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International
Journal
Of Modern Engineering Research (IJMER)

Experimental Investigation of Water Cooler Test Rig Using R-22 as Refrigerant

Prof. Bankar Nandkishor D.[1], Prof. Nagre Gajanan P.[2], Prof. Parihar Amol A.[3]
*(Department Of Mechanical Engineering, MGM's Polytechnic Aurangabad, Maharashtra, India.)1,2,3

ABSTRACT: *This paper describes Water Cooler; a tool that aggregates shared internal social media and cross-references it with an organization's directory. We deployed Water Cooler in a large global enterprise and present the results of a preliminary user study. Despite the lack of complete social networking affordances, we find that Water-Cooler changed users' perceptions of their workplace, made them feel more connected to each other and the company, and redistributed. Water coolers work on vapour compression refrigeration cycle. The behavior of performance parameters of a simple vapour compression refrigeration system were studied while it's working under transient conditions occurred during cooling of a fixed mass of brine from initial room temperature to sub-zero refrigeration temperature. The effects of different lengths of capillary tube over these characteristics have also been investigated. The main advantage of our project is to cool the water with help of test rig.*
Keywords: *compressor, condenser, expansion valve, evaporator and accessories etc.*

I. INTRODUCTION

In 1906 Halsey Willard Taylor and Luther Haws invented the first drinking water fountain, with the primary motivation being to provide safer drinking water and avoid the risk of typhoid fever caused by contaminated water. (Luther Haws' father had died of typhoid fever precipitated by contaminated water. Early drinking fountains provided room temperature drinking water, but demand led to the development of fountains that could provide cooler water thereby killing the micro-organisms responsible for pollution and disease. But early water coolers did not have a discrete water treatment method for purifying the dispensed H2O.As the years went by, water coolers further evolved into smaller, lighter, and more efficient units. They also varied in shape and size, depending on the needs of the consuming. Water cooler is one piece of equipment that we find in our day to day life. Water coolers are used to reduce the temperature of drinking water and to maintain the temperature of the water in a particular range. In this article we will discuss the working and most common types of water coolers made by us. The purpose of water cooler is to make water available at a constant temperature respective of room temperature [1]

II. WORKING PRINCIPLE

The process of refrigeration occurs in a system which encompasses of a compressor, a condenser, expansion device and an evaporator. VCR system functions based on reversed Briton cycle. The VCR system consists of four main components which are compressor, condenser, expansion device and evaporator. Compressor is used to compress the low temperature and pressure refrigerant from the evaporator to high temperature and pressure. After compression the high temperature and pressure refrigerant is discharged into the condenser though the delivery or discharge. The Condenser consists of coils of pipe in which the high temperature and pressure refrigerant is cooled and condensed. There refrigerant, which passing through the condenser, gives up its latent heat to the surrounding condensing medium which is normally air or water. The condensed liquid refrigerant from the condenser is stored in the vessel known as receiver from where it is supplied to evaporator through the expansion valve (i.e. capillary) or refrigerant control valve. The function of the expansion valve is to allow the liquid refrigerant under high temperature and pressure to pass at a controlled rate after reducing its temperature and pressure. Some of the liquid refrigerant evaporates as it passes though the expansion valve, but the greater portion is vaporized anthem evaporator at low temperature and pressure. Next it travels to the evaporator. An Evaporator consists of coils of pipes in which the liquid vapour refrigerant at low temperature and pressure is evaporated and changed into vapour refrigerant at low pressure and temperature. In evaporating, the liquid vapour refrigerant absorbs its latent heat of vaporization from the medium (water) which is to be cooled. The performance of the water cooler system is to be evaluated by using experimental methods which is carried out by using the specially developed test rig. The test rig can be modified and upgraded if

required. The work explains some of the technical modification and evaluation of the refrigeration system under varying load condition. The refrigeration system used to test the concept has a low pressure with single hermetically sealed compressor.

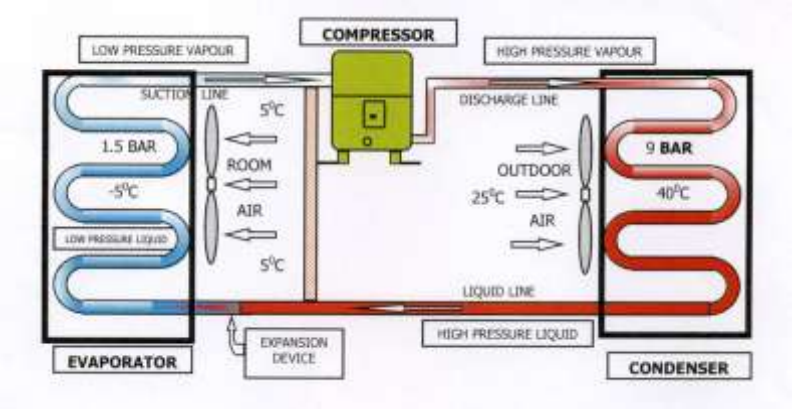

Fig no. 1 Vapour Compression Refrigeration Test Rig[4]

III. REFRIGERENT USED

R-22 Monochloro - Difluoro –methane ($CHCLF_2$)

The R-22 is a manmade refrigerant developed for a refrigeration installation that need a low evaporating temperature as in fast freezing units which maintains a temperature of -29^0C to -40^0C . It has also been successfully used in air conditioning units and household refrigerator. It used with reciprocating and centrifugal compressor. It is not necessary to used R-22 at below atmospheric pressures in order to obtain the low temperatures**.** The boiling point of R-22 is -41^0C at atmospheric pressure. It has a latent heat of 216.5KJ/KG at -15^0C. The normal head pressure at 30^0C is 10.88 bar .This refrigerant is stable and non-toxic, non-corrosive, non-irritating and non-flammable. The evaporator pressure of this refrigerant at -15^0C is 1.92 bars since water mixes better with R-22 than R-12 by a ratio of 3 to 1, therefore driers should be used to remove most of the moisture to keep water to minimum. This refrigerant has good solubility in oil down to -9^0C. However, the oil remains fluid enough to flow down the suction line at temperature as low as -40^0C. The oil will begin to separate at this point. Since oil is lighter, therefore it will collect on the surface of liquid refrigerant.[6]

Table no. 1 Physical properties of refrigerant [R-22]

Chemical Formula	**CHClF2**
Molecular Mass	86.47
Boiling Point at one atmosphere	-40.81°C
Critical Temperature	96.15°C
Critical Pressure	4990 kPa
Critical Density	523.8 kg/m3
Critical Volume	0.0019 m3/kg

IV. SYSTEM DEVELOPMENT

The performance of the water cooler system is to be evaluated by using experimental methods which is carried out by using the specially developed test rig. The test rig can be modified and upgraded if required. The work explains some of the technical modification and evaluation of the refrigeration system under varying load condition. The refrigeration system used to test the concept has a low pressure with single hermetically sealed compressor. In this compressor refrigerant are compressed and supply to condenser forced convection air-cooled condenser. Condenser is one of the essential components of refrigeration system. It is heat rejection component in refrigeration cycle. Condenser is one of the essential components of refrigeration system. It is heat rejection component in refrigeration cycle. In forced convection Air type condensers, the circulation of air over the condenser surface is maintained by using a fan or a blower. These condensers normally use fins on air-side for good heat transfer. Then refrigerants pass to Expansion valve. In our project we use Capillary tube; it is one of the most commonly used throttling devices in the refrigeration and the air conditioning systems. The capillary tube is the expansion device used for small units of 0.5 ton to 2.5 ton. The capillary tube is a copper tube of very small internal diameter. The internal diameter of the capillary tube used for the refrigeration and air conditioning applications varies from 0.5 to 2.28 mm. In capillary tube, the liquid refrigerant from the condenser enters the capillary tube. Due to frictional resistance offered by a small diameter tube, the pressure drops. Since the frictional resistance is directly proportional to the length and inversely to the diameter, therefore longer the

capillary tube and smaller in it's inside diameter, greater is the pressure drop created in the refrigerant flow. Then refrigerants pass to the Evaporator where actual work done. An evaporator is a component of refrigeration system in which liquid refrigerant is vaporized to low pressure and temperature to produce refrigerant effect. An evaporator is a device used to turn the liquid form of a chemical into its gaseous form. The refrigerant is evaporated, or vaporized, into a gas and pass to the compressor. And cycle is repeated. [6]

Fig. no. 2 Actual Water Cooler Test Rig.

V. TECHNICAL SPECIFICATION

- **Name of the make**- Emerson Climate Technology
- **Type**- Hermetically Sealed Reciprocating Compressor
- **Model**- KCJ513HAE
- **Capacity**- 1 Tonne
- **Supply**- 230 V, 50 Hz
- **Refrigerant used**- R-22
- Condenser Inlet Temperature (T_1) = 72^0C
- Condenser Outlet Temperature (T_2) = 48^0C
- Evaporator Inlet Temperature (T_3) = -5^0C
- Evaporator Outlet Temperature (T_4) = 4^0C
- Time taken for collection of 1 liter of water (t) = 20 sec.
- Time of 10 revolution of energy meter disc (T) = 10 sec.
- Temperature of water at inlet (Ti) = 27 °C
- Temperature of water at outlet (To) = 10 °C

VI. DESIGN AND CALCULATION

In our project test rig specially design for students, refrigeration tonnage of water cooler meant for drinking water at 10^0 C for 700 students of **"MGM's Polytechnic"** collage of 7 hours time. The water is available at 27^0C. The heat transfer through insulation is 5% of the total heat load. Recommend the tonnage of water cooler, assuming heavy duty. Also calculate the total water consumption per day.

Solution:-

Given

T (Water outlet temperature) = 10^0C

T_i (Water inlet temperature) = 27^0C

Students = 700

Time = 7 Hours

Heat Transfer = 5% of Total load

Refrigeration tonnage of water cooler:-

Let,
Q_T = Total Refrigeration Tonnage of Water Cooler
From table, we find that drinking water requirement per student is 0.56 liters per hour.
Cold water supply per hour,
M_w = 0.56 X 700 = 392 l/h or 392 KJ / Hr.
We know that cooling load for the water cooler
$Q = M_w C_p (T_i – T_o)$ = 392 x 4.18 x (27-10) = 27855.5 KJ / Hr.
Since heat transfer through insulation is 5% of total load, therefore total cooling load
$Q_T = 0.05X\ Q_T + Q$ OR 0.95QT= Q
Q_T = Q / 0.95 = 27855.5 / 0.95 = 29321.6 KJ / Hr
= 488.7KJ/ min
Or Refrigeration tonnage of water cooler,
Q_T = 488.7 / 210 = 2.32 TR
Water consumption per day
We know that water consumption per day (for 7 Hrs collage time)
= 392 X 7 = 2744 liters / day.
Coefficient of performance of water cooler
m = 1/t = 1/20 = 0.05 kg/sec
N = refrigerating effect = m x 4.187 x (Ti - To)
Specific heat of water = 4.187 kJ/kg° K
= 0.05 x 4.187 x (27 – 10) kW
= 3.55 kW
w = energy supplied /second = (10 / n) × (3600 / T) kW
= (10/3200) x (3600/10)
= 1.125 kW
Where n = energy meter constant in rev/ Kw hour
Coefficient of performance of water cooler = N / w =3.55/1.125
COP of Water cooler = 3.15

VII. CONCLUSION

The objective of carrying out the research work is to observe the coefficient of performance of R-22. The refrigerant is a heat carrying medium which during their cycle (VCR cycle) in the refrigeration system absorbs heat from a low temperature system and discards the heat to a higher temperature system. In the present days, many new refrigerants including halo carbon compounds, hydrocarbon compounds are used for refrigeration applications. R-22 is considered to be the most preferred substitute for water cooler, since the refrigerant R-22 has less global warming potential and zero ozone depletion potential. Hence, various observations and results obtained from the experimental investigations shows that, R-22 is a better substitute for other refrigerants on the basis of COP. Meanwhile, the quest for better refrigerants continues. Seeing new refrigerants, natural refrigerants appear to be the best choice in the long run.

Water consumption per day by water cooler for **MGM'S Polytechnic** students and staffs is 2744 liters per day and COP of Water cooler test rig is 3.15.

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