Improve COP of Water Cooler (Refrigeration System) by Extended Evaporator

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ABSTRACT

Much advancement is taking place to improve the COP of refrigeration system, to reduce the electricity consumption and to get quick output. About 15% of the world's electricity is used to drive refrigerating and air-conditioning systems. Inefficient use of energy is a waste of valuable resource which contributes to global warming. Most of the global warming effect of refrigerating systems comes from generating energy to drive them. Only a small proportion comes from the release of certain refrigerants. This informatory note describes how the efficiency of refrigerating systems can be maximized thereby minimizing their global warming impact. Our project is also aims to increase the efficiency of refrigeration system by extending the evaporator coil. Modification in evaporator is meant to increase Evaporator surface area which increases refrigerating effect our project is based on this concept.

Keyword: *water cooler ,improve COP, Extended evaporator*

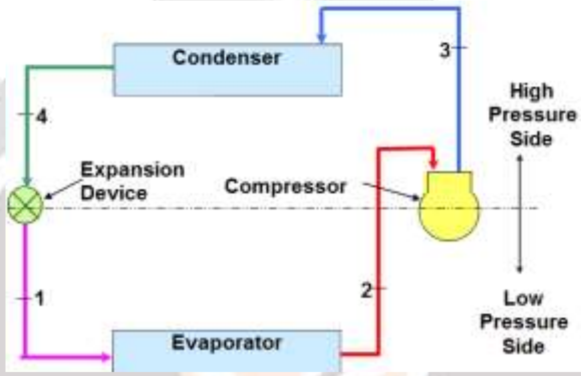
I. INTRODUCTION

Refrigeration is a process of moving heat from one location to another in controlled conditions. Refrigeration has many applications, from which one of the important is household refrigerators. Compressor, Condenser, Evaporator and Expansion valve (capillary tubes) are four main component of the VCRS system. Evaporator is one of the most important components in VCRS system. The refrigerating or cooling effect is obtained by evaporator. Evaporators are designed in such a manner the refrigerant leaving the evaporator are superheated by a few degree so that when they enter the compressor there is no wet compression. The cooling effect of the evaporator is governed by the difference in temperature between the medium being cooled and the evaporating refrigerant. The wider the temperature difference the greater the rate of heat transfer and the size and design of the evaporator. The energy efficiency of a refrigeration system is usually expressed as a Coefficient of Performance (COP) which is the ratio of the heat extraction rate to the rate of energy use.

Whatever type of refrigerating system is being used, it is fundamental to minimize the required heat extraction and to keep the difference between T_C (condensing temperature) and T_0(evaporating temperature) as small as possible. to improve the heat extraction we are going to increase the surface area of the evaporator coil which will be in more contact with the water will give extra cooling within the same compression range and thus as it work faster the power needed to cool the water will be less than the nominal power consumption. The earlier COP of the refrigeration unit without extended evaporator is 1.89 and the improved COP observed after the modification into the evaporator coli is 3.2 so it is a good improvement we achieved. This will give faster and better cooling than the previous model of evaporator and hence reduce the power consumption too.

2. METHODOLOGY

The temperature of the refrigerant at inlet/outlet of each component of the refrigerator is measured with thermometers. Temperature measurement is necessary across each component of the system in order to investigate the performance. Similarly pressure measurements are also taken across different components of the refrigeration system. The Pressure gauges are fitted at the inlet and outlet of the compressor and expansion valve. The pressure gauges are fitted with the T-joint and then brazed with the tube to measure the pressure at desired. A power meter is connected with compressor and Condenser fan to measure the power and energy consumption. Firstly, performance of the old refrigeration system of simple evaporator coil is measured. Then the extension is made by welding fins across the evaporator coil to extend its surface area and its performance is measured.



3. COMPONENTS USED

(a)Compressor: The compressors are one of the most important parts of the refrigeration cycle. The compressor compresses the refrigerant, which flows to the condenser, where it gets cooled. It then moves to the expansion valve, and the evaporator and it is finally sucked by the compressor again.

(b)Condenser: The condenser removes heat given off during the liquefication of vaporized refrigerant. Heat is given off as the temperature drops to condensation temperature. Then, more heat is released as the refrigerant liquefies. There are air-cooled and water-cooled condensers. Here we have used air cooled condenser

(c)Flow control device (expansion valve): This controls the flow of the liquid refrigerant into the evaporator. Control devices usually are thermostatic, meaning that they are responsive to the temperature of the refrigerant.

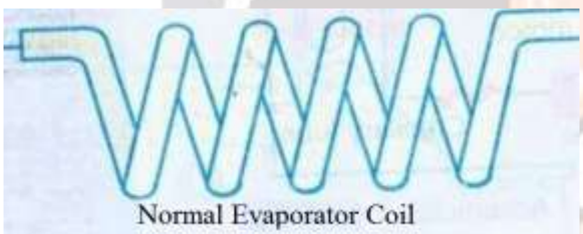
(d)Evaporator: This is the part of the refrigeration system that is doing the actual cooling. Because its function is to absorb heat into the refrigeration system the evaporator is placed in the area to be cooled.It acts as a heat exchanger that transfers heat from the substance being cooled to a boiling temperature.

4. EXPERIMENTAL SET UP

In vapor compression refrigerating system basically there are two heat exchangers. One is to absorb the heat which is done by evaporator and another is to remove heat absorbed by refrigerant in the evaporator and the heat of compression added in the compressor and condenses it back to liquid which is done by condenser. This work focuses on heat rejection in the condenser this is only possible either by providing a fan or by extending the surfaces. The extended surfaces are called fins. The rate of heat rejection in the condenser depends upon the number of fins attached to the condenser or to the evaporator. This work investigated the performance of evaporator using in the present technology and welding the copper plate over the evaporator coil. In this project evaporator surface are is extended or increased by making fin like setup. The performance of the evaporator will help to increase COP of the system. The performance of the system is investigated by present and modified systems. In order to know the performance characteristics of the vapor compression refrigerating system the temperature and pressure gauges are installed at each entry and exit of the component. Experiments are conducted on condenser having fins.Final setup of the project looks like as shown in figure.

Fig*:* project setup

In this we have extended the evaporator coil by fixing the cut piece of copper plate and coil over the evaporator. This is the part of the refrigeration system that is doing the actual cooling. Because its function is to absorb heat into the refrigeration system the evaporator is placed in the area to be cooled. The refrigerant is let into and measured by a flow control device, and eventually released to the compressor. The evaporator consists of finned tubes, which absorbs heat from the air blown through a coil by a fan. Fins and tubes are made of metals with high thermal conductivity to maximize heat transfer. The refrigerant vaporizes from the heat it absorbs heat in the evaporator.



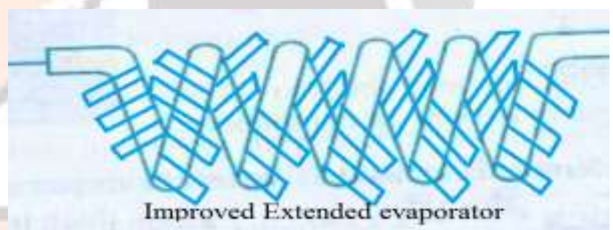


Fig: Evaporator with extended fins

Different types of tools are also used like snips to cut the plated fins to required sizes, tube cutter to cut the tubes and tube bender to bend the copper tube to the required angle. Finally the water cooler is fabricated as for the requirement of the project. All the values of pressures and temperatures are tabulated.

	Energy meter reading		pressure		Temp in ^{0}c				Water Temp	
	Initial	Final	Suction	Discharge	T_1	T_2	T_3	T_4	Initial	Final
Old	.85	1.0	150	200	13	45	42	15	28	16
Improved (New)	1.1	1.20	150	200	12.5	46	44	13	28	15

5. RESULTS AND DISCUSSION

COP is defined as the ratio of refrigeration effect and work input to the system. In this case COP is the ratio of power input to heater submerged in evaporator water to the power consumed by the compressor

$$\textbf{COP}= \frac{\text{Refrigeration Effect}}{\text{work Done}}$$

COP is highly influenced by operating conditions, especially ambient temperature and relative temperatures between sink and system. Here in this experimental study actual COP of refrigeration system has been investigated.

1.For old Water Cooler:

Heat Extracted =Mw x Cpw x (T5 Initial – T5 Final) KJ

= 16 x 4.19 x (28- 16)

=804.48 KJ

Work Done = Initial E.M Reading- Final E.M Reading x 3600 KJ

= (.85 - 1.00) x 3600

= 540 KJ

$$\textbf{Actual C.O.P} = \frac{\text{Heat Extracted}}{Work\ Done}$$

=804.48/540 = 1.48 No Unit

2. For Modified Water cooler with extended evaporator coil:

Heat Extracted =Mw x Cpw x (T5 Initial – T5 Final) KJ

= 16 x 4.19 x (28- 15)

=871.52 KJ

Work Done = Initial E.M Reading- Final E.M Reading x 3600 KJ

= (1.1-1.20) x 3600

= 360 KJ

$$\textbf{Actual C.O.P} = \frac{\text{Heat Extracted}}{Work\ Done}$$

=871.52/360 = 2.42 No Unit

6. CONCLUSION

COP of the water cooler increased and the time taken to cool the preferred amount of water reduces. This reduces the consumption of electricity as well.

7. FURTHER ADVANCEMENT IN REFRIGERATION

The United Nations Environment Program projected hydrocarbon usage to more than double by 2020. Hydrocarbon systems can significantly reduce energy consumption compared to synthetic fluids in commercial applications. Advances in cooling technologies, utilizing propane as a refrigerant specifically, can offer consumers and businesses a reliable, cost-effective and energy-efficient alternative. With growing market demand for environmentally responsible solutions, propane delivers a great option to consumers and companies today. Propane (R-290) is a natural hydrocarbon (HC) refrigerant gas that can be easily applied in commercial and industrial refrigerators, freezers, air conditioning and heat pumps. Besides having an Ozone Depletion Potential (ODP) of 0 and Global Warming Potential (GWP) of 20, propane has a Total Equivalent Warming Impact (TEWI) less than other refrigerant choices due to its thermal physical properties. In comparison, HFC 404-A has an ODP=0.04 and GWP= 3300.

When compared to natural refrigerant CO2 (ODP=0 and GWP= 1), R-290 appears to be a weaker choice. However, due to the overall system efficiency, a system utilizing R-290 consumes significantly less electrical power and therefore has less total effect on the environment.There are many benefits of using propane as an alternative refrigerant; however, there are also safety concerns due to its flammable nature.

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