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RESEARCH ARTICLE

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OPTIMIZATION OF CAR AIR CONDITIONING SYSTEM USING ENERGY FROM EXHAUST GASES

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ABSTRACT

Due to the international attempt to find alternative energies, absorption refrigeration has become a prime system for many cooling applications. Where thermal energy is available the absorption refrigerator can very well substitute the vapour compression system. It is a well-known fact that a large amount of heat energy associated with the exhaust gases from an engine is wasted. A rough energy balance of the available energy in the combustion of fuel in a motor car engine shows that one third is converted into shaft work, one third is lost at the radiator and one third is wasted as heat at the exhaust system. Even for a relative small car-engine, 15 kW of heat energy can be utilized from the exhaust gas. This heat is enough to power an absorption refrigeration system to produce a refrigeration capacity of 5 kW. In this thesis, energy from the exhaust gas of an internal combustion engine is used to power an absorption refrigeration system to air-condition an ordinary passenger car. In this thesis an absorption refrigeration system is designed and parts of the refrigeration system are analyzed. Modeling is done in Pro/Engineer and analysis is done in Ansys. Thermal analysis is done on condenser and evaporator using different materials Copper, Aluminum alloy 204, Brass and Stainless Steel.

Key words: Cooling Fluid, Cylinder fins, Aluminum Alloy 204, Aluminum Alloy 6061, Magnesium

INTRODUCTION

INTRODUCTION TO AIR CONDITIONING

Air conditioning is the process of altering the properties of air (primarily temperature and humidity) to more favorable conditions. More generally, air conditioning can refer to any form of technological cooling, heating, ventil An air conditioner (often referred to as air con, AC or A/C, and not to be confused with the abbreviation for alternating current) is a major or home appliance, system, or mechanism designed to change the air temperature and humidity within an area (used for cooling and sometimes heating depending on the air properties at a given time). The cooling is typically done using a simple refrigeration cycle, but sometimes evaporation is used, commonly for comfort cooling in buildings and motor vehicles. In construction, a complete system of heating, ventilation and air conditioning is referred to as "HVAC".

EXPERIMENTAL IC ENGINE

In an IC engine, fuel (usually petrol or diesel) is combusted inside the cylinder due to which the piston moves outward and rotates the crank, and hence the engine produces work. In IC engines the combustion of the fuel produces heat, which is converted to mechanical work using the piston and crank arrangement. From the heat produced from combustion of fuel only 30% (approx) of heat is converted into useful mechanical work. The remaining heat energy is wasted into the atmosphere in the form of:

(i) Heat carried away by the cooling water,
(ii) Heat taken away by the exhaust gases,
(iii) Heat carried away by the lubricating oil,
(iv) Heat lost by radiation.

The cooling water and exhaust gases carry away the maximum amount of heat from the engine, i.e. around 60% (approx). This heat is called the low grade energy of the engine.

THE ENGINE

Let us consider an engine of an automobile on which the vapour absorption refrigeration system is to be implemented.

Engine parameters

The IC engine based on which the calculations are done is

- Make - Hindustan Motors
- Model - Ambassador
- No of cylinders, n = 4.
- Power, P = 60 bhp at 2000 rpm.
- Capacity, V = 1717cc.
- No of strokes = 4.
- Fuel used = diesel.
- Air-fuel ratio, A/F =15:1

WASTE HEAT OF THE ENGINE

The main two areas through which the heat is exhausted into the atmosphere from the engine are the cooling water and the exhaust gases. It is necessary to calculate the amount of heat energy carried away by the exhaust gases and the cooling water.

Exhaust gas heat

Mass flow rate air into the cylinder,

$m_a = VN\,E_{vo}i/2$

flow rate of fuel,

$m_f = m_a/(A/F \text{ ratio})$

Flow rate of exhaust gas

$m_e = \mathbf{m_a} + \mathbf{mf}$

Heat available at exhaust pipe

$Qe = m_e Cp_e(te-t_a)$

Cooling water heat

Heat carried away by cooling water

$Q_w = m_w Cp_w\,(t_{CO}-t_c i)$

FINAL VALUES

To produce 0.5 TR inside the automobile cabin it is required to have

(a) mass flow rate of refrigerant, **m_r = 0.71 gm/s**

(b) mass flow rate of strong solution from absorber generator, **m_g = 8.804 gm/sec**

(c) mass flow rate of weak solution from generator to absorber, **m_a = 8.094 gm/sec**

(d) Co-efficient of Performance, **COP = 0.2**

DESIGN

Designing involves developing each components of the system that has to be installed on to the automobile to produce the required cooling effect which involves generator, condenser and evaporator

Design of pre-heater

Outside Diameter of the tube, **D_0 = 0.012 m**

Inside Diameter of the tube, **Dj = 0.01 m**

Length of the tube, **L =2m**

Design of generator

Outside Diameter of the exhaust gas tube, **D_0** = 0.04 **m**

Taking inside diameter of the exhaust gas tube, **D_i** = 0.038 **m**

Length of the tube required for the required heat transfer, **L = 1 m**

Design of condenser

Dimensions of the designed condenser

Diameter of the tube, **d = 0.018 m** Thickness of the tube, **a = 0.005 m** Length of the tube, L = 7**.45 m**

Design of Evaporator

Outside Diameter of the tube, **D_0** = 0.01 **m** Inside Diameter of the tube, **Dj** - 0.008 **m** Length of the tube, L = **6.26 m**

Design of absorber

Outside diameter of the absorber, D_0 = 76 mm Total length of the absorber, L = 205 mm Outer diameter of the fins, Df = 109 mm No. of fins, n = 7

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ASSEMBLY OF VAPOUR ABSORPTION SYSTEM

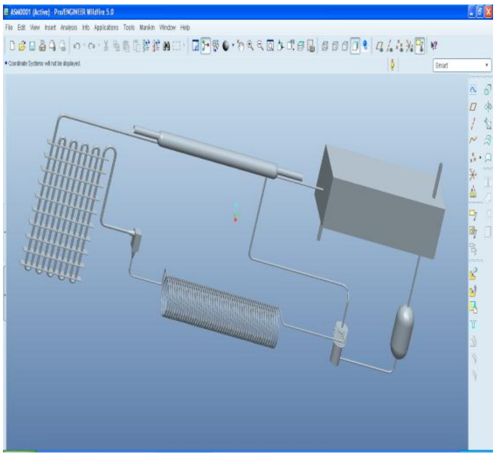

Fig 2.1 Vapour absorption system

2D DRAWINGS

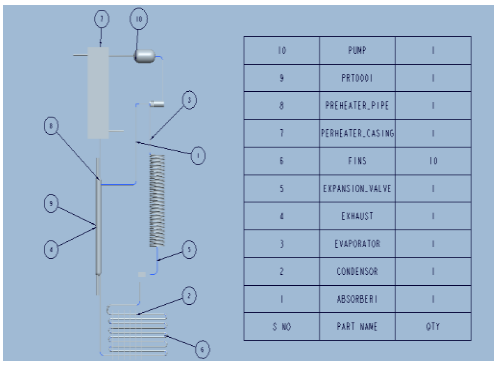

Fig 2.2 2D- Drawing of Vapour absorption system

THERMAL ANALYSIS OF CONDENSER

BRASS

Material Properties:

Thermal Conductivity – 200 W/mK

Specific Heat – 350 J/Kg K

Density - 0.00000850 Kg/mm^3

Nodal temperature

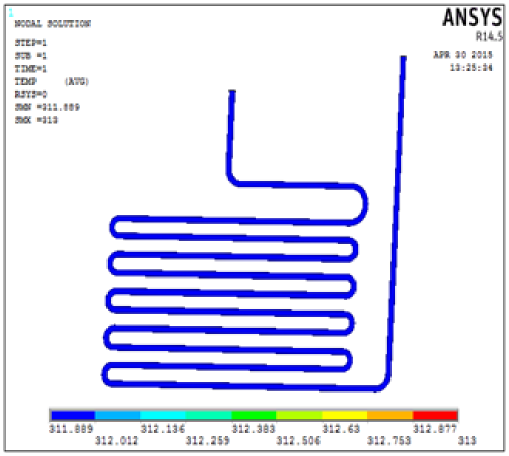

Fig 2.3 Nodal temperature of Condenser

Thermal Gradient

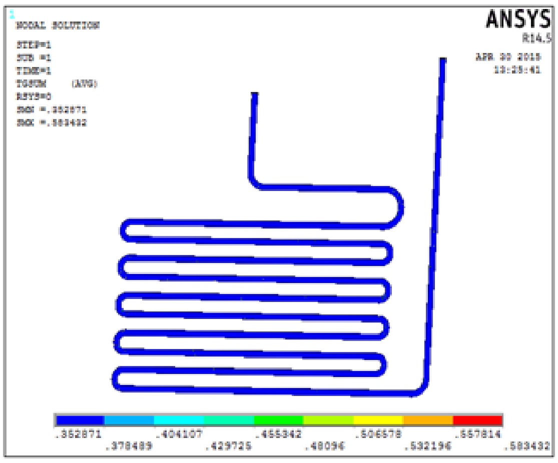

Fig 2.4 Thermal Gradient of Condenser

Thermal Flux

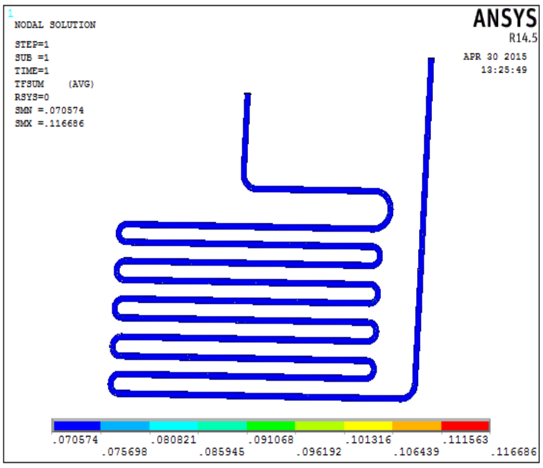

Fig 2.2 Thermal flux Condenser

EVAPORATOR

BRASS

Nodal Temperature

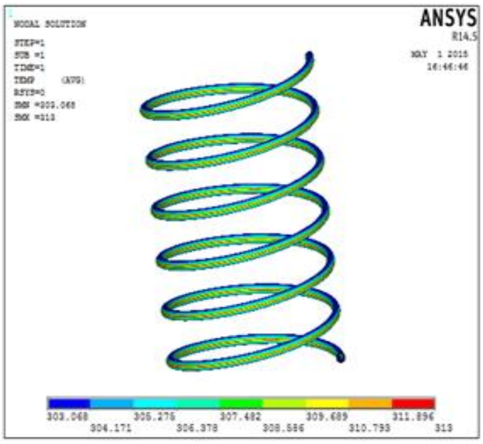

Fig 3.1 Nodal temperature of evaporator

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	Temperatur e (K	Thermal gradient (K/mm)	Heat Flux (W/mm^2)
Coper	313	0.308508	0.118776
Aluminium-204	313	0.768531	0.11528
Brass	313	0.583432	0.116686
Stainless Steel	313	0.577865	0.116729

Thermal Flux

Thermal Gradient

CONDENSER

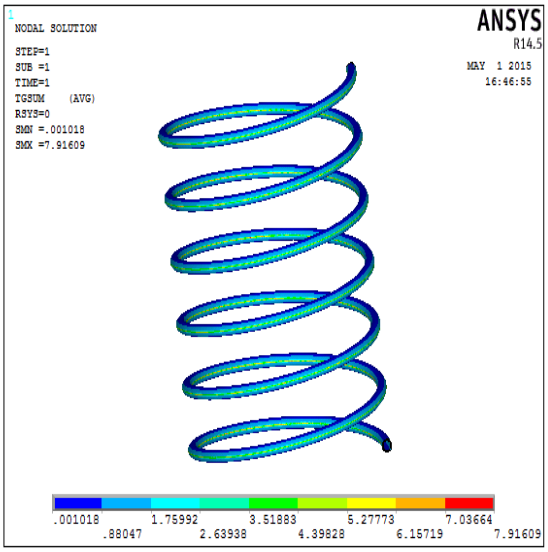

Fig 3.2 Thermal Gradient of evaporator

EVAPORATOR

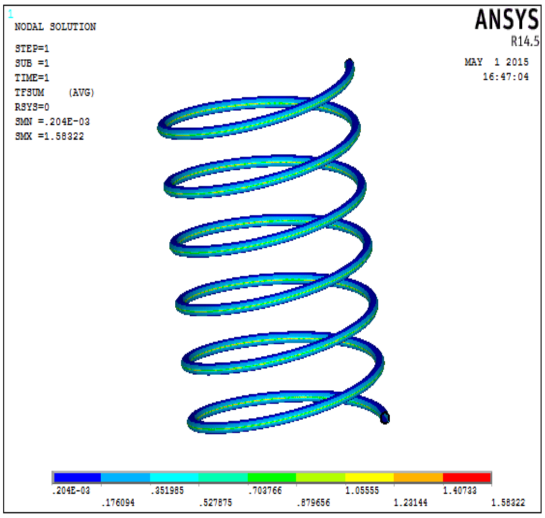

Fig 3.3 Thermal flux of evaporator

RESULT TABLE

	Temperature (k)	Thermal gradient(Kg/mm)	Heat Flux (W/mm^2)
Copper	313	4.6619	1.79483
Aluminium-204	313	9.77183	1.46577
Brass	313	7.91609	1.58322
Stainless Steel	313	7.91609	0.557693

CONCLUSION

In the exhaust gases of motor vehicles, there is enough heat energy that can be utilised to power an air -conditioning system. Therefore, if air -conditioning is achieved without using the engine's mechanical output, there will be a net reduction in fuel consumption and emissions.

Once a secondary fluid such as water or glycol is used, the aqua-ammonia combination appears to be a good candidate as a working fluid for an absorption car air-conditioning system. This minimises any potential hazard to the passengers.

The low COP value is an indication that improvements to the cycle are necessary. A high purity refrigerant would give a higher refrigeration effect, while the incorporation of a solution heat exchanger would reduce the input heat to the generator. The present system has both a reflux condenser and a heat exchanger.

However, the reflux condenser is proved inadequate to provide high purity of the refrigerant and needs to be re-addressed. The evaluation of the COP, with and without the heat exchanger also proves that unless there is a high purity refrigerant, the effect of the heat exchanger to the generator's heat is small.

In this project a pre heater, condenser, generator, evaporator, absorber for required capacity are designed by using theoretical calculations. Thermal analysis is conducted on condenser and evaporator by using materials copper, aluminum alloy 204, Brass and Stainless steel y using refrigerant water ammonia mixture.

By observing the analysis results, thermal flux is more for Copper or both so heat transfer rate is more for both condenser and evaporator.

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