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Exhaust Gas Heat Recovery to Increase the Brake Thermal Efficiency of I.C. Engine

G. Srinivas Kumar[1], V. Viswanatha Chari[2], P. Nagaraju[3], P. Madhuraghava[4]
1. Assistant Professor, Srinivasa Ramanujan Institute Technology, Anantapuramu, India
2. Assistant Professor, Srinivasa Ramanujan Institute Technology, Anantapuramu, India
3. Assistant Professor, Santhiram Engineering College, Nandyal, India
4. Assistant Professor, Santhiram Engineering College, Nandyal, India
E-mail: srinivas.me@srit.ac.in, viswanathchari.me@srit.ac.in, nagaraju.pagidyala@gmail.com.

***Abstract* – Since the discovery of the wheel, man has been trying to find different way to power its propulsion starting with cattle and horses. Then came the steam engine, which was of the open type, and the efficiency was very low. The next major breakthrough was the invention of the I C engine during the 19th century. In this age of ever increasing need for efficient systems to battle environmental deterioration and consumption of fossil fuels, a step that is needed to be taken is to increase the efficiency of the IC engine. It has been noticed that a major portion of the heat liberated while running an automobile is literally wasted through the exhaust gases and this heat can be used to run accessories that aid in the fulfilling of this goal. The heating of the incoming charge helps in its better combustion in the combustion chamber. On the other hand, legislation of exhaust emission levels has focused on carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter (PM). Energy conservation on engine is one of best ways to deal with these problems since it can improve the energy utilization of brake thermal efficiency of engine and reduces emissions at inlet temperatures of about 68° Celsius. The engine under study here is a four stroke single cylinder petrol engine of 100cc capacity.**

***Keyword* – I.C. Engine, Exhaust Gases, Heat Exchanger, Brake Thermal Efficiency.**

I. INTRODUCTION

Internal combustion engines are seen every day in automobiles, trucks, and buses. The piston cylinder engine is basically a crank-slider mechanism, where the slider is the piston in this case. The piston is moved up and down by the rotary motion of the two arms or links. The crankshaft rotates which makes the two links rotate. The piston is encapsulated within a combustion chamber. Internal combustion engines are divided into spark ignition engines and compression ignition engines. In a spark ignition engine a spark plug is required to transfer an electrical discharge to ignite the mixture. In compression ignition engines the mixture ignites at high temperatures and pressures. The lowest point where the piston reaches is called bottom dead center. The highest point where the piston reaches is called top dead center. The ratio of bottom dead center to top dead center is called the compression ratio. The compression ratio is very important in many aspects of both compression and spark ignition engines, by defining the efficiency of engines. Compression ignition engines take atmospheric air, compress it to high pressure and temperature, at which time combustion occurs. These engines are high in power and fuel economy. In internal combustion engines the induction and exhaust processes give importance to the performance and efficiency of the engine. The maximum amount of chemical energy from the hydrocarbon fuel is when it reacts with stoichiometric oxygen. The simplest chemical reaction using the simplest hydrocarbon with stoichiometric oxygen is:

$$CH_4 + 2O_2 \qquad CO_2 + 2H_2O$$

For this reaction to be complete it would take two moles of oxygen to react with one mole of methane to produce one mole of carbon dioxide and two moles of water vapour. The chemical reaction involving isooctane and oxygen is:

$$C_8H_{18} + 12{:}5O_2 \qquad 8CO_2 + 9H_2O$$

The above two chemical reactions involve the reaction of a hydrocarbon with oxygen.

Combustion in SI engines is divided into three categories. Ignition and flame development is the first phase of combustion where only about 5% of the air fuel mixture is consumed. During flame development combustion has barely started and there is very little pressure rise, so there is no significant work done. The second phase consists of the propagation of the flame. This phase consumes about 80-90% of the air-fuel mixture. During this phase there is significant pressure rise, which provides the force that produces the work in the expansion stroke. The third and final phase of the combustion process is the flame termination. This phase consumes only about 5% of the air-fuel mixture. During this phase the pressure quickly decreases and combustion ends.

Heat transfer in IC engines is a very serious problem since you need high temperatures to combust the fuel but you also need to keep the temperature at a controllable level in order to operate the engine safely. Once the temperature in the engine has reached intolerable values the engine block and components may suffer damage. Therefore it is essential to have a heat removal process which will maintain the engine at a safe operating condition. Figure shows the temperature distribution for an IC engine.

A limited research work has been reported on Exhaust Gas Heat Recovery of an I.C engine, the air-fuel mixture is heated through convective heat transfer. The internal combustion engine exhaust waste heat and environmental pollution has been more emphasized heavily recently. Out of the total heat supplied to the engine in the form of fuel, approximately, 30 to 40% is converted into useful mechanical work; the remaining heat is expelled to the environment through exhaust gases and engine cooling systems, resulting in to entropy rise and serious environmental pollution, so it is required to utilized waste heat into useful work. Waste heat recovery system is the best way to recover waste heat and saving the fuel. The recuperation and utilization of waste heat not only conserves fuel (fossil fuel) but additionally reduces the amount of waste heat and greenhouse gases damped to environment. Possible methods to recuperate the waste heat from internal combustion engine and performance and emissions of the internal combustion engine.

In the present work an attempts to increase the Brake thermal efficiency of the engine by capitalizing on the heat being wasted through the exhaust gases, the exhaust pipe is manipulated such that a heat exchanger can be arranged between the exhaust pipe and the pipe area between the air filter and the carburetor to increase the inlet air temperature and through it the air-fuel mixture temperature into the combustion chamber for greater Brake thermal efficiency.

II. Procedure for Paper Submission

2.1 *Engine Restoration*

A working 4 stroke spark ignition petrol engine was acquired along with its transmission I.e., its chain and the rear wheel sprocket. This is done to ensure that the exhaust pipe is running parallel to the pipe attached to the carburetor. 1/4th inch diameter copper tube is bent in such a way that is connected end to end in the shape of a running track. The radius of curvature is 1inch the length from end to end is 6inches long and 2 inches wide, the length of the straight paths being 4inches long.

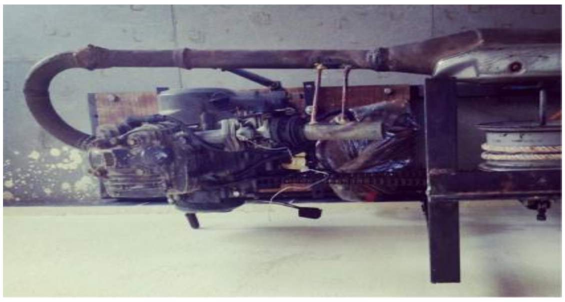

Fig. 1. Heat Exchanger Connection

Fig. 2. Heat Exchanger in closed view

A dynamometer is a brake but in addition it has a device to measure the frictional resistance. Knowing the frictional resistance, we may obtain the torque transmitted and hence the power of the engine. It consists of one, two or more ropes wound around the flywheel or rim of a pulley fixed rigidly to the shaft of an engine. The upper end of the ropes is attached to a spring balance while the lower end of the ropes is kept in position by applying a dead weight as shown in Fig. In order to prevent the slipping of the rope over the flywheel, wooden blocks are placed at intervals around the circumference of the flywheel. In the operation of the brake, the engine is made to run at a constant speed. The frictional torque, due to the rope, must be equal to the torque being transmitted by the engine. Power of the machine = $T\omega = (F\times r)\omega$

As a fluid in the heat exchanger, paraffin oil was made use of. It was introduced into the heat exchanger by drilling two small holes on the copper tube and then by using a syringe slowly injected the oil until the oil was flowing out of the other hole. Due to high viscosity of the oil it offered a lot of resistance. The oil acted as a medium of transfer of heat from the exhaust side of the copper tube to the inlet air entry side of the copper tube. A thermal insulating tube was placed around the copper tubes to avoid loss of heat to the surroundings by convection

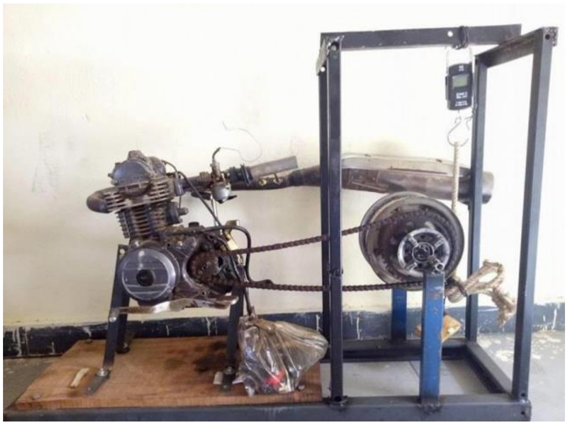

Fig. 3. Whole setup of Experiment

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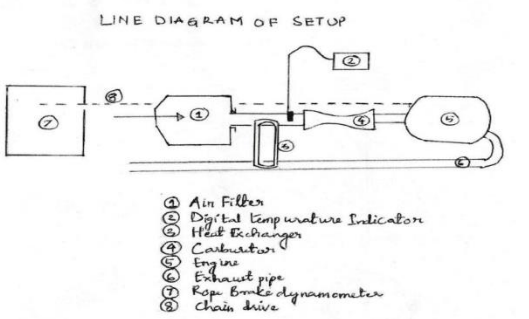


Fig. 4. Schematic layout of Experiment

2.2. *Procedure in Calculating the Performance Characteristics of an I.C Engine*

Load the engine by placing know weights at the arrangement below the brake drum of the rope brake dynamometer. Note down the reading RPM by placing the tachometer at the engine output sprocket. After that note down the time it takes to consume 2 ml of fuel by the help of a stop watch, the 2ml of fuel consumed is know by the use of a calibrated pipette attached to the carburetor using a rubber pipe. Note down the spring balance reading in the rope brake dynamometer setup to get the value of S.

Sample calculations:

Brake power (B.P) = (2π*R*N(W-S)/60000) = 1.06 Kw
Heat supplied (H.S) = mF*cV = 3.05 Kw
Brake thermal efficiency (?) = (B.P/H.S)*100 = 34.76 %

III. Results and Discussion

Tabular column for readings at inlet Ambient Air temperature of 33.7˚C

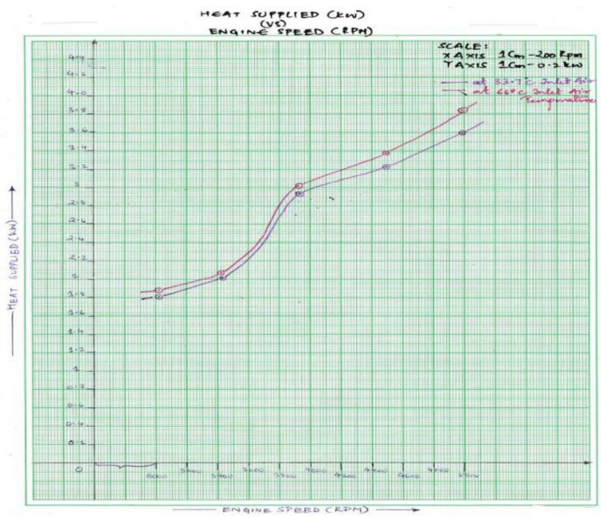
Sl No	Speed in Rpm	Time taken for 2ml (s)	W(kg)	S(kg)	B.P(kw)	H.S(kw)	?(%)
1	3082	36.06	7.68	1.16	0.74	1.83	40.95
2	3415	32.65	7.68	1.2	0.82	2.02	40.86
3	3915	22.47	7.68	1.25	0.93	2.93	32.05
4	4498	20.34	7.68	1.18	1.09	3.24	33.64
5	4998	18.32	7.68	1.09	1.22	3.6	34.12

Tabular column for readings at inlet air temperature of 54˚C

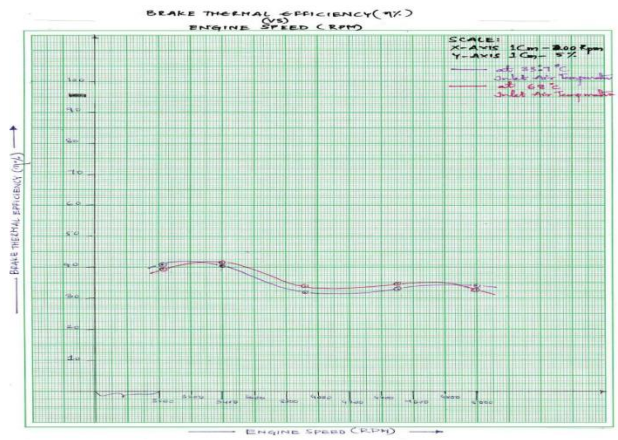
Sl No	Speed in Rpm	Time taken for 2ml (s)	W(kg)	S(kg)	B.P(kw)	H.S(kw)	?(%)
1	3082	35.57	7.68	1.37	0.72	1.85	39.17
2	3415	32.29	7.68	1.15	0.83	2.04	41.09
3	3915	22.04	7.68	0.85	0.99	2.99	33.32
4	4498	19.89	7.68	0.97	1.12	3.31	33.98
5	4998	17.75	7.68	0.92	1.26	3.71	33.96

Tabular column for readings at inlet air temperature of 68˚C

Sl No	Speed in Rpm	Time taken for 2ml (s)	W(kg)	S(kg)	B.P(kw)	H.S(kw)	?(%)
1	3082	35.08	7.68	1.3	0.73	1.88	38.97
2	3415	31.93	7.68	0.99	0.85	2.06	41.3
3	3915	21.62	7.68	0.41	1.06	3.05	34.76
4	4498	19.44	7.68	0.73	1.16	3.39	34.37
5	4998	17.18	7.68	0.73	1.29	3.84	33.71



Graph: Engine speed vs heat supplied efficiency



Graph: Engine Speed Vs Brake thermal

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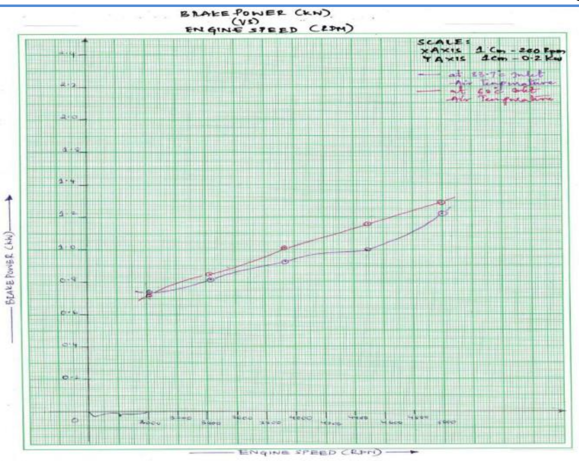
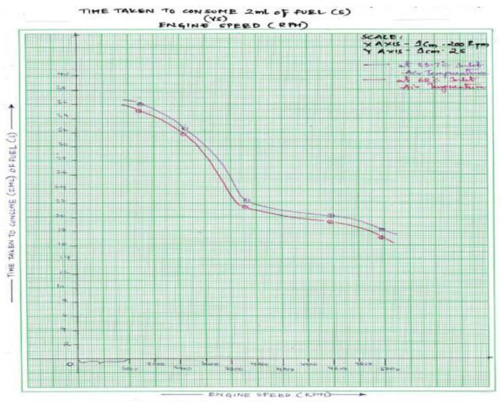


Graph: Engine Speed Vs Brake power



Graph: Engine Speed Vs Time taken to consume fuel (2ml)

IV. Conclusions

The present work on fabrication and finding the performance characteristics of an I.C engine by using of Exhaust Gas Heat Recovery, has led to the following conclusions.

1. Thereby from the experiment performed above and the values obtained thereof show that with the increase of the inlet air temperature to a certain degree causes a slight increase in the Brake thermal efficiency of the engine.
2. The reason for this is might be the fact that at 68˚C petrol turns in its vapor form and this causes efficient burning in the combustion chamber of the engine and thereby slightly increasing the brake thermal efficiency.
3. It is observed from the graphs that with increase in engine speeds there is increase in brake power, decrease in time taken to consume 2ml of fuel, increase in heat supplied and decrease in brake thermal efficiency.
4. This increase in the thermal efficiency can only be seen within a definite range of Rpm, to be exact between 3000-3500 Rpm Engine speeds.

References

[1] Moran and Shapiro, Fundamentals of Engineering Thermodynamics Third Edition, 1995 Stone.

[2] Engineering Fundamentals of the Internal Combustion Engine First Edition, 1997 John B. Howard, Internal Combustion Engine Fundamentals First Edition, 1988

[3] Fuel Economy in furnaces and Waste heat recovery-PCRA

[4] Heat Recovery Systems by D.A.Reay, E & F.N.Span, London, 1979.

[5] T. Endo, S. Kawajiri, Y. Kojima, K. Takahashi, T. Baba, S. Ibaraki, T. Takahashi, "Study on Maximizing Exergy in Automotive Engines," SAE Int. Publication 2007-01-0257, 2007.

[6] Diego A. Arias, Timothy A. Shedd, Ryan K. Jester, "Theoretical analysis of waste heat recovery from an internal combustion engine in a hybrid vehicle," SAE paper 2006-01-1605.

[7] John B. Heywood, "Internal Combustion Engine Fundamental," Tata McGraw Hill Education Private Limited, Edition 2011, pp 249-250.

[8] V Ganeshan, "Internal Combustion Engine," Tata McGraw Hill Publishing Company Limited, Second Edition, pp 35, 606-670

[9] Introduction to Internal Combustion Engines Second Edition, 1992 Pulkrabek.