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Performance (COP) Analysis of a Vapour Compression Refrigeration System component with Nano Coating

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Abstract- *The COP of the refrigeration increasing the performance and to get high efficiency of the refrigeration system. By using nano coating over the evaporator of the refrigeration component the objective can be achieved. The improper heat dissipation occurred in the heat exchanger components causes' effect in performance. The vapour compression refrigeration system consuming the high power. Though the energy taken for the refrigeration process has increased and leads to more power consumption. In order to increase the performance, Nano coating Copper Oxide has been applied over the evaporator. By applying the Nano coating Copper Oxide over the evaporator the COP increased. In result the energy required for the refrigeration process and global warming problems has been reduced. By addition of nanoparticles to the refrigeration results in improvements in the COP of the refrigeration, thereby improving the performance of the refrigeration system. In this experiment the effect of using CuO-R134a in the vapour compression system expected COP will be increased by 5% with nano coating.*

I. INTRODUCTION

Vapour-compression refrigeration, in which the refrigerant undergoes phase changes, is one of the many refrigeration cycles and is the most widely used method for air-conditioning of buildings and automobiles. It is also used in domestic and commercial refrigerators, large-scale warehouses for chilled or frozen storage of foods and meats, refrigerated trucks and railroad cars, and a host of other commercial services.

Oil refineries, petrochemical and chemical processing plants, and natural gas processing plants are among the many types of industrial plants that often utilize large vapour-compression refrigeration systems. Refrigeration may be defined as lowering the temperature of an enclosed space by removing heat from that space and transferring it elsewhere. A device that performs this function may also be called an air conditioner, refrigerator, air source heat pump, geothermal heat pump.

A. Working

The vapour-compression uses a circulating liquid refrigerant as the medium which absorbs and removes heat from the space to be cooled and subsequently rejects that heat elsewhere. Fig. 1 depicts a typical, singlestage vapour-compression system. All such systems have four components: a compressor, a condenser, a thermal expansion valve (also called throttle valve or metering device), and an evaporator. Circulating refrigerant enters the compressor in the thermodynamic state known as a saturated vapour and is compressed to a higher pressure, resulting in a higher temperature as well. The hot, compressed vapour is then in the thermodynamic state known as a superheated vapour and it is at a temperature and pressure at which it can be condensed with either cooling water or cooling air. That hot vapour is routed through a condenser where it is cooled and condensed into a liquid by flowing through a coil or tubes with cool water or cool air flowing across the coil or tubes. This is where the circulating refrigerant rejects heat from the system and the

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rejected heat is carried away by either the water or the air (whichever may be the case).

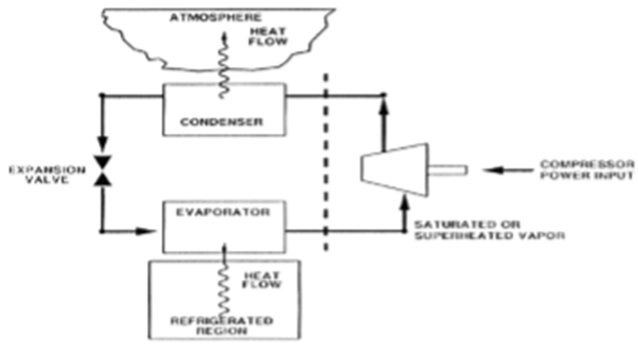

Fig. 1. Vapour Compression refrigeration

The condensed liquid refrigerant, in the thermodynamic state known as a saturated liquid, is next routed through an expansion valve where it undergoes an abrupt reduction in pressure. That pressure reduction results in the adiabatic flash evaporation of a part of the liquid refrigerant. The autorefrigeration effect of the adiabatic flash evaporation lowers the temperature of the liquid and vapour refrigerant mixture to where it is colder than the temperature of the enclosed space to be refrigerated. The cold mixture is then routed through the coil or tubes in the evaporator. A fan circulates the warm air in the enclosed space across the coil or tubes carrying the cold refrigerant liquid and vapour mixture.

That warm air evaporates the liquid part of the cold refrigerant mixture. At the same time, the circulating air is cooled and thus lowers the temperature of the enclosed space to the desired temperature. The evaporator is where the circulating refrigerant absorbs and removes heat which is subsequently rejected in the condenser and transferred elsewhere by the water or air used in the condenser. To complete the refrigeration cycle, the refrigerant vapour from the evaporator is again a saturated vapour and is routed back into the compressor.

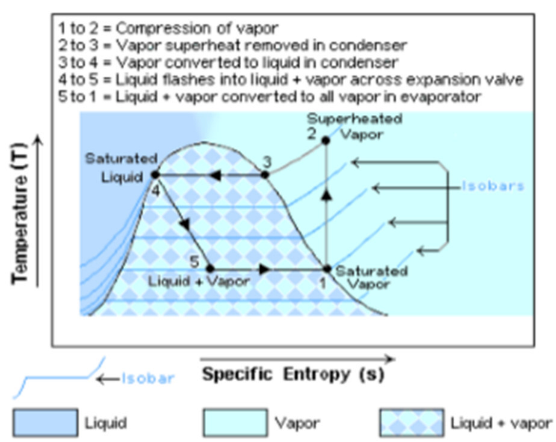

Fig.2. Temperature – Entropy Diagram

The thermodynamics of the vapour compression cycle can be analyzed on a temperature versus entropy diagram as depicted in Fig.2. At point 1 in the diagram, the circulating refrigerant enters the compressor as a saturated vapour. From point 1 to point 2, the vapour is isentropically compressed (i.e., compressed at constant entropy) and exits the compressor as a superheated vapour. From point 2 to point 3, the vapour travels through part of the condenser which removes the superheat by cooling the vapour. Between point 3 and point 4, the vapour travels through the remainder of the condenser and is condensed into a saturated liquid.

The condensation process occurs at essentially constant pressure. Between points 4 and 5, the saturated liquid refrigerant passes through the expansion valve and undergoes an abrupt decrease of pressure. That process results in the adiabatic flash evaporation and auto-refrigeration of a portion of the liquid (typically, less than half of the liquid flashes).The adiabatic flash evaporation process (i.e., occurs at constant enthalpy).

Between points 5 and 1, the cold and partially vapourized refrigerant travels through the coil or tubes in the evaporator where it is totally vapourized by the warm air (from the space being refrigerated) that a fan circulates across the coil or tubes in the evaporator.

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The evaporator operates at essentially constant pressure and boils of all available liquid there after adding 4-8 deg kelvin of super heat to the refrigerant as a safeguard for the compressor as it cannot pump liquid. The resulting refrigerant vapour returns to the compressor inlet at point 1 to complete the thermodynamic cycle.

It should be noted that the above discussion is based on the ideal vapour-compression refrigeration cycle which does not take into account real world items like frictional pressure drop in the system, slight internal irreversibility during the compression of the refrigerant vapour, or non-ideal gas behavior.

II. Description of the Refrigeration System

A refrigerator consists of a compressor connected by pipe line to the condenser, a capillary tube and an evaporator. Refrigerant in vapour state from an evaporator is compressed in the compressor and send to the condenser. Here, it condenses into liquid and it is then throttled. Due to throttling, Temperature of the refrigerant drops and cold refrigerant passes through the evaporator absorbing the heat from the object to be cooled. The refrigerant is then return to the compressor and then cycle is completed. The test rig consists of a hermetically sealed compressor. The compressed from the compressor is send to an air cooled condenser and the condensate in the liquid from is send to the expansion valve and capillary tube for throttling. Due to throttling, the temperature to the refrigerant falls and the cold refrigerants absorb heat from the water in the evaporator tank. The refrigerant is then returned to the compressor.

A suitable filter is fitted in the refrigerant line from condenser to evaporator. A thermo couple is provide to measure the temperature of the water in the evaporator tank. An Energy meter is provided to measure the energy input to the compressor. Suitable pressure gauges are provided at the compressor inlet – low pressure (evaporator outlet), Condenser inlet (Compressor outlet), Condenser outlet- high pressure (Before throttling) and evaporator outlet (after throttling) to study the refrigeration cycle operating between two pressures. A thermostat is provided for cutting of the power to compressor when the water temperature reaches to set value. A voltmeter and an ammeter provided to monitor the inlet power supply. A voltage stabilizer is provided for the protection of the compressor. Additional four no's thermocouple is fitted at the condenser and evaporator inlet and outlet for studying the temperature at four points in the refrigeration cycle.

III. Procedure

Start the compressor and let it run until the evaporator. The evaporator temperature is controlled by controlling the power input to heater. When the evaporator temperature is steady, note the low temperatures at evaporator inlet and outlet and condenser inlet and outlet. Also note down the Temperatures and Pressures at Evaporator inlet and outlet temperature, Condenser inlet and outlet temperature. Calculate the COP.

IV. Result and Discussion

The results that were obtained after the nano coating has applied is tabulated below. Co-efficient of performance COP and power consumption were two parameters, which were changed during the process. Fig. 3. Shows the COP of the refrigeration with and without coating in the compressor are 1.79 and 1.52 respectively. This shows that the COP of the refrigeration makes better performance with nano coating in the compressor. Fig. 4. Shows the power input of the refrigeration with and without coating in the compressor are 60.228 Kw and 77.43 Kw respectively. From the graph which is shown in the fig. 4. Represents that the power input is reduced in the refrigeration after nano coated in its compressor.

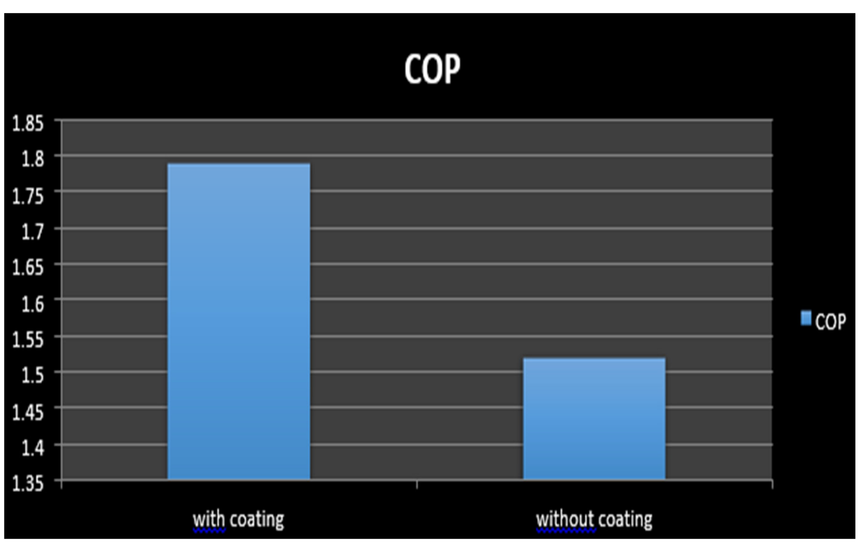

Fig. 3.COP with and without nano coting in Comparison

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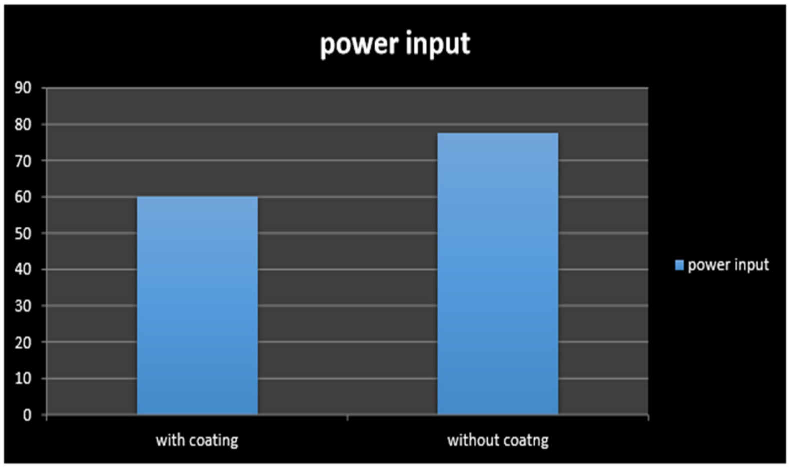

Fig. 4. Power input with and without nano coating in Comparison

V. Conclusion

CuO nanoparticle can be to improve the COP in a refrigeration system. It leads to less usage of power during the refrigeration process. By applying the Nano coating over the evaporator, the required temperature can be easily attained in minimum time. So that the running time of compressor is reduced. Automatically the power required for the running of refrigerator also reduced. In this case, it makes a COP change in the house hold uses of refrigerator. It is very useful for the people who are using refrigerators in the house hold and in industries. In normal the refrigerator would not give efficient refrigeration after some years. By using this Nano coated refrigerator one can use refrigerator for many years. The cost of this refrigerator is also same as that of the previous refrigerator. A successful model has been designed and increase to the COP of the refrigeration system has been done.

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