EXPRIMENTAL STUDY OF PERFORMANCE COMPARISON OF AIR COOLED AND WATER CONDENSER IN AMMONIA VAPOUR ABSORPTION REFRIGERATION SYSTEM

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ABSTRACT

The continuous growth in the energy demand and in the economy cost has led to the more research and development for efficient utilization of available energy resources by minimizing the waste energy. Absorption refrigeration has gained more attraction in the research interest. Absorption cooling offers the possibility of utilizing the heat to provide cooling. For this purpose the heat from conventional boilers can be utilize or the use of waste heat and solar energy can be done. Absorption system falls in two different categories based upon the working fluid or refrigerant. These are the LiBr-H_2O and NH_3-H_2O Absorption Refrigeration system.

In this article the experiment research is conducted in order to study the performance comparison of the air cooled condenser and water cooled condenser in ammonia VARS System. The experiment tests are conducted at three different ambient temperatures 20°C, 25°C and 30°C.Intially at ambient temperature 20°C the COP of Water cooled condenser is 2.14 which is more than air cooled condenser i.e.1.94.Now, at 25°C the COP of air cooled condenser is 1.85 and COP of water cooled condenser is 2.03.Similarly in last case at ambient temperature 30°C.The COP of air cooled condenser is 1.75 and again COP of water cooled condenser is more as compared to air cooled which is 1.95.

Keywords: Water Cooled Condenser, Air Cooled Condenser, Ammonia Vapor Absorption Refrigeration System, Coefficient of Performance.

I. INTRODUCTION

Refrigeration is the process of removing heat from where it is not wanted. Heat is removed from food to preserve its quality and flavor. It is removed from room air to establish human comfort. There are innumerable applications in industry in which heat is removed from a certain place or material to accomplish a desired effect. The first mechanically produced cooling system was developed in England in 1834. The process later became known as vapour compression. After availability of electricity automatic refrigeration system was developed in 1897. Basically a refrigeration or air conditioning is nothing more than a heat pump whose job is to remove heat from a lower temperature and reject heat to high temperature. A vapour absorption refrigerator is a refrigerator that uses a heat source (e.g., solar energy, a fossil-fueled flame, waste heat from factories, or district heating systems) which provides the energy needed to drive the cooling process. Vapour Absorption refrigerators are often used for food storage in recreational vehicles. The principle can also be used to air-condition buildings using the waste heat from a gas turbine or water heater. This use is very efficient, since the gas turbine produces electricity, hot water and air-conditioning (called cogeneration/trigeneration).In this study comparison of air and water cooled condenser take place at three ambient temperature 20°C, 25°C and 30°C.The COP of water cooled condenser is 2.14 and air cooled is 1.94 at ambient temperature 20°C.As ambient temperature increases the COP further goes on decreases i.e.at ambient temperature 25°C the COP of water cooled is 2.03 and air cooled is 1.85.In last case at ambient temperature 30°C the COP of water cooled condenser is 1.95 which is higher than air cooled condenser i.e.1.75.The survey of the literature regarding the VARS system.

John Leslie in 1810 kept H_2SO_4 and water in two separate jars connected together. H_2SO_4 has very high affinity for water. It absorbs water vapour and this becomes the principle of removing the evaporated water vapour requiring no compressor or pump. H_2SO_4 is an absorbent in this system that has to be recycled by heating to get rid of the absorbed water vapour, for continuous operation. **Windhausen** in 1878 used this principle for absorption refrigeration system, which worked on H_2SO_4. **Ferdinand Carre** invented aqua-ammonia absorption system in **1860**. Water is a strong absorbent of NH_3. If NH_3 is kept in a vessel that is exposed to another vessel containing water, the strong absorption potential of water will cause evaporation of NH_3 requiring no compressor to drive the vapours. A liquid pump is used to increase the pressure of strong solution. The strong solution is then heated in a generator and passed through a rectification column to separate the water from ammonia. The ammonia vapour is then condensed and recycled. The pump power is negligible hence; the system runs virtually on low- grade energy used for heating the strong solution to separate the water from ammonia. These systems were initially run on steam. Later on oil and natural gas based systems were introduced. In **1922, Balzar von Platen and Carl Munters**, two students at Royal Institute of Technology, Stockholm invented a three fluid system that did not require a pump. A heating based bubble pump was used for circulation of strong and weak solutions and hydrogen was used as a non-condensable gas to reduce the partial pressure of NH_3 in the evaporator. In **1859, Ferdinand Carre** introduced a novel machine using water/ammonia as the working fluid. This machine took out a US patent in 1860. Machines based on this patent were used to make ice and store food. It was used as a basic design in the early age of refrigeration development.

II. EXPERIMENTAL SETUP

The experimental setup consists of a single stage vapour absorption system with the basic components i.e. evaporator, generator, absorber, pump, expansion device and condenser. The set up was built using the components of refrigerator like a condenser and an evaporative unit. The setup was installed on a wooden plank of length 2’5” and width 2’2”. A frame is built and used the water dipped condenser. A water circulation system within the Generator and the Absorber is achieved by using a submersible pump and with the help of connecting pipes made of aluminum. Water supplied to the condenser is done by using a water pump and connecting pipes. Water circulation rate is constant for all tests. Ambient air passes over the condenser and finally exits from back side of the condenser. A Thermostat is used to limit the supply of heat to the Generator. Temperatures of refrigerant and circulation air at different points are recorded with digital thermometer TPM-10. Before temperature measurement, the surfaces of the tubes are polished for removing any dust or rust and then the thermocouples are laid down on the surface. The readings were just taken at the outlets of the components to reduce the convection effect in the system. The condenser and evaporator are made of aluminum so that ammonia does not react with the material of the pipelines. The evaporative unit is insulated with the help of thermocole material.

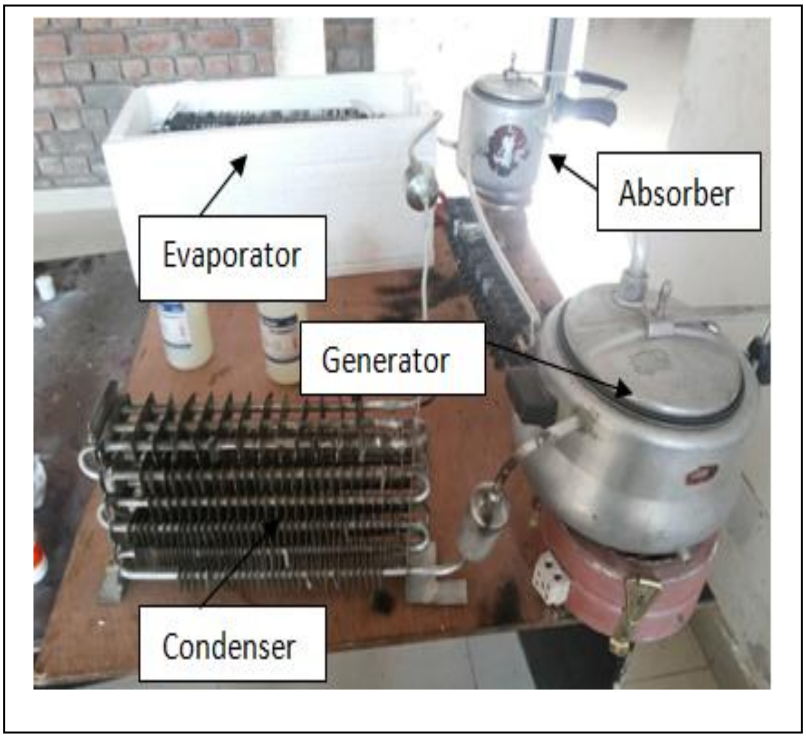

Figure 1: VARS system

The experiment (figure 1) consists of the VARS system having the different parts such as evaporator, generator, absorber, and condenser. The working Refrigerant is ammonia in our setup and experimental performance takes place after steady state is achieved.

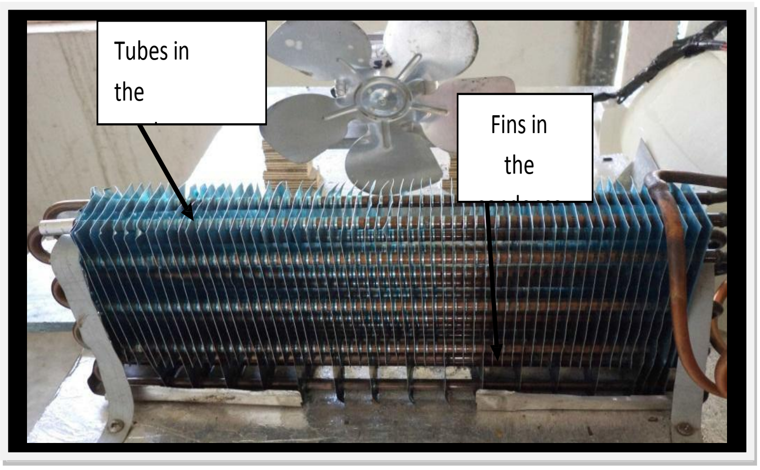

Figure 2: Air cooled condenser

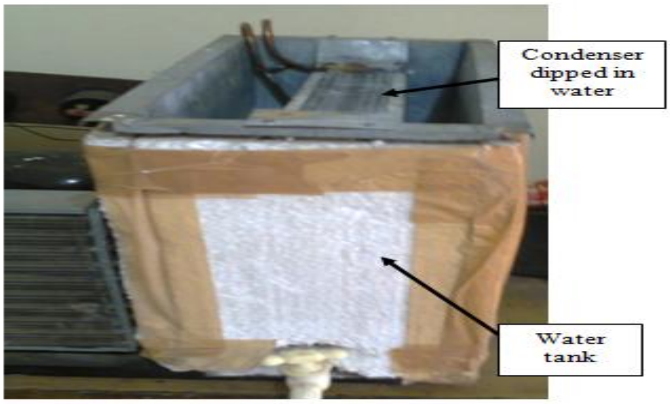

Figure 3: Water cooled condenser

The air cooled condenser (figure 2) represents the condenser that is cooled by external air provided by fan. Similarly (figure 3) represent the condenser that is dipped in water tank. Initially we calculate the value for air cooled condenser and than for water cooled condenser.

Types of condenser	Air cooled condenser	Water cooled condenser
Temperature of generator T_g	120°C	120°C
Temperature of condenser T_c	24.1°C	20.6°C
Temperature of evaporator T_e	-9°C	-10°C

Table 1: Performance at Ambient Temperature T_{amb}=20°C

Types of condenser	Air cooled condenser	Water cooled condenser
Temperature of generator T_g	120°C	120°C
Temperature of condenser T_c	27.5°C	25.3°C
Temperature of evaporator T_e	-6.23°C	-8°C

Table 2: Performance at Ambient Temperature T_{amb}=25°C

Types of condenser	Air cooled condenser	Water cooled condenser
Temperature of generator T_g	120°C	120°C
Temperature of condenser T_c	30°C	29.6°C
Temperature of evaporator T_e	-5°C	-7.23°C

Table 3: Performance at Ambient Temperature T_{amb}=30°C

III. CALCULATION AND RESULT

Many preliminary investigations were performed to prepare the setup for getting reliable data. In order to have a basis for comparison and also to specify the effect of water on condenser, each investigation was carried out in two consequent stages .In the first stage, conventional air cooled condenser was studied and data were recorded after steady state condition was established. Then the investigation on water cooled condenser was carried out. The time difference between two stages was small so the weather condition for two experiments was the same. In all investigation the data were recorded after steady state condition was established and the properties of refrigerant and air remained constant.

Many tests were performed to get the data. The following parameters were recorded during the experimental investigation:

1. Generator outlet temperature (T_g)
2. Condenser outlet temperature (T_c)
3. Evaporator outlet temperature (T_e)

In order to estimate the effect of water cooled condenser on the system and comparing the results of air cooled condenser and water cooled condenser, experimental tests were performed. In the first stage, air-cooled condenser is used and after getting the data, in the second stage water cooled condenser is used. Data is recorded after steady state condition is achieved in the system and the properties of refrigerant (R134a) and air remained constant (after 20 min). Experimental tests are performed at three ambient air temperatures i.e. 20°C, 25°C and 30°C.

COP of the system are calculate from the required following equation.

COP= $[T_e/T_c-T_e]*[T_g-T_c/T_g]$

Performance result of Air Conditioner (T_{amb}-20°C)		
Parameter	**Air cooled condenser**	**Water cooled condenser**
COP	1.94	2.14

Table 4: Result at Ambient Temperature (T_{amb})=20°C

Performance result of Air Conditioner (T_{amb}-25°C)		
Parameter	**Air cooled condenser**	**Water cooled condenser**
COP	1.85	2.03

Table 5: Result at Ambient Temperature (T_{amb}) =25°C

Performance result of Air Conditioner (T_{amb}-30°C)		
Parameter	**Air cooled condenser**	**Water cooled condenser**
COP	1.75	1.95

Table 6: Result at Ambient Temperature (T_{amb}) =30°C

From the above table it is clear mentioned that COP of water cooled condenser is more than that of air cooled condenser .In same ambient temperature COP of water cooled condenser is high as compare to air cooled condenser. Due to cooling action of water in condenser which take latent heat from the condenser and hence condense the refrigerant as high as compare to air in air condenser.

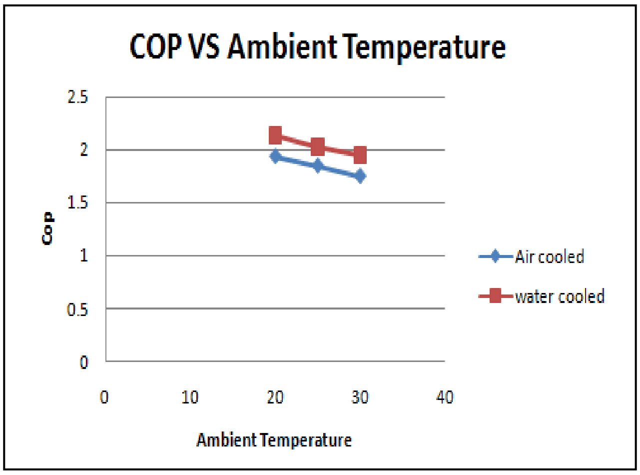

Figure 4: COP VS Ambient temperature

From the (Figure 4) it represent comparison of air cooled and water cooled condenser at three different ambient temperature i.e. 20°C, 25°C and 30°C .As the ambient temperature increase COP of the system goes on decrease in both air cooled and water cooled condenser .Increase in ambient temperature which decrease cooling capacity further decrease in the COP of the system.

IV.CONCLUSION

The effect of water cooling on the condenser generally used in air conditioner in subtropical region where outside ambient temperature is very hot and humid. Experimental results show that there is an increase in the cooling load and COP of the water cooled system as compared to air cooled system. The experimental investigation also verifies that condensing temperature and pressure decreases in case of water cooled condenser. The water cooled condenser thus results in increasing cooling. As we compare the air cooled and water cooled condenser at a particular ambient temperature, so there is increase in COP in case of water cooled condenser as compared to the air cooled condenser. At last we reached at the conclusion that at ambient temperature of 20^{o}C the COP of water cooled condenser is 2.14 which is more than the air cooled condenser i.e. 1.94 at same ambient temperature. Further at the ambient temperature of 25^{o}C the COP of water cooled condenser is 2.07 again is more than the air cooled condenser i.e. 1.84 at same 25^{o}C ambient temperature, so finally at the 30^{o}C the COP of the air cooled condenser is 1.76 which is again lower than the water cooled condenser which is 1.93. So as we increase the ambient temperature the COP of water cooled condenser is increasing as compared to the air cooled condenser.

REFERENCES

[1] John leslie. Evaluation with H_2SO_4 and water in two separate jars connected together (1868)

[2] Ferdinand carre invented aqua-ammonia absorption system in 1860.

[3] Windhausen.Recycling of H_2SO_4 by heating to get rid of the absorbed water vapour, for continuous operation.

[4] Balzar von Platen and Carl Munters, Royal Institute of Technology,Stockholm invented a three fluid system that did not require a pump(1922).

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