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Investigation of Effect of Intake Air Preheating By Heat Wheel on Performance and Emission Characteristics of Diesel Engine

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Abstract - *The performance of Diesel engine is depends upon various parameters. Intake air temperature is one of them which play an important role in achieving better efficiency. This paper work is focused of investigation of effect of increasing intake air temperature on performance and emission characteristics of diesel engine. This paper highlights the provision of heat wheel for preheating intake air by using waste heat from the engine exhaust gases. The test is carried out on four stroke, single cylinder, water cooled, and diesel engine at various loads. The test results show that the increasing inlet air temperature the fuel consumption decreases. Initially with increase in inlate air temperature emission of CO, HC reduces but Nox formation increases with increase in temperature.*

Key Words: **Heat wheel, Intake Air preheating, Performance and Emission, Waste Heat Recovery**,

1. INTRODUCTION

The I.C engine is a device which produces mechanical work as a output due to combustion of fuel converts the chemical energy of fuel into heat and again heat energy in to mechanical work. In general,diesel engine have an efficiency of about 35% and thus the rest of the input energy is wasted.Despite recent improvement in efficiency of diesel engine, a considerable amount of energy is still exhausted to atmospherewith the exhaust gases. In water cooled engines about 25% and 40% of the input energy are wasted through the coolant and exhaust gases,respectively[1,2]. Increase in economy the energy demand also increases which results in more usages of fossil fuels which causes the emission of harmful green house gases. Large amount of heat is released in the atmosphere from the engines without utilizing for any purpose. If some amount of this waste heat could be recovered it possible to reduce the primary fuel required. Waste heat utilization is the major source of cost saving. If exhaust gases of engines are directly released into atmosphere it will not only waste heat but also causes the environmental problems, so it is required to utilize the waste heat for useful work to increase the efficiency of engine. [3] The- recovery and utilization of waste heat from engine results in reduction in fuel consumption, reduction in waste heat loss and engine emission, increases the engine efficiency. It is necessary that continuous and serious efforts should be taken for conserving this waste heat by using proper waste heat recovery techniques. Various researchers made experiments on the duel fuel diesel engine with various methods for intake air preheating. Pradip G. Karale et [4] have explained the review on exhaust gas heat recovery for I.C engine. In this paper it is represented that the large amount of hot flue gases is generated from the I c engine. if that waste heat could be recovered a considerable amount of primary fuel could be save Mahi Md et[5] have proved experimentally by preheating inlet air in single cylinder diesel engine there is % Nox Reduction can be obtained. Maximum length of exhaust pipe was surrounded by the inlet air passage to extracts more heat .Chirtravelan.M et [6] have shown that Nox and emissions at intake air temperature of 55^0C were less compared to 32^0C.Quangang Wang et [7] studied the influence of intake air preheating and injection timing on the engine performance combustion and emission of a methanol fumigated diesel engine has been experimentally investigated that flame propagation increases, combustion delay decrease with increase in intake air temperature.

Abhinay Nigam [8] investigate the effect of intake air temperature in diesel engine on the fuel consumption rate. The results shows that the fuel consumption decreased with increase in inlet air temperature.

1.1 Benefits Of Waste Heat Recovery From I.C. Engine

Benefits of waste heat recovery from engines can be broadly classified in two categories

I) Direct Benefits: Recovery of waste heat has a direct effect on the combustion process efficiency. This is reflected by reduction in the utility consumption and process cost.
II) Indirect Benefits:
a) Reduction in pollution: A number of toxic combustible wastes such as carbon monoxide (CO), hydrocarbons (HC), nitrogen oxides (NOx), and particulate matter (PM) etc, releasing to atmosphere. Recovering of heat reduces the environmental pollution levels.
b) Reduction in equipment sizes: Waste heat recovery reduces the fuel consumption, which leads to reduction in the flue gas produced. This results in reduction in equipment sizes.
c) Reduction in auxiliary energy consumption:

Reduction in equipment sizes gives additional benefits in the form of reduction in auxiliary energy consumption [9].

1.2 Effect of low temperature intake air [10]

1. Incomplete combustion and high pressure gradients occur as a result of abrupt mixture conversion in the cylinder
2. Local over-enrichment
3. Increase in emission delay.
4. Time from the entry of the fuel into the combustion chamber until the ignition of the same becomes too long.
5. An inadequate final compression temperature occurs.

1.3 Consequences of Low Temperature Intake Air

1. Increase in emission of hydrocarbons in the exhaust gas. 2. Knocking of the diesel engine. 3. Severe loading of the environment.[4]

2. HEAT WHEEL

The Heat wheel is a type of air-to-air rotating recovery device. Their primary use is in HVAC systems that operate on the principle of heat and moisture transfer between outside air and building's exhaust air. These devices have the ability to lower peak energy demand and total energy consumption. Surface through which the gases flow is called as wheel matrix. Here the attempt is made to use the heat wheel to pre heat engine intake air by using waste heat of engine exhaust gases. In this heat wheel the wheel matrix is formed by making small holes of 5 mm, 7mm, and 9mm diameter on the circular disc. This disc is enclosed in a casing and covering plates. Covering plates have provision for piping connections for inlet and outlet of exhaust gas and fresh air. For rotating the heat wheel a small motor is used.

Heat wheel:

Material Aluminum
Thermal conductivity- 204 w/mk
Matrix Disc Diameter- 156 mm
Disc Thickness-3 mm
Pipe diameter- 40mm
Matrix Hole Size- 5mm, 7mm, 9mm Diameter.

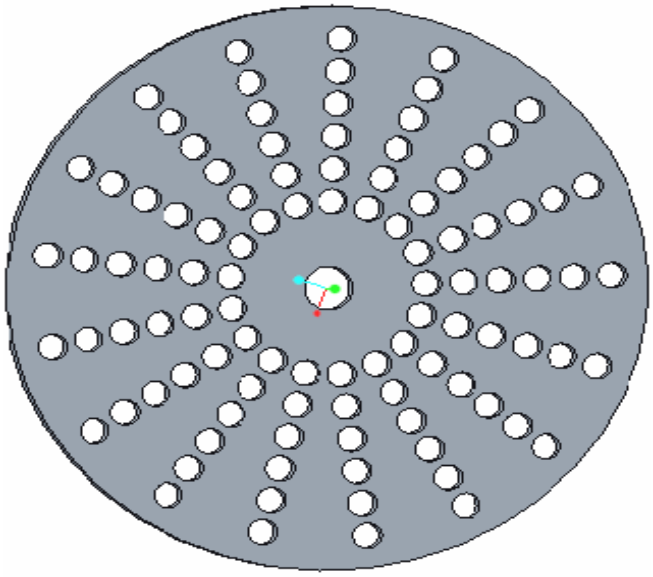

Fig. 1 Drawing of Wheel matrix (7mm diameter hole).

3. EXPERIMENTAL SET UP AND PROCEDURE

Engine Details:

IC Engine set up under test is Kirloskar TV1 having power 5.20 kW @ 1500 rpm which is 1 Cylinder, Four stroke , Constant Speed, Water Cooled, Diesel Engine, with Cylinder Bore 87.50(mm), Stroke Length 110.00(mm), Connecting Rod length 234.00(mm), Compression Ratio 16.00, Swept volume 661.45 (cc).

Air is drawn from the upstream side of an intake manifold using an air supply unit. The air and exhaust gases of engine flows in opposite direction. The required piping for inlet and outlet of exhaust gases and fresh air to the heat wheel are made, .also thermocouples are connected to pipe for recording required temperature. The air is heated using a waste heat from exhaust gas by using heat wheel. In this way, vaporization of the fuel is enhanced. One feature of the present disclosure provides an intake air heating apparatus having capability of waste heat recovery.

Fig. 2 side view of Heat Wheel Set up with inlet outlet pipe openings

Fig.3 Experimental Set up

Components Used

1. Single cylinder diesel engine.
2. Heat Wheel, Motor and Casing.
3. Necessary piping.
4. Dynamo meter.

Instrumentation Used

1. K Type thermocouples.
2. Tachometer.
3. Emission checking instrument. (ALV 5Gas Analyzer)

4. RESULT AND DISCUSSION

The performance of Heat Wheel is experimentally evaluated. Experimentation was carried out to investigate the effect of variation in wheel porosity (Wheel Matrix Hole Diameter), Heat Wheel Speed (RPM) and engine load on the effectiveness.

4.1 Analysis of Effectiveness of Heat Wheel

On the basis of the observations recorded with variation in wheel hole size, wheel RPM and engine load the effectiveness of heat wheel is calculated. The variations in effectiveness of heat wheel are represented graphically.

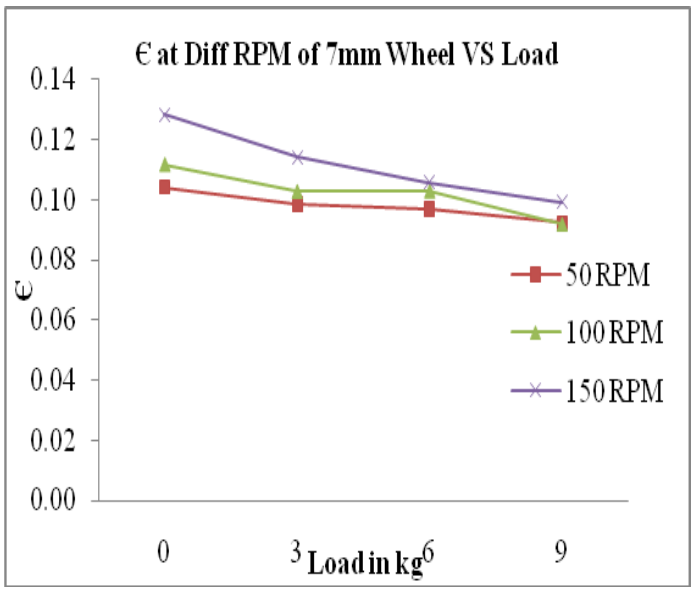

Chart-1 Effectiveness at various Engine Load and 7mm Heat Wheel RPM

The above graph of Effectiveness at various Engine Load and Heat Wheel RPM shows that effectiveness is increases as heat wheel RPM increases. Effectiveness decreases as engine load increases.

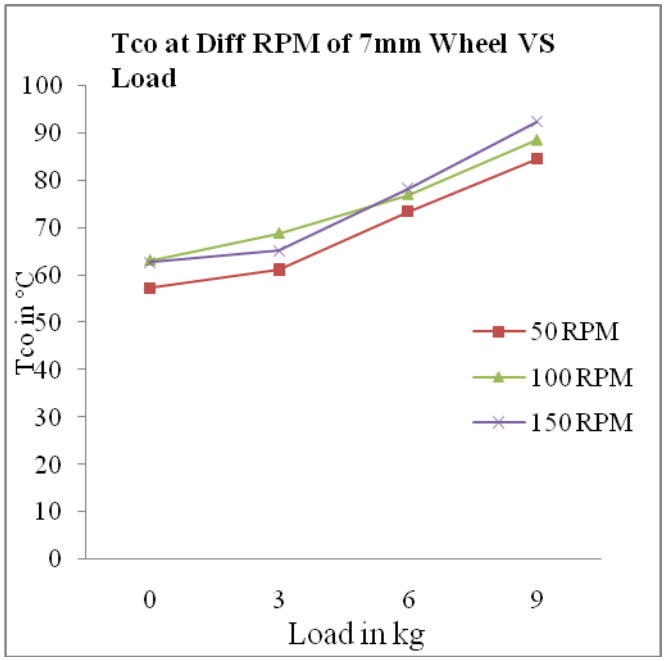

Chart-2 Heat wheel outlet temperature at various Engine Load and 7mm Heat Wheel RPM

The above graph of heat wheel outlet temperature at various Engine Load and Heat Wheel RPM shows that heat wheel outlet temperature is increases as heat wheel RPM increases. Heat wheel outlet temperature increases as engine load increases.

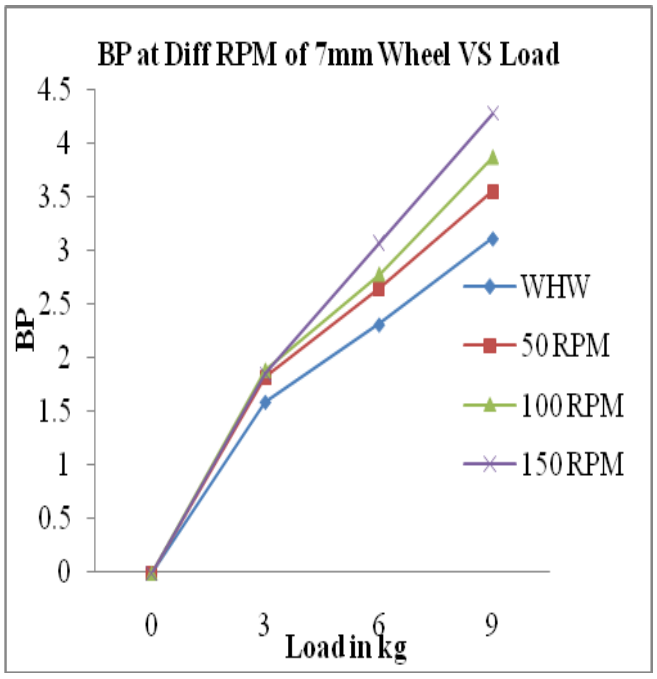

Chart-3 BP at various Engine Load and 7mm Heat Wheel RPM

The above graph of BP at various Engine Load and Heat Wheel RPM shows that BP is increases as heat wheel RPM increases. BP increases as engine load increases.

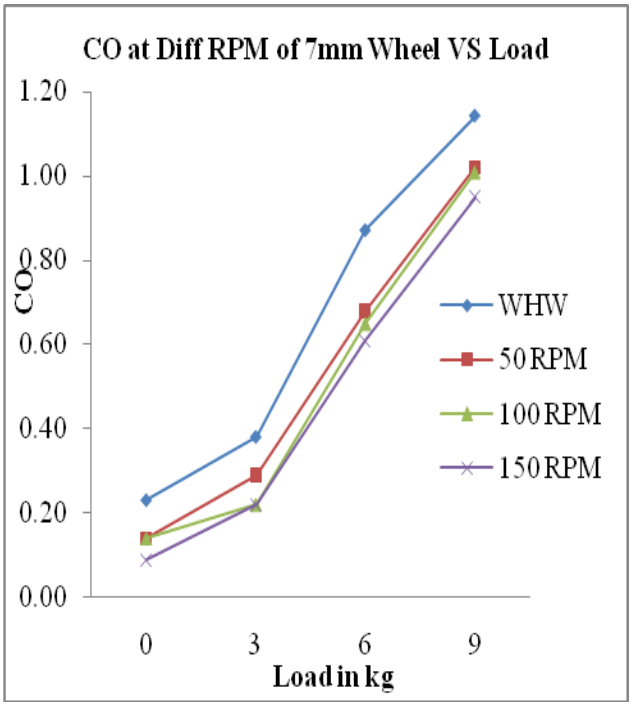

Chart-4 CO at various Engine Load and 7mm Heat Wheel RPM

The above graph of CO at various Engine Load and Heat Wheel RPM shows that CO is decreases as heat wheel RPM increases. CO is increases as load on engine increases.

5. CONCLUSIONS

The recovery and utilization of waste heat not only conserves fuel but also reduces waste heat by increasing the efficiency of engine and the green house gases. This study shows the Benefits of waste heat recovery, Heat carried away by the exhaust gas, to pre heat the intake air. The results of this experiment shows that the effectiveness of heat wheel increases with increase in wheel RPM. The outlet temperature of heat wheel increases with increase in wheel RPM and with increase in engine load. Specific fuel consumption decreases with increase in air temperature. CO at various Engine Load and Heat Wheel RPM shows that CO is decreases as heat wheel RPM increases. CO is increases as load on engine increases

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