prescribe the initial path but will not lead to the final goal of achieving the reductions in greenhouse gas emissions necessary to help stabilize global temperatures. Effectively mitigating climate change requires identifying exactly how can we transform energy economy to attain international goals to help protect our climate but will also generate new jobs.

Why go net-zero! "Because we believe very strongly in the future of our children and sustainability is probably the most important thing today in our lives and we really have to protect the Earth for our new generation.

Saving energy is great, but so is saving money

The best tools and tips can offer both, according to local businesses, whose lines of energy-efficient products and services are expanding to meet demand for saving green and leaving smaller carbon footprints.

"For most, it has a lot to do with comfort, investing in a house they know they will be in for a long time, "There are a lot of people motivated by minimizing their impact on climate change or costs, too. They don't want to have to worry every winter about their heating bill. It's a way to stabilize their cash flow."

The design-build firm creates greener homes from blueprint to finished product, incorporating advanced building envelopes, high-efficiency mechanical systems and passive solar energy, a technique that positions a home and landscaping to collect the greatest natural benefits of sunshine through trees and shrubbery that are bare in winter and offer shade in summer.

"It is the smallest investment one can make, but it gives everybody a capital improvement plan for their house, It will outline all the other investments they can make and identifies all the opportunities to reduce energy usage. "That's our path to getting people to net zero energy." ■

Busey Bank

Schneider Electric uses EnergyEdge and powerful HVAC building controls and components to re-commission antiquated 70,000 sq ft building

Busey Bank realizes a 52% reduction in natural gas consumption and a 30% kwh savings; all with fast payback and a better bottom line

When Jason Vogelbaugh of Alpha Controls & Services, Schneider Electric's Rockford, IL partner, visited Busey Bank's 100 year-old Executive Center building in Champaign, IL he saw challenges – and enormous potential. "It was 'the poster child' for buildings of this vintage," recalls Vogelbaugh. "The entire building was one zone, running at full heating or full cooling. We were there to quote new controls on one of the RTUs, but I found an extremely receptive audience at Busey Bank for making significant across-the-board improvements in energy efficiency in this older building."

Getting busy at Busey – with EnergyEdge

Armed with Busey Bank's utility bills, Vogelbaugh put Schneider Electric's EnergyEdge program to work. EnergyEdge is a proven, proactive process used to assess and analyze a facility's energy usage and costs, and then create and implement a program that delivers sustained energy efficiency and operational cost savings. "Typically, facilities are managed reactively, meaning obvious problems are fixed as they arise, but little is done proactively to counter ever-rising energy costs," says Vogelbaugh. "But EnergyEdge makes it easy, and in the case of Busey Bank it quickly confirmed what we suspected. For example, we determined that the building's annual electricity usage was about 1.8 million kwh – or 2-1/4 times greater than a typical building of this size and type. We also could see that the 3 million BTU boiler system was running at only about 60% of its nameplate rating, meaning there was an enormous potential for saving 'therms'."

> *"To say that Busey runs a 'tight ship' where costs are concerned would be a bit of an understatement." In this challenging economic environment, we're keenly aware of operational costs – and at the same time the need for green, sustainable practices. What Schneider Electric was able to tell us about the building was a real eye-opener."*
> ***Donald J. Schlorff***
> *Busey Bank Executive Vice President*

Re-commissioning: combining HVAC brains – and brawn

With the green light from Busey Bank, Vogelbaugh, Alpha Controls and Schneider Electric proceeded full steam ahead with the re-commissioning project. "We install building management systems that act as the 'brains' of the building so it can detect, and react swiftly to, even the most subtle building changes caused by solar load, outdoor air temperature, humidity and even occupancy," says Vogelbaugh. "We design and install a system of rugged field devices to provide the 'muscle' to work dependably around the clock. Schneider Electric gives us the complete range of solutions so the process of installation and integration is that much easier." For example, the vintage 70's rooftop unit was originally designed to run at constant volume, so the fan always operated at full speed regardless of outdoor air temperatures or internal

> *Making the project even more attractive to Busey was the exceptionally short Return on Investment (ROI) period, adds Busey's Schlorff. "Clearly, the energy savings would be significant, but there was also a powerful additional incentive through our electric utility provider Ameren Illinois, which provides businesses with financial incentives for upgrades of older HVAC systems. Ultimately, we qualified for a 20% rebate on the total project cost, which essentially gave us a new Schneider Electric control system practically free.*

load conditions, accounting for considerable energy waste. But by installing a Schneider Electric Altivar Variable Speed Drive (VFD), it now became possible for fan motor speed to be matched exactly to changing load requirements within the building, and either increase or reduce fan speed and corresponding outside air volume accordingly. Installation of Schneider Electric S-Link temperature sensors and thermostats provide building heat load control. When, for example, a thermostat calls for cooling, a Schneider Electric I/A Series® MNB-1000 Plant Controller activates one of four cooling stages and instructs the VFD to increase fan motor speed accordingly – and to reduce speed just as quickly and efficiently as soon as the desired temperature is detected. With the entire air conditioning system now operating with vastly improved energy efficiency, Busey Bank reduced its kwh usage over the course of 12 months from 1.8 million kwh to just 1.2 million kwh – an impressive 30% savings.

EnergyEdge had also shown that the two 2,500 gallon, 3,000,000 BTU antique Aerco condensing boiler systems used for the building's steam heat were running at just 60% of nameplate efficiency and consuming, and wasting thousands of natural gas 'therms' a year. The complete lack of separate space temperature zones, or any way to quickly and efficiently adjust for fast changing building load changes anywhere in the building, had created an incredibly inefficient, and uncomfortable, environment. Alpha Controls instead created 16 separate heating zones, and a network of Schneider Electric DuraDrive zone valves and valve actuators to precisely regulate steam flowing through the 2" steam distribution piping running to each zone. Schneider Electric Altivar 21 VFDs were installed on the hot water pumps to provide more precise control, along the lines of the RTU fan motors. And Schneider Electric temperature sensors, thermostats and MNB-1000 controllers were again used throughout the system to provide exceptionally accurate, and responsive, heating control in each separate zone based on changes in load, time of day, and the demands of the occupants. Today, annual BTU consumption in the Busey Bank Executive Center has been cut in half.

Financial Results

• Annual kWh usage reduced from 1.8 million to 1.2 million – a 30% savings.
• Annual natural gas consumption reduced by 52%.
• 20% rebate earned from electrical utility provider's HVAC upgrade incentive program virtually pays for a new Schneider Electric control system.
• 100% Return On Investment (ROI) on total project cost just 18 months after completion.

Schneider Electric's HVAC controls respond to changes in load, time of day and occupancy demands to optimize annual energy savings


SE's I/A Series® MNB-1000 Plant Controllers put powerful information at fingertips of the building's managers to help reduce energy consumption & troubleshoot problems – all available anywhere via the Internet

The solution

Busey Bank turned to Schneider Electric and a wide range of powerful HVAC building automation controls and components to re-commission its Executive Center building.

Project Assessment

SE's EnergyEdge® program assesses, analyzes and helps implement a program for sustained energy efficiency and operational cost savings.

Air Conditioning

Building rooftop units equipped with Schneider Electric Altivar Variable Speed Drives; conversion from constant volume to exceptionally precise fan motor control results in significant energy savings and vastly improved occupant comfort and productivity. SE's S-Link temperature sensors and thermostats provide input & heat load control.

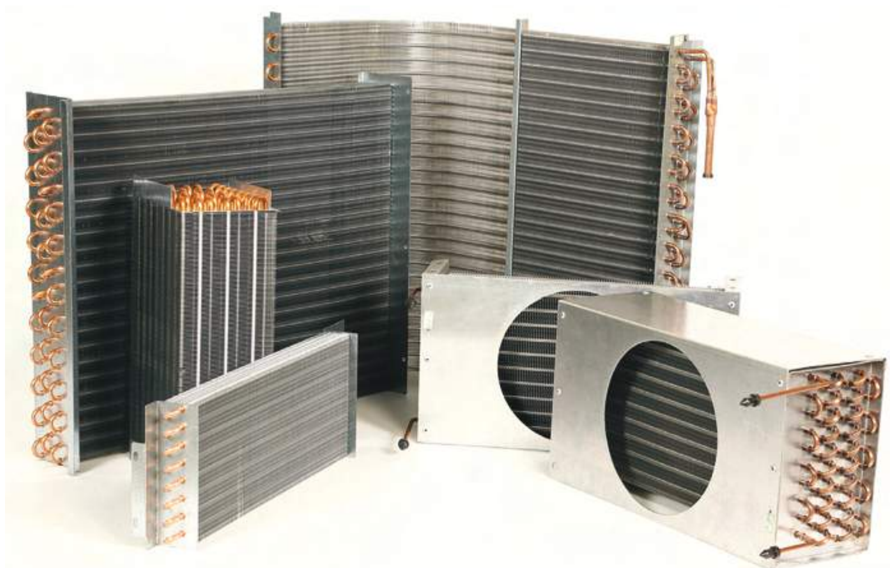
Heating

A single heating zone is converted to 16 separate heating zones, all with the ability to quickly and efficiently adjust for fast changing building load changes. Schneider Electric DuraDrive zone valves and valve actuators precisely regulate steam and return lines; Schneider Electric Altivar 21 VFDs provide precise hot water pump control.

Results

Busey Bank is busy reaping rewards of building re-commissioning project, including significantly lower energy costs and an ROI fast approaching 100%. "It's proof that making an investment of this type in an older building is good business and great for the bottom line," concludes Busey's Schlorff. ■

Courtesy:
Schneider Electric India



Copper-based heat exchangers for alternative refrigerants

The ongoing global effort to replace, currently and widely used refrigerants, such as R22 and R410A with zero Ozone Depletion Potential (ODP) and virtually zero Global Warming Potential (GWP) alternative refrigerants, have important implications for heat exchangers, air conditioning system design, and materials choices in these designs.

Leading refrigerant candidates include the natural refrigerants like propane (R290) with higher flammability, CO_2 (R744), new hydrofluoroolefins (HFO's) and blends of HFOs with R32, a component of R410A, a hydrofluorocarbon (HFC). Each places different requirements on the heat exchanger design, whether it be for higher equipment efficiency, for reduced refrigerant charge, to operate to much higher operating pressures or temperatures, to prevent corrosion or to avoid leakage.

Several copper-based technologies can enable the transition to these new alternative refrigerants in both room air conditioning systems and commercial refrigeration systems, providing synergies with key performance characteristics of the refrigerants, and providing technologies that address the impact of energy efficiency degradation from mold growth.

- Small diameter inner grooved thinner wall tubes with outer diameters of 7mm, 6.25mm, 5mm and 4mm for reduced charge, and wall thicknesses of 0.26 to 0.21mm
- Higher strength copper alloy tube for high pressure refrigerants like CO_2 (R744).

Traditional copper tube/ aluminum fin coil manufacturing technology when modified for smaller diameter copper tubes of 7mm to 5 mm, can achieve significant improvements in heat transfer. When coupled with internal enhancements to the copper tubes such as higher strength, thinner walls and internal micro-grooves, newer optimized heat exchanger designs can be smaller, more efficient, and lower cost compared.

A major innovation of small diameter copper tube technology enhances heat transfer by rifling or grooving the inside surface of the tube. This increases the surface-to-volume ratio, mixes the refrigerant, moves the refrigerant into contact with the interior surface of the tube, and homogenizes refrigerant temperature across the tube, resulting in more efficient conductive and convective heat transfer. The high efficiency of the inner grooved tube stimulates and promotes the development of energy-saving, high efficiency and miniaturization for air conditioning systems. Typically, such surface enhancement can significantly increase overall heat transfer performance, with different inner groove geometries available for optimization under various refrigerants and conditions.

The family of this range of small diameter inner grooved copper tubes, from 7mm down to 4mm O.D., shown in Figure 1, permit significantly smaller refrigerant charge, compared to heat exchangers made with standard 9.53mm diameter copper tube, and equivalent to those using aluminum microchannel extrusions, and they maintain energy efficiency similar to units using traditional refrigerants with larger diameter tube heat exchangers. They have been found to provide a proven and safe solution for air conditioners using refrigerant R290 (propane) which requires very limited charge size under new regulations for use in air conditioners (Ding, 2012).

A newer herringbone inner grooved version of this tube, also in Figure 1, enhances heat transfer over conventional inner-grooved heat exchanger tube without increasing pressure drop. With good fin design, an entire condenser row can be dropped. This performance enhancement has meant lower raw material cost in refrigeration applications, and in residential air conditioning, systems were smaller in size with reduced refrigerant charge and lower raw material cost. A study of heat-transfer performance of different inner-grooved copper tubes for CO_2 heat pumps found the highest heat transfer and the lowest effect of PAG lubricating oil with herringbone patterned inner-grooved copper tube (Kaji, 2012).

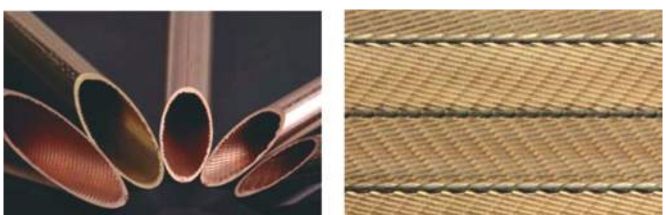


Fig. 1: Inner grooved small diameter copper tube and example of enhanced inner tube surface herringbone pattern

The small diameter tubes have the high strength needed to sustain CO_2 operating conditions. They have a higher level of solution flexibility versus microchannel, through special circuiting to eliminate mal-distribution of refrigerant and over-sizing for standard products (Filippini, 2011).

Performance

The performance effects of using small diameter inner-grooved copper tubes are shown in Figure 2, where enhanced inner-groove shape tube increased heat transfer rate by 50% over standard inner-grooved tube, and at least 100% over smooth tube. The observed increased pressure drop with smaller diameter tubes can be addressed by changes in circuitry design (Wu, 2012). Energy efficiency and reduced overall system size can be achieved at a lower material cost with small diameter copper tube technology via reduced usage of tube and fin materials and refrigerants, contributing to overall reduction of system cost (Holland, 2013). The impact of changing from traditional 7 mm tube to 5mm inner-grooved tube can be significant:

- 20-30% reduction in tube weight
- 20-30% reduction in fin weight
- 25+% reduction in internal volume and refrigerant charge
- 30% reduction in required wall thickness to meet pressure requirements
- 10+% heat transfer coefficient that improves heat exchanger efficiency
- 25% reduction in heat exchanger cost.

The application of smaller diameter tubes will affect heat exchanger performance on both the air side and refrigerant side. On the air side, the fin size is related to the balance of heat transfer resistance between fin and tube, so fin size for smaller diameter tubes is usually smaller. The fin pitch (the distance between fins), which depends on tube diameter, is also decreased. These may decrease the heat transfer capacity and increase air side pressure drop. But there is also a compounding benefit of smaller diameter tubes as shown by the following equation of heat flow, indicating greater effective primary fin metal area and higher inside and outside heat transfer coefficient, illustrated in Figure 3 (Holland, 2013).

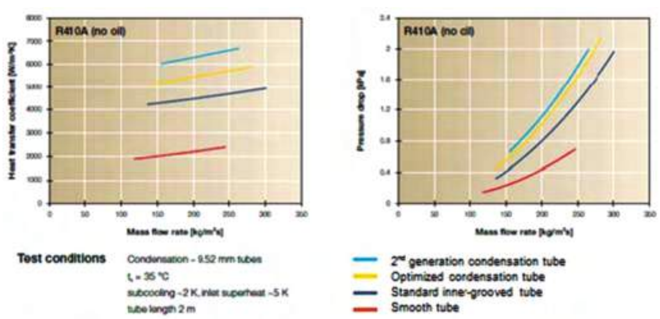


Fig. 2: Performance of various inner grooved copper tubes on heat transfer coefficient and pressure drop with R410A refrigerant

On the refrigerant side, smaller tube increases the refrigerant pressure drop. More compressor energy is required to circulate the refrigerant through a given length of tube when the pressure drop is higher. However this increase in pressure drop can be offset by designing heat exchangers with shorter tube lengths and/or increasing the number of parallel tube circuits. It is known that with round tubes, a greater variety of circuitry options are available, than with microchannel, such as counter flow configurations and optimization of mass flux along refrigerant flow direction through tube merging or splitting (Hipchen, 2012). Smaller diameter tube limits the boundary layer near the surface resulting in an advantageous increase of the internal heat transfer coefficient using 5mm inner-grooved tube, as shown in Figure 4, where a 15 – 20% increase has been demonstrated versus an inner-grooved 9.53mm copper tube using an HFC refrigerant (Yang, 2010).

Total heat transfer coefficient is improved using small diameter inner-grooved tubes from the additive benefits of

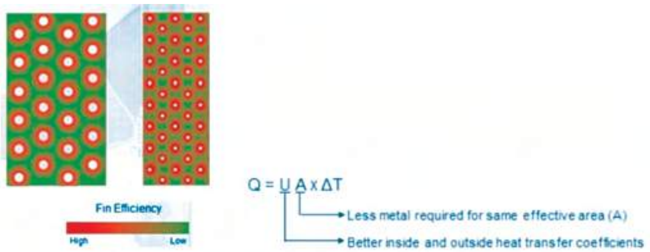


Fig. 3: Fin hole patterns for 9.53mm tube (left) and 5mm tube (right) showing more primary (red area around tubes) heat transfer effective area using 5mm tube so fins can be downsized for more compact heat exchanger

both internal surface enhancement and diameter reduction, contributing to a significant total gain in heat transfer performance as shown in the results in Figures 2 and 4.

In order to have a high performance air conditioner with small diameter tubes, it is necessary to develop principles of designing fin-and-tube heat exchangers, including designing the fin configuration and tube circuits. These interdependencies required a computationally intensive optimization program. Therefore, within the small diameter copper tube technology platform, specific heat exchanger design and system optimization software has now been developed to enable manufacturers to design high performance heat exchangers for air conditioners and refrigeration systems based on small diameter copper tube. A result of such optimization work is shown in Figure 5 where R290 refrigerant was used. A mini-split room air conditioner using R290 with cooling capacity of 2,600 watts designed, using 5mm diameter inner-grooved copper tube, demonstrated improved performance over a conventional system with 9.53 mm and 7 mm tubes. Systems like this up to 3,000 watts cooling capacity represent 30% of the room air-conditioning market. The heat exchangers with 5mm tube had 50% lower refrigerant charge in the indoor unit and 45% lower charge in the outdoor unit. Total charge was reduced by 36% versus the original system (Zheng, 2014).

Enabled by the smaller refrigerant charge, the explosion risk of using inflammable natural refrigerants like propane can

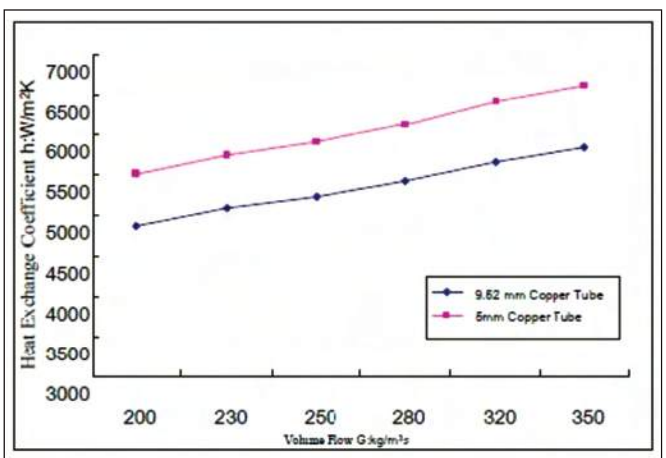


Fig. 4: Local heat exchange coefficients for 9.52mm and 5mm inner-grooved copper tubes for different mass flows

be decreased. Higher pressures typically are required to condense alternative refrigerants like R32 or CO_2, compared to traditional refrigerants that are being phased out (i.e. R22). Permissible working pressure is directly proportional to wall thickness and inversely proportional to diameter. So for tubes with the same wall thickness, smaller diameter tubes can withstand higher pressures than larger diameter tubes, and particularly for CO_2 in refrigeration, tubes and components must exhibit high resistance to pressure.

Smooth and inner-grooved seamless tubes and fittings are available in high-strength copper-iron alloy known as $CuFe_2P$ or C19400, with outer diameters of 6.35mm and above. Reduced wall thickness is possible, which reduces material usage. Processing can usually be performed with already existing machines and tools as the alloys are very brazeable and solderable. These alloy tubes can sustain pressures 100% higher than standard copper tubes for air conditioning & refrigeration, up to 12 MPa (1,740 psi), with corresponding high strength fittings. Since the volume of CO_2 required to achieve the same cooling effect is at least 50% lower than for HFCs, components and tubing can be smaller than conventional installations. In practice the high pressure of CO_2 has proved to be an advantage because it results in the need for very small diameter tubes,

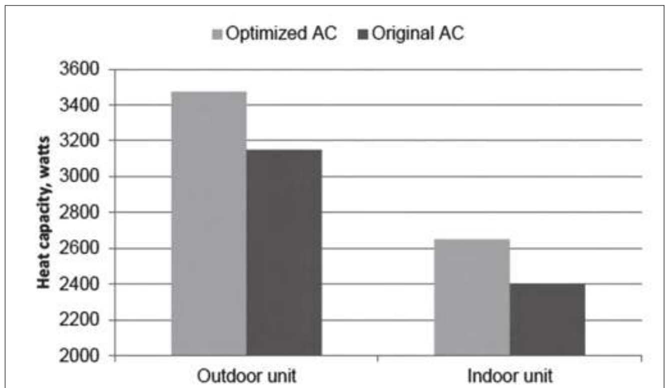


Fig. 5: R290 split system comparison of cooling capacity between a conventional unit and optimized unit using 5mm copper tube

which are very strong under pressure. $CuFe_2P$ alloy tubes at small diameters are advantaged for application in high pressure CO_2 cascade, transcritical, and secondary loop refrigeration systems due to their high strength without increasing wall thickness.

R32 is another interesting alternative refrigerant which has properties of similar pressure and pressure ratio to R410A, being a component of R410A, making it a close drop-in replacement without major system redesign except for compressor modification to accommodate the higher discharge temperature. The higher cooling capacity and efficiency of R32 facilitates at least a 15% lower system charge. With its excellent heat transfer, lower vapor density and lower system mass flow rate, about a 50% lower pressure drop is expected, suggesting that the properties of R32 (and R32- HFO blends) can be optimized in small diameter copper tube compact systems. This can facilitate the direction toward lower-charge, compact heat exchangers for addressing the GWP phase down and reducing A2L flammability risk.

At an equivalent performance level, a theoretical comparison between using R32 and R410A found a reduction of 30% in the diameters of heat exchanger tube & connecting pipe using R32, synergistic with small diameter (5mm to 7mm) copper tube systems. The ultimate volume ratio of an air-conditioning unit using R32 could be downsized to 85 – 95% of the size of a unit with either R410A or R22 (Dieryckx, 2012).

Effects of copper finned heat exchangers on LCCP

Life cycle climate performance (LCCP) has been shown to be driven mainly by the indirect emissions effect from lifetime operating efficiency (Pham, 2012). LCCP will therefore be significantly affected by key contributing factors leading to degradation of efficiency over the operating life, which includes mold growth. Intrinsic microbial biofilms on air handling exchanger coils are associated with lowered heat transfer efficiencies and increased corrosion (Characklis,1990) as well as potential odor issues (Rose, 2000). Pure copper and copper alloys have intrinsic antimicrobial properties that kill microorganisms on contact and prevent the growth of bacteria and mold. Copper surfaces in the heat exchanger environment were found to have fungicidal properties and prevented the germination and release of spores (Schmidt, 2012). Uncoated copper surfaces have shown they limit the growth of pathogenic bacteria by 99.9% and fungi by 99.74% of that observed on the control, aluminum-based heat exchangers. Most fungal species show a total die off within 24 hours of exposure to copper, but conversely, fungi have been found to survive for a month or more on surfaces made from stainless steel or aluminum (Weaver, 2010).

This effectiveness of copper has been proven in rigorous studies that led to EPA registration of 479 copper alloys as public health antimicrobial touch-surface products (EPA, 2008). In a long-term performance test of all copper heat exchangers versus copper tube/aluminum fin heat exchangers shown in Figure 7, both units were treated with mold (Ding, 2007).

After 28 days of incubation, the all copper units exhibited no mold growth, whereas the mold-treated aluminum units exhibited considerable mold growth of up to 60% of the frontal area. Figure 8 shows test results of normalized heat flow to mold growth area on aluminum fins and all-copper heat exchangers with mold areas 0%, 10%, 30% and 60%, showing heat transfer performance declined a maximum of 19% with aluminum fins while the all-copper units showed no

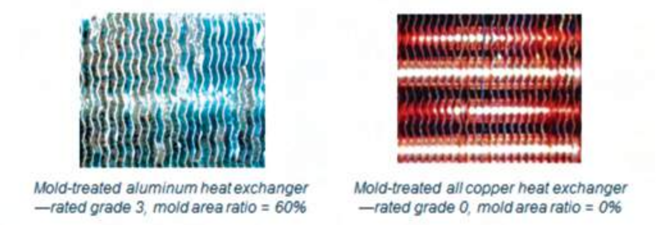


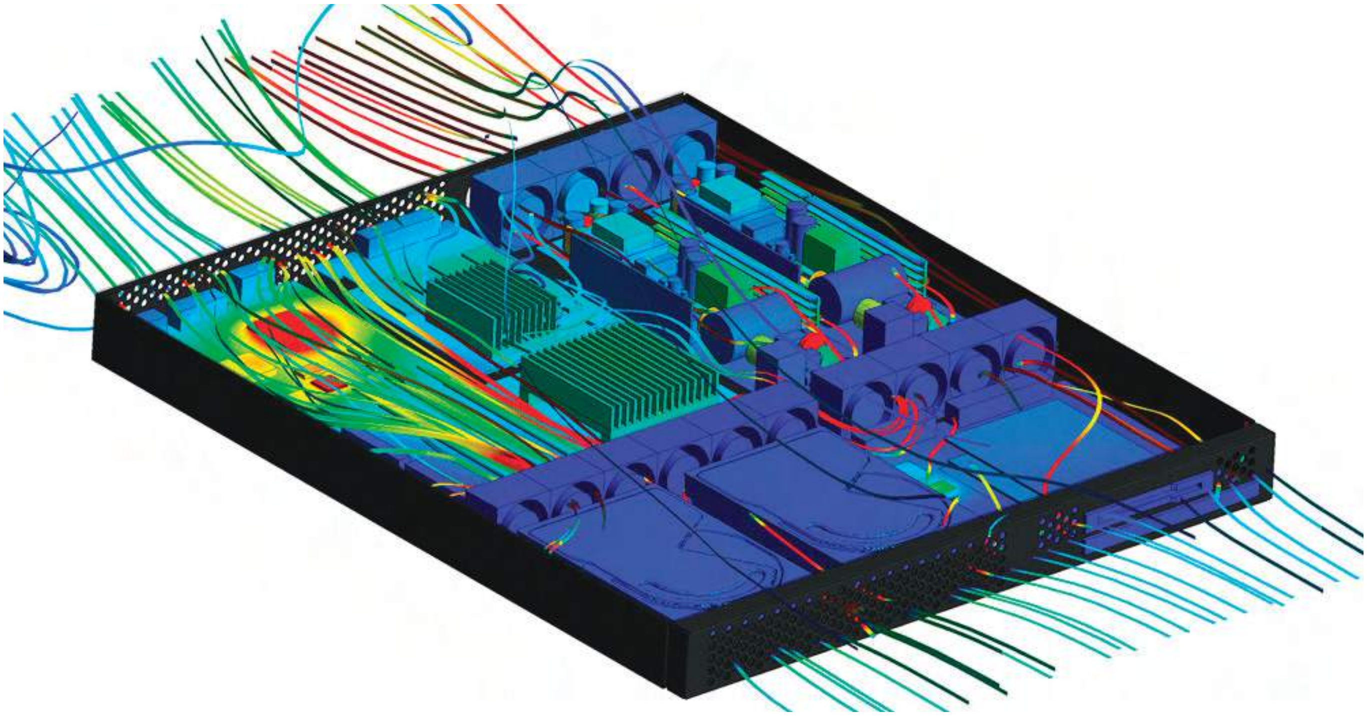
Fig. 7: Mold treated aluminum and all copper heat exchangers after 28 days incubation, showing no growth on the all copper unit

performance deterioration from mold. Due to lower efficiency, the unit with aluminum fins will consume more energy, resulting in higher lifetime equivalent CO_2 emissions and LCCP. Since indirect emissions account for the largest impact on LCCP, approximately 90% of total emissions for R410A and up to 99% for a very low GWP refrigerant like R1234yf (Zhang, 2012), mitigating as much as a 19% loss of efficiency would have a similarly proportionate impact on LCCP.

Conclusions

- New copper-based technologies for heat exchangers are available to enable a smooth transition to alternative refrigerants in residential and commercial air-conditioning systems and commercial -refrigeration systems, which provide synergies with key performance characteristics of the refrigerants.
- Total heat-transfer performance is improved using small-diameter inner-grooved tubes with additive benefits from both internal surface enhancement & diameter reduction.
- Alternative refrigerants R290 (propane) and R744 (CO_2), and to a lesser extent R32 and R32-HFO blends, require low charge, compact heat exchanger designs for which small-diameter copper-tube heat exchangers provide synergies, lower cost, and further performance optimization.
- High-strength copper-alloy tube ($CuFe_2P$) in small diameters meets the needs of higher pressure, more compact R744 (CO_2) refrigeration systems.
- All-copper heat exchanger technology with its antimicrobial properties can mitigate the impact of energy-efficiency degradation due to mold growth over a unit's operating life, which has the largest positive leverage on Life Cycle Climate Performance. ■

Source:
International Copper Association India.



Trends driving **Thermal Management**

Thermal Management encompasses the discipline behind generation, control and dissipation of heat produced by electronic devices and solutions. Heat is a common by-product of most electronic devices and systems, impeding performance as well as reliability of the system.

Understandably, the market for thermal management solutions shows tremendous potential for growth. A recent report by BCC research predicts that the market for such solutions will grow from about $10.1billion in 2013 to reach $14.7 billion by 2019. The need for thermal management will be exacerbated by the growing demand for increased functionality on a single device unit including miniaturization as well as from the next generation of data centers that allow organizations to store, process and analyse huge realms of data. Understanding trends in thermal management assists enterprises to effectively analyse, understand & act on data for more efficient & sophisticated real-time environmental control.

India and transition

In India, the demand for thermal management solutions is expected to rise sharply with the adoption of several technologies such as storage, big data, data centres and bandwidth. Currently, roughly one per cent of India's total energy consumption is contributed by datacentres and today's highly competitive business environment requires companies to effectively manage their core systems. With these critical systems performing at optimum levels, businesses and enterprises gain the advantage of increased productivity and maintain a competitive edge.

To keep up with the changes in technology and environment, thermal management approaches are widening to include a variety of next generation methods such as software and hardware integration, optimizing current technologies or innovative new materials to reliably, efficiently and cost-effectively control and manage heat. Today the application of thermal management solutions has widened from merely using hardware to control temperatures, to now using pioneering hardware, software and services in differing degrees of integration.

Form Factors driving evolution of thermal management solutions

Power and space are at a premium in today's economic environment. Depending on the configuration of the room, whether it is size or height, thermal management solutions are now being made available in a variety of sizes from a single cabinet sized cooler to rows of cooling equipment. A business priority in the face of multiplying heat density and expensive power is the optimization of operational and energy expenditure without compromising on its availability as there is increased flexibility for enterprises to choose from; depending on their requirements and equipment. New solutions driving evolution in this segment includes self-contained precision cooling units for smaller and medium sized data centers. IT managers are also exploring solutions that offer complete control over temperature, air, humidity and even air filtration. For larger data centers, cooling solutions are being deployed with open or closed architectures and cooled by pumped refrigerant-based or water-based technology. Recently many larger data centers are also evaluating high density cooling enclosures that offer a pre-packaged solution to housing and cooling rack equipment.

Data Centers and Specialised environments

The data center is an active, dynamic ecosystem where IT needs, geographic location and external weather conditions are inter-connected, and as such any changes in any one area have broad-reaching implications for the organization. Traditional approach towards thermal management in the data center involved deploying air, waterside and innovative pumped-refrigerant economizers to maximize efficiency. The latest trend in thermal management is the addition of state-of-the-art controls with both wired and wireless sensors. The next generation of data center cooling solutions will thus feature innovative services with an integration of both software and hardware to reliably, efficiently and cost-effectively control and manage heat. With the increased deployment of technologies such as cloud, big data as well as demand for enhanced mobility features, the next generation approach to thermal management will mean an increased focus on specialized environments for the optimal performance of hyper scale data centres, high and performance computing systems, & environments customized to process and store vast volumes of data.

New trends in Thermal management

For Thermal management businesses it is imperative to maintain equilibrium for a solution that is cost effective yet offers reliable and efficient cooling solutions given the rising costs of electricity.

Sushanta Ghosh, Country Manager, Thermal Management at Emerson Network Power India

Up to now the advancements in thermal management solutions has progressed through hardware innovation and use of more effective transmitters of electricity. As the world moves towards a software-based model of thermal management, the industry has become a witness to deployment of sophisticated electronic software aimed at analysing and controlling the thermal characteristics of an electronic system design. Automation is another trend that is rapidly transforming the processes associated with Data center thermal management in close concert with real time insights into IT, power and space. Automation helps identify on-going power utilization (i.e., to identify energy spikes and other environmental changes) in real time rather than just a one-time snapshot. By analyzing this collected data, actual energy consumption and total carbon footprint statistics can be compiled to help determine where the greatest opportunities for energy reductions can be found and to track improvements after solutions have been implemented. Real-time measurements and historical reporting on data center environmental conditions can identify optimal sizing configurations for electrical and cooling components.

The efficiency of thermal management cooling has been drastically improved due to environmental concerns and increased energy prices. Once haphazard, air distribution is now able to achieve great levels of precision, requiring decreased power and the widespread adoption of outside air for cooling. The evolution is further supported by the introduction of Wireless environmental monitoring systems that help data centre operators to efficiently examine the data center environment thus identifying hot spots and make airflow management more effective.

Modern thermal management solutions utilize almost all aspects of hardware, software and automation to offer technologies and solutions for data centers and IT facilities of all sizes including air, waterside and pumped-refrigerant economizers in addition to state-of-the-art controls and wireless sensors to maximize efficiency. Included in the solutions are custom air-handling solutions with chilled water, direct and indirect evaporative and refrigerant technologies. The focus will remain on utilizing more intelligent, versatile cooling tools with the ability to conduct remote service delivery programs.

Future improvements in thermal management will be necessary to sustain the ongoing improvements in system performance and energy efficiency with the data centre environment requiring more granular monitoring and management with thermal problems being quickly detected and addressed with state-of-the-art controls and wireless sensors. ■

HVAC systems for Large Retail Facilities – An Overview

The retail revolution in India started with the sprouting up of Malls in the late nineties and early part of this century. These developments were more of standalone spaces, with a mid-sized "anchor" and a few "vanilla" stores. The ambience and amenities were very basic and air condition requirements were usually met with standalone DX type systems fitted for each of the stores. This early phase of retail space development was followed by a rapid rise in both the number as well as size of the malls which in turn led to bigger and more complex anchor stores. Large departmental stores as well as supermarkets integrated with the Mall environment and allowed consumers to do their daily needs as well as high end shopping all under one roof. While the retail industry faced a slowdown over the last 3 – 4 years, there is still a steady supply of large format malls as well as retail chains. More than 300 Malls have been developed in the last decade and studies show a potential for over 1500 – 2000 more malls in the near future. The market is thus sizeable and there will thus be a great demand for optimized air conditioning systems for Malls as well as the large format stores both within and as standalone developments. As for commercial buildings, energy is a major component of the retail development running costs – in fact, the costs are higher than commercial spaces due to the larger common areas as well as higher heat loads. Typical Common Area Maintenance Charges (CAM) for a Mall is in the range of Rs 25 -30 per sq ft per month whereas for a commercial building, the rate varies from Rs 15 – 20 per sq ft per month. Supermarkets typically use 4 – 5 times more energy per sq ft than commercial buildings. HVAC systems for the large retail stores are complex and require a highly evolved design approach to ensure that cost of energy of the HVAC system is optimized.

Retail Store HVAC requirements

The most common model of large retail stores found in India is a mixed development, where there are both food products as well as consumer products such as clothing, furniture, kitchen, appliances etc. Thus, there are varying requirements for these different spaces. ASHRAE guidelines are available for different formats such as Supermarkets and Departmental stores whereas in India, these are usually combined. ASHRAE guideline, being

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focused on the Americas' where heating is an integral part of HVAC is hence not directly applicable to Indian conditions but provide guidance for designers. Key aspects that make design of HVAC for retail different from commercial spaces are as follows.

Load Variation: Due to the store format and product mix, there are sizeable variations in the cooling load of a retail store. The foods section may also have an area used for a bakery or live cooking counters for customers, which will result in higher heat loads compared to the clothes section which has a much lower heat load. Load variation is also seen due to the occupancy patterns. Entrances will usually have a higher load due to frequent opening and closing of the doors. Similarly, the checkout aisles will have a higher heat load due to the stacking up of customers on their way to the check out counters

Refrigerated Displays: In the frozen and refrigerated sections of large retail stores, a considerable amount of sensible heat is taken out due to the cooled refrigerated spaces inform of the product display sections and this is called the case load. The HVAC design should thus cater for some sensible heat load being reduced due to the refrigerated displays and focus more on the latent heat removal. The HVAC thus can be sized to a lower level.

Impact of Moisture: Due to the higher number of footfalls in retail stores, higher amounts of air changes are required. This leads to improved air quality, but has a negative impact on the refrigerated displays as moisture entering with the air will lead to a frosting of the glass panels. There will thus need to be a provision of heaters on the panels which increase energy usage. The moisture can also freeze on the refrigerator evaporator coils leading to poor heat transfer as well as possible damage to the equipment. Another negative impact of higher moisture levels is the detrimental impact on products in the store, leading to lower shelf life in some cases and actual damage in more sensitive products.

Humidity control: Higher humidity levels in the store will lead to higher energy costs as well as customer discomfort. Use of dehumidifiers to keep the RH below 55 or around 40 will enable increasing the set point of the air temperature while not negatively impacting customers.

Air Distribution: Due to the variation of loads in the retail space, air requirements can vary considerably. Typically, the ventilation design is such that about one third of the cooled air is directed to the front of the store where footfall is highest. Another consideration to be kept in mind is the circulation of the cold air around the refrigerators. As this air is cooler that the ambient, it tends to settle down around the base of the display units, which can lead to localized condensation. Thus, arrangements are made to circulate this air through the ventilation ducts.

Internal Load: In departmental stores, the load is mainly due to the heat load of the store staff and intermittent load due to customers entering and leaving the store. In a supermarket, the load cold is due to the occupants as well as the equipment in use. In both set ups, the load due to lighting is also an important factor. In departmental stores, the lighting loads are higher as strong lights are used for product displays and area illumination. A typical garments section of a departmental store can have loads of around 20 – 30 W/sq mtr.

The HVAC design of retail developments is a complex process, with a large set of variables in play. The designer and HVAC equipment manufactures thus need to work closely together to find an optimum solution, keeping in mind that margins in the retail sector are still very low in the Indian context and hence, operating costs need to be kept as low as possible. Another important aspect to be kept in mind while designing the HVAC systems is that the equipment would be operated by store staff who typically has limited technical knowledge of the HVAC systems. Thus, the whole set up needs to be highly reliable and user friendly.

Conclusion

With the opening up of the economy and renewed interest in the retail space, the need for developing better and more efficient HVAC systems for these spaces will only increase. There is tremendous scope of retro fitments as well for the large number of retail stores already in place. Designers for these environments would need to consider the key aspects discussed in this article as well as many other interrelated challenges when arriving at the final solution for the store owner. The aim of both the store owner as well as the designer is to ensure that the customer has an enjoyable experience in the store, which indirectly increases the possibility of higher spending by the customer which will lead to increased profits in the long run. ■

Carbon dioxide as Refrigerant in Air-Conditioning Systems: Present and Future

Due to significantly higher GWP, presently used refrigerants will be phased out very soon and either synthetic refrigerant HFO-1234yf or natural refrigerant CO_2 seems to be the future option for air-conditioning systems.

Carbon dioxide (CO_2) is one of the natural refrigerants, which has emerged as a suitable alternative to synthetic working fluids in automobile and stationary air-conditioning devices due to its eco-friendliness, higher volumetric capacity, good heat transfer properties, etc. In this article, the basic technology, environmental safety issues, comparison with existing technologies and commercial status of transcritical CO_2 refrigeration cycle are being discussed for air-conditioning applications.

The natural refrigerant carbon dioxide, which has been completely abandoned for more than 40 years, was revived as a potential refrigerant in air conditioning applications in early 1990s. Along with environment friendliness, low price, easy availability, non-flammability, non-toxicity, compatibility with normal lubricants and common machine construction materials, greatly reduced compression ratio, high volumetric refrigerant capacity, system compactness due to high operating pressures, excellent transport properties are cited as some of the reasons behind the revival of carbon dioxide as a refrigerant. R12 is old use refrigerant, which is now abandoned. R22, R134a, R407C, R410A and R438A are now widely used as refrigerants for air-conditioners. However, due to significantly higher global warming potential (Table 1),

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HFO1234yf, propane and CO_2 has been proposed recently, although propane is highly flammable. Although present use is very limited, it expected to capture all the vapor compression systems based air-conditioners by HFO1234yf and CO_2 very soon.

Transcritical CO_2 Refrigeration Cycle

Due to the low critical temperature of CO_2 (Table 1), the evaporator operates at subcritical regimes whereas the heat rejection takes place at supercritical regimes and hence the cycle is called transcritical cycle. Hence, main difference between this cycle and conventional cycle is that the heat rejection component is called gas cooler instead of condenser. As the temperature-entropy diagram shown in Figure 1, the basic transcritical CO_2 vapor compression cycle consists of four processes: compression (1-2), gliding temperature heat rejection in gas cooler (2-3), isenthalpic expansion to required evaporator temperature (3-4) and heat absorption by evaporation (4-1) to give cooling effect.

For conventional vapor compression refrigeration cycle, the condenser temperature is decided based on temperature of external fluid (e.g. ambient air for refrigerator) and the corresponding saturation pressure is taken as condenser pressure. Whereas, for the transcritical CO_2 vapor compression cycle, gas cooler exit temperature will be generally fixed based on the inlet temperature of external fluid; however, due to transcritical operation, the gas cooler pressure is independent on the gas cooler exit temperature. The COP (coefficient of performance) of the transcritical carbon dioxide system is significantly influenced by the gas cooler pressure, and interestingly non-monotonically. Studies show that with increase in discharge pressure, COP increases and attains a maximum value at a particular pressure, termed as optimum pressure, and then fall. This indicates that there exists an optimum pressure where the system yields the best COP and the knowledge of the optimum operating conditions corresponding to maximum COP is a very important factor in the design of a transcritical carbon dioxide cycle.

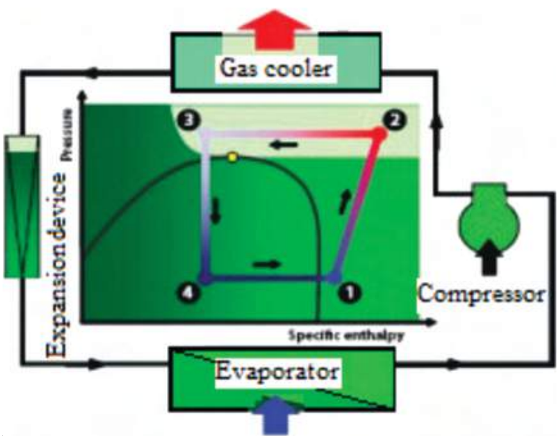


Fig. 1: Transcritical CO_2 vapor compression refrigeration system

As the COP of transcritical CO_2 vapor compression cycle is significantly lower due to huge throttling loss compared conventional cycle, researches and developments are going on to improve the performance by various cycle modifications, which include the use of internal heat exchanger (IHX), expansion turbine, multi-stage compression, ejector, parallel compression economization (PCE) and vortex tube. It is noteworthy that all the modifications improve the system performance and

Refrigerant	Formula	NBP (^oC)	P_C (bar)	t_C (^oC)	ODP	GWP
R12	CCl_2F_2	- 29.8	41.2	112	1	4300
R22	CHF_2Cl	- 40.81	49.90	96.15	0.3	1700
R134a	$C_2H_2F_4$	- 26.07	40.59	101.1	0	1300
R407C	Mixture	- 43.6	86.7	46.2	0	1530
R410A	Mixture	- 52.7	72.5	49.5	0	1730
R438A	Mixture	- 42.33		85.28	0	2264
HFO1234yf	$C_3H_2F_4$	- 42.1	33.82	94.7	0	4
R290	C_3H_8	- 42.1	42.50	96.7	0	3
R744	CO_2	-------	73.72	31.1	0	1

Table 1: Refrigerants for Air-conditioning applications

reduce the optimum discharge pressure, which can be advantageous in high pressure side component design. Studies show that the highest improvement of the transcritical CO_2 vapor compression cycle can be achieved by replacing the expansion device with a work recovery expansion machine or by using multi-staging (Figure 2). However, these are costly improvement compared to others. Hence, the recent research concentrates mostly on ejector expansion cycle due to significant COP improvement and no moving part in ejector.

The absolute pressures are much higher than are encountered in traditional refrigeration system. However, the compressor pressure ratio is less resulting in more isentropic efficiency. Since the volumetric capacity is very high compared to other refrigerants, the compressor size and mass flow rate are less for same capacity. Heat transfer coefficient of CO_2 is also higher than that of halocarbons. Thus, pipe diameter of refrigeration piping and therefore, the weight and occupied volume of the heat exchangers can be decreases significantly compared to conventional heat exchanger, which leads to development of microchannel heat exchanger.

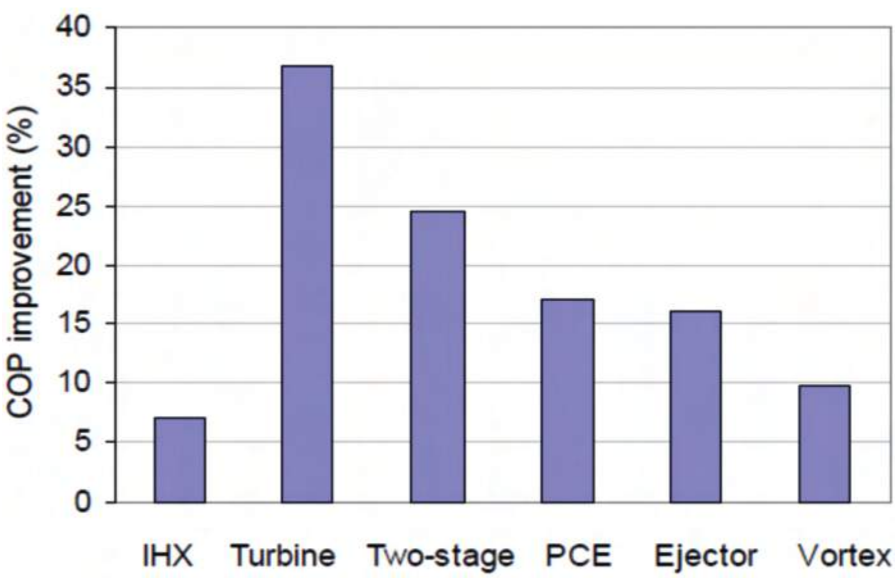


Fig. 2: Comparison of various cycle modifications

Comparison with existing refrigerants

Mobile air conditioning applications were among the first to be considered for application of the transcritical CO_2 cycle due to various disadvantages with R22 and R134a including high leakage rate through the flexible nylon or butyl rubber hoses needed for vibration protection, and through the compressor shaft seal needed to avoid the additional weight and conversion losses associated with the hermetic electric compressors used in other applications as well as high GWP. The CO_2 system showed comparable performance with the R12 system. Also the prototype CO_2 system provided a comparable performance to the current production R134a system for both steady state and cyclic operation. Some studies showed CO_2 having an inferior COP to R134a. The COP disparity depends on compressor speed (system capacity) and ambient temperature; the higher the COP and discharge temperature, the lower was the COP difference. At the same speed and lower ambient temperature, the COP disparity was lower; however at higher speed and ambient temperatures, it was greater. Hence, better transport properties and compressor isentropic efficiency did not compensate for its thermodynamic disadvantage compared to R134a when equivalent heat exchangers were used for both refrigerants. Experimental study showed that the CO_2 based Military Environmental Control unit did not perform as well as the R-22 baseline unit in either capacity or efficiency. Electrical air conditioning system with R744 using an inverter driven compressor showed better performance than that with R-134a for a fuel cell electric vehicle. SAE international cooperative research program, sponsored by major automotive manufacturers, recently released a report summarizing results of its industry evaluation of low global warming potential (GWP) refrigerant, hydrofluoro olefin (HFO)-1234yf, which was co-developed by DuPont. The report validated that HFO-1234yf is safe to use in mobile air conditioning, and that, of all the proposed alternatives considered, HFO-1234yf has significant environmental benefits. The report concluded HFO-1234yf offers "the greatest potential to meet environmental and consumer needs."

Environmental issues

Under increasing pressure to address global warming concerns, the industry is spending more effort to understand the environmental impact of air conditioning systems using different refrigerants and technologies. The environmental performance of air conditioning systems is partially defined by life cycle impacts on climate, including the direct impacts of refrigerant emissions, the indirect impacts of energy consumption used to operate the system, and the energy to manufacture, transport, and safely dispose of the system. From an environmental perspective, CO_2 is a very attractive refrigerant with zero ODP and a GWP of 1. It is a naturally occurring substance and abundant in the atmosphere.

Environmental effect can be also measured by Total Equivalent Warming Impact (TEWI), which confirms the importance of energy efficiency and emissions reduction for system. Study showed that the CO_2 system displayed a significantly lower TEWI than other systems. Another environmental parameter is global temperature change potential (GTP) and the GTP of CO_2 retain negligible for longer time horizon. Hence, there is no compelling reason to believe that the recent rise in global air temperature was caused by the rise in CO_2. Furthermore, it is highly unlikely that future increases in the CO_2 emission will produce any global warming; for there are numerous problems with the popular hypothesis that links the two phenomena. There were also long periods of time when atmospheric CO_2 remained unchanged, while air temperature dropped. The climate history of the past half-million years provides absolutely no evidence to suggest that the ongoing rise in the air's CO_2 concentration will lead to significant global warming. Further more, simply with the biospheric benefits that come from the aerial fertilization effect of atmospheric CO_2 enrichment: enhanced plant growth, increased plant water use efficiency, greater food production for both people and animals, plus a host of other biological benefits too numerous to describe in this short statement. All indications are that both nature and humanity will be well served by the ongoing rise in atmospheric CO_2 concentration & hence the CO_2 system can be treated as eco-friendly.

Current commercial status

In 1993, Professor Lorenten first tested a prototype CO_2 system for automobile air-conditioning at Norway Institute of Technology. In 1995, actual research began and developments progressed until it was found that CO_2 had a global warming factor of only 1/1,300th of HFC-134a, and could be used as a refrigerant gas with a high efficiency heat pump. Thus, the merits of CO_2 were finally realized. Initial result motivated the number of development and projects, initiated by research sector and industries in European countries, Japan and USA. Various techniques have been developed to control high side system pressure. Denso of Japan has developed first CO_2 air conditioning system for car (Figure 3). Visteon of Europe developed car air-conditioning system using CO_2 as refrigerant. Volkswagen, Daimler, Audi, BMW and Porsche have announced plans to develop CO_2 technology as a more climate-friendly refrigerant for air conditioning systems. Nissan Motor Co Ltd, is willing to launch the fuel cell vehicles (FCVs) equipped with a CO_2 air-conditioning system, jointly developed by Nissan and Calsonic Kansei Corp. Denso and Daimler Chrysler AG are working together to develop a carbon dioxide air conditioning system for a Mercedes vehicle. Konvekta (Germany) has developed CO_2 bus air conditioning. Green & Cool (Sweden) has developed air conditioning units. Star Corporation developed transcritical CO_2 air handling units for building HVAC applications.

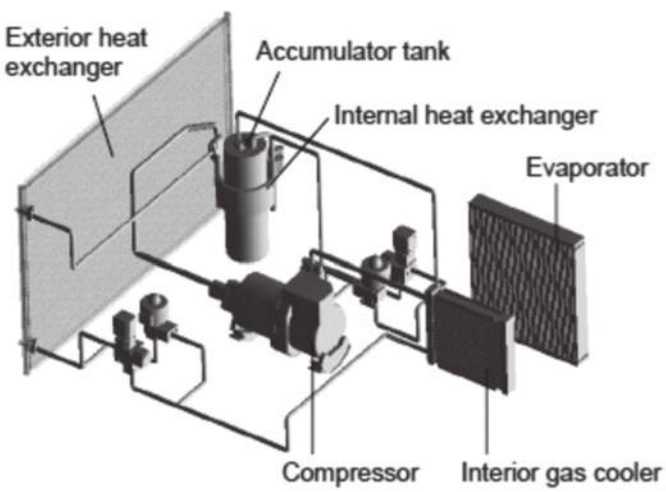


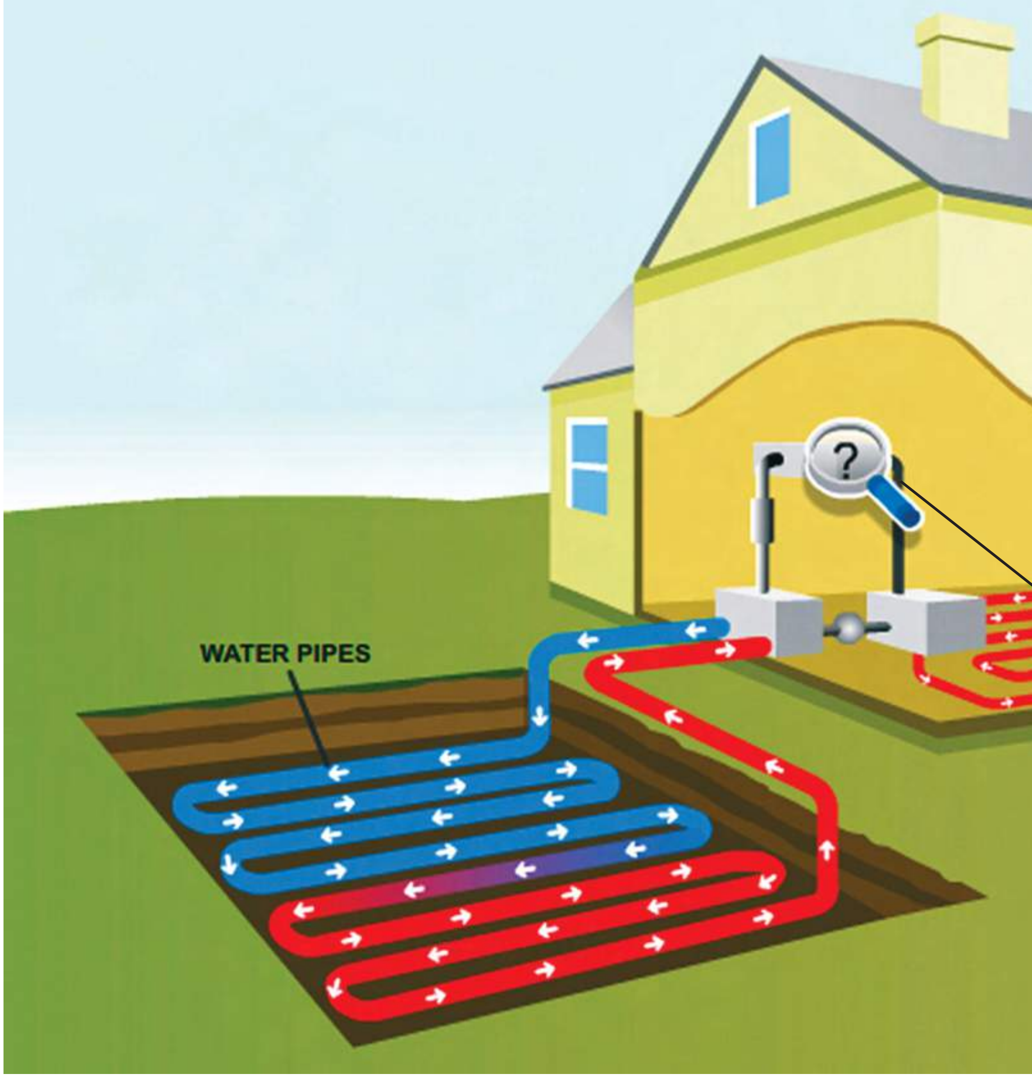
Fig. 3: Layout of CO_2 car air conditioning system (Denso)

Sanyo (Japan) and Danfoss (Denmark) are main suppliers of CO_2 hermetic compressors. Mitsubishi Heavy Industries Ltd developed CO_2 scroll compressor for air conditioning applications. Dorin Co, of Italy has been manufacturing of semi-hermetic CO_2 compressors. Other manufactures are Tecumseh, Clinton, Mich. (USA), Doowin Group (South Korea), Bock compressor, ixetic and Bitzer (Germany), and Frascold (Italy). Danfoss is also providing other components such as pressure transmitter, pressure switch, liquid level transmitter, electrically operated expansion valve, other valves, filter and sensor. OBRIST Engineering is providing CO_2 compressor, coaxial internal heat exchanger and control system. Hydro (Denmark) is also providing coaxial internal heat exchanger. Temprit Company (USA) is the supplier of oil separator. Many manufacturers including Danfoss and Alfa Lavel are suppliers of compact microchannel evaporators and gas coolers (as in Figure 4) for transcritical CO_2 air-conditioners.

Fig. 4: Example of micro-channel heat exchangers

Conclusions and Perspectives in India

Although, the development of commercial CO_2 air-conditioners had been started by many leading manufacturers 10 years back, it is not in use now due to higher installation as well as running costs. However, presently used refrigerants will be banned very soon and future refrigerant for air-conditioning systems will be either synthetic refrigerant HFO-1234yf or natural refrigerant CO_2. Neither commercial development nor field testing of CO_2 air-conditioner has been done in India. Main problem of using carbon dioxide in India is that the climate is relatively hotter, which degrades the system performance significantly. These will lead to the development of novel systems for warmer climates (like in India) also that are more energy efficient and user friendly. ■

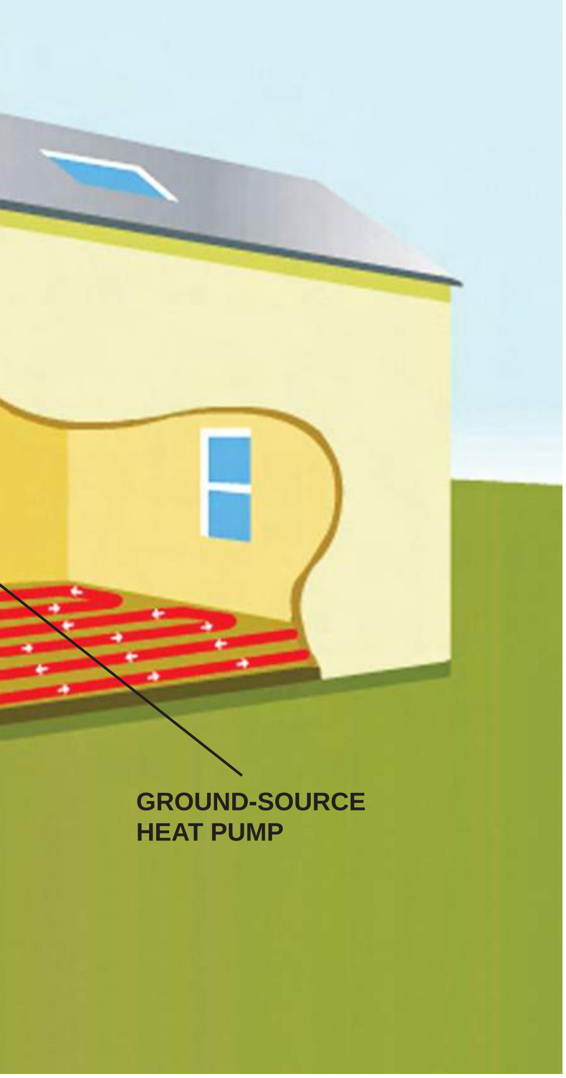


Experimental and Modelling Investigation of the Performance of a Ground-Source Heat Pump System for Buildings Heating and Cooling

Geothermal heat pumps (GSHPs), or direct expansion (DX) ground source heat pumps, are a highly efficient renewable energy technology, which uses the earth, groundwater or surface water as a heat source when operating in heating mode or as a heat sink when operating in a cooling mode.

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

Direct expansion GSHPs are well suited to space heating and cooling and can produce significant reduction in carbon emissions. In the vast majority of systems, space cooling has not been normally considered, and this leaves ground-source heat pumps with some economic constraints, as they are not fully utilised throughout the year. The tools that are currently available for design of a GSHP system require the use of key site-specific parameters such as temperature gradient and the thermal and geotechnical properties of the local area. A main core with several channels will be able to handle heating and cooling simultaneously, provided that the channels to some extent are thermally insulated and can be operated independently as single units, but at the same time function as integral parts of



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the entire core. Loading of the core is done by diverting warm and cold air from the heat pump through the core during periods of excess capacity compared to the current needs of the building. The cold section of the core can also be loaded directly with air during the night, especially in spring and fall when nighttimes are cooler and daytimes are warmer. The shapes and numbers of the internal channels and the optimum configuration will obviously depend on the operating characteristics of each installation. Efficiency of a GSHP system is generally much greater than that of the conventional air-source heat pump systems. Higher COP (coefficient of performance) is achieved by a GSHP because the source/sink earth temperature is relatively constant compared to air temperatures. Additionally, heat is absorbed and rejected through water, which is a more desirable heat transfer medium due to its relatively high heat capacity.

The GSHPs in some homes also provide:

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

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

An air-source heat pump is convenient to use and so it is a better method for electric heating. The ambient temperature in winter is comparatively high in most regions, so heat pumps with high efficiency can satisfy their heating requirement. On the other hand, a conventional heat pump is unable to meet the heating requirement in severely cold regions anyway, because its heating capacity decreases rapidly when ambient temperature is below -10^{O}C. According to the weather data in cold regions, the air-source heat pump for heating applications must operate for long times with high efficiency and reliability when ambient temperature is as low as -15^{O}C. Hence, much researches and developments has been conducted to enable heat pumps to operate steadily with high efficiency and reliability in low temperature environments. For example, the burner of a room air conditioner, which uses kerosene, was developed to improve the performance in low outside temperature. Similarly, the packaged heat pump with variable frequency scroll compressor was developed to realise high temperature air supply and high capacity even under the low ambient temperature of –10 to –20^{O}C. Such a heat pump systems can be conveniently used for heating in cold regions. However, the importance of targeting the low capacity range is clear if one has in mind that the air conditioning units below 10 kW cooling account for more than 90% of the total number of units installed in the EU.

Laboratory Measurements

This chapter describes the details of the prototype GSHP test rig, details of the construction and installation of the heat pump, heat exchanger, heat injection fan and water supply system. It also, presents a discussion of the experimental tests being carried out.

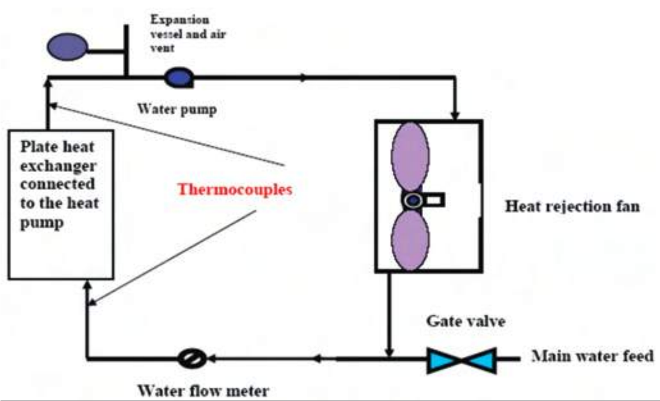

Fig. 1: Sketch of installing heat pump

Main experimental test rig

The schematic of the test rig that was used to support the two ground-loop heat exchangers is shown in Fig. 1. It consisted of two main loops: heat source loop and evaporation heat pump. Three horeholes were drilled each 30 meters deep to provide sufficient energy. The closed-loop systems were laid and installed in a vertical well. The ground-loop heat exchangers were connected to the heat pump.

Direct expansion heat pump installation

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

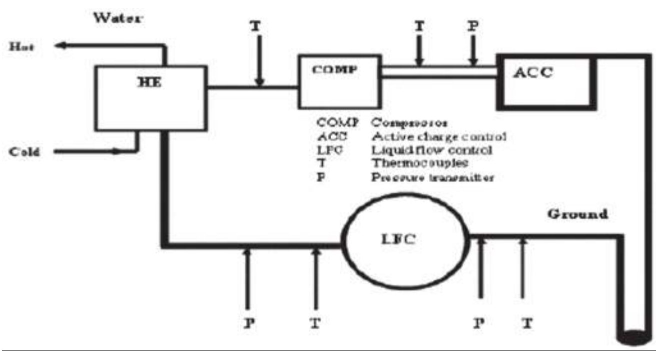

Fig. 2: shows the connections of ground loops to heat pump & heat exchanger

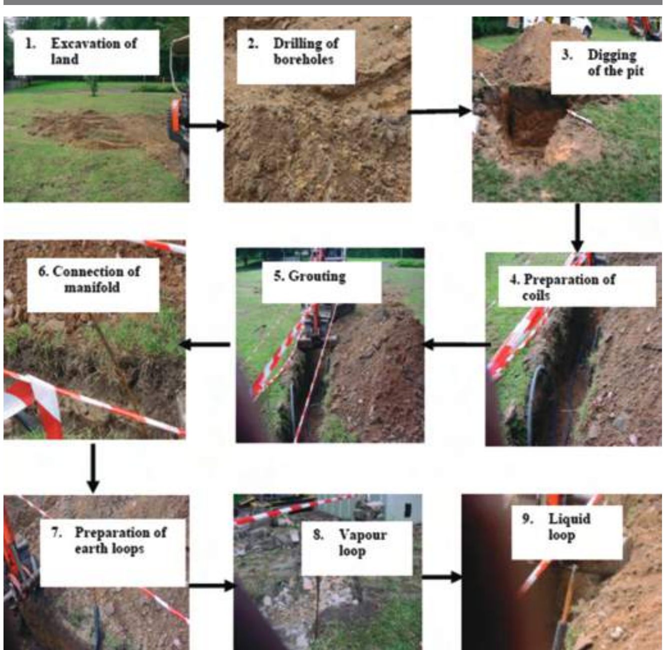

Fig. 3: Showing the drilling (1-2) digging of the pit (3), connection of the manifolds (4), grouting, preparation of the coils (5-6) and the source loop, which consists of two earth loops: one for vapour and one for liquid (7-9)

The aim of this project is to present and develop a GSHP system to provide heating and cooling for buildings (Fig. 2). The heat source loop consisted of two earth loops: one for vapour and one for liquid. A refrigeration application is only concerned with the low temperature effect produced at the evaporator; while a heat pump is also concerned with the heating effect produced at the condenser.

The earth-energy systems, EESs, have two parts; a circuit of underground piping outside the house, and a heat pump unit inside the house. And unlike the air-source heat pump, where one heat exchanger (and frequently the compressor) is located outside, the entire GSHP unit for the EES is located inside the house.

The outdoor piping system can be either an open system or closed loop. An open system takes advantage of the heat retained in an underground body of water. The water is drawn up through a well directly to the heat exchanger, where its heat is extracted. The water is discharged either to an above ground body of water, such as a stream or pond, or back to the underground water body through a separate well. Closed-loop systems, on the other hand, collect heat from the ground by means of a continuous loop of piping buried underground. An antifreeze solution (or refrigerant in the case of a DX earth-energy system), which has been chilled by the heat pump's refrigeration system to several degrees colder than the outside soil, circulates through the piping, absorbing heat from the surrounding soil.

Fig. 4: Showing preparation of coils (1-2), installation of heat pump (3-6) and connection of water supply system (water pump, flow metre, expansion valve and the boiler) (7-9)

The Direct Expansion GSHP installed for this study was designed taking into account the local meteorological and geological conditions. The site was at the School of the Built Environment, University of Nottingham, where the demonstration and performance monitoring efforts were undertaken Figs (3-4). The heat pump has been fitted and monitored for one-year period. The study involved development of a design and simulation tool for modelling the performance of the cooling system, which acts a supplemental heat rejecting system using a closed-loop GSHP system. With the help of the Jackson Refrigeration (Refrigeration and Air Conditioning engineers) the following were carried out:

- Connection of the ground loops to the heat pump
- Connection of the heat pump to the heat exchanger
- Vacuum on the system
- Charging the refrigeration loop with R407C refrigerant.

Water supply system

The water supply system consisted of water pump, boiler, water tank, expansion and valve flow metre (Fig. 4). A thermostatically controlled water heater supplied warm water, which was circulated between the warm water supply tank & warm water storage tank using a pump to keep the surface temp. of the trenches at a desired level.

The ground source heat pump system, which uses a ground source with a smaller annual temperature variation for heating and cooling systems, has increasingly attracted market attention due to lower expenses to mine for installing underground heat absorption pipes and lower costs of dedicated heat pumps, supported by environmentally oriented policies. The theme undertakes an evaluation of heat absorption properties in the soil and carries out a performance test for a DX heat pump and a simulated operation test for the system. In fact, these policies are necessary for identifying operational performance suitable for heating and cooling, in order to obtain technical data on the heat pump system for its dissemination and maintain the system in an effort of electrification. In these circumstances, the study estimated the heat properties of the soil in the city of Nottingham and measured thermal conductivity for the soil at some points in this city, aimed at identifying applicable areas for ground source heat pump system.

Design and installation

Installation of the heat pump system and especially the ground heat exchanger needs to be carefully programmed so that it does not interfere with or delay any other construction activities. The time for installation depends on soil conditions, length of pipe, equipment required and weather conditions. DX systems are most suitable for smaller domestic applications.

The most important first step in the design of a GSHP installation is accurate calculation of the building's heat loss, its related energy consumption profile and the domestic hot water requirements. This will allow accurate sizing of the heat pump system. This is particularly important because the capital cost of a GSHP system is generally higher than for alternative conventional systems and economies of scale are more limited. Oversizing will significantly increase the installed cost for little operational saving and will mean that the period of operation under part load is increased. Frequent cycling reduces equipment life and operating efficiency. Conversely if the system is under sized design conditions may not be met and the use of top-up heating, usually direct acting electric heating, will reduce the overall system efficiency. In order to determine the length of heat exchanger needed to piping material. The piping material used affects life; maintenance costs, pumping energy, capital cost and heat pump performance.

Heat pump performance

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

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

Efficiencies for the GSHPs can be high because the ground maintains a relatively stable temperature allowing the heat pump to operate close to its optimal design point. Efficiencies are inherently higher than for air source heat pumps because the air temperature varies both throughout the day and seasonally such that air temperatures, and therefore efficiencies, are lowest at times of peak heating demand.

A heat pump is a device for removing heat from one place - the 'source' - and transferring it at a higher temperature to another place. The heat pumps consist of a compressor, a pressure release valve, a circuit containing fluid (refrigerant), and a pump to drive the fluid around the circuit. When the fluid passes through the compressor it increases in temperature. This heat is then given off by the circuit while the pressure is maintained. When the fluid passes through the relief valve the rapid drop in pressure results in a cooling of the fluid. The fluid then absorbs heat from the surroundings before being re-compressed. In the case of domestic heating the pressurised circuit provides the heating within the dwelling. The depressurised component is external and, in the case of ground source heat pumps, is buried in the ground. Heat pump efficiencies improve as the temperature differential between 'source' and demand temperature decreases, and when the system can be 'optimised' for a particular situation. The relatively stable ground temperatures moderate the differential at times of peak heat demand and provide a good basis for optimisation.

The refrigerant circulated directly through the ground heat exchanger in a direct expansion (DX) system but most commonly GSHPs are indirect systems, where a water/antifreeze solution circulates through the ground loop and energy is transferred to or from the heat pump refrigerant circuit via a heat exchanger. This application will only consider closed loop systems. The provision of cooling, however, will result in increased energy consumption and the efficiently it is supplied. The GSHPs are particularly suitable for new build as the technology is most efficient when used to supply low temperature distribution systems such as underfloor heating. They can also be used for retrofit especially in conjunction with measures to reduce heat demand. They can be particularly cost effective in areas where mains gas is not available or for developments where there is an advantage in simplifying the infrastructure provided.

Coefficient pf performance (COP)

Heat pump technology can be used for heating only, or for cooling only, or be 'reversible' and used for heating and cooling depending on the demand. Reversible heat pumps generally have lower COPs than heating only heat pumps. They will, therefore, result in higher running costs and emissions. Several tools are available to measure heat pump performance. The heat delivered by the heat pump is theoretically the sum of the heat extracted from the heat source and the energy needed to deliver the cycle. Fig. 5 shows the variations of temperature with the system operation hours. Several tools are available to measure heat pump performance. The heat delivered by the heat pump is theoretically the sum of the heat extracted from the heat source and the energy needed to derive the cycle. For electrically driven heat pumps the steady state performance at a given set of temperatures is referred to as the coefficient pf performance (COP). It is defined as the ration of the heat delivered by the heat pump and the electricity supplied to the compressor:

$$COP = [heat\ output\,(kW_{th})]\,/\,[electricity\ input\,(kW_{el})] \quad (1)$$

For an ideal heat pump the COP is determined solely by the condensation temperature and the temperature lift:

$$COP = [condensing\ temperature\,(^{o}C)]\,/\,[temperature\ lift\,(^{o}C)] \quad (2)$$

Fig. 6 shows the COP of heat pump as a function of the evaporation temperature. Fig. 7 shows the COP of heat pump as a function of the condensation temperature. As can be seen the theoretically efficiency is strongly dependent on the temperature lift. It is important not only to have as high a source temperature as possible but also to keep the sink temperature (i.e., heating distribution temperature) as low as possible. The achievable heat pump efficiency is lower than the ideal efficiency because of losses during the transportation of heat from the source to the evaporator and from the condenser to the room and the compressor. Technological developments are steadily improving the performance of the heat pumps.

The need for alternative low-cost energy has given rise to the development of GSHP systems for space cooling and heating in residential and commercial buildings. GSHP systems work with the environment to provide clean, efficient and energy-saving heating and cooling the year round. GSHP systems use less energy than alternative heating and cooling systems, helping to conserve the natural resources. GSHP systems do not need large cooling towers and their running costs are lower than conventional heating and air-conditioning systems. As a result, GSHP systems have increasingly been used for building heating and cooling with an annual rate of increase of 10% in recent years. While in some zones such as hot summer and cold winter areas, there is a major difference between heating load in winter and cooling load in summer. Thus the soil temperature increases gradually after yearly operation of the GSHP system because of the inefficient recovery of soil temperature as the result of imbalance loads (Fig. 8). Finally, the increase of soil temperature will decrease the COP of the system.

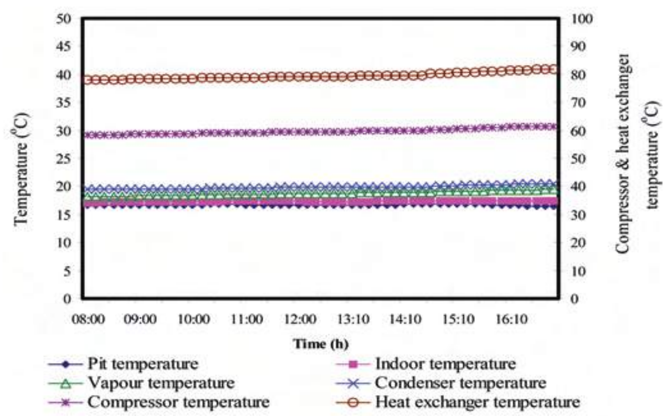

Fig. 5: Variation of temperatures per day for the DX system

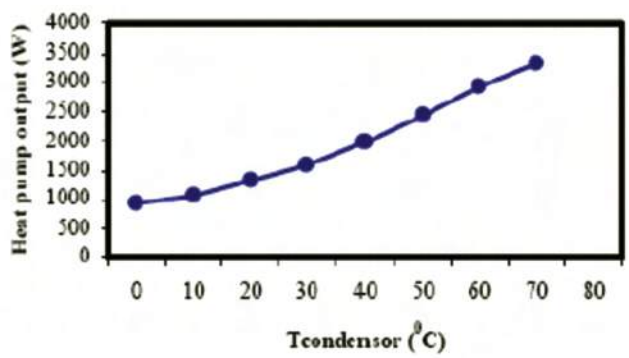

Fig. 6: Heat pump performance vs evaporation temperature

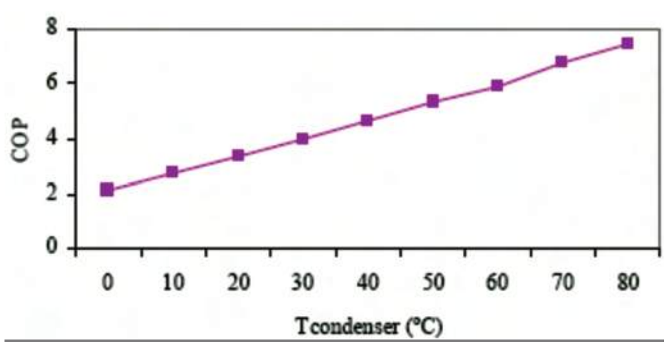

Fig. 7: Heat pump performance vs condensation temperature

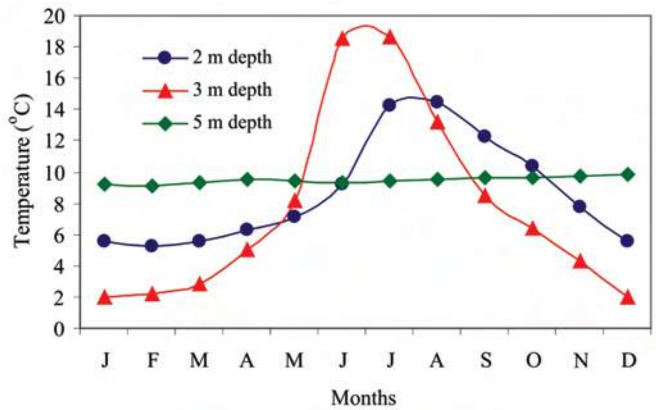

Fig. 8: Seasonal temperature variations

The first law of thermodynamics is often called the law of conservation of energy. Based on the first law or the law of conservation of energy for any system, open or closed, there is an energy balance as:

$$[Net\ amount\ of\ energy\ added\ to\ system]$$

$$= [Net\ increase\ of\ stored\ energy\ in\ system] \quad (3)$$

Or

$$[Energy\ in] - [Energy\ out]$$

$$= [Increased\ of\ stored\ energy\ in\ system] \quad (4)$$

In a cycle, the reduction of work produced by a power cycle (or the increase in work required by a refrigeration cycle) equals the absolute ambient temperature multiplied by the sum of irreversibilities in all processes in the cycle. Thus, the difference in reversible & actual work for any refrigeration cycle, theoretical or real, operating under the same conditions becomes:

$$W_{actual} = W_{reversible} + T_O \Sigma I \quad (5)$$

Where:

I is the irreversibility rate, kW/K.

T_o is the absolute ambient temperature, K

Refrigeration cycles transfer thermal energy from a region of low temperature to one of higher temperature. Usually the higher temperature heat sink is the ambient air or cooling water, at temperature To, the temperature of the surroundings. Performance of a refrigeration cycle is usually described by a coefficient of performance (COP), defined as the benefit of the cycle (amount of heat removed) divided by the required energy input to operate the cycle:

$$COP = [Useful\ refrigeration\ effect] /$$

$$[Net\ energy\ supplied\ from\ external\ sources] \quad (6)$$

For a mechanical vapour compression system, the net energy supplied is usually in the form of work, mechanical or electrical and may include work to the compressor and fans or pumps. Thus,

$$COP = [Q_{evap}] / [W_{net}] \quad (7)$$

In an absorption refrigeration cycle, the net energy supplied is usually in the form of heat into the generator and work into the pumps and fans, or:

$$COP = (Q_{evap}) / (Q_{gen} + W_{net}) \quad (8)$$

In many cases, work supplied to an absorption system is very small compared to the amount of heat supplied to the generator, so the work term is often neglected. Applying the second law of thermodynamic to an entire refrigeration cycle shows that a completely reversible cycle operating under the same conditions has the maximum possible COP. Table 1 lists the measured and computed thermodynamic properties of the refrigerant. Departure of the actual cycle from an ideal reversible cycle is given by the refrigerating efficiency.

$$\eta_R = COP / (COP)_{rev} \quad (9)$$

Seasonal Performance Factor

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

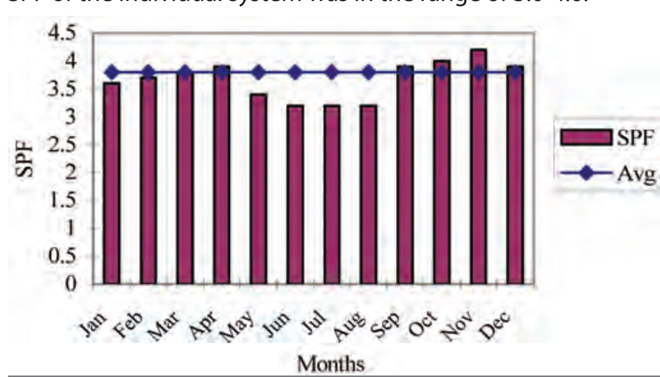

Fig. 9: Seasonal performance for individual months and average for 2008

The preliminary results show that the GSHP are especially promising when it comes to reaching high efficiencies under real conditions. However, there is still a need for optimisation in the integration of the unit in the supply system for the house and for the control strategies of the heat pump. Thus, a poorly integrated heat source or an incorrectly designed heat sink can decrease the seasonal performance factor of the heat pump. The main point to consider is the careful layout of the system as a whole, rather than with respect to single components.

State	Measured		Computed		
	Pressure (kPa)	Temperature (^{O}C)	Specific enthalpy (kJ/kg)	Specific entropy (kJ/kg^{O}K)	Specific volume (m^3/kg)
1	310	-10	402.08	1.78	0.075
2	304	-4	406.25	1.79	0.079
3	1450	82	454.20	1.81	0.021
4	1435	70	444.31	1.78	0.019
5	1410	34	241.40	1.14	0.0008
6	1405	33	240.13	1.13	0.0008
7	320	-12.8	240.13	1.15	0.0191

Table 1: Measured and computed thermodynamic properties of R-22

Comparison of numerical simulation and experiments

The GSHPS are generally more expensive to develop, however they have very low operating cost, and justify the higher initial cost. Therefore, it is necessary to have an idea of the energy use and demand of these equipments. The performances are normally rated at a single fluid temperature (0^{O}C) for heating COP and a second for cooling EER (25^{O}C). These ratings reflect temperatures for an assumed location and ground heat exchanger type, and are not ideal indicators of energy use. This problem is compounded by the nature of ratings for conventional equipment.

The complexity & many assumptions used in the procedures to calculate the seasonal efficiency for air-conditioners, furnaces, and heat pumps (SEER, AFUE, and HSPF) make it difficult to compare energy use with equipment rated under different standards. The accuracy of the results is highly uncertain, even when corrected for regional weather patterns. These values are not indicators for demand since they are seasonal averages and performance at severe conditions is not heavily weighted.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) recommends a weather driven energy calculation, like the bin method, in preference to single measure methods like seasonal energy efficiency ratio (SEER), seasonal performance factor (SPF), energy efficiency rating (EER), coefficient of performance (COP), and annual fuel utilisation efficiency rating (HSPF). The bin method permits the energy use to be calculated based on local weather data and equipment performance over a wide range of temperatures. Both solid and liquid parts co-existed in one control volume of non-isothermal groundwater flow. It was therefore necessary to integrate the two parts into one energy equation. Accordingly, the governing equation describing non-isothermal groundwater flow in a saturated porous medium was as follows:

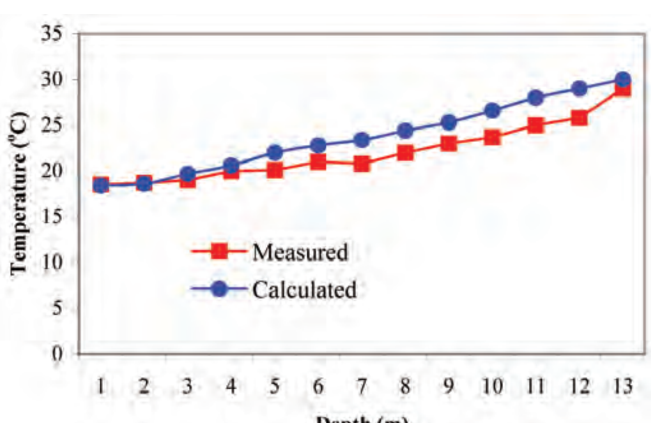

Fig. 10: Comparison of calculations and experiments for saturated soil with groundwater flow (SSG)

$$T(\Delta v) + (\delta T/\delta t)\,\sigma = \alpha t \Delta^2 T + qt/(\rho C_p)_f \qquad (10)$$

$$(\rho C_p)_t = \psi(\rho C_p)_f + (1 - \psi)(\rho C_p)_s \qquad (11)$$

Latent heat during phase changes between freezing soil and thawing soil was regarded as an inner heat source described as follows:

$$WH(\sigma_d)\,\delta f_s/\delta t_s = q_s \qquad (12)$$

$$(\delta T/\delta t)\,\sigma + U_x \delta T_f/\delta x = \alpha_t \Delta^2 T + qt/(\rho C_p)_f \qquad (13)$$

Where:

C_p is the specific heat (J kg^{-1} K^{-1}); q is the internal heat source (Wm^{-3}).
W is the water content in soil (%); T is the temperature (^{O}C).
H is the condensation latent heat of water (J kg^{-1}).
t is the times (s); U is the velocity (ms^{-1}).
f_s is the solid phase ratio.
s is the soil; f is the groundwater.
Ψ is the porosity.
α is the convective heat transfer coefficient (Wm^{-2}K^{-1}).
δ is volumetric specific heat ratio.
ρ is the density (kg m^{-3}).

The experiments and calculations are conducted for unsaturated soil without groundwater flow (US), saturated soil without groundwater flow (SS) and saturated soil with groundwater flow (SSG) under same conditions and their results are compared with each other in Figs 10-13.

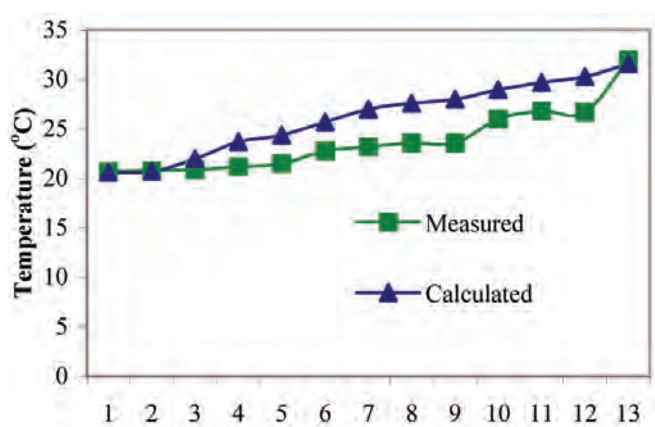

Fig. 11: Comparison of calculations and experiments for saturated soil without groundwater flow (SS)

Performance enhancement of GSHP

The heat transfer between the GSHP and its surrounding soil affected by a number of factors such as working fluid

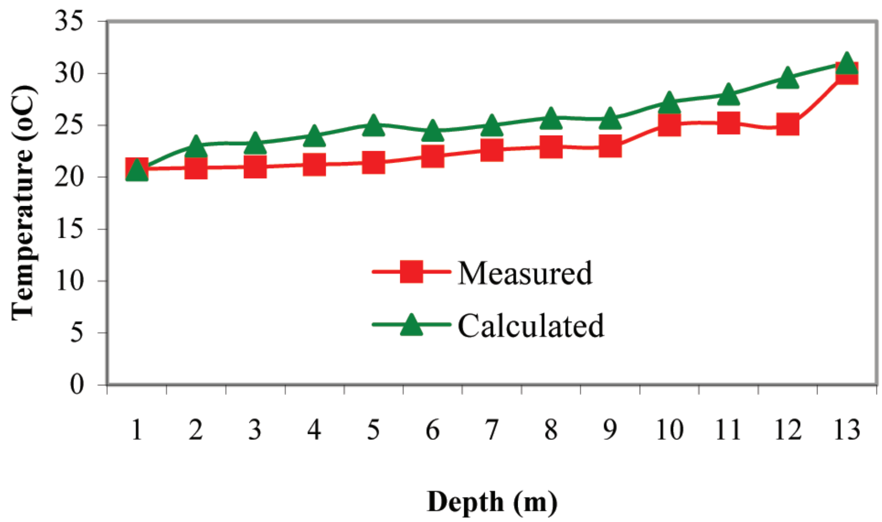

Fig. 12: Comparison of calculations and experiments for unsaturated soil without groundwater flow (US)

cost-effective globally than other forms of renewable power, being on par with hydro-electricity (however, it is important to note that costs will vary between countries).

Energy source	Energy costs (US¢/kWh)	Potential future energy costs (US¢/kWh)
Hydro	2-10	2-8
Biomass	5-15	4-10
Geothermal	2-10	1-8
Wind	5-13	3-10
Solar	25-125	5-25
Tidal	12-18	4-10
coal	4	.4

Table 2: Comparison of energy costs between different energy sources

properties (e.g., 20% glycol) and its flow conditions, soil thermal properties, soil moisture content and groundwater velocity and properties, etc.

GSHP has a great potential to be one of the main energy sources in the future as it can be tapped in a number of different ways and can be used to produce hot water as well as electricity. It has a large spatial distribution with almost all countries having at least low enthalpy resources available (less than 125^{O}C) and many countries around the world in both developing and developed countries are already harnessing it. It is a resource that has always been there and always with be and does not rely on specific factors such as the wind to be blowing or the sun to be shining, as is the case with other forms of renewable energies. GSHP is inherently clean and environmentally sustainable and will soon become more economical than combustion (fossil fuel) plants as regulations on plant emission levels are tightened and expensive abatement measures such as carbon capture and storage become compulsory. This study urges the need for GSHP to be considered much more strongly than it currently is in environmental policies as it has been overlooked as a main alternative to fossil fuels and other forms of renewable energies.

Geothermal power utilises the heat energy naturally produced within the earth. Its wide abundance and renewable nature make it an attractive alternative

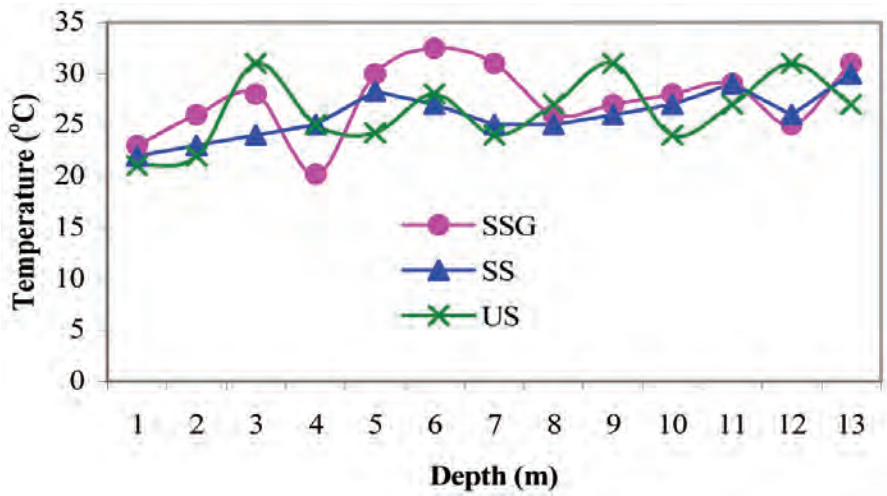

Fig. 13: Comparison of experiments for saturated soil with groundwater flow (SSG), saturated soil without groundwater flow (SS) and unsaturated soil without groundwater flow (US)

energy source to fossil fuels. The environmental impact of geothermal power plants is negligible in comparison to combustion plants & it is progressively becoming more financially viable as emission regulations are tightened.

The technology is increasingly being utilised by countries all over the world, as there are many different ways in which geothermal can be harnessed. Geothermal power is very competitive with other sources of energy when it comes to energy costs. Table 9.2 shows the globally averaged energy costs in 2008 for different energy sources and shows what the potential future energy costs for different sources will be. As the Table 2 shows, geothermal is already generally more financially viable and

Energy Efficiency Ratio (EER) is a ratio calculated by dividing the cooling capacity in watts per hour by the power input in watts at any given set of rating conditions. Coefficient of Performance (COP) is a ratio calculated for both the cooling (C) and heating (H) Capacities by dividing the capacity expressed in watts by the power input in watts (excluding any supplementary heat). Table 3 summarises COP for different loops.

Type of system	COP_C	COP_H
Opened loops	4.75 at 15^{O}C	3.6 at 10^{O}C
Closed loops	3.93 at 25^{O}C	3.1 at 0^{O}C
Internal loops	3.52 at 30^{O}C	4.2 at 20^{O}C

Table 3: COPs for different loops

Tables 4-5 present energy efficiency ratios for cooling and heating purposes.

Application	Type of system	Minimum EER	Minimum COP
Cooling	Opened loops (10^{O}C)	13.0	-
	Closed loops (25^{O}C)	11.5	-
Heating	Opened loops (10^{O}C)	-	3.1
	Closed loops (0^{O}C)	-	2.8

Table 4: Energy efficiency ratios for cooling and heating applications

Ground storage systems can be classified in many different ways. One of the most important classifications is in accordance to the temperature of the storage. The ground storage systems are classified as follows:

- GSHPs, without artificial charging the soil - temperature about 10^{O}C.
- Low temperature ground storage - temperature < 50^{O}C.
- High temperature ground storage - temperature > 50^{O}C.

Table 6 shows COP & EER for different applications.

Application	Type of system	Minimum EER	Minimum COP
Cooling	Opened loops (10^{O}C)	11.0	3.2
	Closed loops (25^{O}C)	10.5	3.1
Heating	Opened loops (10^{O}C)	-	3.0
	Closed loops (0^{O}C)	-	2.5

Table 5: Direct expansion closed loop ground or water source heat pumps

Product Type	Minimum EER	Minimum COP	Water Heating (WH)
Closed-loop	14.1	3.3	Yes
With integrated WH	14.1	3.3	N/A
Open-loop	16.2	3.6	Yes
With integrated WH	16.2	3.6	N/A
DX	15.0	3.5	Yes
With integrated WH	15.0	3.5	N/A

Table 6: Key energy star criteria for ground-source heat pumps

Heat exchanger design

A heat exchanger is usually referred to as a micro heat exchanger (μHX) if the smallest dimension of the channels is at the micrometer scale, for example from 10 μm to 1 mm. Beside the channel size, another important geometric characteristic is the surface area density ρ (m^2/m^3), which is defined as the ratio of heat exchange surface area to volume for one fluid. It reflects the compactness of a heat exchanger and provides a criterion of classification. Note that the two parameters, the channel size and surface area density, are interrelated, and the surface area density increases when the channel size decreases. The exchangers that have channels with characteristic dimensions of the order of 100 μm are likely to get an area density over 10,000 m^2/m^3 and usually referred to as μHXs.

By introducing α in the specific heat exchanger performance equation, the volumetric heat transfer power P/V (W/m^3) can be expressed as follows:

$$P = FUA\Delta T_m = FUA\rho\alpha V\Delta T_m \quad (14)$$

$$P/V = \rho FU\Delta T_m \quad (15)$$

Where, U, ΔT_m and F refer to the overall heat transfer coefficient (W/m^2 K), the mean temperature difference (K) and the dimensionless mean temperature difference correction factor for flow configuration respectively. Note that for a specific heat exchanger performance, high values of α lead to a corresponding high volumetric heat transfer power, larger than that of the conventional equipment by several orders of magnitude. As a result, heat exchanger design by miniaturisation technology has become a common research focus for process intensification.

The main advantages of μHX design are "compactness, effectiveness and dynamic". These properties enable exact process control and intensification of heat and mass transfer.

Compactness: The high surface area density reduces substantially the volume of the heat exchanger needed for the same thermal power. As a result, the space and costly material associated with constructing and installing the heat exchanger could be reduced significantly. Moreover, the fluid holdup is small in a μHX; this is important for security and economic reasons when expensive, toxic, or explosive fluids are involved.

Effectiveness: The relatively enormous overall heat transfer coefficient of μHXs makes the heat exchange procedure much more effective. In addition, the development of microfabrication techniques such as LIGA, stereolithography, laser beam machining, and electroformation allows designing a μHX with more effective configurations and high pressure resistance.

Dynamic: The quick response time of a μHX provides a better temperature control for relatively small temperature differences between fluid flows. The quick response (small time constant) is connected to the small inertia of the heat transfer interface (the small metal thickness that separates the two fluids).On the other hand, the exchanger as a whole, including the "peripheric" material, usually has a greater inertia than conventional exchangers, entailing a large time-constant. Thus the response of one fluid to a temperature change of the other fluid comprises two "temperature-change waves", with very distinct time-constants. In conventional exchangers, it is possible that the two responses are blurred into one.

However, μHXs are not without shortcomings. On one hand, the high performance is counterbalanced by a high pressure drop, a rather weak temperature jump and an extremely short residence time. On the other hand, those fine channels (~100 μm) are sensitive to corrosion, roughness and fouling of the surfaces. Moreover, the distinguishing feature of the μHXs is their enormous volumetric heat exchange capability accompanied with some difficulties in realisation. μHXs design optimisation lies, on one hand, in maximising the heat transfer in a given volume taking place principally in microchannels, while, on the other hand, minimizing the total pressure drops, the dissipations, or the entropy generation when they function as a whole system. Moreover, difficulties such as the connection, assembly, and uniform fluid distribution always exist, all of which should be taken into account at the design stage of μHXs. All these make the optimisation of μHXs design a multi-objective problem, which calls for the introduction of multi-scale optimization method to bridge the microscopic world and the macroscopic world. In recent years, the fractal theory and constructal theory are introduced to bridge the characteristics of heat and mass transfer that mainly takes place in micro-scale & the global performance of the heat exchanger system in macro-scale.

The concept of multi-scale heat exchanger is expected to have the following characteristics:

- A relatively significant specific heat exchange surface compared to that of traditional exchangers;
- A high heat transfer coefficient, as heat transfer is taking place at micro-scales and meso-scales;
- An optimised pressure drop equally distributed between the various scales;
- A modular character, allowing assembly of a macro-scale exchanger from microstructured modules.

Some difficulties still exist. On one hand, the properties of flow distribution in such an exchanger are still unknown. A lot of research work still needs to be done for the equidistribution optimization. On the other hand, 3-D modelling of heat transfer for such an exchanger requires a thorough knowledge of the hydrodynamics and profound studies on elementary volume (smallest scale micro channels). Finally, maintenance problems for this type of integrated structures may become unmanageable when fouling; corrosion, deposits or other internal perturbations are to be expected. Figs 4-16 show the connections of the heat exchanger, water pump, heat rejection fan and expansion valve.

Fig. 14: Shows the heat exchanger

Fig. 15: shows the connections of the heat exchanger, water pump, heat rejection fan & expansion valve

Fig. 16: shows the connections of the heat exchanger and expansion valve

T1 is the Heat exchanger temperature
T2 is the compressor temperature
T3 is the condenser temperature
T4 is the vapour temperature
T5 is the indoor temperature
T6 is the pit temperature.

Figs 17-19 show daily system temperatures for a sample day in each period and the periods of operation of the auxiliary heater and the immersion heater. The performance of the heat

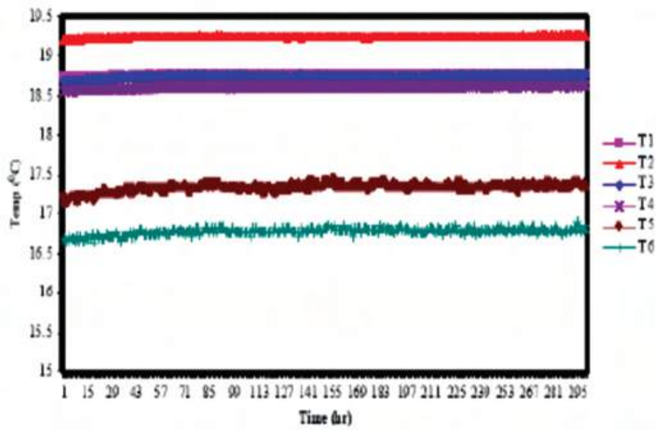

Fig. 17: Variation of temperatures for heat exchanger for two weeks

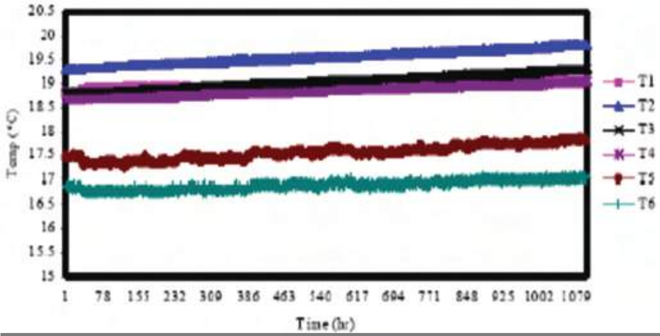

Fig. 18: Variation of temperatures for heat exchanger for 45 days

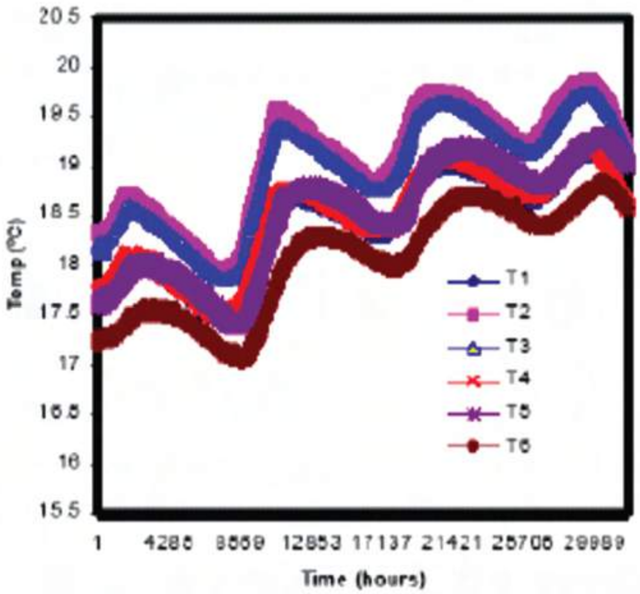

Fig. 19: Variation of temperatures for heat exchanger for year

pump is inversely proportional to the difference between the condensation temperature and the evaporation temperature (the temperature lift). Fig. 20 shows the output of the heat pump for a range of output (condensation) temperatures. These are stable operating conditions, but not true steady state conditions. At output temperatures greater than 40^{O}C, the heat pump was providing heating to the domestic hot water. The scatter in the points is largely due to variations in the source temperatures (range 0.2^{O}C to 4.3^{O}C). These results indicate that the system performance meets and possibly exceeds the specified rating for the heat pump of 3.7 kW at an output temperature of 45^{O}C. Two different control mechanisms for the supply of energy from the heat pump for space heating were tested. From March 2007 until July 2008, the supply of energy from the heat pump to the space heating system was controlled by a thermostat mounted in the room.

From August 2008, an alternative control using an outside air temperature sensor was used. This resulted in the heat pump operating more continuously in cold weather and in considerably less use of the auxiliary heater. The amount the auxiliary heater is used has a large effect on the economics of the system. Very stable internal temperatures were maintained.

Fig. 20 shows the daily total space heating from the heat pump and the auxiliary heater for the two heating control systems. The same period of the year has been compared, using the room temperature sensor and an outdoor air temperature sensor. The operating conditions were not identical, but the average 24-hour temperatures for the two periods were quite similar at 9.26^{O}C and 9.02^{O}C respectively.

Performance of the ground collector

The flow rate in the ground coil is 0.23 l/s. The heat collection rate varies from approximately 19 W to 27 W per metre length of collector coil. In winter, the ground coil typically operates with a temperature differential of about 5^{O}C (i.e., a flow temperature from the ground of 2^{O}C to 3^{O}C and a return temperature to the ground coil of -1^{O}C to -2^{O}C). Icing up of the return pipework immediately below the heat pump can be quite severe. The ground coil temperatures are considerably higher in summer when, for water heating, the temperature differential is similar but flow and return temperatures are typically 11^{O}C and 6^{O}C respectively. When the heat pump starts, the flow & return temperatures stabilise very quickly. Even over sustained periods of continuous operation the temperatures remained stable. The ground coil appears adequately sized and could possibly be oversized. Fig. 20 shows the variation of ground source heat pump against ground temperatures.

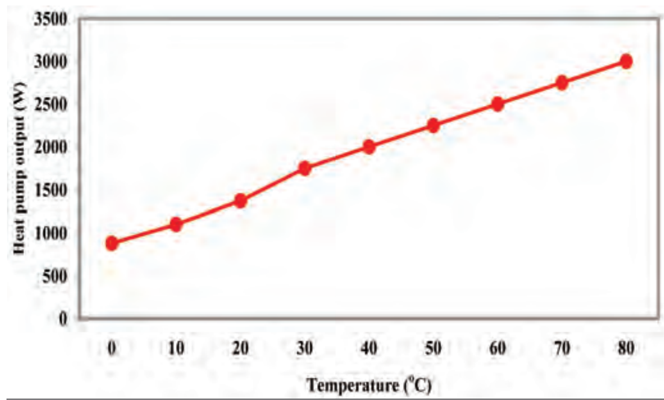

Fig. 20: Variation of heat pump output with temperature

Geothermal energy: electricity generation and direct use at end 2008

Concerning direct heat uses, three countries with the largest amount of installed power: USA (5,366 MWt), China (2,814 MWt) and Iceland (1,469 MWt) cover 58% of the world capacity, which has reached 16,649 MWt, enough to provide heat for over 3 million houses.

Out of about 60 countries with direct heat plants, beside the three above-mentioned nations, Turkey, several European countries, Canada, Japan & New Zealand have sizeable capacity. Most systems have less than 15 kWth heating output, and with ground as heat source, direct expansion systems are

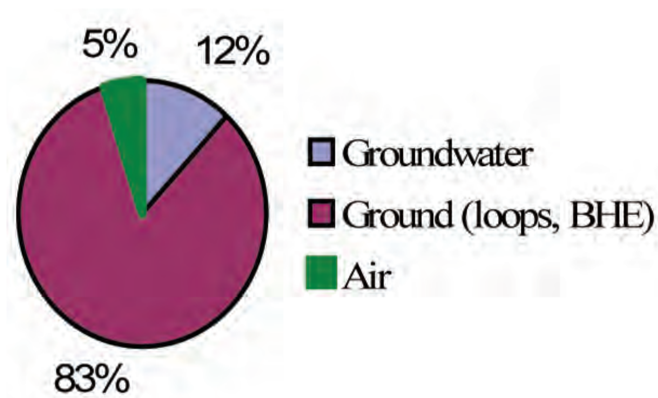

Fig. 21: Distribution of heat sources for heat pumps (for space heating)

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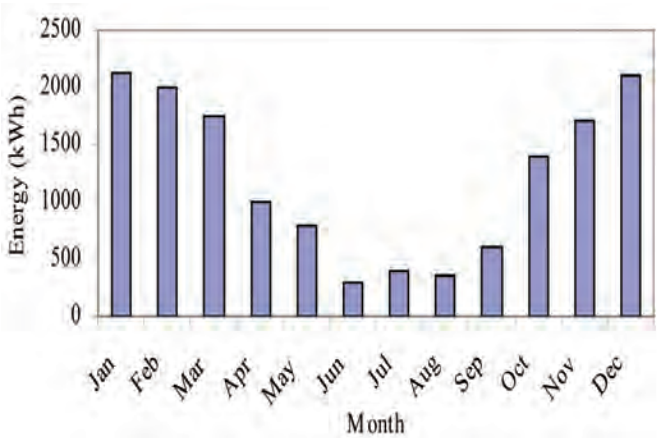


Fig. 22: Monthly heating energy demands

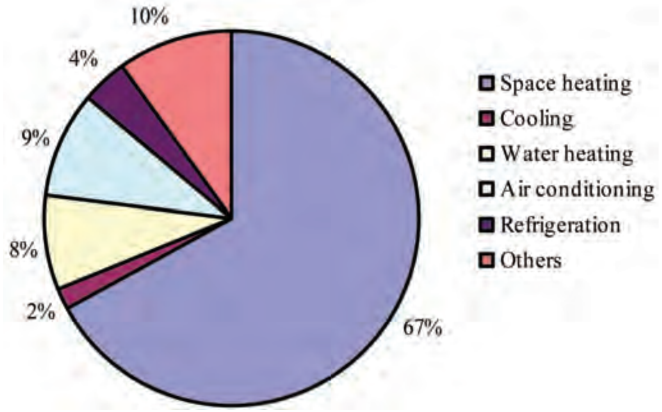


Fig. 24: Commercial energy consumptions according to end use

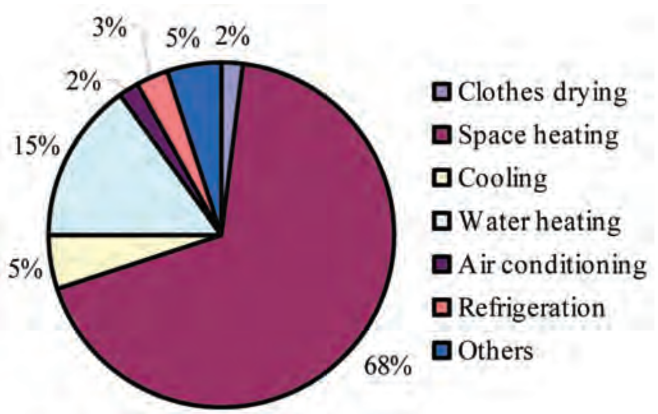


Fig. 23: Residential energy consumptions according to end use

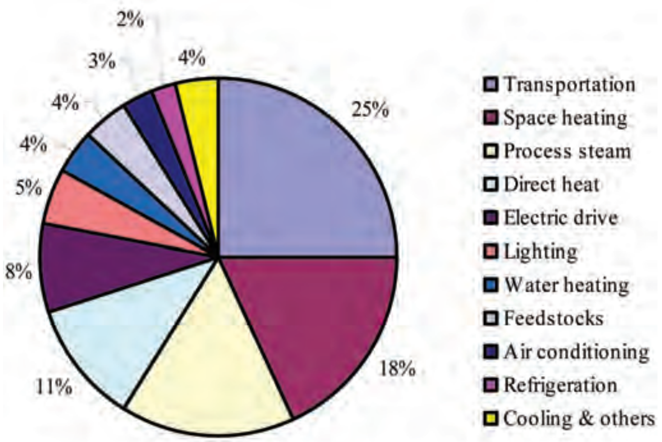


Fig. 25: Energy consumptions according to end use

predominant. Ground-source heat pumps had a market share of 95% in 2006 (Fig. 21). Fig. 22 illustrates the monthly energy consumption for a typical household in the United Kingdom.

There is clearly a lot more that must be done to support distribution GSHPs in general especially from the perspective of buildings in the planning and operation, and distribution GSHP systems (Figs 23-25).

Conclusions

The direct expansion (DX) ground source heat pump (GSHP) systems have been identified as one of the best sustainable energy technologies for space heating and cooling in residential and commercial buildings. The GSHPs for building heating and cooling are extendable to more comprehensive applications and can be combined with the ground heat exchanger in foundation piles as ell as seasonal thermal energy storage from solar thermal collectors. Heat pump technology can be used for heating only, or for cooling only, or be 'reversible' and used for heating and cooling depending on the demand. Reversible heat pumps generally have lower COPs than heating only heat pumps. They will, therefore, result in higher running costs and emissions and are not recommended as an energy-efficient heating option.

The GSHP system can provide 91.7% of the total heating requirement of the building and 55.3% of the domestic water-heating requirement, although only sized to meet half the design-heating load. The heat pump can operate reliably and its performance appears to be at least as good as its specification. The system has a measured annual performance factor of 3.16. The heat pump system for domestic applications could be mounted in a cupboard under the stairs and does not reduce the useful space in the house, and there are no visible signs of the installation externally (no flue, vents, etc.).

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

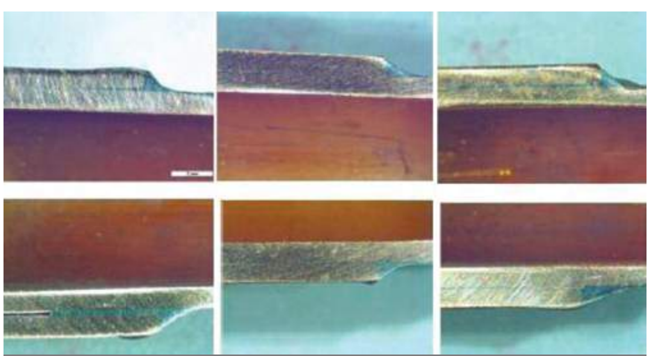
Oxyhydrogen gas generator

How Brazing Process is Changing

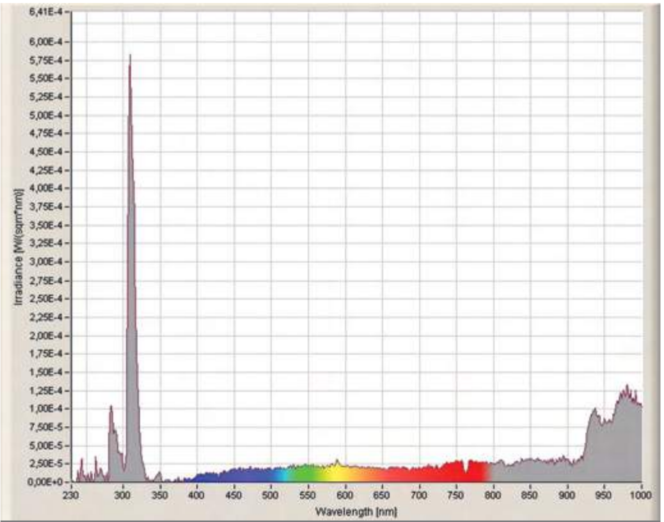
Mixed Oxyhydrogen Gas Generators

A technology is capable of splitting water into hydrogen and oxygen through the electrolysis process and the gas thus obtained replaces the conventional gas cylinders. Now this type of brazing is getting common also in India.

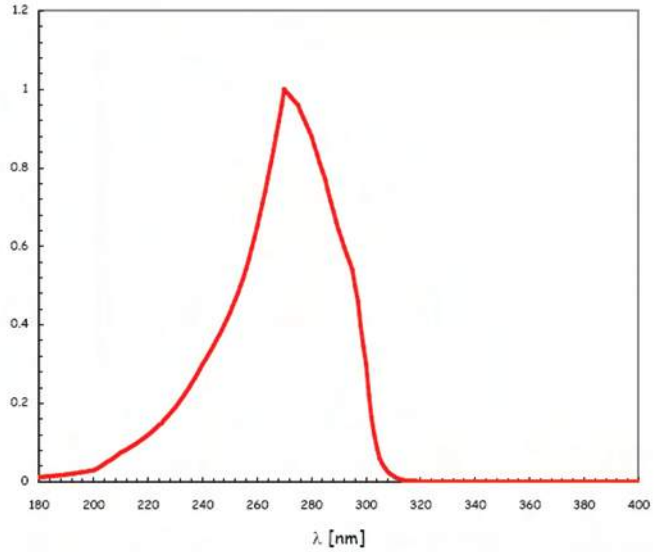
In this type of gas generator the two gases (oxygen and hydrogen) are mixed automatically by the machine and not by the operator and the quality is superior if compared with traditional manual gases. This formula allows to standardize production and brazing process. Eliminating the normal variability, flame's inconsistencies and errors in mixing the two gases in the torch, the quality is always guaranteed. Thanks to the concentrated flame: the mechanical stress of the materials is reduced, guaranteeing stronger joints. Many savings can increase the quality. Thanks to the automatic mixed gases, the leakages can be reduced by at least 50% because we have given to the operator a flame - which is stable and perfectly mixed. Many of those leakages have to be repaired at customer site, in guarantee and it's a cost. Moreover, with this technology you do not need a certified brazing operator. Thanks to the flame's temperature the brazing speed will be double, with a second saving per connection.



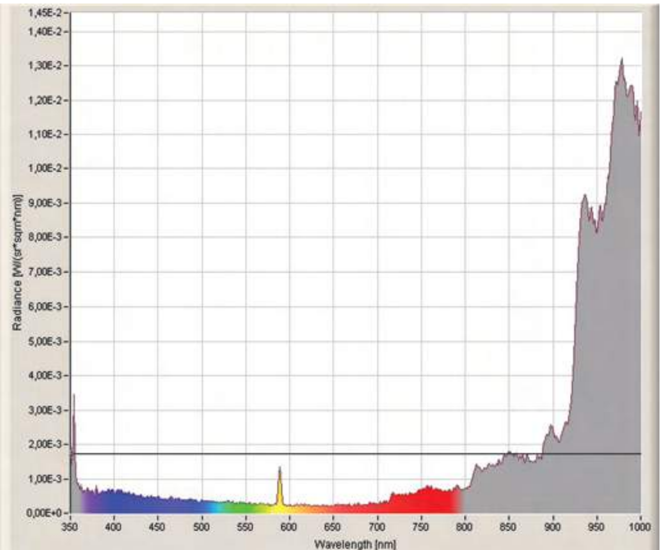
Copper pipe. Alloy's penetration at the microscope



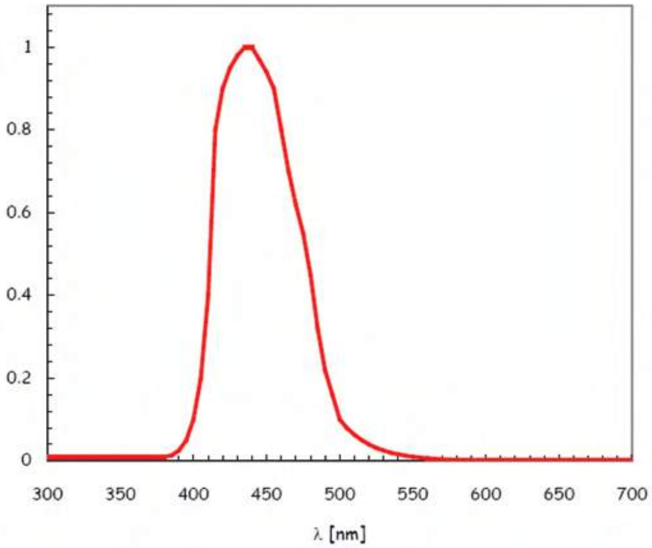
Irradiance, wawe's range (230-1000) nm



UV radiations range (180-400) nm

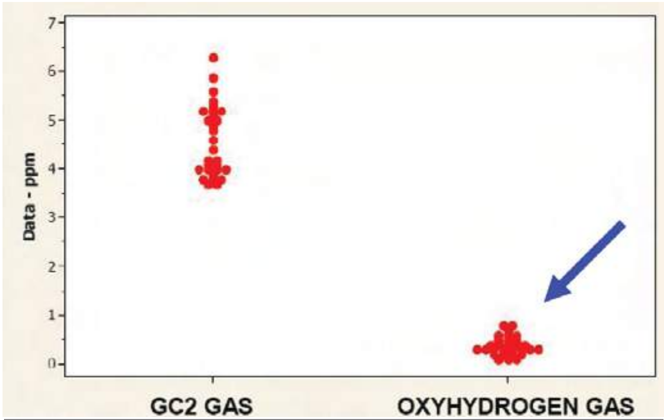


Radiance, wave's range (350-1000) nm

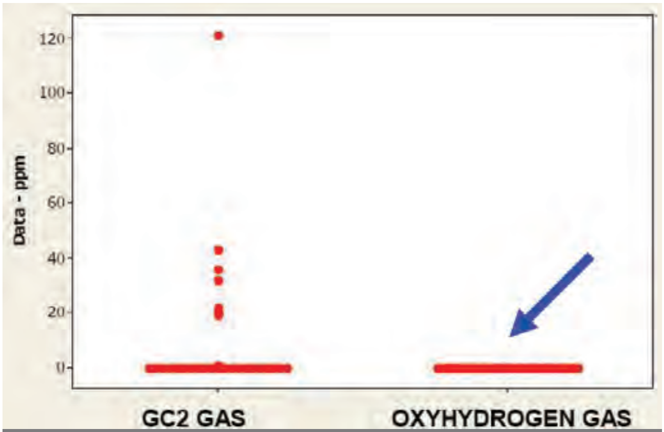


Visibile radiations range (400-700) nm

Diego Andreetta,
with Degree in Economy, is the Sales Manager at Oxyweld. He is author of many publications in HVACR field.



Carbon Monoxide concentration



Carbon dioxide concentration

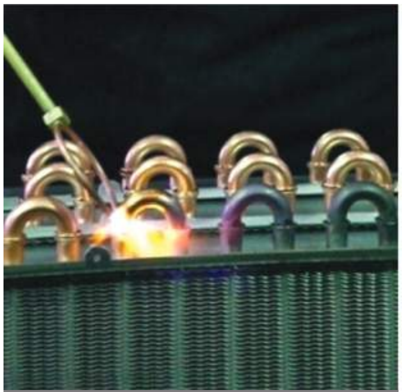
The flame is neutral and concentrated, the heat is therefore localized and does not spread, eliminating the risk to overheat the copper and nearby components. Such a flame drastically reduces the oxidation inside the brazed pipes. For HVACR industry less internal oxidation results in extended life-time of the components in the circuit.

This choice allows to eliminate the usage of cylinders and the possibility of explosion because there is no storage of gas and the pressure in the pipe line is below 0.5 Bar. There is no hydrogen storage - machine produces it only on demand.

The flame is environment friendly because the combustion of oxyhydrogen produces only water vapour, without CO_2 emissions. No need to use special goggles, the flame doesn't damage eyes and skin because there are no infrared and visible emissions.

See charts herein.

The fumes are reduced by about 70% without carbon dioxide and monoxide concentrations.


U-bend brazing


Copper-Copper connections


Copper-Copper connection


Brazing copper pipe


Copper-brass connection


Connections with double nozzle

Source: Oxyweld

These gas generators generate gas from distilled water only, saving - gases cost, cylinders rental and transportation, cost to train operators and manufacturing costs. Thanks to the flame's temperature, operator will be two times faster if compared with acetylene gas, bringing more saving for each connection. ■

Smart HVAC Controls Market worth $26.60 Billion by 2020

According to a new market research report of "Smart HVAC Controls Market by product type (Temperature, Ventilation, Humidity, Integrated), Components (Sensors, Controlled devices, Smart Vents), Application (Residential, Commercial), Operation and Geography - Analysis and Forecast to 2014 - 2020", published by Markets & Markets, the market is expected to grow at a CAGR of 8.22% from 2014 to 2020, and reach $26.60 Billion in 2020. The Smart HVAC Controls market is a growing market, which includes sensors, controlling devices and Smart Vents. In future, Smart HVAC controls are expected to control the HVAC industry because of its high quality contribution to the nation and increased comfort in the HVAC ecosystem. The overall Smart HVAC Controls market is segmented into five major segments- product type, mode of operation, components, application, and geography. All the major segments are further segmented into sub segments. All the segments and sub segments are separately classified in the report. The Smart HVAC Controls market is expected to reach up to $26.60 billion by 2020, at an estimated CAGR of 8.22% from 2014 to 2020.The two major driving factors for the smart HVAC controls market are need for energy efficient solutions and consumer demand for remote access control. Both are expected to boost the market in coming years. The growing concept of Internet of things (IOT) is considered as well planned and is important for the Smart HVAC Controls market. In the report, different modes of operation are also discussed which includes wireless controls, remote controlled controls, programmed controls and integrated controls. Various innovations are taking place to develop the Smart HVAC Controls market which includes the introduction and development ofweather compensating controls along with the related components. Geographical split for the smart HVAC controls market is included in the report. It presents the market share of the different geographies of the smart HVAC controls. This report divides the overall market based on the four major geographical segments: The Americas, Europe, APAC, and Rest of the world (ROW). APAC is considered the market leader in the overall Smart HVAC controls market, which is followed by the Americas and Europe. ■

Need for Green Growth

One of the biggest problems India facing today is the availability of clean water. A recent study indicates that by 2030 the water supply in India will be half of its demand – enough to significantly hamper the social & economic development of the country. At the same time, the rapid expansion of cities and industries has rapidly raised the amount of waste water. Adequate waste water disposal & sanitation facilities have thus become very crucial.

India's water situation, primarily depending on fickle rainfall with much variability, is quite serious. Our aquifers are mostly in poor condition, with deficient safeguards to prevent "water mining" and growing contamination due to industrial pollution and human runoff. Our growing population and climate change have started to exert pressure on our water supplies. We know that water is critical to life, but there is increasing evidence that water quality is even more important than we imagined. The effects of polluted water cannot be overemphasized. It is a known fact that chemicals in water can affect our hormonal system and cause cancer. Unclean water leads to an increase in many infectious diseases. And recent studies strongly suggest that faecal contamination of water is leading to malnutrition in children who are drinking such water, even where they are consuming enough nutritious food.

So, it is a welcome sight to see the government creating a lot of buzz about the environment and seems to be intent about improving water quality and is very strongly promoting sanitation and sewage treatment. It is critical that these initiatives are taken up seriously and actually implemented – too many past efforts have been poorly planned or just left halfway. Implementation of environmental rules has often been lax and uneven. Legislation on a comprehensive approach to water pricing is also needed, which on one hand allows "water for life" to be free or very cheap, but prices other consumption in a manner that encourages efficiency. Integration of laws, of projects, and continuous monitoring of air and water quality are perhaps as important as defense to ensure a secure future for our country. For better public health and economic development, it is essential to deploy adequate technology, infrastructure, & stringent environmental policies. And such efforts also need to be undertaken worldwide to combat climate change and water scarcity.

ETP UF RO at Jeyavishnu Textile Processors

At A.T.E., our efforts are focused on developing world-class solutions for many aspects of our water problems. We have many smoothly running installations that showcase green technology that saves money. For example, our AAA process generates gas, saves energy, reduces chemical consumption and greatly reduces sludge. Our screening grit and sludge management solutions from Huber enable sewage treatment plants to work optimally andensure clean and safe working conditions for workers at these plants. Our SUPERAxis™ framework can be deployed for monitoring air and water treatment plants and wastewater treatment plant – giving us information that helps us act in the right way with less resources used, and in time.

Huber RakeMax

Environment management is a massive task and is of top most priority. Only a joint effort by the government, corporates and the citizens can make a positive impact in conservation, to ensure sustainability. ■

Anuj Bhagwati,
Director, ATE Group.

Usefulness and subtlety of the overall coefficient of Heat Transfer in Cooling Containers

Insulating packaging and containers refrigerated by the latent heat of fusion of a phase change material (PCM) are used to guarantee the cold chain during transportation. These static cooling containers can be characterized by the overall coefficient of heat transfer.

The calculated heat transfer coefficient K_{th} is used to size cooling containers. K_{th} is calculated in terms of the thermal conductivity λ of PU panels and the outer packaging (cardboard). The insulating thickness and the cold load are defined on the basis of heat balance. The heat Q exchanged across the surface S, during a duration t, for a difference of temperature ΔT between the inner of the container and the surroundings must equal the quantity absorbed by the cold source. We determine the experimental (evaluated) heat transfer coefficient K_{exp}, using the test results & Q. K_{exp} is about 3% lower than the calculated value K_{th} & 6% lower than the coefficient K_{mes} measured by Cemafroid. The experimental value characterizes the container performances because it integrates the components of heat exchanges by conduction, convection and radiations, as well as the quality of manufacturing and the airtightness of the container. It allows the qualification

of the container. For varying temperature profiles comprising extreme warm and cold segments, it is necessary to study heat exchanges inside the container, in addition to K values.

Static cooling containers are refrigerated by the latent heat of fusion of a phase change material. They are used to guarantee the cold chain for heat-sensitive and perishable products, during transportation and throughout the logistic circuit. The thermal conductivity coefficient λ characterizes the insulation material, but it is not sufficient to design cooling containers. We use the coefficient of heat transfer to size & to characterize containers. This coefficient can be calculated, experimental or measured.

The theoretic (calculated) coefficient is used to have an approximate dimensioning of the container. The experimental (evaluated) and the measured values allow the characterisation of the insulating container. We treat in this study containers intended to maintain products between +2 and +8^{O}C, because this temperature range is the more requested and the most complicated case. The coefficient of heat transfer is useful, because it allows a good approximation to size a solution and an overall qualification of the insulating container, but doesn't allow the final design of a validated solution, to maintain products strictly between +2 & +8^{O}C without excursions, for varying temperature profiles including extreme warm and cold segments.

Abbes Kacimi, Cold Chain Expertise Manager, Sofrigam, France, graduated from Constantine University and Ecole Centrale Paris, has Engineer degree in Refrigeration and Air-Conditioning. He studied at French Institute of Industrial Refrigeration. He is an expert at International Institute of Refrigeration. He is co-author of "Practical Guidelines, Cold Chain for Medicines". He published about fifty articles.

Materials and Methods

We used for this study an insulating container with an internal volume of 50 litres, manufactured with rigid PU panels, 60 mm thick. The outer packaging is composed of double wall corrugated cardboard. This container is refrigerated by eutectic gel packs (cold source). It is the result of the sizing carried out in the first stage of our study (See Fig. 1).

Tests are performed using qualified equipment: calibrated measuring chain, thermostatic chamber, freezer & refrigerator. We simulated the worst case of pharmaceutical products by empty vials to have the lowest thermal inertia.

Different K values are used in this study

- **Theoretic value K_{th}:** calculated with the coefficient of thermal conductivity λ and the thickness of the walls, including PU panels and the cardboard (outer packaging).
- **Experimental value K_{exp}:** evaluated with a specific methodology based on thermal performance tests of the insulated container.
- **Measured value K_{mes}:** determined by the internal heating method, according to international standards adapted for small insulated boxes.

Initially the cooling container is sized on the basis of the energetic balance, to maintain products between +2 & +8^{O}C, for 96 hours at least, at an ambient temperature between +20 & +25^{O}C. The quantity of cooling elements (frozen gel packs) and the thickness of PU walls are determined, using the payload (net volume), the average of the temperature range required

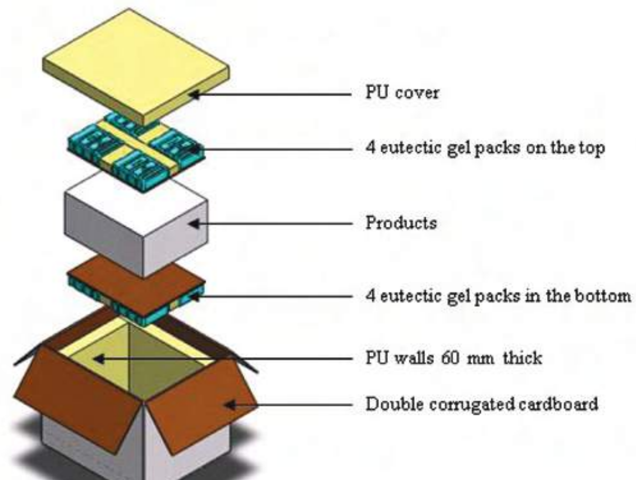


Fig. 1: Components of the simple cooling container

to maintain products, and the calculated coefficient of heat transfer K_{th}.

The test results and the exchanged heat Q, which equal the heat absorbed by the cold source, are used to determine the experimental coefficient of heat transfer K_{exp}.

Results and Discussion

On the basis of the heat balance, using the theoretical (calculated) coefficient K_{th}, we defined an approximate size of the container, the insulating thickness and the necessary cold load for the required duration and for an average of external temperature. We considered that the temperature inside the cooling container is the average of the required storage temperature range (+5^{O}C for the required range between +2 & +8^{O}C), and the ambient temperature is +20^{O}C. The quantity of heat exchanged between the inner of the designed cooling container and the ambient surrounding is absorbed by the gel packs (cold source).

Calculated coefficient of heat transfer K_{th}

The theoretic coefficient of heat transfer K_{th} is given in eq. (1).

$$1/K_{th} = e/\lambda + 1/h_{int} + 1/h_{ext} \quad (1)$$

λ is the thermal conductivity of rigid PU panels, e is the thickness of the wall, and h is the convection and radiation coefficient.

The K value of PU panels 60 mm thick is KPU = 0.37 W/m^{2}K.

The calculated coefficient K_{th} of the insulated container, including the PU in-cover (20 mm thick) and the outer packaging (double wall corrugated cardboard), is K_{th} = 0.32 W/m^{2}K (±6%).

Test at +20^{O}C and experimental coefficient of heat transfer K_{exp}

The heat Q exchanged, across the surface S, during a duration t, for a difference of temperature ΔT between the inner of the container and the ambient surrounding is given in eq. (2).

$$Q = K \cdot S \cdot \Delta T \cdot t \quad (2)$$

Q must equal the quantity absorbed by the cold source (solid sensitive heat + fusion latent heat + liquid sensitive heat of eutectic gel).

The experimental coefficient of heat transfer K_{exp} is given in eq. (3).

$$K_{exp} = Q / (S \cdot \Delta T \cdot t) \quad (3)$$

The heat exchanged with the surrounding for 96 hours at least and for an ambient temperature of +20^{O}C is 2130 KJ. This quantity of heat is raised to have an entire number of gel packs. The quantity Q used in tests corresponds to 8 gel packs (Q = 2170 KJ).

The test carried out at +20^{O}C is used to evaluate the overall coefficient of heat transfer K_{exp}, for the tested container. The temperatures recorded by the probes placed on the products used in this test were maintained between +2 and +8^{O}C without excursions, during 115 hours, (See Fig. 2).

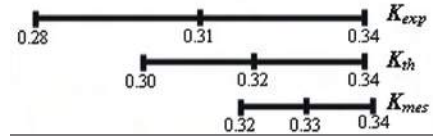


Fig. 3: The 3 different results of K values in W/m²K (K_{th}, K_{exp} & K_m)

ambient temperature profile. The zone close to the cold source (frozen gel packs) is colder, and the zone far from the cold source is hotter, for warm ambient temperatures. The temperature distribution can be different in the container, for cold ambient temperatures.

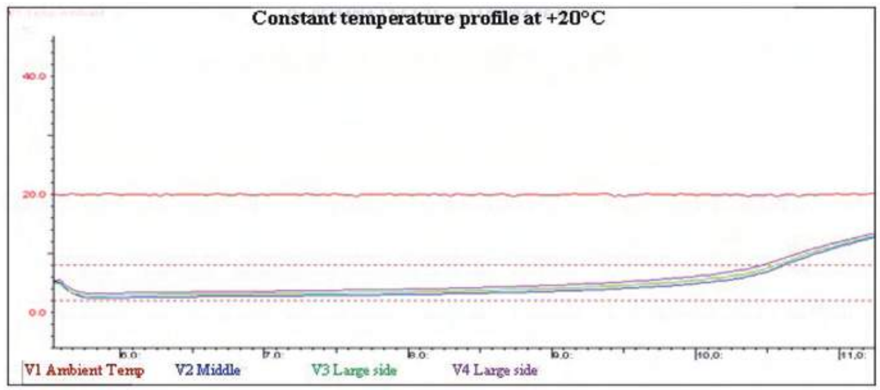


Fig. 2: Performance test at +20^{O}C

According to this test, the experimental overall coefficient of heat transfer K_{exp} for this container is:

K_{exp} = 0.31 W/m^{2}K (±9%).

The coefficient of heat transfer K_{mes} measured in Cemafroid laboratory, using the internal heating method is

K_{mes} = 0.33 W/m^{2}K (±3.7%).

Comparison of K values (K_{th}, K_{exp} and K_{mes})

The experimental coefficient K_{exp} is about 3% lower than the calculated value K_{th} & 6% lower than the coefficient K_{mes} measured by Cemafroid laboratory. Whilst the differences are within possible experimental error (See Fig. 3), they may also be explained by two other factors:

- Neglected parameters in calculation, which are in the favour of the thermal performances, like thermal inertia of the load (products and the plastic packs of gel used in tests).
- Assumptions: Really the temperature inside the container is between +2 & +8^{O}C, but it is not constant (+5^{O}C) in any point of the net volume. It depends of the cold source and the

Performance test for varying temperature profile

Temperature profiles generally requested for the validation of static cooling containers integrate warm and cold segments. The same container was tested according a varying profile, integrating 2 segments at +40^{O}C, 1 segment at 0^{O}C, 1 segment at +5^{O}C and 4 segments at +20^{O}C.

The goal of this performance test, under restricting conditions, is to analyze the pertinence of the coefficient of heat transfer, and to verify the method used to size this container.

- The temperatures recorded by the probes placed on products were between +2 and +8^{O}C, for all the segments at +20^{O}C, the minimum was +2.25^{O}C, recorded in the first one.
- During the segments at +40^{O}C, the product temperatures increase, exceed +5^{O}C and approach +8^{O}C. Logically, if the segment at +40^{O}C is prolonged they will exceed +8^{O}C.
- During the segment at 0^{O}C, the temperatures decrease and cross

+2^{O}C. The minimum is +1.1^{O}C recorded at the end of the segment. Logically, if this segment is prolonged they will lead to 0^{O}C.

- During the segment at +5^{O}C, the temperatures decrease and 2 probes out of 3 cross +2^{O}C. The minimum is +1.6^{O}C recorded at the end of the segment.
- This test showed excursions out of the range +2/+8^{O}C, at the extreme segments (See Fig. 4). The coefficient of heat transfer cannot predict these excursions, because the three K values are based on a constant ambient temperature (the average of the temperature profile).

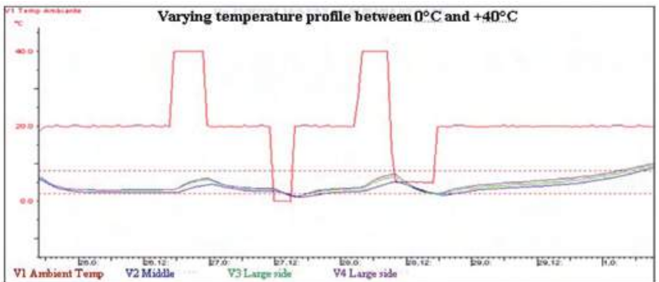


Fig. 4: Performance test under a varying temperature profile between 0^{O}C and +40^{O}C

Stress tests: Extreme warm temperature

A warm stress test was carried out, at an ambient temperature between +45 & +50^{O}C, after a first segment at +20^{O}C during 24 hours. The goal of this test is to qualify the limit of the container performance for extreme warm conditions, and to confirm the analysis of the preceding stage, concerning the pertinence of the coefficient of heat transfer and the method of sizing.

- During the 24 hours at +20^{O}C, all the probes were between +2 and +8^{O}C.
- When the ambient temperature is increased between +45 and +50^{O}C, the product temperatures increase, & after 8 hours one probe exceeded +8^{O}C.
- When the ambient temperature is decreased to +20^{O}C, after about 12 hours at +40^{O}C, the product temperature decrease quickly to be stabilized between +2 and +8^{O}C (See Fig. 5).

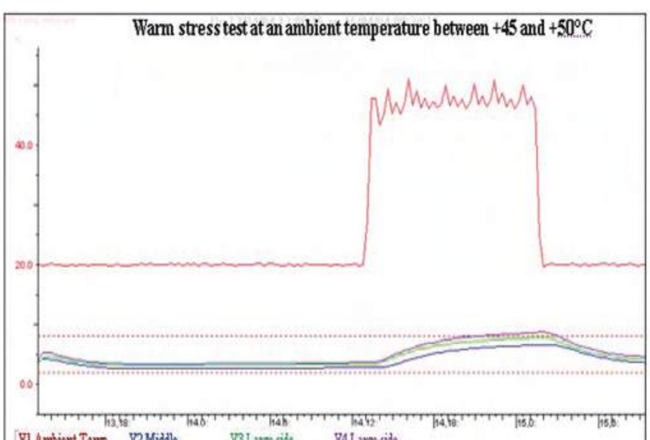


Fig. 5: Warm stress test at an ambient temperature between +45 and +50^{O}C

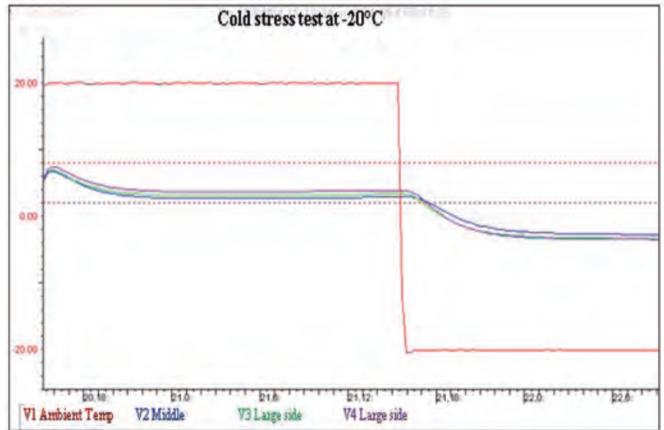


Fig. 6: Cold stress test at -20^{O}C

the varying temperature profile. The heat transfer coefficient cannot predict the limits of the container performances under an extreme warm temperature.

Stress tests: Extreme cold temperature

A cold stress test was carried out, at -20^{O}C, after a first segment at +20^{O}C during 24 hours. The goal of this test is to qualify the limit of the container performance for extreme cold conditions, and to confirm the analysis, about the pertinence of the coefficient of heat transfer and the sizing method.

- During the 24 hours at +20^{O}C, all the probes were between +2 and +8^{O}C.
- At -20^{O}C, the product temperatures decrease.
- After less than 2 hours, one probe crossed +2^{O}C, and it was followed by the others.
- After 3 hours, the first probe crossed 0^{O}C, and it was followed by the others (See Fig. 7).

The coefficient of heat transfer cannot predict the limits of the container performances under an extreme cold temperature.

Results Analysis

The theoretical (calculated) heat transfer coefficient allows an initial sizing, based on the average of the ambient temperature (between +20 & +25^{O}C), and the average of the internal temperature (+5^{O}C). We neglect also in the calculation of the heat balance the thermal inertia of the load. This assumption involves a reduced validity field of the theoretic coefficient of heat transfer.

The overall experimental heat transfer coefficient K_{exp} characterizes the container performances because it integrates the parts of heat exchanges by conduction, convection and radiations, as well as the quality of manufacturing (the assembly) and the airtightness of the container. It provides information on the homogeneity of the insulating material and on thermal bridges that may reduce the performances. K_{exp} allows also the evaluation of damages after n uses, and the qualification of the container for the reuse.

The value K_{mes} measured by Cemafroid laboratory integrates the quality of manufacturing and the airtightness of the container, but the measurement method require a small fan inside the container, and it doesn't take into account the thermal inertia of the load.

	Advantages	Disadvantages
K_{th}	Allows the calculation of the heat balance and a quick approximate sizing, simple, cheap and do not require tests.	Not applicable to all the insulating materials, it is difficult to estimate λ values of different components of walls and heat exchanges by convection and radiations; it does not integrate the quality of manufacturing.
K_{exp}	Take into account all the exchanges of heat and the thermal inertia of the load, quick, allows the sizing, the verification and the qualification of the container, allows the follow-up of the production, medium cost.	Uncertainty (about 9%), require tests.
K_{mes}	Allows the comparison of different containers (insulating material and quality of manufacturing), very good uncertainty (3.7%), repeatability, conventional method.	Require tests, it doesn't integrate the thermal inertia of the load, impact of the fan placed inside the container, high cost, this method is not adapted for static cooling containers.

Advantages and disadvantages of presented K values

The development of a validated solution to maintain products strictly between +2 & +8^{O}C, under temperature profiles comprising warm and cold segments, requires the study of heat exchanges inside the container. The container designed initially, must be improved to avoid excursions for extreme constraints. The solution will be larger, heavier and more expensive.

Conclusion

The theoretical heat transfer coefficient K_{th} allows the design of cooling containers for simple cases of logistic circuits. The precision of the sizing is acceptable for a good insulation material, and for an ambient temperature between +20 and +25^{O}C.

The overall experimental coefficient of heat transfer K_{exp} characterizes the container performances. It informs about the quality and the homogeneity of insulating material as well as the quality of manufacturing (airtightness, thermal bridges). K_{exp} can be used also in the qualification of the container for the reuse.

The measured coefficient K_{mes} allows the comparison of different concepts. It integrates the quality of the insulation and the quality of manufacturing.

K values cannot predict the limits of the container performances for extreme cold or warm ambient temperatures. It is necessary to study heat exchanges inside the container, via temperature tests, to develop a solution able to maintain products between +2 & +8^{O}C without excursions, under extreme conditions. It is very interesting to develop a simulation tool to predict the variation of the temperature inside the container, for varying temperature profiles. The simulation facilitates the investigation and rapid designing of reliable solutions, for different constraints. ■

Data Centres could experience 30% more Failures as Temperatures Increase

Many data centre operators have been increasing the operating temperature in their data centres to reduce the massive costs of cooling. Alan Beresford, Technical Director and MD with EcoCooling says, they run the risk of significantly more failures. ASHRAE is generally considered to set the standards globally for data centre cooling. A few years ago it relaxed its recommended operating range for data servers from 20-25^{O}C to 18-27^{O}C. "For decades," said Beresford, "data centres have operated at a 20-21^{O}C temperature. With the relaxation in the ASHRAE 2011 recommendation plus the pressure to cut costs - data centres have begun to significantly increase the 'cold aisle' temperature to 24-25^{O}C & in some cases right up to 27^{O}C. "But many of them have not taken into account the study of server reliabilities detailed in the ASHRAE 2001 Thermal Guidelines for Data Processing Environments - which predicts that if the cold aisle temperature is increased from 20^{O}C to 25^{O}C, the level of failures increases by a very significant 24%. Upping the temperature to 27.5^{O}C increases the failure rates by a massive 34%. Warns Beresford, "And if the air temperature going into the front of the servers is 27^{O}C it's going to be very hot (34-37^{O}C) coming out of the rear. For blade servers it can be a blistering 42^{O}C at the rear! "It's not just the servers that can fail," states Beresford, "at the rear of the servers are electric supply cables, power distribution units and communication cables. Most of these are simply not designed to work at such elevated temperatures and are liable to early mortality." According to ASHRAE's published figures, if the temperature is reduced to 17^{O}C – the server reliability is improved by 13% compared to conventional 20^{O}C operations. "To cool the air to 17^{O}C would be completely uneconomic with conventional refrigeration cooling," said Beresford, "our modelling shows it would require over 500kW kilowatts of electricity for every megawatt of IT equipment."However, with our evaporative direct air cooling CRECs (Computer Room Evaporative Coolers), this 17^{O}C operation would require less than 40kW kilowatts – a saving of over 450kW compared to conventional refrigeration and a reduction of PUE (Power Usage Effectiveness) of 0.45.When given the option of cooling a data centre with refrigeration at 27^{O}C compared with evaporative cooling at 17^{O}C at less than 10% of the energy use, 40% less temperature related server failures and a more stable environment for other components it is clear why over 150 UK data center operators have adopted this approach. Beresford remarks, keeping working environment under 30^{O}C is a far more acceptable solution. ■

INFRACA

Infraca is a market leading company in the manufacture of cold room- rapid and interior dot Mainly targeting the industrial sector, such as agriculture, pharmaceutical, medical and the a industry as well as supermarkets, hyper markets and the logistics platform. With more than thirty years experience in the market, they have Infraca presence in all continents. Infraca's principle production plant was inaugurated in January of 2010. Located Valencia -Spain's third largest city of more than 1.5 million habitants and the first port in Mediterranean- Infraca has an excellent logistic location of only 10 Km from the port and mint from the A-7 motorway, giving it a very advantageous access to cities such as Barcelona, Mai and Alicante. This purpose built manufacturing plant has more than 6,000 m^2 of production spa and a production capacity of more than 30,000 doors annually.

2013. Infraca Latam

As a result of constant growth and expansion of the company and a demand for their prodi in the industrial and professional sector in January 2013 we established a new production in Latin America. Located in Villa El Salvador industrial state -Lima- Peru this manufacturing boasts over 2000 m^2 of production space and is equipped with the technical and mechanical kr how as well as a very skilled work force to ensure uncompromising effort in maintaining their drive to achieve a very high standard in all our product range. ■

Website:
www.infraca.com

Sarthak Refrigeration

Saarthak Refrigeration Colt Compressor Series are most suitable for industrial refrigeration and low Temperature Applications such as Cold Storage, Ice Plants, Fisheries Plants, Ice Cream Plants, Dairy Plants, beverage making plants Chemical Plants, Pharmaceutical Plants, Vanaspati Plant & Air Con¬ditioning Plants etc. Saarthak Refrigeration is a manufacturer of Colt Brand air and gas compressors.

Saarthak Refrigeration range of open type compressors are available in single as well in double stage versions with use on Ammonia (NH3) and R-22 Refrigerant etc. They are well-designed and robust machines capable of running continuously, for prolonged period with minimum attention. These compressors by virtue of their high speed and multiplicity of cylinder exceptionally compact and economical of space. These machines are also designed to accommodate varying refrigeration demands with maximum economy in power and are well suited to automatic installations.

Saarthak Refrigeration has a countrywide Sales & Service Network for upkeep of every compressor it manufactures and every refrigeration package it builds. The international Customers in the Middle East, South East Asia and African Subcontinent has resulted in customer satisfaction abroad through trouble free operation of COLT compressors. Saarthak refrigeration has developed the required infrastructure to support all its manufacturing processes. They have an in-house testing lab, CNC machining centers, stress relieving furnaces, testing facilities and Paint shops. With decades of experience and reliable performance of their compressors across the country, they have earned the trust of many customers. They are now leading amongst the leaders in the manufacture of reciprocating open type refrigeration compressors. ■

Website:
www.coltfreeze.com

Sukavach Containers LLP

Established in the year 2010, at Ahmedabad (Gujarat, India), "Sukavach Containers LLP" are the leading names engaged in Manufacturing, Exporting, Trading and Supplying a qualitative assortment of Refrigerated Container, Insulated Shipping Container, Thermo King Refrigeration Unit, Carrier Refrigeration System, Cool Wave, etc. These are manufactured using optimum quality raw material and sophisticated technology and designed with high precision in order to meet the set universal standards. Offered range is widely appreciated among their prestigious clients for their features like rigid construction, corrosion resistance, low maintenance and durability. Clients can avail these products from company. They are exporting their products in Indian Subcontinents. ■

Website:
www.sukavach.com

Complete Logistics Solutions by Gandhi Automations Pvt Ltd

Gandhi Automations Pvt Ltd offers complete logistics solutions by providing Dock Levelers, Dock Shelters, Sectional Overhead Doors and Dock Houses. Electro-hydraulic, mechanical and air-powered Dock Levelers offered by Gandhi Automations are not only "a bridge for connecting a vehicle", but also facilitate fast, smooth and safe transition by compensating the difference in heights between the loading bay and the vehicle. This contributes to minimizing energy used and savings on heating and chilling costs resulting in maintaining the quality of the transported goods. Dock Levelers offered by Gandhi Automations are designed as per EN 1398 standard for the most demanding loading and unloading operations.

Efficient loading & unloading the goods

The importance of efficient loading the goods has always been evident, essentially for two reasons: the lesser availability and the higher cost of

manpower. The Dock Levelers offered by the company ensure loading and unloading with lesser effort and minimal cost. The loading bay remains with the Dock Leveler in rest position and the Sectional Overhead Door closed, until the vehicle is positioned. The driver drives back centring to the Dock Shelter and stops the vehicle the moment it gets in contact with the bumpers. The Sectional Overhead Door is then opened only when the vehicle is positioned, brakes applied and engines shut off. This eliminates the exit of hot air, intake of cold air (or the opposite in hot and inside conditioned places) and intake of exhausting gases in the warehouse. At the end of the loading/unloading the Dock Leveler is put in rest position and the Sectional Overhead Door is closed, without moving the vehicle. The vehicle then departs at the end of the process.

Radius Lip Dock Levelers allow the dock to connect with the truck-bed, thus making it possible to drive directly on and off with fork-lift trucks, roll containers etc. Loading and unloading operations become quick, safe and economical.

Telescopic Lip Dock Levelers are ideal for connecting vehicles that cannot travel to the dock (e.g. sea containers, side loading railway wagons etc.). These types can be supplied with a lip extending up to 1 m.

Gandhi Automation's Dock Levelers are equipped with the most secure safety devices and accessories. ■

Website:
www.geapl.co.in

Hub Cold Room Fittings by Smart Marketing

HUB, Taiwan is manufacture of high end fitting for Cold Rooms, Sold all over the world. Recently they launched five most popular models out of their complete range for Indian market.

Handle AH-1178L;Mechanical Latch AH-1200L;
Mechanical Latch AH-1400L;
Reach-in Door Hinge AH-1460H;
Reach-in Door Hinge AH-1470H.

All these are made of high quality Zinc and plated as per International Standard to meet any environmental abuse. ■

For further details:
marketing@smartmarketing.co.in

Icesnow block ice machine by Shenzhen Icesnow Refrigeration Equipment Co Ltd

With the accumulation of rich experience of products development and comprehensive experiment in the past decades, Icesnow launched KBJ series block ice machine according to the demand of current market. Icesnow block ice machine is a newly high efficient block ice making product specially designed for the customers need. The block ice machine adopt integrated design which is very easy and simple for installation. Ice making pool of block ice machine use polyurethane foaming technology which has good thermal insulation effect as well as fluid design which has good flow stability. They use environmental friendly secondary refrigerant which has good heat transfer effects.

Features:

Icesnow block ice machine is comapact in design, beautiful in shape, convenient for transport and simple in operation. The block ice machine make use of environmental protection secondary refrigerant and the machine has corrosion resistance features as well. Icesnow block ice has big density, high cleanliness, large cold accumulation and selectable sizes. ■

Website:
www.icesnower.com

Monitoring Mold conditions is the only way to prevent it

Mold is a fungus. Outdoor mold breaks down dead trees and fallen leaves and hence plays an important role in nature. Mold requires a nutrient source, proper temperature and moisture to grow. Nutrients to support mold growth are ubiquitous in the building environment. The temperatures required for mold growth are in the same range as indoor building environments. Most molds grow in the temperature range of 15°C to 30°C (59° to 87°F). Control of moisture is the only practical way to control mold growth. In fact a 1°F change in room temperature can change the relative humidity by 2%. If outside air at 85°F (29.5°C) and 60% RH is cooled to 72°F (22°C) degrees without any moisture removal, the RH will increase to almost 90%.

Telaire NDRI DEW point sensor

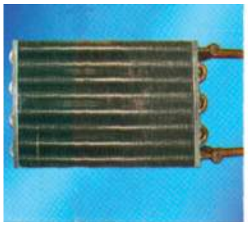
Protimeter Mini & Psyclone for measuring MC% and Dew Point

What is moisture content?

Moisture content is not relative humidity. Moisture Content (MC) is the mass of the moisture in a material relative to the dry mass of the material, expressed as a percent. For example if there is 17 grams of water in a piece of wood that weighs 100 grams when dry, then the wood has a Moisture Content (MC) of 17%. We must therefore measure and control the temperature at which the water condenses on the surface, thereby controlling mold conditions. This temperature is called Dew point. Instruments that monitor dew point directly can be used for direct control, as usually the coldest surfaces in a building are known. Dew point instruments are even now considered complicated, expensive devices. Contrary to this belief, the new technologies have made these instruments very compact, user-friendly and maintenance free. Unlike the RH sensors which cannot be calibrated the Dew point sensors offer calibration possibility and an enhanced design life of over 15 years. These devises come in wall mount and duct mount designs. Dew point measurement besides in mold control have proved to be a better tool for controlling all aspects of building operation from cooling, to economizer control to dehumidification control. Alternatively one can also measure the surface MC% and absolute humidity or dew point as part of the preventive maintenance. ■

Email:
sarfraz@almontazar.com

Talos Dual Tubes from Halcor



TALOS DUAL tubes consist of two seamless metallic layers, an inside layer made from copper and an outside layer made from aluminum. The two layers are unified by strong metallurgical bonds between the copper and the aluminum. This fundamental material unification enables the TALOS DUAL tube to behave like a seamless homogeneous tube, exhibiting however unique properties that originate from its constituents.

Advantages

Retention of the advantageous properties of copper; lower total price compared to copper (per meter); reduced weight per meter; product can be optimally tailored-made. ■

Website:
www.halcor.gr

Castle Motorized Butterfly Valves by Castle Valves Actuators

The imported high quality potentiometer made of precise conductive plastic makes resolution higher and service life longer. The stroke switch adjustment on-site correction of indication and passive signal adjustment are on the top of the instrument which is the most convenient operating position with clear functions and indications. The installation mode of opening gear at the bottom reduces the affect of sampling and accuracy of reading due to the position variance of output shaft, climinates the factor of amplifying the error and makes the reading more reliable and accurate. The allocation of double wire lock makes the power line control single line be laid through separated holes, which effectively eliminates the interference in single working frequency. The servo controller is allocated directly inside the actuator and no servo amplifer is required for making the whole unit integrated. The unique anti-backlash mechanism of the spring climinates any clearance in gear effectively and guarantees continuous real time sampling.

Applications

These valves are designed to meet the stringent needs of the HVAC and commercial applications requiring tight shut-off for liquids. ■

Website:
www.castlevalves.com

Falling Film Water Chiller by Fujian Snowman Co Ltd

Product Description

Cold water temperature ≤ 2^{0}C.
Production capacity: 2.5^3 /h~100m^3/h.
The stainless steel evaporator is solid and durable, made with most advanced laser welding technology. The cold water is cooled on the outer surface of evaporator, and even if the water is frozen, it will not do harm to the evaporator.

Features

Water flows from top to bottom on the surface of the falling film water chiller evaporator, forming as thin water curtain, refrigerant goes through the internal side of evaporator to exchange the heat, and then different temperature and different flow of chilling water produced. Falling film water chiller evaporator exists expansive and special refrigerant runner; multiple liquid feeding pipes and gas exiting pipe, large heat exchange areas. It suits for much refrigerant going through, so that refrigeration system has great high efficiency. Falling film-type water chiller can deal with different kinds of liquid, including clean water and solution, even moderate viscosity content can be economy cooling as well. ■

Website:
www.snowkey.com

Open Reciprocating Compressors: High Speed by Sea Birds Refrigeration Pvt Ltd

This model series has been further developed from the proven two, four, and six cylinder series after extensive research. Open Type Reciprocating Compressors; A2-2N, AK-4N, WAK-4N, WAK-2N. R22, R134a, R404A, R507 etc. By a number of way it has been possible to improve again refrigerating performance, efficiency and operating reliability and to conceive once again a further- oriented new compressor generation. Crankshaft with special surface finish. Optimized Aluminium piston shape and Chromium-plate piston rings guarantee low frictional losses and long living service life. High efficient, extremely robust valve plate design as the result of newly developed valve plate from Germany. ■

Website:
www.amoking.com

Advance Valves offers Filter Ball

The Pettinaroli FILTERBALL valve is n off ball valve containing an interchangeable cylindrical filter which is easy to inspect and remove for normal maintenance operations. A single valve therefore has two important functions: perfect sealing of the ball valves and careful filtering of the fluid, so that their great ability protects all the components in the plant. Compared with traditional use of two components, apart from the obvious advantages in terms of cost, installation and space, the

Technical Specifications

Double tightening in the joint between body and end-connection. Stuffing box movable. Solid spheres are made using diamond tools and chromium plated to the required thickness. ■

Website:
www.advancevalves.com

HydroGuard Series by Global Water Solution Ltd

HydroGuard shock arrestors are especially designed for use in hydraulic hammer arresting applications. HydroGuard shock arrestors are built to reduce or eliminate hydraulic shock, otherwise known as water hammer. They do this by absorbing pressure surges within water or other fluids that are suddenly stopped or forced in other directions by fast closing valves. The products shock arrestors are best used at the point of shock and should be installed as close to the valve or piping where the shock originates from. A high grade chlorobutyl diaphragm is sealed inside the vessel creating a barrier between fluid and air chambers. The air acts as a cushion which compresses when system pressure suddenly increases or surges as a result of hydraulic shock. HydroGuard shock arrestors are quality tested at several stages along the production line in ensure the structural integrity of every tank. And also represent the best value for the investment and are the best quality shock arrestors available.

Features

Single diaphragm design; patented stainless steel or Noryl water connection; two part polyurethane, epoxy primed paint finish; leak free, o-ring sealed air valve cap and is maintenance free. ■

Website:
www.globalwatersolutions.com

Index to **Advertisers**

High-tech fridge magnets that could save the world billions of dollars in energy costs

One of the world's biggest draws of electricity is refrigeration and air conditioning. It is somewhat ironic that, by trying to stay cool, we pump millions of tons of greenhouse gases into the atmosphere. General Electric, GE, believes it has discovered a new method of magnet-based refrigeration that is 20-30% more efficient than existing refrigeration technology, which almost universally uses a liquid refrigerant and compressor. GE launched the first commercial electric refrigerator in 1927 - and fridges have fundamentally remained unchanged for almost 100 years. GE hopes that its magnet-based tech can become the refrigeration method of choice for the next 100 years. At the heart of GE's new refrigeration technology is the magnetocaloric effect. The magnetocaloric effect, like vapor-compression refrigeration (the method used in all modern

cars, fridges, etc.) was discovered a very long time ago, but there have always been large barriers preventing its commercial adoption. Basically, some metals get warmer when exposed to a magnetic field, and then cool down again when the magnet is removed. By doing this repeatedly, you can create a heat pump that moves thermal energy from one place and deposits it elsewhere. This is exactly what your AC unit does, incidentally. ■

Eco Factor: Homes made from natural materials require no air conditioning

Technology might have provided us with the latest in cooling systems that can allow us to stand the heat of the desert sun without sweating. However, like most electronic products, our beloved air conditioners consume a large amount of electricity, which shows some effect on our electricity bills and the environment. Industrial designers are working on possible uses of solar energy to keep our homes cool, there were times when people didn't have modern technology at their disposal but still managed to keep their homes cool. Examples of such homes are still seen in Syria where they are referred to as the Beehive Homes. These traditional homes are made using natural materials that offer a great defence against the forces of nature. The thick mud brick walls trap the cool air and keep the sun out. The high domes of these homes collect the hot air that is generated by the inhabitants and keep the interior temperatures conditioned between 75-85 degrees Fahrenheit. With the world looking for low-emission and preferably zero-emission homes, history is a good guide, using which one can understand the art of living comfortably without having any impact on the environment. Adding sophisticated green technology to these homes such as the use of solar panels for electricity and water, one can definitely better his living style without spending millions of dollars. ■

Cooling Castle

It was built between 1381 and 1385 to protect the River Thames. It has a double bailey, the eastern side having a tower in each corner and earth walls in between surrounded by a dry moat and accessed through the ornate gateway. The smaller western bailey has stone walls which are still at least half their original height with a tower in each corner and a wet moat on three sides. The entrance is through the eastern bailey on the fourth side. It is now in ruins with a more recent house inside the grounds but the gatehouse remains in good condition. The castle was besieged in 1554 and suffered damaged by cannon fire. Private, but can be seen from the road. ■

RNI Reg. No.: MAHENG/2005/18432