



PERFORMANCE ANALYSIS OF COEFFICIENT OF PERFORMANCE IN VAR SYSTEM AND THERMAL ANALYSIS OF IT.

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Abstract-*The aim of our project is to improve the COEFFICIENTS OF PERFORMANCE (COP) and THERMAL ANALYSIS in vapour absorption refrigeration system. In the current trends globally, the excessive utilization of the energy and overconsumption of fuel has resulted in the global warming and environmental pollution. The absorption cooling offers the possibility of the using heat to provide cooling. For cooling purpose the required heat input is obtained from the excessive heat of the boiler or from non-conventional power sources like solar energy. NH₃-H₂O system ammonia used as a refrigerant and water is used as an absorbent, these two liquids served as standard and a refrigerant cycle is produced. The system VARS in environment friendly and does not deplete the atmosphere. Thus it is essential to create awareness in the world for this system for it is an alternative system which is more environmental friendly.*

KEYWORDS:- generator, absorber, pump, condenser, evaporator, refrigerant etc.

1. INTRODUCTION

In recent developments of thermal engineering the Refrigeration technologies play an important role in today's industrial applications [1]. But as far as COP of these refrigeration system is concerned, it is always a challenge to the researchers to significantly increase the COP for these systems. The most popular refrigeration and air conditioning systems at present are those based on the vapour absorption systems. These systems are popular because they are reliable, relatively inexpensive and their technology is well established. However, these systems require high grade energy (mechanical or electrical) for their operation. Apart from this, the recent discovery that the conventional working fluids of vapour absorption systems are causing the ozone layer depletion and greenhouse effects has forced the scientific researchers to look for alternative systems for cooling applications. The natural alternative is of course the absorption system, which mainly uses heat energy for its operation. Moreover, the working fluids of these systems are environment friendly [2]. A suitable working fluid is probably the single most important factor in any refrigeration system. The cycle efficiency and operation characteristics of an absorption refrigeration system depend on the properties of refrigerant, absorbent and their mixtures. The most important thermo-physical properties are: heat of vaporization of refrigerant, heat of solution, vapour pressure of refrigerant and absorbent, solubility of refrigerant in solvent, heat capacity of solution, viscosity of solution and surface tension and thermal conductivity of the solution. Apart from this, the other selection criteria for the working fluids are their toxicity, chemical stability and corrosivity. Vapour Absorption Refrigeration Systems belong to the class of vapour cycles similar to vapour absorption refrigeration systems. However, unlike vapour absorption refrigeration systems, the required input to absorption systems is in the form of heat. Hence these systems are also called as heat operated or thermal energy driven systems. Both vapour absorption and absorption refrigeration cycles accomplish the removal of heat through the evaporation of a refrigerant at a low pressure and the rejection of heat through the condensation of the refrigerant at a higher pressure. The basic difference is that a vapour absorption system employs a mechanical compressor to create the pressure differences necessary to circulate the refrigerant whereas an absorption system uses heat source and the differences cause an absorption system to use little to no work input, but energy must be supplied in the form of

heat. This makes the system very attractive when there is a cheap source of heat, such as solar heat or waste heat from electricity or heat generation [3].



Fig.1 vapour absorption refrigeration system

Vapour Absorption Systems offer many advantages like it offers flexibility to utilize any sort of low grade, low cost heat energy available to produce cooling and thus giving a high savings in operating costs. It can operate on steam or any other waste heat source as the energy source instead of costly and unreliable electric power. No moving parts ensure noiseless, vibration-less and trouble free operation. Moreover maintenance costs are negligible as compared to power driven mechanical systems. Refrigerating effect is produced using a clean refrigerant in place of ozone-depleting chlorine based compounds[2].

Components of a Vapour Absorption Cooling System: The components of Vapour Absorption Refrigeration Cooling System are as[4].

Generator: The purpose of the generator is to deliver the refrigerant vapour to the rest of the system. It accomplishes this by separating refrigerant from the solution. In then generator, the solution vertically falls over horizontal tubes with hightemperature energy source typically steam or hot water flowing through the tubes. The solution absorbs heat from the warmer steam or water, causing the refrigerant to boil (vaporize) and separate from the absorbent solution. As the refrigerant is boiled away, the absorbent solution becomes more concentrated. The concentrated absorbent solution returns to the absorber and the refrigerant vapour migrates to the condenser.

Condenser: The purpose of condenser is to condense the refrigerant vapours. Inside the condenser, cooling water flows through tubes and the hot refrigerant vapour fills the surrounding space. As heat transfers from the refrigerant vapor to the water, refrigerant condenses on the tube surfaces. The condensed liquid refrigerant collects in the bottom of the condenser before travelling to the expansion device. The cooling water system is connected to a cooling tower

Expansion Valve: From the condenser, the liquid refrigerant flows through an expansion device into the evaporator. The expansion device is used to maintain the pressure difference between the high-pressure (condenser) and low-pressure (evaporator) sides of the refrigeration system. As the high- pressure liquid

refrigerant flows through the expansion device, it causes a pressure drop that reduces the refrigerant pressure to that of the evaporator. This pressure reduction causes a small portion of the liquid refrigerant to boil off, cooling the remaining refrigerant to the desired evaporator temperature. The cooled mixture of liquid and vapour refrigerant then flows into the evaporator.

Evaporator: The purpose of evaporator is to cool the circulating water. The evaporator contains a bundle of tubes that carry the system water to be cooled/chilled. At low pressure existing in the evaporator, the refrigerant absorbs heat from the circulating water and evaporates. The refrigerant vapours thus formed tend to increase the pressure in the vessel. This will in turn increase the boiling temperature and the desired cooling effect will not be obtained. So, it is necessary to remove the refrigerant vapours from the vessel into the lower pressure absorber. Physically, the evaporator and absorber are contained inside the same shell, allowing refrigerant vapours generated in the evaporator to migrate continuously to the absorber.

Absorber: Inside the absorber, the refrigerant vapour is absorbed by the solution. As the refrigerant vapour is absorbed, it condenses from a vapour to a liquid, releasing the heat it acquired in the evaporator. The heat released from the condensation of refrigerant vapours by their absorption in the solution is removed by the cooling water circulating through the absorber tube bundle. The weak absorbent solution is then pumped to the generator where heat is used to drive off the refrigerant. The hot refrigerant vapours created in the generator migrate to the condenser. The cooling tower water circulating through the condenser turns the refrigerant vapours to a liquid state and picks up the heat of condensation, which it rejects to the cooling tower. The liquid refrigerant returns to the evaporator and completes the cycle.

Refrigerant-Absorbent combinations for Vapour Absorption Cooling Systems:

Absorption machines are commercially available today in two basic configurations. For applications above 50C (primarily air- conditioning) the cycle uses ammonia/water. For applications below 50C, ammonia/water cycle is employed with ammonia as the refrigerant and water as the absorbent.

Desirable Properties of Refrigerant-Absorbent mixtures:

Refrigerant-absorbent mixtures for Vapour Absorption Cooling System should possess some desirable properties like the refrigerant should be more volatile than the absorbent in other words the boiling point of refrigerant should be much lower than the absorbent. There must be large difference in the boiling points of refrigerant and absorbent (greater than 2000 0C), so that the solution in the Generator need only to be heated to the temperature required to boil off only the refrigerant. This ensures that only pure refrigerant circulates through refrigerant circuit (condenser-expansion valve-evaporator). The refrigerant should exhibit high solubility with solution in the absorber. The absorbent should have strong affinity for the refrigerant. This will minimize the amount of refrigerant to be circulated. Operating pressures should be preferably low, so that the walls of the shells and connecting pipes need not to be thick. It should not undergo crystallization or solidification inside the system. Because crystallization will block the free flow of solution in the line. The mixture should be safe, chemically stable, non- corrosive, inexpensive and should be available easily. The refrigerant should have high heat of vaporization.

Ammonia-Water (NH₃-H₂O) system for low temperature(less than 50 C) refrigeration applications with ammonia as refrigerant and water as absorbent.

Ammonia-Water Systems:

Since the invention of absorption refrigeration system, NH₃- Water has been widely used. Both NH₃ (refrigerant) and water (absorbent) are highly stable for a wide range of operating temperature and pressure. NH₃ has a high latent heat of vaporization, which is necessary for efficient performance of the system. It can be used for low temperature applications, as the freezing point of NH₃ is -77°C. But since both NH₃ and water are volatile, the cycle requires a rectifier to strip away water that normally evaporates with NH₃ .Without a rectifier, the water would accumulate in the evaporator and offset the system performance. There are other disadvantages such as its high pressure, toxicity, and corrosive action to copper and copper alloy. Ammonia/Air mixtures are barely inflammable but may be explosive in the case of high percentages of ammonia between 15.5 and 27 % by volume[7].

2. Thermodynamic analysis and cop derivation of it.

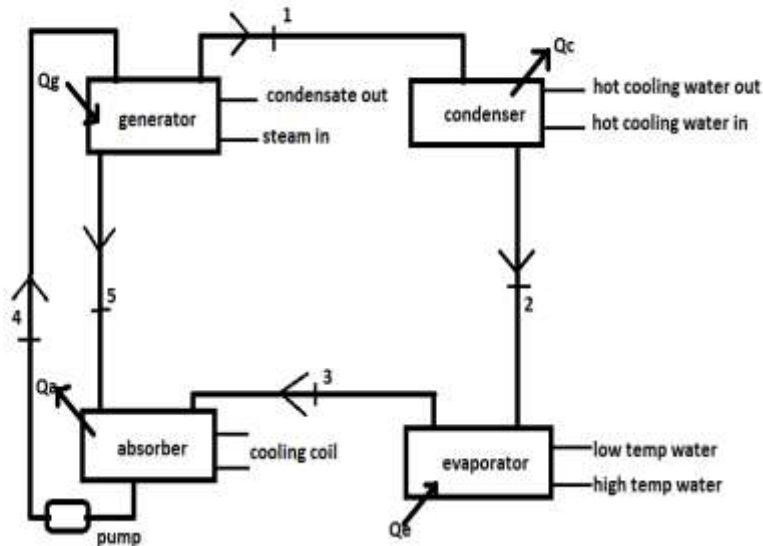


Fig.2 vapour absorption refrigeration system

Let m = mass flow rate of refrigerant, kg/s

T_g = temperature of generator, °C

T_e = temperature of evaporator, °C

T_s = temperature of steam, °C

H = enthalpy, kJ/kg

T_c = temperature of condenser, °C

T_1 = temperature of condensate, °C

T_a = temperature of absorber, °C

Z = concentration

So we have reading in our system then calculating to a coefficient of performance.

$$T_g = 80^\circ\text{C} = 80 + 273 = 353\text{ K}$$

$$T_c = T_a = 30^\circ\text{C} = 303\text{ K}$$

$$T_g = 10^\circ\text{C} = 283\text{ K}$$

$$T_2 = 25^\circ\text{C} = 298\text{ K}$$

$$T_s = 120^\circ\text{C}$$

$$T_1 = 100^\circ\text{C} = 373\text{ K}$$

$$Z_5 = 0.65 \quad H_5 = -75\text{ kJ/kg}$$

$$Z_4 = 0.51 \quad H_4 = -170\text{ kJ/kg} \quad H_1 = 2620\text{ kJ/kg}$$

$$m_1 = m_2 = m_3 = 0.4\text{ kg/s}$$

Pressure at a stage,

$$P_G = 0.4736\text{ bar} = 0.4736 \times 760 / 1.013$$

$$= 355.3\text{ mm}$$

$$P_C = P_A = 0.04242\text{ bar} = 31.82\text{ mm}$$

$$P_E = 0.01227\text{ bar} = 9.206\text{ mm}$$

Enthalpy of liquid water (condensate) at 25 °C; $H_2 = C_p \cdot T_2 = 4.19 \cdot 25 = 104.75 \text{ KJ/kg}$

Assuming the vapour leaving the evaporator is dry-saturated at $T_e = 10^\circ\text{C}$

From steam tables we get,

$$H_e = 2519.8 \text{ KJ/kg} = H_3$$

Cooling capacity,

$$\begin{aligned} R_e = Q_E = m_2(H_3 - H_2) &= 0.4 (2519.8 - 104.75) = 966.02 \text{ KJ/s} \\ &= 966.02 / 3.517 = 274.672 \text{ TR} \end{aligned}$$

Heat rejected to condenser

$$Q_C = m_1 (H_1 - H_2) = 0.4 (2620 - 104.75) = 1006.1 \text{ KW}$$

Let m_4 = mass flow rate of liquid leaving the absorber

M_5 = mass flow rate of liquid leaving the generator

by mas balance of absorber we get,

$$m_3 + m_5 = m_4$$

$$m_4 \cdot z_4 = m_5 \cdot z_5 ; m_4 \cdot 0.51 = m_5 \cdot 0.65 \quad m_4 / m_5 = 1.2745$$

$$0.4 + m_5 = 1.2745 \cdot m_5 \quad ; \quad m_5 = 1.4572 \text{ kg/s}$$

$$\text{And } m_4 = 1.2745 \cdot m_5 = 1.2745 \cdot 1.4572 = 1.8572 \text{ kg/s}$$

By energy balance of absorber we get ;

$$M_3 \cdot H_3 + m_5 \cdot H_5 = m_4 \cdot H_4 + Q_a$$

$$0.4 \cdot 2519.8 + 1.4572 \cdot (-75) = 1.8572 \cdot (-170) + Q_a$$

$$Q_a = 1214.36 \text{ kJ/s}$$

COP:

Consider energy balance of generator:

$$M_1 \cdot H_1 + m_5 \cdot H_5 = m_4 \cdot H_4 + Q_g$$

$$0.4 \cdot 2620 + 1.4572 \cdot (-75) = 1.8572 \cdot (-170) + Q_g$$

$$Q_G = 1214.36 \text{ kJ/s}$$

$$\text{So, COP} = Q_E / Q_G = 966.02 / 1254.4 = 0.77$$

3. result

In this paper, we have developed a method of calculation that is based on simple analytical data which relate the thermodynamic variable of the H₂O-NH₃ fluid couple. Detailed analytical procedure for the calculation of the COP for the design is given and the COP of the system.

4. Conclusion

COP of the system is greatly influenced upon the system temperatures. The effect of parameters like Condenser, Generator, Absorber and Evaporator temperature on system COP have been studied. The results have shown that all these four parameters greatly influence the system COP.

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