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Effect of Inlet Air Preheating on Exhaust Gases in Single Cylinder I.C Engine

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Abstract - *A four stroke single cylinder I.C engine is selected for the experimentation of waste heat recovery from the exhaust gas temperature. Waste heat can be utilized for the heating purpose like preheating intake air and fuel, space heating, dryer etc. This paper includes the analysis of preheating intake air on emissions (CO, CO_2, HC and NOx) and time required for fuel consumption. Engine exhaust gas temperature is used to preheat the inlet air, heat exchanger is used to transfer heat from exhaust gases to inlet air. Results show that on preheating the inlet air there is a considerable decrease in CO, HC and NOx emissions. There are unaltered results obtained for CO_2 emissions. The time required for consumption of fuel increases considerably.*

***Key Words*: Waste heat recovery, Inlet air preheating, I.C engine, Emission gases, Fuel consumption.**

1. INTRODUCTION

The IC engines are used in number of applications on great scale. They are key sources of mechanical energy in number of applications like automobiles, machines, ships etc. The efficiency and emissions of IC engines are rising as a fear to different investigators in the world. The efficiency of IC engine is very low as large part of supplied energy is lost into the mechanical thermal losses. These engines use chemical energy of fuel, converts it into pressure and heat by combustion due to this huge amount of heat is formed inside combustion chamber, much of heat is lost to the engine body which then requires cooling preparation and other heat passes through exhaust gases. This loss of energy can't be evaded completely but can be minimized by refining design of IC engines which gives preventive action to the heat loss. The solution for the heat loss is known as Waste heat recovery. This uses heat from the exhaust gases of IC engines and can be used for applications like cooling, battery recharging, heating air, electricity source etc. This type of engine preheating is good for the environment and cost-effective. In addition to producing fast starts, air intake heaters reduce white smoke, battery consumption, engine wear and fuel consumption during start up. Lower temperature intake air leads to increase in emission delay and longer time between the injection of the fuel to ignition, inadequate final compression temperature, incomplete combustion, local over-enrichment and high-pressure gradients due to rapid mixture conversion in the cylinder. These factors affect as knocking of the diesel engine, increase in emission of hydrocarbons in the exhaust gas leading to harsh loading of the environment. Cold air intake (CAI) is not better as compare to warm air intake (WAI) on a diesel engine. Warm air intake improves fuel economy on a gas engine for three reasons: (1) As the warm air is less dense, the throttle opens more to get the same air, therefore throttling losses are reduced. (2) The warm air progresses the flame speed. (3) The warm air progresses the vaporization of the fuel.

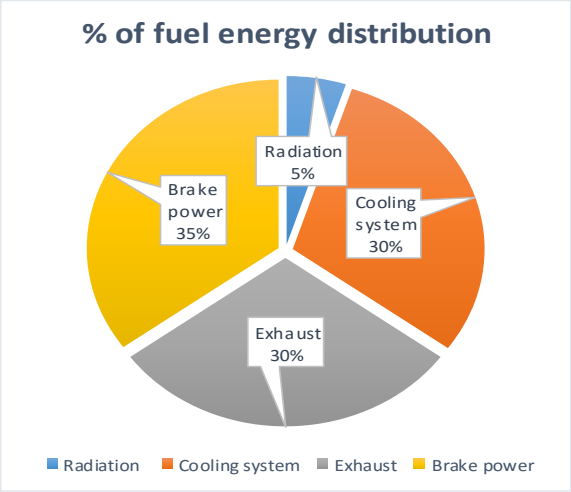

Fig- 1: I.C engine fuel energy distribution

2. EXPERIMENTAL SETUP

As engine gets started the exhaust gases will flow from exhaust pipe. Heat recovery system using inlet air preheating is made such that air gets heated because of the temperature from exhaust gases. A tube heat exchanger type arrangement as shown in Fig.2 is made so that the exhaust gases will flow from inner pipe and at the same time inlet air will flow from outer pipe. During this heat liberated by exhaust gases will be absorbed by inlet air and its temperature increases. This warm air is now supplied to IC engine instead of cold air. The load varied from 0 to 10kg for each trial.

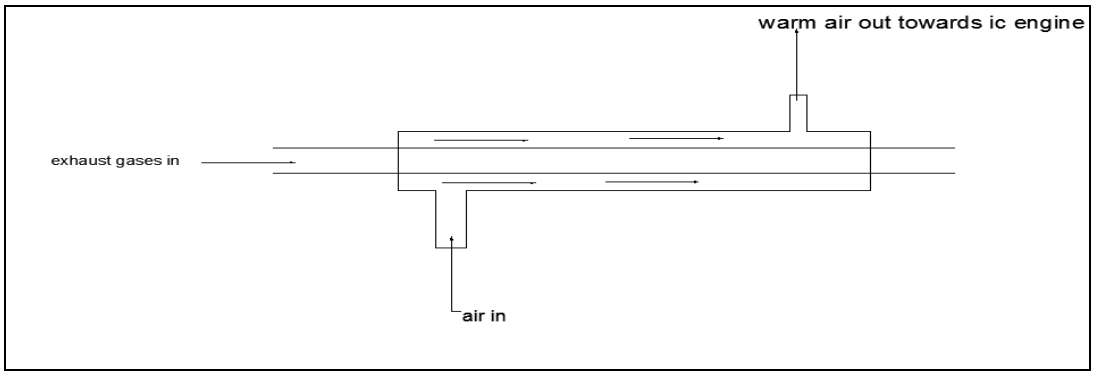

Fig- 2: Schematic diagram of inlet air preheating system

Table-1: Specification of present experimental setup

Specification of diesel engine	
No. of cylinders	1
No. of strokes	4
Rated speed	1500
Fuel	H.S. diesel
Rated power	5.2 kw
Cylinder diameter	87.5mm

3. RESULTS AND DISCUSSIONS

The experimentation is carried to find the effect of air preheating on engine emissions and engine efficiency. Effect of variation of load on emissions and time required for fuel consumption with and without inlet air preheater are plotted.

3.1 Effect of Inlet Air Preheating on CO Emissions

Without air preheating CO emission at 2 kg load was 0.11 % vol. but after air preheating CO emission is reduced to 0.09% vol. For 2 kg load air temperature after preheating is 47^{0}C. For other loads also, CO emission are reduced after inlet air preheating.

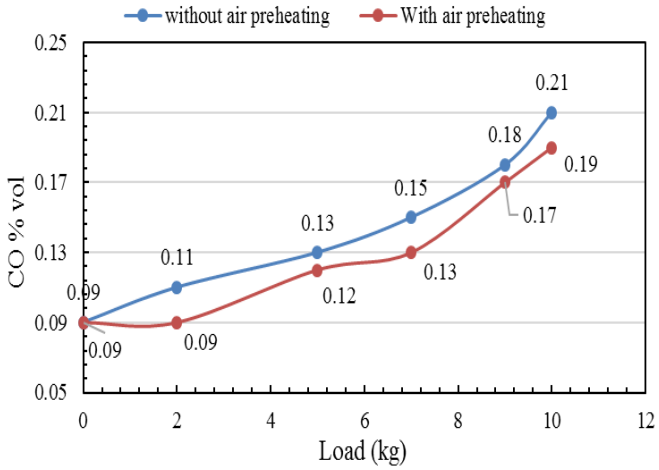

Fig-3: Effect of Inlet air preheating on CO emissions

3.2 Effect of Inlet Air Preheating on CO_2 Emissions

From the Figure 4, CO_2 content in the exhaust gas remains unaltered with increase in intake air temperature.

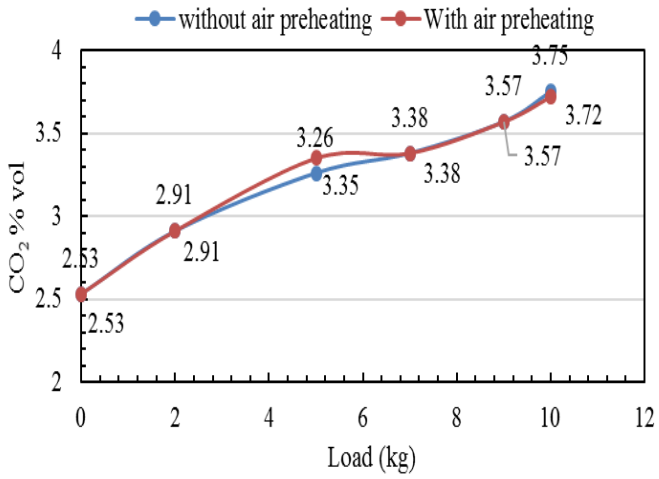

Fig-4: Effect of Inlet air preheating on CO_2 emissions

3.3 Effect of Inlet Air Preheating on HC Emission

From the Figure 5, With intake air preheating HC content in the emission is reduced. For no load condition HC content without air preheating was 23% vol. but after air preheating HC content reduces to 21% vol. For 2 kg load condition HC content reduces to 21% vol. from 24 % vol. after air preheating. For other load conditions also, HC content in the emissions reduces after air preheating.

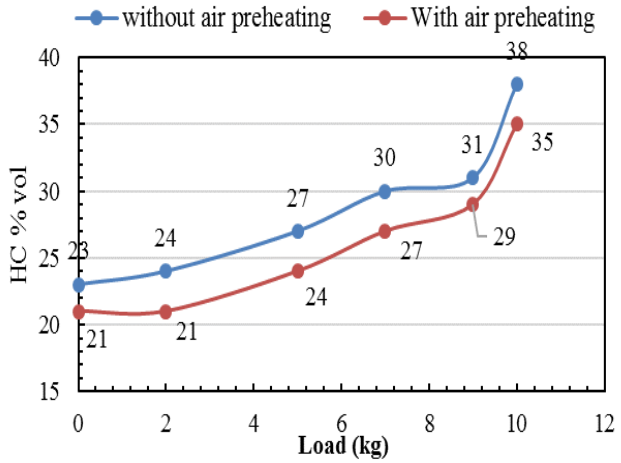

Fig-5: Effect of Inlet air preheating on HC emissions

3.4 Effect of Inlet Air Preheating on NO_X Emissions

From the Figure 6, NOx content in the exhaust gas slightly decreases with increase in intake air temperature.

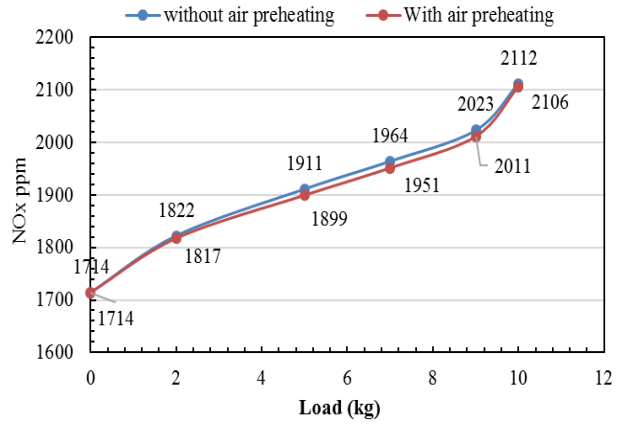

Fig-6: Effect of Inlet air preheating on NO_X emissions

3.5 Effect Inlet Air Preheating on Time Required for Consumption of Fuel

From the Figure 7, with increase in intake air temperature time required for fuel consumption increases, in other words we can say that fuel efficiency increases. For example, 100 ml fuel in engine runs for 10.7 min without air preheating for no load condition, with increase in intake air temperature engine runs for 10.87 min with same fuel consumption.

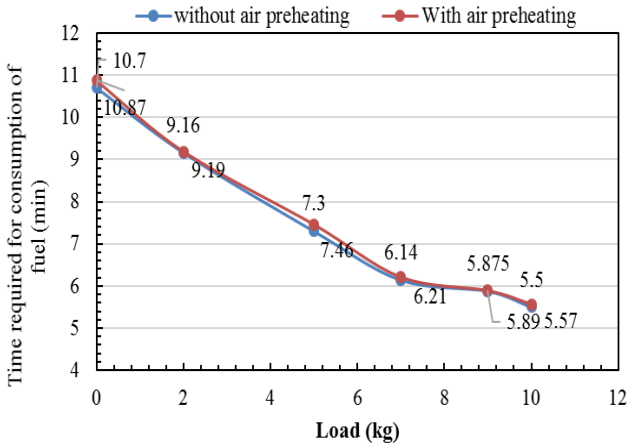

Fig-7: Effect of Inlet air preheating on time required for consumption of fuel

4. CONCLUSIONS

Following conclusions are derived from the experimentation on single cylinder I.C engine:

1. CO and HC content in the exhaust gas reduces with increase in intake air temperature.
2. CO2 content in the exhaust gas remains unchanged with increase in intake air temperature.
3. NOx content in the exhaust gas slightly decreases with increase in intake air temperature.
4. Overall with increase in intake air temperature fuel efficiency increases.

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