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Fabrication of Refrigeration Using Engine Waste Heat

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ABSTRACT

This work deals with the modelling and the animation of exhaust heat driven vapour absorption refrigeration system. The refrigerating units currently used in road transport vehicles are of Vapour Compression Refrigeration system (VCRS). This system utilizes power from the engine shaft as the input power to drive the compressor of the refrigeration system, hence the engine has to do extra work to run the compressor of the refrigerating unit, thus utilizing extra amount of fuel. This loss of power of the vehicle for refrigeration can be neglected by utilizing another refrigeration system i,e. a Vapour Absorption Refrigeration System (VARS).It is well known that an IC engine has an efficiency of about 35-40%, which means that only one-third of the energy in the fuel is converted into useful work and about 60-65% is wasted to environment. In which about 28-30% is lost by cooling water and lubrication losses, around 30-32% is lost in the form of exhaust gases and remaining by radiation, etc. In vapor Absorption Refrigeration System, a physicochemical process replaces the mechanical process of the Vapour Compression Refrigeration System by using energy in the form of heat rather than mechanical work. The heat required for running the Vapour Absorption Refrigeration System can be obtained from that which is wasted into the atmosphere from an IC engine. In this project we created 3D model &Animation is done by CREO 1.0 Software.

INTRODUCTION

Refrigeration is the process of removing heat from an enclosed or controlled space or from a substance and moving it to a place where it is unobjectionable. The primary purpose of refrigeration is lowering the temperature of the enclosed space or substance and then maintaining that lower temperature as compared to the surroundings. Cold is the absence of heat, hence in order to decrease a temperature, one should "remove heat", rather than "adding cold."

The basic objective of developing a vapour absorption refrigerant system for cars is to

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cool the space inside the car by utilizing waste heat and exhaust gases from engine. The air conditioning system of cars in today's world uses "Vapour Compression Refrigerant System" (VCRS) which absorbs and removes heat from the interior of the car which is the space to be cooled and further rejects the heat to be elsewhere. Now to increase an efficiency of car beyond a certain limit vapour compression refrigerant system resists it as it cannot make use of the exhaust gases from the engine. In vapour compression refrigerant system, the system utilizes power from engine shaft as the input power to drive the compressor of the refrigerant system.

LITERATURE REVIEW

Andy Pearson (2008) selected ammonia which is widely used as a refrigerant in industrial systems for food refrigeration, distribution warehousing and process cooling. It has more recently been proposed for use in applications such as water chilling for air-conditioning systems but has not yet received widespread acceptance in this field. This review paper assesses the reasons why ammonia is so popular in industrial systems, the reasons why it is deemed less suitable for other applications and the possible benefits at local, national and international levels that might be gained by more general acceptance of ammonia as a refrigerant. The paper also considers other possible applications which might benefit from the use of ammonia as refrigerant.

Refrigeration is the process of removing heat from an enclosed space, or from a substance, and moving it to a place where it is unobjectionable. The primary purpose of refrigeration is lowering the temperature of the enclosed space or substance and then maintaining that lower temperature. The term cooling refers generally to any natural or artificial process by which heat is dissipated. The process of artificially producing extreme cold temperatures is referred to as cryogenics. Cold is the absence of heat, hence in order to decrease a temperature, one "removes heat", rather than "adding cold." In order to satisfy the Second Law of Thermodynamics, some form of work must be performed to accomplish this. This work is traditionally done by mechanical work but can also be done by magnetism, laser or other means.

Fired system. It also suggested that, with careful design, inserting the VAR system generator into the main engine exhaust system need not impair the performance of the vehicle propulsion unit. Acomparison of the capital and running costs of the conventional and proposed alternative system is made.

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COMPONENTS AND DESCRIPTION

IC ENGINE CONSTRUCTION

In this project we use SPARK IGNITION engine of the type two stroke single cylinder of Cubic capacity 75 cc. Engine has a piston that moves up and down in cylinder. A cylinder is a long round air pocket somewhat like a tin can with a bottom cut out. Cylinder has a piston which is slightly smaller in size than the cylinder the piston is a metal plug that slides up and down in the cylinder Bore diameter and stroke length of the engine are 50mm and 49mm respectively.

I.C ENGINE

Internal combustion engines are those heat engines that burn their fuel inside the engine cylinder. In internal combustion engine the chemicalengine energy stored in their operation.

The heatengine energy is converted in to mechanicalengine energy by the expansion of gases against the piston attached to the crankshaft that can rotate

PETROL ENGINE

The engine which gives power to propel the automobile vehicle is a petrol burning internal combustion engine. Petrol is a liquid fuel and is called by the name gasoline in America. The ability of petrol to furnish power rests on the two basic principles;

- Burning or combustions always accomplished by the production of heat.
- When a gas is heated, it expands. If the volume remains constant, the pressure rises according to Charlie’s law.

WORKING

There are only two strokes involved namely the compression stroke and the power stroke; they are usually called as upward stroke and downward stroke respectively.

Upward Stroke

During this stroke, the piston moves from bottom dead center to top dead center, compressing the charge-air petrol mixture in combustion chamber of the cylinder.

At the time the inlet port is uncovered and the exhaust, transfer ports are covered. The compressed charge is ignited in the combustion chamber by a spark given by spark plug

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ENGINE TERMINOLOGY

The engine terminologies are detailed below,

CYLINDER

It is a cylindrical vessel or space in which the piston makes a reciprocating motion.

PISTON

It is a cylindrical component fitted to the cylinder which transmits the bore of explosion to the crankshaft.

COMBUSTION CHAMBER

It is the space exposed in the upper part of the cylinder where the combustion of fuel takes place.

CONNECTING ROD

It inter connects the piston and the crankshaft and transmits the reciprocating motion of the piston into the rotary motion of crankshaft.

CRACKSHAFT

It is a solid shaft from which the power is transmitted to the clutch.

CAM SHAFT

It is drive by the crankshaft through timing gears and it is used to control the opening and closing of two valves.

CAM

These are made as internal part of the camshaft and are designed in such a way to open the valves at the current timing.

PISTON RINGS

It provides a tight seal between the piston and cylinder wall and preventing leakage of combustion gases.

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GUDGEON PIN

It forms a link between the small end of the connecting rod and the piston.

INLET MANIFOLD

The pipe which connects the intake system to the inlet valve of the engine end through which air or air fuel mixture is drawn in to the cylinder.

EXHAUST MANIFOLD

The pipe which connects the exhaust system to the exhaust valve of the engine through which the product of combustion escape in to the atmosphere.

DESIGN AND CALCULATIONS

SPECIFICATION OF TWO STROKE PETROL ENGINE

Type : Two stroke

Cooling System : Air Cooled Bore/Stroke
50 x 50 mm Piston Displacement

Compression Ratio : 6.6: 1

Maximum Torque : 0.98 kg-m at 5,500RPM 98.2 cc

CALCULATIONS

COMPRESSION RATIO = SWEPT VOLUME + CLEARANCE VOLUME
CLEARANCE VOLUME

Here,

Compression ratio = 6.6:1

$\therefore$ 6.6 = (98.2 + Vc)/Vc

Vc = 19.64

Assumption

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1. The component gases and the mixture behave like ideal gases.
2. Mixture obeys the Gibbs-Dalton law

Pressure exerted on the walls of the cylinder by air is P_1 $P_1 = (M_1RT)/V$
Here,

$M_1 = m/M$ = (Mass of the gas orair)/(Molecularweigt)

R = Universal gas constant = 8.314 KJ/Kg mole K.

T_1 = 303 ºK

V_1 = V = 253.28×10^{-6} m³

Molecular weight of air = Density of air x V mole

Here,

Density of air at 303ºK = 1.165 kg/m³

V mole = 22.4 m³/Kg-mole for all gases.

∴ Molecular weight of air = 1.165 x 22.4

$$\therefore \quad P_1 = \{[(m_1/ (1.165 \times 22.4)] \times 8.314 \times 303\}/253.28 \times 10^{-6}$$

$$P_1 = 381134.1\ m_1$$

Let Pressure exerted by the fuel is P_2 $P_2 = (N_2\ R\ T)/V$
Density of petrol = — 800 Kg/m³

$$\therefore \quad P_2 = \{[(M_2)/ (800 \times 22.4)] \times 8.314 \times 303\}/ (253.28 \times 10^{-6}$$

$$P_2 = LM324.02\ m_2$$

Therefore Total pressure inside the cylinder

PT = $P_1 + P_2$

= 1.01325 x 100 KN/m²

$\therefore$ 381134.1 m_1 + LM324.02 m_2 = 1.01325 x 100**(1)**

Calculation of air fuel ratio

Carbon = 86%

Hydrogen = 14%

We know that,

1Kg of carbon requires 8/3 Kg of oxygen for the complete combustion.

1Kg of carbon sulphur requires 1 Kg of Oxygen for its complete combustion.

(From Heat Power Engineering-Balasundrrum)

Therefore,

The total oxygen requires for complete combustion of 1 Kg of fuel

= [(8/3c) + (3H_2) + S] Kg

Little of oxygen may already present in the fuel, then the total oxygen required for complete combustion of Kg of fuel

= {[(8/3c) + (8H_2) + S] - O_2} Kg

As air contains 23% by weight of Oxygen for obtain of oxygen amount of air required

= 100/23 Kg

$\therefore$ Minimum air required for complete combustion of 1 Kg of fuel

= (100/23) {[(8/3c) + H_2 + S] - O_2} Kg

So for petrol 1Kg of fuel requires = (100/23) {[(8/3c) x 0.86 + (8 x 0.14)]}

= 14.84 Kg of air

$\therefore$ Air fuel ratio = m_1/m_2 = 14.84/1

= 14.84

$\therefore$ m_1 = 14.84 m_2 **(2)**

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Substitute (2) in (1),

1.01325 x 100 = 3.81134 (14.84 m_2) + LM324.02 m_2

$\therefore$ m_2 = 1.791 x 10^{-5} Kg/Cycle

Mass of fuel flow per cycle = 1.791 x 10^{-5} Kg cycle

Therefore,

Mass flow rate of the fuel for 2500 RPM [(1.791 x 10^{-5})/3600] x (2500/2) x 60

= 3.731 x 10^{-4} Kg/sec

Calculation of calorific value

By Delong's formula,

Higher Calorific Value = 33800 C + 144000 H_2 + 9270 S

= (33800 x 0.86) + (144000 x

0.14) +

0

HCV = 49228 KJ/Kg

Lower Calorific Value = HCV – (9H_2 x 2442)

= 49228 – [(9 x 0.14) x 2442]

= 46151.08 KJ/Kg

LCV = 46.151 MJ/Kg

Finding CP and CV for the mixture

We know that,

Air contains 77% N_2 and 23% O_2 by weight But total mass inside the cylinder = m_1 + m_2

= 2.65 x 10^{-4} + 1.791 x 10^{-5} Kg

= 2.8291 x 10^{-4} Kg

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Weight of nitrogen present = 77% = 0.77 Kg in 1 Kg of air

∴In 2.65 x 10^{-4} Kg of air contains,

= 0.77 x 2.65 x 10^{-4} Kg of N_2

= 2.0405 x 10^{-4} Kg

i. Percent of N_2 present in the total mass

= (2.0405 x 10^{-4}/2.8291 x 10^{-4})

= 72.125 %

ii. Percentage of oxygen present in 1 Kg of air is 23% Percentage of oxygen present in total mass

= (0.23 x 2.65 x 10^{-4})/(2.8291 x 10^{-4})

= 21.54 %

iii. Percentage of carbon present in 1 Kg of fuel 86% Percentage of carbon present in total mass

= (0.866 x 1.791 x 10^{-5})/(2.8291 x 10^{-4})

= 5.444%

iv. Percentage of Hydrogen present in 1 Kg of fuel 14% Percentage of Hydrogen present in total mass

= (0.14 x 1.791 x 10^{-5})/(2.8291 x 10^{-4})

= 0.886 %

Total Cp of the mixture is = ∑msiCpi

Cp = (0.72125 x 1.043) + (0.2154 x 0.913)

+ (0.54444 x 0.7) + (8.86 x 10^{-3} x 14.257)

Cp = 1.1138 KJ/Kg.K

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$Cv = \sum msiCvi$

$= (0.72125 \times 0.745) + (0.2154 \times 0.653)$

$+ (0.05444 \times 0.5486) + (8.86 \times 10^{-3} \times 10.1333)$

$=$ 0.8 KJ/Kg.K

(All Cvi, Cpi values of corresponding components are taken from clerks table)

n For the mixture $= (Cp/Cv)$

$= 1.11/0.8$

$n = 1.38$

Pressure and temperature at various PH

$P_1 \; T_1$ = 1.01325 x 100 bar

P_2/P_1 = 1.01325 bar 30ºC = 303 K

=

$(r)^{n-1}$

=

Where,

P_1 = 1.01325 bar

r = 6.6

n = 1.38

$\therefore P_2$ = 13.698 bar

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$T_2 = (r)^{n-1} \times T_1$

Where,

$T_1 = 303$ K

$\therefore T_2 = 620.68$ K

Number of Piston Rings

No. of piston rings = 2 x D½

Here,

D - Should be in Inches = 1.968 inches

∴ No. of rings = 2.805

We adopt 3 compression rings and 1oil ring **Thickness of the ring**

Thickness of the ring = D/32

= 50/32

= 1.5625 mm

Width of the ring

Width of the ring = D/20

= 2.5 mm

The distance of the first ring from top of the piston equals

= 0.1 x D

5 mm Width of the piston lands between rings

= 0.75 x width of ring

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= 1.875 mm

Length of the piston

Length of the piston = 1.625 x D

Length of the piston = 81.25 mm

Length of the piston skirt = Total length – Distance of
rings x ring x

The first ring (No. of landing
between
Width of land) – (No. of
compression Width of ring)

= 81.25 – 5 – 2 x 1.875 –3 x 2.5

= 65 mm

Other parameters

Centre of piston pin above the centre of the skirt =
0.02 x D

= 65 mm

The distance from the bottom of the piston to the
Centre of the piston pin = ½
x 65 + 1

= 33.5 mm

Thickness of the piston walls at open ends = ½ x 12

= 6 mm

The bearing area provided by piston skirt = 65 x 50

= 3250 mm^2

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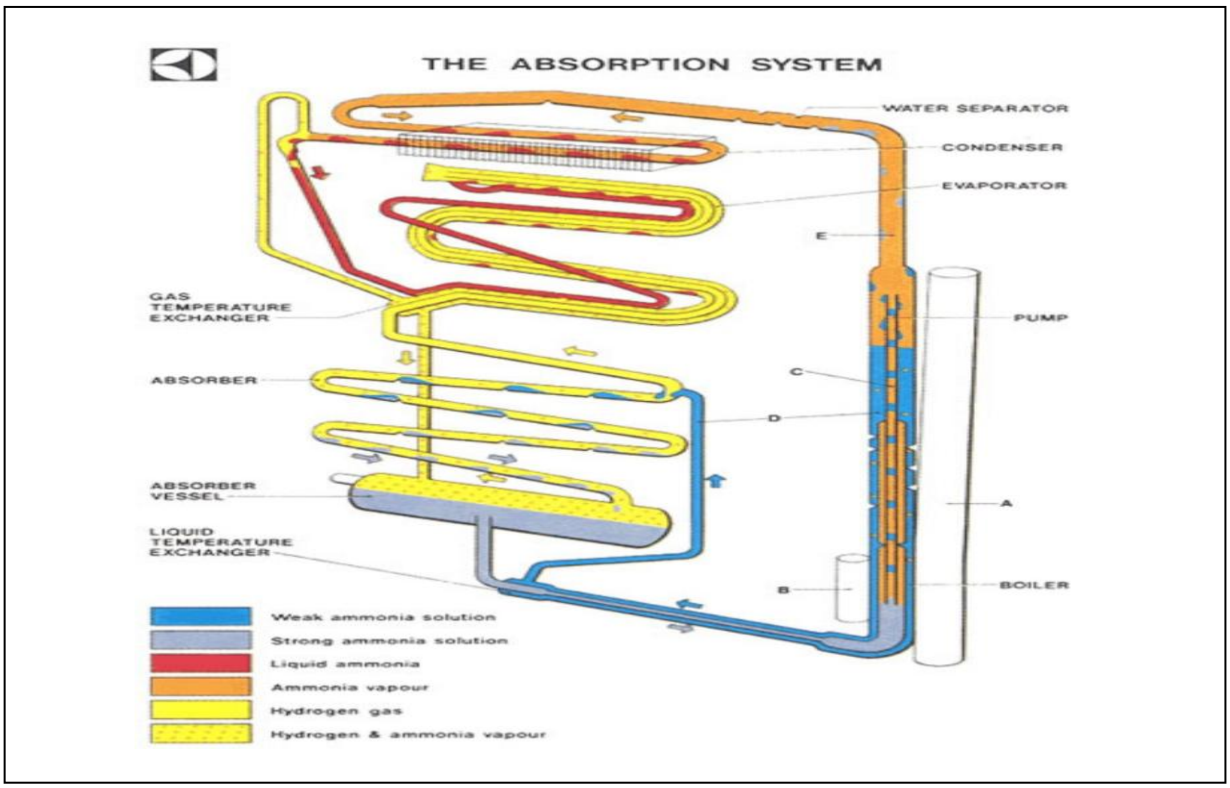
WORKING PRINCIPLE

The continuous absorption type of cooling unit is operated by the application of a limited amount of heat furnished by exhaust gas. No moving parts are employed.

The unit consists of four main parts - the boiler, condenser, evaporator and the absorber. The unit can be run on waste exhaust gasheat. When the unit operates on the exhaust gas, the heat is supplied by the exhaust gas which is fitted underneath the central tube (A) and when the unit operates on electricity the heat is supplied by a heating element inserted in the pocket (B).The unit charge consists of a quantity of ammonia, water and hydrogen at a sufficient pressure to condense ammonia at the room temperature for which the unit is designed. When heat is supplied to the boiler system, bubbles of ammonia gas are produced which rise and carry with them quantities of weak ammonia solution through the siphon pump (C). This weak solution passes into the tube (D), whilst the ammonia vapour passes into the vapour pipe (E) and on to the water separator. Here the water vapor is condensed and runs back into the boiler system leaving the dry ammonia vapour to pass to the condenser. Air circulating over the fins of the condenser removes the heat from the ammonia vapour to cause it to condense into liquid ammonia which flows into the evaporator. The evaporator is supplied with hydrogen.



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CONCLUSION

This work has provided us an excellent opportunity and experience, to use our limited knowledge. We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work. We feel that the project work is a good solution to bridge the gates between the institution and the industries.