Research article Available online www.ijsrr.org ISSN: 2279–0543

International Journal of Scientific Research and Reviews

Heat Pump- Future Energy Solution for Chemical Industry

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ABSTRACT:

The objective of this paper is to make industrial community aware about available technologies and possible applications. This will help industry to reduce some portion of energy consumption using renewable sources and directly assist in saving on recurring expenditure. "We can dream of world (not only chemical) industry using at least one heat pump in their one or other application then only we can reduce load on non-renewable energy source and make world self-sufficient". As heat pump provides multiple functions and utility, one can achieve higher no. of COP.

KEY WORDS: Heat Pump, COP, desuperheater

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INTRODUCTION:

Heat pump is a device which pumps heat from, one or more low temperature sources to one or more high temperature sinks simultaneously, with the help of an external source of energy. Heat pump can be of various types, viz. vapor compression, thermoelectric, absorption, adsorption and ejector. Vapor compression heat pump is driven using electrical energy or shaft power as input energy, while the energy input to the absorption, adsorption and ejector type heat pumps is in the form of heat. This heat can be obtained by direct burning of fuel or by recovering heat from various waste heat sources.

Heat pumps can significantly reduce the fossil fuel consumption and green house emission in various chemical industry applications. Most of the energy for heating and cooling can be diverted to this upcoming technology of heat pump. The heat transferred can be 3 to 4 times larger than the electrical power consumed, giving the system a coefficient of performance (COP) of 3 to 4, as opposed to a COP of 1 in direct electrical equipment's. Heat pumps are designed to move thermal energy opposite to the direction of spontaneous heat flow by absorbing heat from a cold space and releasing it to a warmer one, and vice-versa. Air conditioners and freezers are familiar examples of heat pumps in day today life[1].

HISTORY:

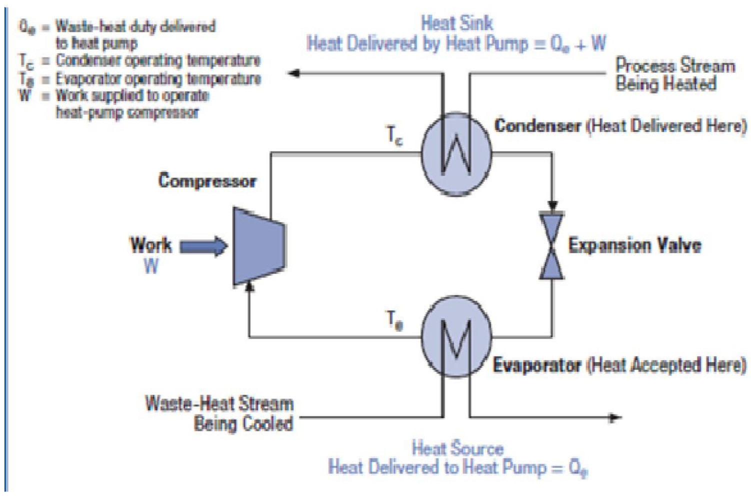
The First heat pumps were mentioned as early as in the 19th century. Lord Kelvin developed the concept of heat pump. Robert C Webber, an American inventor, is credited with building the first heat pump during the late 1940's. Webber got the idea for the heat pump by accident when he was experimenting with his deep freezer, and burned his hand after unintentionally touching the outlet pipes of the cooling system. The burning of his hands gave him ideas for the basic mechanics of how he would build the heat pump. Then Webber used a small fan to propel the warm air in the building. After he saw that his invention was successful, he built a full size heat pump to provide heat for his entire home. These are used in domestic and institutional purpose worldwide now days but still focus is needed for their industrial uses[3].

WORKING:

A heat pump is essentially a reversible air conditioner. The way air conditioners and refrigerators cool air is by using a compressed gas to leach heat out of the air to evaporate itself. The cold air is forced into your home with fans, and the hot air produced by the evaporation is blown out into the atmosphere. The gas remains contained in the system and is recycled.

In a heat pump, this process can be reversed, so that the evaporation process leaches heat out of the outside air (or ground) and blows the hot air into the home

Figure No: 1 Working of Heat Pump



There are various refrigerant's used in heat pump area R22/R134a/R404a/R507a/ iso-butane/ Ammonia and last but not least is CO_2. The use of refrigerant depend upon the application where it is used[2]. R22 is the hydrochloroflurocarbon (HCFC) is still widely used in domestic and residential applications. Iso butane is also getting its popularity in recent days.

The design of the evaporator and condenser heat exchangers is also very important to the overall efficiency of the heat pump. The heat exchange surface areas and the corresponding temperature differential (between the refrigerant and the air stream) directly affect the operating pressures and hence the work the compressor has to do in order to provide the same heating or cooling effect. Generally, the larger the heat exchanger the lower the temperature differential and the more efficient the system becomes.

HEAT PUMP CLASSIFICATION:

Air to air

- ***Cold Utility***: comfort air conditioning, cold store operation
- ***Hot Utility***: heating air for drying of clothes, agro products, regeneration of desiccants, etc.

Air to Water

- ***Cold Utility***: comfort air conditioning, cold store operation
- ***Hot Utility***: heating water, direct heating of process fluids like cleaning solutions in Industrial washing machines, drying agro products, regeneration of desiccants which can be used for taking care of latent cooling load, etc.

Water to Water

- ***Cold Utility***: comfort air conditioning, precooling of fresh fruits, vegetables or flowers, direct process fluid cooling in chemical, pharmaceutical and food processing industry
- ***Hot Utility***: heating water, direct heating of process fluids like cleaning solutions in industrial washing machines, drying agro products, regeneration of desiccants which can be used for taking care of latent cooling load, etc.[4]

Water to Air

- ***Cold Utility***: comfort air conditioning, precooling of fresh fruits, vegetables or flowers, direct process fluid cooling in chemical, pharmaceutical and food processing industry
- ***Hot Utility***: space air heating, heating air for drying of clothes, agro products, regeneration of desiccants, etc.

Heat interactions in the evaporator and the condenser can be with multiple sources and sinks respectively. This enables generating multiple cold and/or hot utilities simultaneously. It also gives greater flexibility to fully tap the benefits of a heat pump.

One more heat pump type is Ground source heat pump. In cold climates, ground source heat pumps are appropriate, since the ground retains heat below the frost line more efficiently than the air.

VARIOUS APPLICATIONS OF HEAT PUMP

Hence Multi utility Heat pumps can find applications in various segments of the HVAC&R market:

Commercial Segment: Restaurants, Hotels, Health Clubs, Spas, Hospitals, etc Cold Utility: air conditioning and potable water cooling

· Hot Utility: heating water for bathing, sanitation, etc
· Industrial Segment: Dairy, Pharmaceutical, Textile, Food Processing and Cold Stores, Automobile, etc.
· Cold Utility: air conditioning, process cooling and potable water cooling
· Hot Utility: process heating, boiler feed water preheating, drying, liquid desiccant

Regeneration, etc.

APPLICATION ENGINEERING:

Objective of increasing energy efficiency and reducing operating cost needs to be achieved while simultaneously ensuring high reliability, simplicity of operation and ease of maintenance. The system should preferably be compact and have low initial cost or have a short payback period. Integration of new systems should be done with care. Fail-safe non-intrusive integration in to the main plant operation should be ensured to eliminate the risks of any new technology introduction. Conventional utility generators may be left intact till full confidence is developed with any new technology. In comparison to conventional heat exchanger like shell and tube heat exchanger and plate type heat exchanger, Use of the vented double wall Tube in Tube heat exchangers or Tube-Tube Heat Exchangers (developed by IIT Bombay) helps to minimize the risks of leakage and mixing of the refrigerant and process fluids.

Design should be arrived at after giving due consideration to:

Variation in Load Patterns: design cooling, heating and/or drying dehumidification loads

· Specific Process Requirements: mode of heat recovery, in the form of potable hot water,boiler feed water, direct heating of process fluids or sea water for desalination, regeneration of liquid desiccant
· Water Quality: passage dimensions
· Concept and Culture of Maintenance: reflects on water passage dimension
· Choice of Wetted Material: Tube MOC has to be appropriately selected and wall thickness is to be determined based on corrosion characteristics and expected life

Variables that Play an Important Role in Design Optimization

- Pressure Drop on Refrigerant Side: affects size, weight and cost; especially capacity of the Chiller / refrigeration unit may reduce if not designed properly
- Refrigerant Velocities: oil return and heat transfer coefficients
- Water Velocities: fouling, heat transfer coefficients and pumping costs

Advantages of Heat Pump:

- It saves up to 75% of your water heating costs.
- Compact in size as compared to Solar Water Heating System.
- No dependability on Sunlight or other natural sources.
- Can work in all atmospheric conditions.
- Easy operation And Very Low Maintenance.
- Low Carbon Emissions
- Easy Installation with very less piping, preventing heat loss.

Market Status:

Considering the huge market potential for air conditioning and heating still left unexplored in this region. The resulting future impact on global environment, development of advanced energy-efficient and environmentally friendly technologies is of vital importance for sustainable development in the foreseeable future. Heat pump is one of the part of it. The largest increase in demand of air conditioning has come from China (18.0 million units/year) followed by Japan (7.2 million units/year), South Korea (1.5 million units/year) and India (1.0 million units/year). Industrial application is still not explored thing in heat pump market.[7]

Application:

The existing application of heat pumps are domestic, institutional such as hotel industry, hospitals, and swimming pools where hot and cold both water is required. Looking at its features the heat pumps can be used widely in chemical industry, some of the possible applications are;

1. Boiler Feed water: Air to water heat pump is utilized for this applications. This can be used as boiler feed water which will reduce the steam going to the deareator and cold part is used to cool

the control room which will save by closing the existing AC of that control room or at least reduce the load of AC.

2. Boiler feed water and cool water for cooling tower : Water to water heat pumps are used for this application, in which hot water is taken to deareator and cold stream can be diverted to cooling tower make up water this will help in reducing the cooling tower load.[8]
3. Hot water for heating system: Any type of heat pump can be utilized as final objective is to get the hot water for the products where constant temperature or heating is required. If we use only one stream then COP will come down below 3.0
4. Applications where we require the hot water of the temperature around 60-70 ^{0}C on regular basis.
5. This concept can be clubbed with the existing chiller system and condensers are clubbed with the desuper heater which will give you hot water and continue with the existing application and reduce the power consumption as low temperature refrigerant will come back to compressor.
6. Simple split AC's can also be clubbed with the desuper heater and get the hot water out of it and this will improve the capacity of the existing Air conditioner.
7. This can be implemented in the big industry in canteen for getting hot water for utensils cleaning and cold water for drinking.[8]

Such many more industrial application can be possible in chemical industry, just imagine and you will find application relevant to your industry. This technology is more versatile in comparison to solar systems. The actual operating time for solar systems is less than (2880 hrs) where as we can use this heat pump for more than 300 days.

CHALLENGES AHEAD -HEAT PUMP -MARKET:

- Initial high installation cost but less than 18 months payback compared to conventional systems.
- Pump delivers the least amount when demand is peak. Hence proper capacity sizing is required to be done.
- The technology is not fully matures.
- Reliability issue and not skilled man power available in this area.
    - Working for 24 X365 hr.

Challenges for Heat Pump:

- Air pre heater: Due to poor heat transfer coefficient of air, in the existing system we are not able to get this application by using heat pump, if this application get succeed then fuel consumptions will decrease dramatically.
- Application in distillation columns: The heat pumps can be used for heating the feed in columns and for cooling the condenser by using the cold portion, limitation in this material compatible heat exchangers. This application had already started for some of the chemicals such as ethanol, ethylene glycol, 1 butene, Isopropeyl alcohol, hydrogen peroxide and many more.[6]

OUR EXPERIENCE:

We have installed one small trial model of Heat pump at Godrej Industries Limited, Valia from M/s Air Tech India (OEM being Mech World Eco) that had patented technology from IIT, Bombay. We are in a process of scaling up for various application heating and cooling are required simultaneously. They are having good team of application who will study our application and suggest the best possible heat pump for your requirement. Prof. MilindRane from IIT Mumbai, who has done good amount of research in the field of “Heat pump”, will be supporting and assisting to our future requirement and expect this will defiantly help Indian chemical industry to reach a level where we do not require to take energy from grid or other non-renewable energy.

CONCLUSION:

Techno-economic benefits of the Heat Pumps, generating multiple hot and/or cold utilities simultaneously give added flexibility in matching the heating and cooling effects. Attractive paybacks, in the range of 3 to 18 month, are achieved in most of the cases with proper application engineering. Ground coupling along with radiant cooling or heating panels also offers avenues for significant energy saving. Various opportunities for utilizing the surplus hot utility for drying and dehumidifying using liquid desiccants are also briefly discussed. Revenue generated through recovered heat can more than pay for the cost of operating the cold utility generators!

Increasing energy costs and raising concern for environment heightens the need to go for heat recovery systems. Various reliable options are available; with Double Wall Vented Designs the worry of cross contamination is eliminated. Installations have been working satisfactorily for several years, in many cases without a service call.

Co-production of multiple utilities using a single system helps reducing space requirement, initial cost and maintenance. CO_2 emissions are also reduced and electrical demand reductions are also realized. Proper application engineering can ensure a Win-Win situation of simultaneously reducing initial and operating cost. Yes it is also possible to get paid for enjoying air conditioning!

ACKNOWLEDGMENT:

I am thankful to senior management of Godrej Industries Limited specially Mr. Atul Prakash for their constant support. I am equally thankful to Mr. BirenShah , Mr. Anant Khandagale and Mr. Shirish Deshpande for their valuable inputs. I am also thankful to whole team at GIL valia, who had helped in commissioning of heat pump at site.

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