

Evaluating The Performance of Insulation Material [Glass wool] By Applying Coating on It.

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Abstract:

A refrigerator is a popular household appliance that consists of a thermally insulated compartment and a heat pump that transfers heat from the inside of the fridge to its external environment so that the inside of the fridge is cooled to a temperature below the ambient temperature of the room. Refrigeration is an essential food storage technique. Insulating material is the one of the main sub systems. The primary function of thermal insulating material used in domestic refrigerator is to reduce the transfer of heat. Hence the efficiency of the system is depends upon the on the insulating material use in the refrigerator. [1]The insulating capability of a material is measured with thermal conductivity (k). Low thermal conductivity is equivalent to high insulating capability (R-value). In thermal engineering, other important properties of insulating materials are product density (ρ) and specific heat capacity (c)[2]. In this paper the insulating material observed with applying coating for the performance in domestic refrigeration. The name of insulating material is Glass wool. And the coating is known as Polymethyl methacrylate (PMMA).[11] The Glass wool is an insulating material made from fibers of glass arranged using a binder into a texture similar to wool. The process traps many small pockets of air between the glass, and these small air pockets result in high thermal insulation properties. This paper gives the idea, that insulating material and coating is best combination for the domestic application and good temperature holding capacity.

Keyword:

Domestic refrigeration system, Glass Wool, Polymethyl methacrylate (PMMA).

Introduction

Vapor-Compression Refrigeration or vapor-compression refrigeration system (VCRS) in which the refrigerant undergoes phase changes, is one of the many refrigeration cycles. It is also used in domestic and commercial refrigerators, frozen storage of foods and meats, Refrigeration may be defined as lowering the temperature of an enclosed space by removing heat from that space and transferring it elsewhere.[3] Insulating material is the one of the main sub systems. The primary function of thermal insulating material used in domestic refrigerator is to reduce the transfer of heat through the walls, pipes of the system. Hence the efficiency of the system is depends upon the on the insulating material in the refrigerator. So the selection of proper insulating material for the refrigerator system is therefore significant factors in order to improve the performance of the system.[10] In this paper we use Glasswool as insulating material, and chemical coating name as Polymethyl methacrylate (PMMA), the key properties of glasswool are Saving energy by reducing the rate of heat transfer , Maintenance of process temperature, Prevention of condensation on surface of equipment conveying fluids at low temperature, Avoidance of increase in equipment temperature from outside fire [11]To conserve refrigeration, Offers better process

control by maintaining process temperature, Prevention of corrosion by keeping the exposed surface of a refrigerated system above the dew point , Absorption of vibration. In case of coating i.e. Polymethyl methacrylate (PMMA), it is a lightweight, alternative to glass. This coatings, is stable at low temperature and it has capacity resistance heat and hold the temperature for low time. The main object of this paper is Evaluate the performance of domestic refrigerator with the insulating material glass wool and chemical coating w. r .t parameters such as ,Heat transfer rate, Capacity of holding the temperature. And Energy requirement.

Method

Principle The Refrigeration Test Rig works on Vapor Compression Cycle. The refrigeration i.e. (process of maintaining a closed space temperature below ambient temperature), as shown in fig 1. Is accomplished by continuously circulating, evaporating and condensing a fixed supply of refrigerant in a closed system.



Figure 1: vapor Compression cycle.

Evaporation occurs at a low temperature and low pressure while condensation occurs at a high temperature and pressure. Thus it is possible to transfer heat from an area of low temperature (in this case test chamber) to an area of high temperature (the surroundings). The compressor pumps the low-pressure refrigerant from the evaporator, increases its pressure, and discharges the high pressure gas to the condenser. In the condenser, the refrigerant rejects its heat to the surroundings by passing air over it. At that

pressure, the refrigerant loses its latent heat and liquefies. Then the refrigerant passes through the drier/filter where any residual moisture or foreign particles present, these are plugged. The flow of refrigerant into the evaporator is controlled by expansion device where its pressure and consequently temperature is lowered to the saturation temperature at the corresponding pressure. The low temperature refrigerant enters the evaporator where it absorbs heat from the surrounding medium and evaporates. The compressor sucks the cold vapors and the cycle repeats. The required instrumentation is provided to measure the various parameters at different points. This includes pressure gauges, temperature indicators and controller, energy-meters for compressor and heater. Figure 1: Test Rig of Refrigeration System In this set up Glasswool with applying coating P.M.M.A on insulating material used to study heat distribution and temperature holding capacity of evaporator. Principally the glass wool insulating materials are used in the set up. During the first term with help of the glass wool the construction of insulating cabinet done and capacity of heat transfer and temperature holding of glass wool has been studied. In second term glass wool with applying chemical coating has been used, In this case the with help of the this combination construction of insulating cabinet done and capacity of heat transfer and temperature holding has been studied.

Observation s for Glass Wool

- The compressor ON for 4 min to 5 min.
- The compressor OFF for 6 min to 8 min.
- In 24 hours with the ambient temp. 27 to 31oC .the energy meter show the following readings
 - Initial energy meter reading: 5.5
 - Final energy meter reading: 6.4
- Total power consumption= Final energy meter reading - Initial energy meter reading.
- Total power consumption= 6.4 – 5.5=0.9
- Total power consumption= 0.9/24=0.037 Kw hrs

To Evaluate Theoretical C.O.P. for glass wool:

Suction gas temperature = 10

Discharge gas temperature = 55

Temperature after condensation = 45

Temperature after expansion = 2

Average suction pressure in bar = 32 to 36 psi

Average discharge pressure in bar = 150 to 170 psi

Absolute suction pressure = suction gauge pressure + barometric pressure.

Absolute suction pressure = $32/14.5 + 1.014 = 3.22$ bar

Absolute discharge pressure = discharge gauge pressure + barometric pressure.

Absolute discharge pressure = $150/14.5 + 1.014 = 11.35$

accordingly enthalpies of refrigerant at salient point are, H1 = enthalpies of refrigerant at inlet of compressor = 400

H2 = enthalpies of refrigerant at outlet of compressor = 430

H3 = enthalpies of refrigerant after condensation = 260

H4 = enthalpies of refrigerant after expansion = 260

Theoretical refrigeration effect = $N = H1 - H4 = 140$

KJ/KG Theoretical compressor effect = $W = H2 - H1$

= 30 KJ/KG Coefficient of performance = C.O.P = $N/W = 140/30 = 4.66$

To calculate the actual C.O.P for Glass Wool

Actual refrigeration effect = heater load Initial energy meter reading = 1.5 Final energy meter reading = 1.8

Final energy meter reading - Initial energy meter reading = $1.8 - 1.5 = 0.3$

KWHR. Actual refrigeration effect = $1.8 - 1.5 = 0.3$

Actual compressor work: Initial energy meter reading 10.3 Final energy meter reading 10.6

Actual compressor work: = Final energy meter reading - Initial energy meter reading

Actual compressor work: $10.6 - 10.3 = 0.3$ KWHR Actual C.O.P $0.3/0.3 = 1$

Observations of Glasswool and P.M.M.A

The compressor ON for 3 min to 5 min.

The compressor OFF for 6 min to 9 min.

In 24 hours with the ambient temp. 27 to 31°C .the energy meter show the following readings

Initial energy meter reading: 9.1

Final energy meter reading: 9.9

Total power consumption = Final energy meter reading - Initial energy meter reading.

Total power consumption = $9.9 - 9.1 = 0.8$

Total power consumption = $0.8/24 = 0.033$ Kwhrs

To Evaluate Theoretical C.O.P.

Suction gas temperature = 13

Discharge gas temperature = 57

Temperature after condensation = 47

Temperature after expansion = -1

Average suction pressure in bar = 32 to 36 psi

Average discharge pressure in bar 150 to 170 psi

Absolute suction pressure = suction gauge pressure + barometric pressure.

Absolute suction pressure = $32/14.5 + 1.014 = 3.22$ bar

Absolute discharge pressure = discharge gauge pressure + barometric pressure.

Absolute discharge pressure = $150/14.5 + 1.014 = 11.35$

H1 = enthalpies of refrigerant at inlet of compressor = 410

H2 = enthalpies of refrigerant at outlet of compressor = 437

H3 = enthalpies of refrigerant after condensation = 265

H4 = enthalpies of refrigerant after expansion = 265

Theoretical refrigeration effect = $N = H1 - H4 = 145$ KJ/KG

Theoretical compressor effect = $W = H2 - H1 = 27$ KJ/KG

Coefficient of performance = C.O.P = $N/W = 145/27 = 5.3$

To calculate actual C.O.P

Actual refrigeration effect = heater load

Initial energy meter reading = 4

Initial energy meter reading=4.6

Actual refrigeration effect =Final energy meter reading-Initial energy meter reading

Actual refrigeration effect=4.6-4.0=0.6 KWHR.

Actual compressor work:

Initial energy meter reading=12.3

Final energy meter reading= 12.6

Actual compressor work =Final energy meter reading-Initial energy meter reading

Actual compressor work= 12.6-12.3=0.3 KWHR

Actual C.O.P= Actual refrigeration effect/ Actual compressor work

Actual C.O.P= 0.6/0.3=2

Conclusion

Theoretical C.O.P glass wool= 4.66 Actual C.O.P glass wool= 1 Power consumption of glass wool= 0.037kwhrs Theoretical C.O.P glass wool with P.M.M.A = 5.3 Actual C.O.P glasswool with P.M.M.A = 2 Power consumption of glasswool with P.M.M.A =0.033kwhr

From reading and calculation it is found out that Capacity of heat resistance of glass wool with P.M.M.A is more than that of glass wool, besides it produces temperature holding more than glass wool. If glasswool with P.M.M.A used instead of glass wool less quantity of electricity is used by refrigeration system.

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