"Experimental Investigation on Measurement of Heat Recovery With Electrolux Refrigeration From C.I. Engine With Blending of Ethanol"

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Abstract- *Efficiency of diesel engine is much less. There are 31 to 33% of heat is loses in the environment by exhaust gases. This is generally creating pollution in the environment. And another side 20% of all the electricity produced in the world is used for Air-conditioning and refrigeration purpose, So all above reason vapor absorption refrigeration techniques have advantages that there is no use of electrical energy. and it can also operate with waste heat of the engine. So my aim is to measure the heat recovery from engine exhaust gases. This is used in vapour absorption refrigeration system.(Electrolux refrigeration system.)*

Keywords- Electrolux refrigerator, Heat recovery, IC engine

I. INTRODUCTION

It is well known that energy shortage and environmental pollution have become global issues of common concern. As the most widely used source of primary power for machinery critical to the transportation, construction and agricultural sectors, engine has consumed more than 60% of fossil oil. On the other hand, the amount of CO2 gas released from engine, just for transportation applications, makes up 25% of all human activity related CO2 emissions. Thus, energy conservation on engine is one of best ways to deal with these problems since it can improve the energy utilization efficiency of engine and reduces emissions.

Given the importance of increasing energy conversion efficiency for reducing both the fuel consumption and CO2 gas emissions of engine, scientists and engineers have done lots of successful research aimed to improve engine thermal efficiency, including supercharge, lean mixture combustion, etc. However, in all the energy saving technologies studied, engine exhaust heat recovery (EHR) is considered to be one of the most effective means and it has become a research hotspot recently.

II. DIESEL ENGINES

Improvement of fuel economy and reduction of exhaust gas and particulate emissions are key development items for automotive internal combustion engines. Diesel engines are typically more efficient than gasoline engines and therefore preferred for professional use like mail or food delivery operations where fuel economy is an important cost factor.

A diesel engine is an internal combustion engine which operates using the diesel cycle. Diesel engines have the highest thermal efficiency of any internal or external combustion engine, because of their compression ratio. Diesel engines are manufactured in two stroke and four stroke versions. The diesel internal combustion engine differs from the gasoline powered Otto cycle by using a higher compression of the air to ignite the fuel rather than using a spark plug for this reason it is known as compression ignition and the petrol engine is referred as spark ignition engine. In the diesel engine, only air is introduced into the combustion chamber. The air isthen compressed with a compression ratio typically between 15 and 22 resulting into a 40 bar pressure compared to 14 bar in the gasoline engine. This high compression heats the air to 550 °C. At about this moment (the exact moment is determined by the fuel injection timing of the fuel system), fuel is injected directly into the compressed air in the combustion chamber.

III. REFRIGERATION

The production of cold has applications in a considerable number of fields of human life, for example the food processing field, the air-conditioning sector, and the conservation of pharmaceutical products, etc. The conventional refrigeration cycles driven by traditional vapor compression in general contribute significantly in an opposite way to the concept of sustainable development. Two major problems have yet to bead dressed:

The global increasing consumption of limited primary energy: The traditional refrigeration cycles are driven by electricity or heat, which strongly increases the consumption of electricity and fossil energy. The International Institute of Refrigeration in Paris (IIF/ IIR) has estimated that approximately 15% of all the electricity produced in the whole world is employed for refrigeration and air-conditioning processes of various kinds, and the energy consumption for Air-conditioning systems has recently been estimated to 45% of the whole households and commercial buildings. Moreover, peak electricity demand during summer is being re-enforced by the propagation of air conditioning appliances.

The refrigerants used cause serious environmental problems: The traditional commercial, non-natural working fluids, like the chlorofluorocarbon (CFCs), the hydro chlorofluorocarbon (HCFCs) and the hydrofluocarbon (HFCs) result in both ozone depletion and/or global warming. Since the protocol of Montreal in 1987, international agreements have been signed to reduce the emissions of these refrigerants. European Commission Regulation 2037/2000, which has been implemented on 1 October 2000, treats the whole spectrum of control and phase-out schedule of all the ozone depleting substances. It is indicated that till 2015 all HCFCs will be banned for servicing and maintaining existing systems.

During recent years research aimed at the development of technologies that can offer reductions in energy consumption, peak electrical demand and energy costs without lowering the desired level of comfort conditions has intensified. By reason that absorption refrigeration technologies have the advantage of removing the majority of harmful effects of traditional refrigeration machines and that the peaks of requirements in cold coincide most of the time with the availability of the waste heat, the development of absorption refrigeration technologies became the worldwide focal point for concern again. Waste heat energy can be transformed either to electricity or to heat to power a refrigeration cycle. During the past decade, more interests have been paid to the waste heat-driven refrigeration technologies, especially absorption and adsorption systems.

The most common types of refrigeration systems are as follows:

(1) Vapor Compression Refrigeration (VCR)System
(2) Vapor Absorption Refrigeration (VAR) System

IV. ELECTROLUX REFRIGERATION SYSTEM

A single-pressure absorption refrigerator uses three substances: ammonia, hydrogen gas, and water. At standard atmospheric conditions, ammonia is a gas with a boiling point of -33°C. The system is pressurized to the point where the ammonia is liquid. The cycle is closed, with all hydrogen, water and ammonia collected and endlessly reused.

1. The cooling cycle starts with liquefied ammonia entering the evaporator at room temperature. The evaporated ammonia is mixed with hydrogen. The partial pressure of the hydrogen is used to regulate the total pressure, which in turn regulates the vapor pressure and thus the boiling point of the ammonia. As the ammonia boils in the evaporator, it pulls heat from the refrigerators interior and provides are the cooling is required in thissystem.

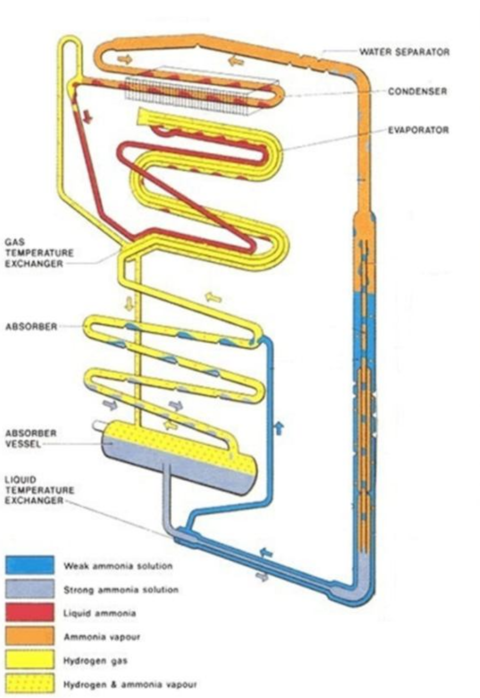

Figure 1 Electrolux Refrigeration system

V. EXPERIMENTAL SETUP

Experimental setup description:

The setup consists of single cylinder, four strokes IC Engines, with Electrical dynamometer for loading purpose. There are cooling water system is provided in the IC engine. Here fuel as a diesel and Ethanol blend (E20) is used. The Experimental setup is shown in a below figure. The setup enables study of engine performance for brake power, indicated power, frictional power, Brake thermal efficiency, Indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio, heat balance and combustion analysis. Here by using of E20 blending of ethanol there are no change in engine is needed. Here by changing the different load on engine the engine performance is measured. And based on performance reading graph is generated between different parameters of engine.

VI. ENGINE SPECIFICATION

No. of cylinder	Single cylinder
No. of stroke	4
Cylinder dia.	87.5 mm
Stroke length	110 mm
C.R. length	234 mm
Orifice dia.	20 mm
Dynamometer arm length	185 mm
Fuel	Diesel & ethanol blend.(E20)
Power	3.5 KW
Speed	1500 rpm
C.R. range	12:1 to 18:1
Inj. Point variation	0 to 25 Btdc

Table 1 Engine specification

VII. SPECIFICATION OF ELECTROLUX REFRIGERATOR

ELECTROLUX	
Model	RA 212 B
Prod. No.	9282624
Type	262A 4 Absorption system
Gross Volume	60L
Refrigerant NH3	1-2kg
Nominal voltage	220 V 50-60Hz
Nominal Current	0.41A
Nominal Input	95W

Table 2 Specification of Electrolux Refrigerator

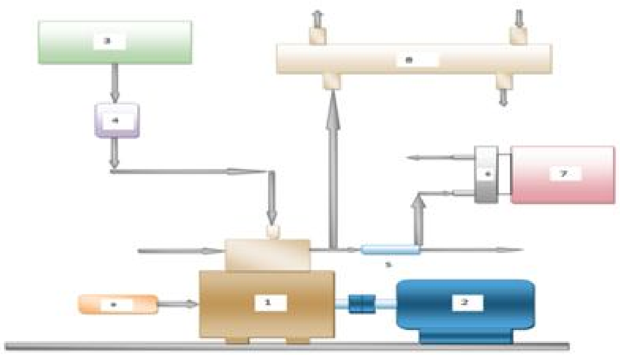

Figure: 2 Block diagram of experimental setup

VIII. SAMPLE CALCULATION FOR HEAT RECOVERY

The Reading of heat recovery is taken on the load on engine is 1kg, 5kg and 9kg accordingly. And rpm and fuel consumption accordingly this load is shown in observation table.

Mass flow rate of engine cooling water $(m_w)_{en}$ = 250 LPH(liter per hour)

$= 250 \times 10^{-3}/3600$ m^3/sec

$=(250 \times 10^{-3}/3600) \times$ density of water

$= (250 \times 10^{-3}/3600) \times 1000$ kg/sec

= 0.06944 kg/sec

Mass flow rate of calorimeter water $m_{wcal} = 4LPM$

$= (4 \times \frac{10^{-3}}{3600}) \times 1000$

m_{wcal} = 0.067 kg/sec

Mass of fuel consumed per unit time $\dot{m}_f = \frac{volume\ of\ fuel\ consume}{time\ taken} \times density\ of\ fuel$

$= \frac{10 \times 10^{-6}}{33.35} \times 825$

$= 2.4707 \times 10^{-4}$ kg/sec

= 0.000247 kg/sec

Heat supplied to the engine per unit time

$\dot{Q}_{in} = \dot{m}_f \times LCV$

$= 0.000252 \times 41874$

= 10.34 kW

Heat carried away by cooling water of the engine

$Q_{CW} = m_{cw} \times C_{pw} \times (T_2 - T_1)$

$= 0.02222 \times 4.187 \times (312 - 303)$

= 0.8373 kW

Heat carried away by exhaust gases

Heat loss by exhaust gases = heat gain by calorimeter water
(mg. x Cpg ΔT)exhaust =(mw .x Cpw ΔT)water
mg. X Cpg X (T5 - T6) = 0.067 X 4.186 X (T2 - T1)
mg. X 1.3 X (390-313) = 0.067 X 4.186 X (39 - 30)
mg = 0.0252 kg / sec
Heat energy available in exhaust gas = mg. x Cp x ΔT

$= 0.0252 \times 1.3 \times (360 - 42)$

= 10.41 kW

Heat gain by Heat exchanger =

$mg \times CP_g \times (1\text{-bypass factor}) \times \Delta T$

$= 0.025 \times 1.3 \times (1 - 0.6) \times (324 - 304)$

$= 393.12$ W

Heat gain by generator =

$\text{Heat gain by Heat exchanger} \times \text{Effectiveness of Heat Exchanger}$

$= 393.12 \times 0.5$

$= 196.56$ W

Water volume = 5 liter

Time = 110 min

Temperature, Ta=38 °C & Tb = 7.5 °C

Cooling effect $= 4.187 \times \text{water volume} \times (T_a - T_b)$

$= 4.187 \times 5 \times (38 - 7.5)$

$= 638.52$

Cooling effect in watt $= \frac{\text{Cooling Effect} \times 1000}{\text{Time Duration} \times 60}$ W

$= \frac{638.52 \times 1000}{110 \times 60}$ W

$= 96.74$ W

COP of refrigeration $= \frac{\text{cooling effect}}{\text{heat gain by generator}}$

$= \frac{96.74}{196.56}$

$= 0.4921$

Percentage of heat recovers $= \frac{\text{Heat gain by generator}}{\text{Heat energy available in exhaust gas} \times (1 - 0.6)}$

$= \frac{196.56}{10410 \times (1 - 0.6)}$

$= 0.0472$

$= 4.72\%$

VII. RESULT TABLE

Sr No.	Load (kg)	Brake power (kw)	Mass flow rate of exhaust gas (kg/s)	By pass factor	Heat gained by Heat Exchanger (W)	Effectiveness of Heat Exchanger	Heat gained by Generator	Cooling effect (W)	COP of refrigerator	% of heat recovery
1	1	0.31	0.040	0.3	124.8	0.5	62.4	64	1.032	0.015
2	5	1.48	0.041	0.3	214.4	0.5	107.3	77.29	0.342	1.72
3	9	2.64	0.0252	0.6	393.12	0.5	196.56	96.74	0.4921	4.72

IX. RESULT AND DISCUSSION

Heat loss in exhaust gas

Above all experimental data it is analyzed that ,heat loses in exhaust gases is depend on load means it is ultimately depend on engine brake power.

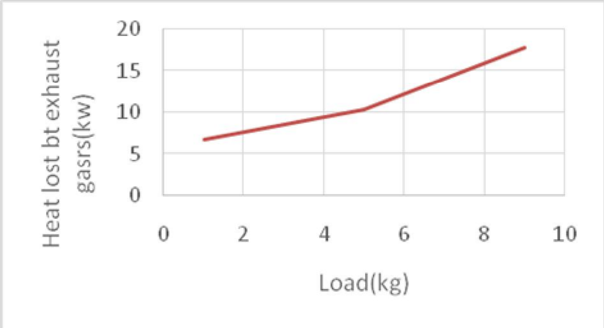

Figure:3 Variation in heat loss by exhaust gas with Load

Here graph shows that heat loses is increase with increase increase with load on the engine

Heat recovery

Here above all readings and mathematical calculation it is proved that % of Heat recovery is increased with load on the engine and it is proved by mathematical calculation.

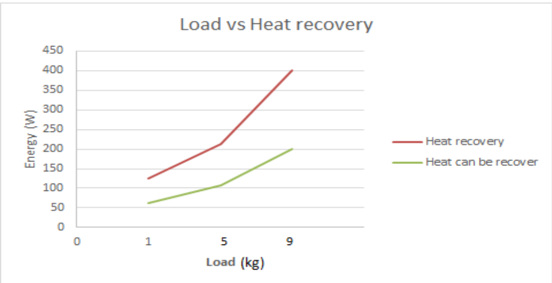

Figure : 4 Load vs Heat Recovery

COP of refrigerator

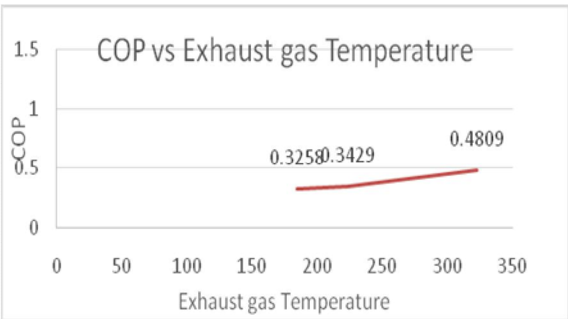

Figure : 5 COP vs Exhaust gas temperature

Here on the basis of experimental readings it is shown that COP of refrigerator is also increase with increase in temperature of the engine exhaust gases.

X. CONCLUSION

The vapour absorption refrigeration system is is more eco-friendly and beat alternative of vapour compression system. Here mainly in vapour absorption system there are exhaust gases of the engine is used as a heating source in the generator. So here there are no use of compressor and also it is not required any kind of electrical energy. So now a days in the shortage of electricity it is best way to use vapour absorption system. And another way engine exhaust gases is also harmful for environment. So there are two Aimed is achieved by this Experiment.

1. **There is no use of any kind of electricity for refrigeration purpose.**
2. **Harmful exhaust gases of the engine are used as a heating purpose in absorption system. So there are environment is also less polluted by engine exhaust gases.**

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