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REFRIGERATOR CUM BICYCLE

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Abstract – *After so much development, still there are some areas where electricity is not available also there is no service of electricity. So cooling may not be achieved in conventional ways. Cooling can be achieved by non-conventional ways in these areas. So for cooling effect the air or gas can be compressed by manual motion. To achieve this motion, a bicycle is used. A reciprocating compressor is driven by cycle wheel motion and compresses the gas. After compression the gas temperature increases. This heat is dissipated in condenser by contacting fresh air in atmosphere. After cooling the gas becomes in liquid state and goes to the cooling area where it takes the heat energy and becomes vapor. This vapor is again compressed in compressor and the cycle repeats. By this method, cooling effect is achieved in remote and non-electric areas.*

Key Words: **Conventional, Reciprocating, Compressor, Dissipated, Vapour.**

1. INTRODUCTION

Refrigeration is the removal of heat from a space at a temperature lower than the surrounding temperature. If we remove a bucket of water from a tank, the surrounding water rushes into fill the cavity. Similarly heat rushes into replace the heat remove. Insulation reduces in-rush of heat. Whatever heat enters through the insulation into the refrigerated space has to be removed with the help of the refrigerating machine. The refrigerating machine gets rid of the energy received by it, by rejecting it to the surroundings in the form of heat. Refrigeration thus amounts of pumping of heat from lower to higher temp. Heat has a natural tendency of flow from higher to lower temperature. Hence input of work is essential. According to second law of thermodynamics, "In any cyclic process the entropy will either increases or remain the same".

2. VAPOUR COMPRESSION REFRIGERATION SYSTEM

In Vapour Compression Refrigeration System, the working fluid used is in the form of gas. This gas is compressed with the help of compressor which increases the pressure of gas with increment in temperature also. This compressed gas is passed to the condenser and transfers its latent heat into the atmosphere to change its phase into liquid from vapour. Now the high pressurised liquid is collected into liquid receiver. Further this liquid is expanded through throttle valve and sent to evaporator. Evaporator is the confined area of which temperature is to be decrease. Here the liquid refrigerant takes its latent heat and changes phase from liquid to vapour. Then again comes to compressor and cycle repeats.

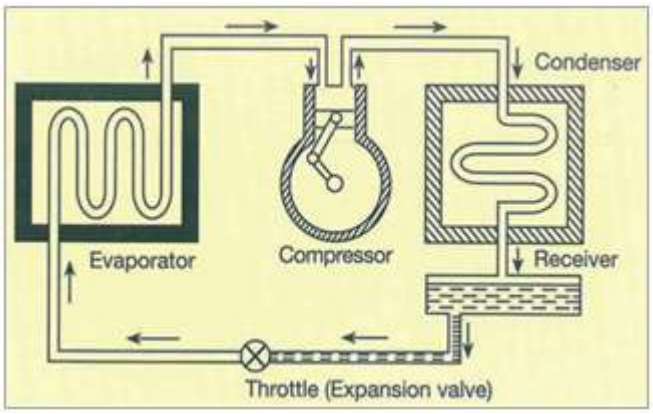


Fig: Vapour Compression Refrigeration System

Now these days VCRS is most commonly used in home appliances like fridge, air conditioner, water cooler etc. VCRS consist of following components:

1. Compressor
2. Condenser
3. Liquid Receiver
4. Expansion Valve
5. Evaporator
6. Refrigerant

2.1 COMPRESSOR

Compressor is a device which takes fluid at lower pressure and delivers at higher pressure with the help of external work. Compressor are also have sort of types like rotary compressor, reciprocating compressor, screw compressor, etc.

Rotary compressor compresses the fluid with the help of a rotating vane in a closed chamber. Due the movement of

fluid in this chamber the pressure increases with movement.

Reciprocating compressor takes the fluid in a closed chamber and pushes is with the help of ram and due to volume reduction, pressure increases.

2.2 CONDENSER

Condenser is a device which decreases the temperature of containing fluid. It takes heat from the containing fluid and transfers it to surrounding or atmosphere. Condensers require more surface area for more heat dissipation so they are spiral of tubes. Tubes have larger surface area and Coils or spirals increases length.

2.3 LIQUID RECEIVER

Liquid receiver stores the fluid which is cooled in condenser. It also helps in converting all the fluid into liquid form. It works as a filter and stores all the water vapour mixed with refrigerant.

2.4 EXPANSION VALVE

It helps in decreasing the pressure of fluid. It is a capillary tube of a long and small cross sectional area pipe. During the entering of the fluid, fluid particles collides to each other for enters and loses their energy. This reduction in energy decreases the pressure of fluid. Over the whole length its pressure comes to initial pressure which was before compression.

2.5 EVAPORATOR

Evaporator is a device which works opposite to the condenser. It transforms the liquid of fluid to vapour phase by transferring heat. It is the area where cooling is achieved or the area where cooling is required. This contains a pipe which touches the surface so the heat inside it is transferred to flowing fluid.

3. WORKING

It works on the principle of reverse cycle which is used in steam power plants like Rankine Cycle. It consist of 4 processes.

Process 1 – 2: - In this process refrigerant is adiabatically compressed into compressor. Due to the compression the temperature and pressure increases. Volume decreases with increase in pressure and thus delivery volume is less than the suction volume. For this process work is done on the compressor.

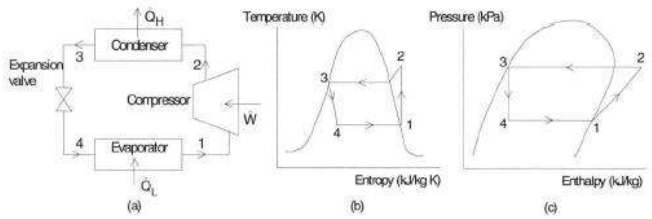


Fig: Working of Vapour Compression Refrigeration System

Work done on the compressor = $h_2 - h_1$

$W_{comp} = (h_2 - h_{1)}$

Process 2 – 3: - The compressed refrigerant is now passed to condenser for heat rejection. During compression temperature also increases with increase in pressure. This heat is rejected in condenser to the surrounding or atmosphere. During the heat rejection enthalpy decreases so

Heat rejected by the condenser = $h_2 - h_3$

$Q_{rej} = (h_2 - h_3)$

Process 3 – 4: - In condenser heat rejection of compressed refrigerant changes its state liquid from vapour. The change will occur when the working fluid i.e. refrigerant will lose its latent heat at that pressure. This liquid refrigerant is stored in liquid receiver and allowed to pass through expansion valve. During the passing of expansion valve the pressure of liquid refrigerant decreases. Pressure is directly proportional to temperature so the temperature of refrigerant falls down to its liquid temperature for that pressure. There is no work production during expansion.

Process 4 – 1: - Now the liquid refrigerant is passed to the evaporator for heat absorption. Evaporator is sealed from the atmosphere for maintaining temperature difference. The liquid refrigerant absorbs its latent heat and changes its form to vapour. The vapour refrigerant is again sent to compressor and the whole process repeats.

The cooling effect produces in this process because heat addition takes place.

Heat added to the refrigerant = $h_1 - h_4$

Q_{add} (Refrigerating Effect) = $(h_1 - h_4)$

Hence

$$C.O.P = \frac{\text{refrigerating effect}}{\text{work done}}$$

$$C.O.P = \frac{(h1 - h4)}{(h2 - h1)}$$

4. DESIGN OF REFRIGERATOR CUM BICYCLE

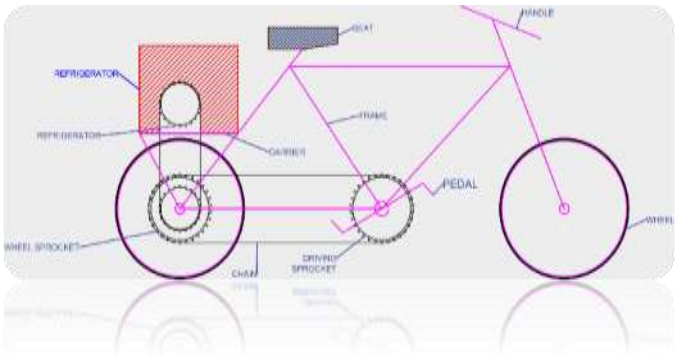


Fig: Schematic diagram of Refrigerator cum Bicycle

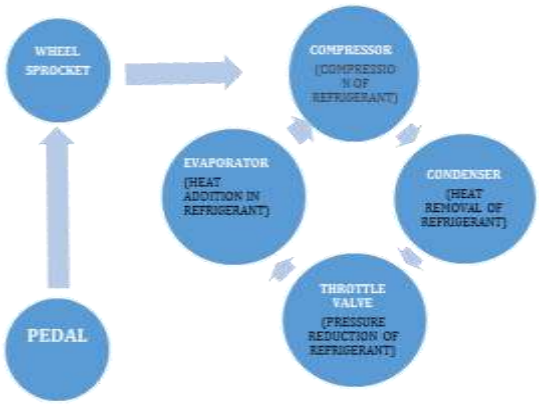


Fig: Line Diagram of Refrigerator cum Bicycle

5. DESIGN OF REFRIGERATION SYSTEM

- **Compressor**

  The compressor is the heart of the refrigeration system so the compressor required should be of high pressure.

  Specification
  Number of cylinder = 1
  Stroke length = 2 cm
  Bore Diameter = 2 cm
  Volume = 6.28 cm^3
  Pressure Ratio = 8:1

- **Condenser**

  Condenser is the heat rejecter. The heat may be rejected in form of conduction, convection or radiation. There is a chance of more energy loss if a water cooled system is used also the use of forced convection may increase the work load. A condenser of copper is used.

  Specification

  Material = Copper (Cu)
  Thermal conductivity = 399 W/mk
  Diameter of tube = 5mm
  Thickness of tube = 0.5 mm
  Length of tube = 8000mm

- **Throttle valve**

  Throttle valve decreases the pressure without increasing its velocity so a capillary tube is used for this purpose.

  Specification
  Diameter of tube = 0.8 mm
  Length of tube = 2.8 m

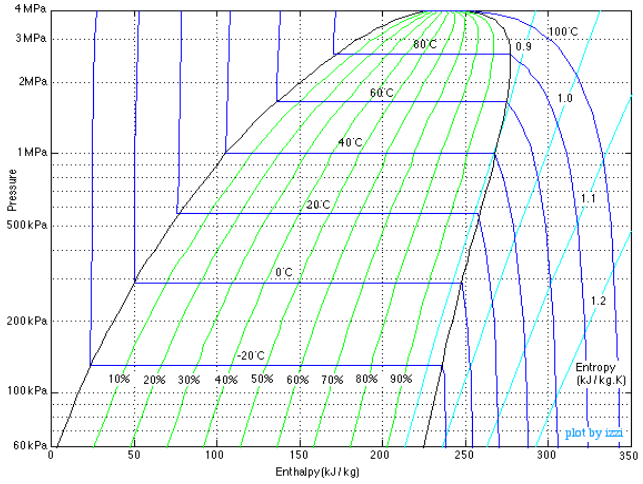
- **Evaporator**

  Evaporator absorbs the heat from the object put inside and transfer it to refrigerant.

  Specification
  Length = 56 cm
  Width = 19 cm
  Height = 30 cm

- **Refrigerant**

  Refrigerant is responsible for cooling of evaporator so refrigerant of good conductivity should be used.



Specification

Name = Freon (Tetrafluoroethane) (R-134a)
Chemical Formula = CH_2FCF_3
Density = 0.00425 g/cm^3
Melting point = -103.3 ^0C

Boiling point = -26.3 ^{0}C
γ = 1.13

5.1 CALCULATIONS

Inlet condition of refrigerant at compressor:

Temperature = 20^{0}C = 293 k, Pressure = 100 kPa

From the chart inlet Enthalpy h_1 = 275 kJ/kg

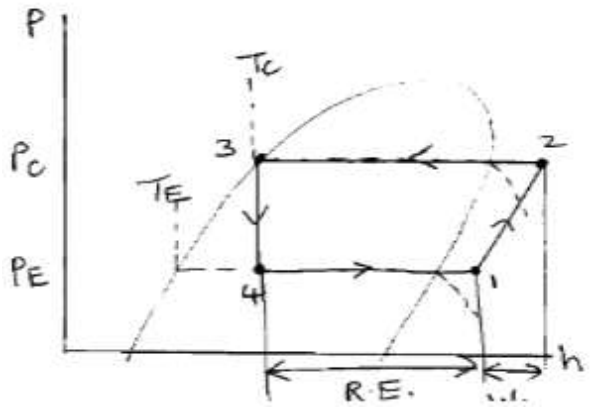


Fig: Pressure-Enthalpy curve

Outlet condition of refrigerant from compressor

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{\gamma-1}{\gamma}}$$

$$T_2 = 293\left(\frac{8}{1}\right)^{\frac{1.13-1}{1.13}}$$

T_2 = 373 K = 100 °C

Enthalpy from chart h_2 = 340 kJ/kg

Now work done on the compressor

$P_{compressor}$ = 340 – 275= 65 kJ/kg

Heat rejected in condenser Q_c = 340 – 90 = 250 kJ/kg (data from chart)

After heat rejection enthalpy h_3 = 90 kJ/kg

Now after expansion the refrigerant again comes to normal pressure 1 bar

So
temperature after expansion (at constant enthalpy) = -24 °C

Heat absorbed in evaporator i.e. cooling effect produced in evaporator

= 230 – 90
= 140 kJ/kg

Ideal C.O.P = $\frac{140}{340-275}$ = 2.15

6. CONCLUSION

The requirement to develop a potable refrigerator is fulfilled. It also helps for health like cycling is an excersize and during cycling the refrigerator will also work on. We can get cooled water during travelling also carry some fruits for consumption. There is no conversion of energy so more efficient also require less energy to operate. Finally a good try to make a portable and negligible cost refrigerator. It is not only for water but vegetables, fruits also that makes it more important in daily life use. Due to some losses like pressure drop in condenser, heat leakage in evaporator, piston leakage etc, it do not provide the calculated temperature drop. It takes about 12 minutes for temperature drop of 1 degree of 1 kg water. Further modification can give best result.

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