

EXPERIMENT

AIM: To Study working principle of steam jet refrigeration system.

APPARATUS USED: Reference of steam jet refrigeration system diagram and P -H and T - S diagrams.

THEORY:

The steam jet refrigeration system (also known as ejector system refrigeration system) is one of the oldest methods of producing refrigeration effect. The basic components of this system are an evaporator, a compressor device, a condenser and a refrigerant control device. This system employs a steam injector or booster (instead of mechanical compressor) to compress the refrigerant to the required condenser pressure level. In this system, water is used as the refrigerant. Since the freezing point of water is 0°C , therefore, it cannot be used for applications below 0°C . The steam jet refrigeration system is widely used in food processing plants for pre-cooling of vegetables and concentrating fruit juices, gas plants, paper mills, breweries etc.

Principle of steam jet refrigeration system: -

The boiling point of a liquid changes with change in external pressure. In normal conditions, pressure exerted on the surface of a liquid is the atmospheric pressure. If this atmospheric pressure is reduced on the surface of a liquid, by some means, then the liquid will start boiling at lower temperature, because of reduced pressure. This basic principal of boiling of liquid at lower temperature by reducing the pressure on its surface is used in steam jet refrigeration system.

The boiling point of pure water at standard atmospheric pressure of 760 mm of Hg is 100°C. It may be noted that water boils at 12°C if the pressure on the surface of water is kept at 0.014 bar and at 7°C if the pressure on the surface of water is 0.01 bar. The reduced pressure on the surface of water is maintained by throttling the steam through the jets or nozzles.

Working of steam jet refrigeration system: -

The flash chamber or evaporator is a large vessel and is heavily insulated to avoid the rise in temperature of water due to high ambient temp. It is fitted with perforated pipes for spraying water. The warm water coming out of the refrigerated space is sprayed into the flash water chamber where some of which is converted into vapours after absorbing the latent heat, thereby cooling the rest of water.

The high pressure steam from the boiler is passed through the steam nozzle thereby increase its velocity. The high velocity steam in the ejector would entrain the water vapours from the flash chamber which would result in further information of vapour. The mixture of steam and water vapour passes through the ventilate-tube of the ejector and gets compressed. The temperature and pressure rises considerably and fed to the water cooled condenser where it gets condensed. The condensate is again fed to the boiler as feed water. A constant water level is maintained in the flash chamber and any loss of water due to evaporation is made up from the makeup water line.

Steam Ejector: -

The steam ejector is one of the important components of a steam jet refrigeration system. It is used to compress the water vapours coming out of the flash chamber. It uses the energy of fast moving jet of steam to entrain the vapours from the flash chamber and then compress it. The high pressure steam from the boiler expands

while flowing through the convergent divergent nozzle. The expansion causes a very low pressure and increases steam velocity. The steam attains very high velocities in the range of 1000 m/s to 1350 m/s. The nozzles are designed for lowest operating pressure ratio between nozzle throat and exit. The nozzle pressure ratio of less than 200 is undesirable because of poor ejector efficiency when operating at low steam pressure.

The water vapour from the flash chamber are entrained by the high velocity steam and both are mixed in the mixing section at constant pressure. The mean velocity of the mixture will be supersonic, after the mixing is complete. This supersonic steam gets a normal shock, in the constant area throat of the diffuser. This results in the rise of pressure and subsonic flow. The function of the diverging portion of the diffuser is to recover the velocity head as pressure head by gradually reducing the velocity.

Analysis of Steam Jet Refrigeration System: -

The temperature – entropy ($T-s$) and enthalpy-entropy ($h-s$) diagrams for a steam jet refrigeration system are shown in fig. (a) and (b) respectively.

The point A represents the initial condition of the motive steam before passing through the nozzle and the point B is the final condition of the steam, assuming isentropic expansion. The point C represents the initial condition of the water vapour in the flash chamber or evaporator and the point E is the condition of the mixture of high velocity steam from the nozzle and the entrained water vapour before compression. Assuming isentropic compression, the final condition of the mixture discharged to the condenser is represented by point F. The final condition of the before mixing with the water vapour is shown at point D. The make-up water is supplied at point G whose temperature is slightly lower than the condenser temperature and is throttled to point H in the flash chamber.

VIVA QUESTIONS

1. What is principle of a steam jet refrigeration system?
2. Explain the working of steam jet refrigeration system?
3. What are the advantages of steam jet refrigeration system?
4. What are the disadvantages of steam jet refrigeration system?
5. What is Steam Ejector?