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Heat exchangers technology and applications in heat exchanger engineering

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ABSTRACT

Over the years, all parts of a commercial refrigerator, such as the compressor, heat exchangers, refrigerant, and packaging, have been improved considerably due to the extensive research and development efforts carried out by academia and industry. However, the achieved and anticipated improvement in conventional refrigeration technology are incremental since this technology is already nearing its fundamentals limit of energy efficiency is described is 'magnetic refrigeration' which 'is an evolving cooling technology. The word 'green' designates more than a colour. It is a way of life, one that is becoming more and more common throughout the world. An interesting topic on 'sustainable technologies for a greener world' details about what each technology is and how it achieves green goals. Recently, conventional chillers using absorption technology consume energy for hot water generator but absorption chillers carry no energy saving. With the aim of providing a single point solution for this dual purpose application, a product is launched but can provide simultaneous chilling and heating using its vapour absorption technology with 40% saving in heating energy. Using energy efficiency and managing customer energy use has become an integral and valuable exercise. The reason for this is green technology helps to sustain life on earth. This not only applies to humans but to plants, animals and the rest of the ecosystem. Energy prices and consumption will always be on an upward trajectory. In fact, energy costs have steadily risen over last decade and are expected to carry on doing so as consumption grows. Refrigerants such as hydrochloroflurocarbons (HCFCs) are present in the ground source heat pump (GSHP) systems and can pose a threat to the environment through being toxic, flammable or having a high global warming potential.

However, new types and blends of refrigerant with minimal negative impacts are being developed. A correctly fitted system will also greatly reduce the potential for leakage, which is why using a professional installer is highly recommended. Significant CO_2 savings can be gained by displacing fossil fuels. Even compared to the most efficient gas or oil condensing boilers, a well-designed heat pump with COP of 3-4 will reduce emissions by 30-35%. Further carbon savings can be made if the electricity used to power the pump comes from a renewable energy source such as photovoltaic or a renewable electricity tariff. Also, measures can be taken to reduce the impact of pollution from using grid electricity generated through fossil fuel. For example, one can purchase dual tariff green electricity from a number of suppliers. However, even if ordinary grid electricity is used to run the compressor, the system will still produce less CO_2 emissions than even the most efficient condensing gas or oil boiler with the same output. The term "vapour compression refrigeration" is somewhat of a misnomer, it would be more accurately described as 'vapour suction refrigeration'. Vapour compression is used to reclaim the refrigerant and is more aptly applied to heat pumps. Vapour compression refrigeration exploits the fact that the boiling temperature of a liquid is intimately tied to its pressure. Generally, when the pressure on a liquid is raised its boiling (and condensing) temperature rises, and vice-versa. This is known as the saturation pressure-temperature relationship.

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1. INTRODUCTION

One of the most energy efficient methods of domestic heating is to use heat pumps. Heat pumps use electrical energy to reverse the natural flow of environmental heat from cold to hot. A typical heat pump requires only 100 kWh of electrical power to turn 200 kWh of freely available environmental heat into 300 kWh of useful heat Luo, Tondeur, Le Gall, and Corbel (2007). In every case, the useful heat output will be greater than the energy required to operate the pump itself. Heat pumps also have a relatively low carbon dioxide output, less than half that of oil, electric and gas heat production.

Heat pumps for domestic heating are a relatively new concept in Britain; however the technology is widely used in an industrial capacity. Across Europe, hundreds of thousands of domestic heat pump units are in use, and the technology is tried, tested and reliable.

Ideally, a refrigerant will have the following characteristics.

- Non-toxic - for health and safety reasons.
- Non-flammable - to avoid risks of fire or explosion.
- Operate at modest positive pressures - to minimise pipe and component weights (for strength) and avoid air leakage into the system.
- Have a high vapour density – to keep the compressor capacity to a minimum and pipe diameters relatively small.
- Easily transportable - because refrigerants are normally gases at SSL conditions they are stored in pressurised containers.
- Environmentally friendly - non-polluting and non-detrimental to the atmosphere, water or ground.
- Easily re-cycleable.
- Relatively inexpensive to produce.
- Compatible with the materials of the refrigeration system - non-corrosive, miscible with oil, chemically benign.

In practice, the choice of a refrigerant is a compromise, e.g., Ammonia is good but toxic and flammable. R12 is very good but detrimental to the Ozone layer Luo, Fan, and Tondeur (2007). 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 it’s 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 have been conducted to enable heat pumps to operate steadily with high efficiency and reliability in low temperature environments Luo, Fan, and Tondeur (2007). For example, the burner of a room air conditioner, which uses kerosene, was developed to improve the performance in low outside temperature Philappacopoulus, and Berndt (2001). 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 Jo, Katsumi, Benson, and Edil (2001). 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 Anandarajah (2003).

2. ENERGY EFFICIENT CONSIDERATIONS IN HEAT EXCHANGERS DESIGNS

Heat exchangers are devices, designed to efficiently transfer heat, from one medium to another, i.e., water-to-air, refrigerant-to-air, refrigerant-to-water, stream-to-water. Heat exchangers are widely used in power engineering, chemical industries, petroleum refineries, food industries and in HVAC technology. Therefore, heat transfer and the design of heat transfer equipment continue to be a centrally important issue in energy conservation. With increasing worldwide awareness of the serious environmental problems due to fossil fuel consumption, efforts are being made to develop energy efficient and environmentally friendly systems by utilisation of non-polluting renewable energy sources, such as solar energy, industrial waste heat or geothermal water. The GSHPs are suitable for heating and cooling of buildings and so could play a significant role in reducing CO_2 emissions. Ground source or geothermal heat pumps are a highly efficient, renewable energy technology for space heating and cooling. This technology relies on the fact that, at depth, the Earth has a relatively constant temperature, warmer than the air in winter and cooler than the air in summer.

2.1 Heat Transfer Mechanisms

- Single-phase convection on both sides
- Single-phase convection on one side
- Two-phase convection on other side
- Two-phase convection on both sides

Examples: condensers, boilers, evaporators and radiators (Fig. 1).

Naturally, it would be preferred, for comfort reasons that this index would be small, preferably nil. It may be seen that the variable is directly related to temperature discomfort: the larger the value of the index, the farthest will inside conditions be from expected wellbeing. Also, the use of electricity operated air conditioning systems will be more expensive the higher this variable is. Hence, energy expenditure to offset discomfort will be higher when comparing two index values; the ratio of them is proportional to the expected energy savings.

When the external shade blocks the windowpane completely, the excessive heat gains belong to the lowest values in the set, and the dimensionless index will be constant with orientation. For the climate conditions of the locality, it can be seen that a naked window can produce undesirable heat gains if the orientation is especially unfavourable, when the index can have an increase of up to 0.3 with respect to the totally shaded window.

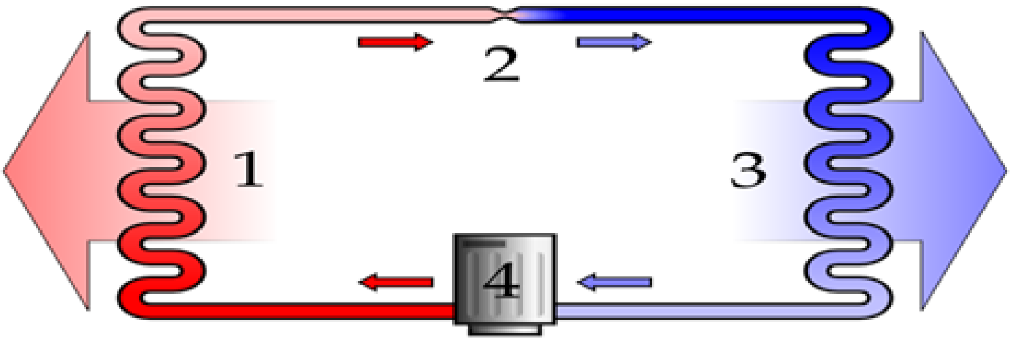

Fig. 1 Diagram of a phase change heat pump: 1) condensator coil 2) expansion valve 3) evaporator coil and 4) compressor.

3. CONCLUSIONS

The building sector is a major consumer of both energy and materials worldwide, and the consumption is increasing. Most industrialised countries are in addition becoming more and more dependent on external supplies of conventional energy carriers, i.e., fossil fuels. Energy for heating and cooling can be replaced by new renewable energy sources. New renewable energy sources, however, are usually not economically feasible compared with the traditional carriers. In order to achieve the major changes needed to alleviate the environmental impacts of the building sector, it is necessary to change and develop both the processes in the industry itself, and to build a favourable framework to overcome the present economic, regulatory and institutional barriers. Today, buildings are largest consumers of energy. Air conditioning and heating consume about 40% of the power in the buildings. Demand to conserve energy has become necessity as there has been rising costs of energy consistently and this make us to think to go green and innovate the greener concept for buildings. A green building uses less water, optimises energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants. And, a green home can have benefits, such as reduction in water and operating energy costs of the building. This may also mean refrigerant-based chillers and compressors to be shut off or to be operated at reduced capacity. With the environmental protection posing as the number one global problem, man has no choice but reducing his energy consumption, one way to accomplish this is to resort to passive and low-energy systems to maintain thermal comfort in buildings.

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