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A CAR AIR-CONDITIONING SYSTEM BASED ON AN ABSORPTION REFRIGERATION CYCLE USING SOLAR ENERGY

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ABSTRACT
The main purpose of this paper is to design and study an environment friendly vapour absorption refrigeration system of 0.2 TR capacity using ammonia (R-717) and water as the working fluids. In sunny days (summer season) vehicles becomes too much warm within a few hours and that heat is not sustained. So, we design theoretically to remove this excess heat using solar power vapour absorption system without any environmental pollution caused by the heating system as well as causing a lower global warming. The system is designed and tested for various operating conditions using hot water as heat source. The basic idea of this paper is derived from the solar heating panel installed on car roof. The main components of the absorption cycle were designed and fabricated for optimal performance. The system was found to be applicable and ready to produce the required conditioning effect without any additional load to the engine.

Keywords: *Solar energy, Absorption Refrigeration System, Car Specification, Cop etc.*

I. INTRODUCTION
In vapour absorption refrigeration system, physiochemical process replaces the mechanical process of the vapour compression system by using energy in the form of heat rather than mechanical work. The main advantage of this system lies in possibility of utilizing energy from exhaust a sofvehicle and alsousinganeco-friendly refrigerant such as water. The vapour absorption system has many favorable characteristics; typically a much smaller electrical input is required to drive the solution pump as compared to the power requirement of the compressor in the vapour compression system. Also, few moving parts mean lower noise level, higher reliability and improved durability in vapour absorption system. The solar panel is made from bendy materials which can fit perfectly on any vehicle rooftop, giving it a sleek appearance. It also serves as a good thermal insulation for the interior and other valuable equipments inside the vehicle.

Idling not only pollutes the air, but is also bad for the engine as it may contaminate engine oil and accelerate the deterioration of engine components due to higher operational temperature and unnecessary prolonged operation. According to recent statistics, leaving a vehicle on idle for as short as 10 minutes a day will consume an average of 100 litres of petrol in one year. In other words, adopting our SAV can help save drivers' petrol and fuel cost.

II. SYSTEM DESCRIPTION
Some liquids like water have great affinity for absorbing large quantities of certain vapors (NH3) and reduce the total volume greatly. The absorption refrigeration system differs fundamentally from vapor compression system only in the method of compressing the refrigerant. An absorber, generator and pump in the absorption refrigerating system replace the compressor of a vapor compression system. Figure shows the schematic diagram of a vapor absorption system. Ammonia vapor is produced in the generator at high pressure from the strong solution of by an external heating source. The water vapor carried with ammonia is removed in the rectifier and only the dehydrated ammonia gas enters into the condenser. High pressure vapour is condensed in the condenser. The cooled solution is passed through a throttle valve and the pressure and temperature of the refrigerant are reduced below the temperature be maintained in the evaporator. The low temperature refrigerant enters the evaporator and absorbs the required heat from the evaporator and leaves the evaporator as saturated vapor.

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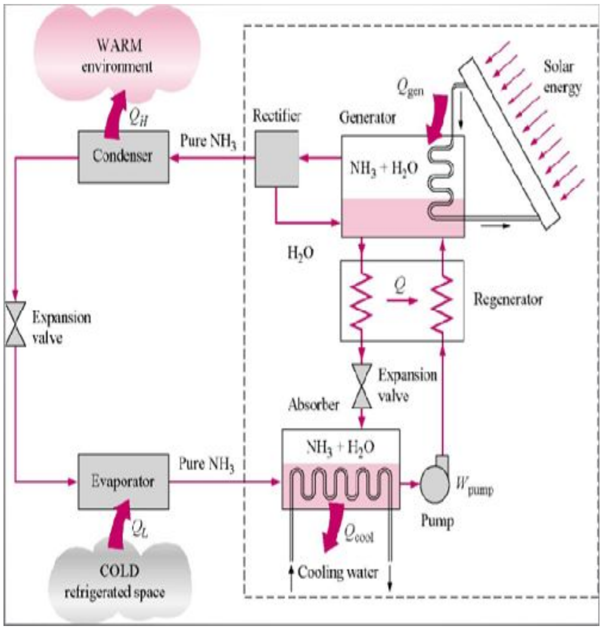

Fig. solar vapour absorption refrigeration system

Slightly superheated, low pressure vapor is absorbed by the weak solution of which is sprayed in the absorber as shown in figure. Weak solution (aqua–ammonia) entering the absorber becomes strong solution after absorbing vapor and then it is pumped to the generator through the heat exchanger. The pump increases the pressure of the strong solution to generator pressure. The strong solution coming from the absorber absorbs heat form high temperature weak solution in the heat exchanger. The solution in the generator becomes weak as vapour comes out of it. The weak high temperature ammonia solution from the generator is passed to the heat exchanger through the throttle valve. The pressure of the liquid is reduced to the absorber pressure by the throttle valve.

III. NECESSARY DESIGN DATA FOR TONNE OF REFRIGERATION REQUIRED FOR A "TOYOTA KIJANG INNOVA 2.4 Q CAR":

Overall dimensions

- Overall length 4,735 mm
- Overall height 1,830 mm
- Wheel base 2,750 mm
- Overall width 1,830 mm

The necessary data that must be considered in car air-conditioning system design include.

- Occupancy data
- Dimensions and optical properties of glass
- Outside weather conditions
- Dimensions and thermal properties of materials in bus body
- Indoor design condition.

IV. MATHEMATICAL PROCEDURE FOR SYSTEM DESIGN

The operating condition at which the system works, it should be necessary to determine the pressure and the corresponding temperature by using enthalpy concentration chart. After determining the condenser pressure and evaporator pressure and corresponding temperature can be fixed on the enthalpy concentration chart as shown in figure. The various other points and condition lines for different parts of the system such as absorber, generator, heat exchangers etc can be determined and subsequently fixed on the chart.

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A. Condenser Pressure (Pc)

The condensing medium is used for phase change inside the condenser as water at a temperature 26°C and corresponding to this temperature find the value of condenser pressure from refrigeration table of ammonia. The pressure at this temperature is fixed at 10.34 bar.

B. **Evaporator pressure (Pe)**

The evaporator pressure can be fixed as atmospheric pressure because at higher pressure it is difficult to maintain the system and also costly. Moreover it also has leakage problem. So, according to design economy the evaporator pressure is maintain at atmospheric pressure (1 bar) and the corresponding temperature is -33 °C.

Now, by using the pressure enthalpy chart of ammonia find the value of enthalpies corresponding to these pressures marking as a point 1, 2, 3 and 4 on the chart.

h1= 1627 KJ/Kg

h2= h3= 465 KJ/Kg (due to throttling process, constant enthalpy)

h4= 1530 KJ/Kg

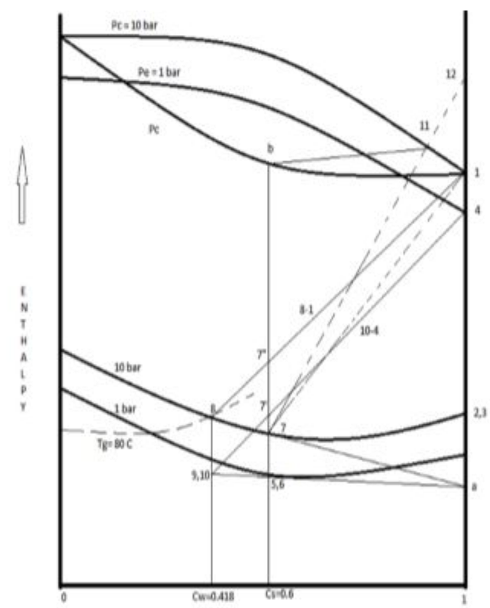

Fig. enthalpy-concentration chart

Now, let us assume that the refrigeration capacity of the unit to be 0.2 TR.
Refrigeration effect = –
Mass flow rate of ammonia is.
Therefore,
× – = 0.2TR
× (– = 0.2×210 KJ/min.
× (1530 – 465) = 42
= 0.04 Kg/min.
Therefore, mass flow rate of ammonia inside the evaporator is:
= 0.04 Kg/min.
The temperature Of inside the generator is more than 85°C which is comes from solar water heater but we are taking 80°C due to some losses in the chart point 8 intersect the pressure line 10.3 bar. This intersecting point gives the value of concentration of weak solution. The value of Cw = 0.421 from the enthalpy concentration chart. After

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finding the value of concentration of weak solution then the value of concentration of strong aqua solution coming out from evaporator is determined by degasifying factor as point 5 on chart i.e = Cw + 0.04 = 0.461.If one time point 8 is fixed then point 5 automatically fixed.

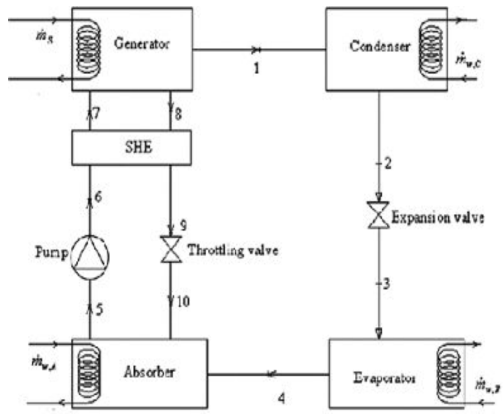

Fig. Flow of refrigerant at different states in the system

When strong aqua solution passes through the pump from evaporator to condenser then its pressure increases but the concentration is same as the point 5 and name as the point 6 i.e = = 0.461. When the strong low aqua solution passing through heat exchanger it gain heat so enthalpy of this point will rise but there is no effect on concentration and pressure Pc and mark this point as 7 on the enthalpy concentration chart.

Now join the point 7 and 8 and extend line from right side and cut the Y axis at the point 'c' after we will draw the line between point 5 and c and extend from left side to cut the vertical line of Cw and point 8 at the point 9 and 10. When it passes through pressure reduction valve reduce pressure (Pe) but enthalpy will be same, so point10 and 9 at same point.

C. Absorber

In the absorber week solution coming at condition 10 and pure ammonia comes at condition 4 after both are mixing strong aqua solution comes out at condition 5. Now draw the line between point 4 and point 10 and extend the vertical line passing through point7 till it cut at point 7''.

D. Generator

In the generator, the strong aqua solution entered in the generator at condition 7 and vapour comes at point 1 and ammonia and week aqua at condition 8 in the generator strong aqua is heated by supplying the heat Qg. Now draw line between point 1 and 8 and extend the vertical line through point 7 at the line 1-8, point 7'' will be marked.

V. CALCULATION

Mass flow rate of refrigerant ammonia = 0.04 Kg/min.
Refrigeration effect = 42 KJ/min. is equal to heat removed in evaporator.
Now, the mass flow rate of cold water = ΔT = 42 if ΔT = 18°C
Then = 0.55 Kg/min.
Heat removed in condenser, = × (– = 0.04 × (1530 – 465)
= 42.6 KJ/kg
Heat remove in absorber is Qa = (h7''– h5) per kg of aqua the tringle 10-7''-5 towards right till 10-7''cut at 4 and 10-5cutsatpoint 'a' on x axis then,
Qa = Mr (h4 -ha)
= 0.04 (1530 –70)
= 58.4 KJ/min.
In absorber, the rate flow of cooling water is equal to
ΔT = 58.4
= 58.4

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= 0.26 Kg/min.
Heat given in the generator
Let is the heat supplied in the generator and is the heat removed from water vapour then the net heat removed per kg of aqua is given by –= (h7' – h7) per kg of aqua as the aqua goes out in at condition 7 and comes out at condition 8 and 1, which can be considered as a combined condition 7'.Then draw a horizontal line through c which cuts Pc line in vapour region at point 11. Then join the points 7 and 11 and extend the line till it cuts y axis at 12.
Then is given by
= () per kg of ammonia
= 0.04 × (1760 –1627)
= 5.32 KJ/min
Now, = ()
– 5.32= 0.04× (1627 – 70)
67.6 KJ/min.
So, heat emits from the solar water heater is 67.6 kJ/Min. The temperature of the hot water coming out from the flat plate collector is assuming 80°C.

VI. SIZE CALCULATION OF SOLAR COLLECTOR

Energy absorbed by the solar collector
Q = K × S × A
K= efficiency of collector plate (assume k=0.85)
S = average solar heat falling on earth's surface = 6 kw- hr//day= 250 W/
A = Area of collector plates
Now, required area of solar collector = (67.6 × 1000 / 60) ÷ (250×0.85) =5
So, total area of solar collector plate
A = 5

VII. COP OF THE SYSTEM

The cop of refrigerating unit is defined as ratio of refrigerating effect to the heat supplied in generator, i.e
Cop = refrigerating effect / heat supplied in the generator
= 42/67.6 = 0.62

Now, the COP of the complete system (including solar water heater) is determined by
Cop = net refrigeration effect / heat input at solar collector
Heat input at the collector = Solar constant X area
= 250 X 5
= 1250 W
= 75 KJ/min
Cop = 42/75 = 0.56

Therefore, theoretical COP of the whole system comes out to be 0.56.

VIII. RESULTS AND CONCLUSION

Design of air conditioning system in automobiles is done successfully for TOYOTA car. The parameters of the bus are 15.86 cu.metre. The TOYOTA KIJANG INNOVA 2.4 Q CAR considered is having Comfortable application. The aim of the Project is achieved by the designing. The heat input required to run the 0.2TR vapour absorption refrigeration system is about 67.6 KJ/min. This required heat in the generator is supplied by the hot water coming from the solar flat plate water heater. The result for this system is described in brief as:

- Mass flow rate of cold water = 0.55 Kg/min
- Condenser pressure = 10.3 bar
- Evaporator pressure = 1 bar
- Heat input required = 67.6 KJ/min
- Output temp of water from solar heater = 85°
- COP of refrigeration unit = 0.62
- COP of the whole system (including solar collector) = 0.56

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Therefore, during summer season solar potential is very high which is used to derive a solar refrigeration system for the vehicle. It is very helpful to reduce the environmental pollution and global warming.

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