

# Performance Test on Diesel engine by Pre – Heating the inlet air using heat recovery from Exhaust gases

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**Abstract-** In Diesel engine the air is introduced at a temperature equal to surrounding area and after combustion the gases are released into atmosphere. The heat generated in the combustion process is partially converted into work, which is used to drive the vehicle. The efficiency of the engines is 20-30%. Efficiency of the engine can be increased by sending more quantities of air like super charging and turbo charging, the Pre - heating of the inlet gases (air) is also one of the main reason for the efficiency. Here the Pre – heating of the incoming air is done by using the exhaust gas temperature. The effect of preheated air on standard diesel fuel engine indicated a good result on emission control. Higher inlet air temperature causes lower ignition delay, which is responsible for lower NO<sub>x</sub> formation. Uniform or better combustion is occurred due to pre-heating of inlet air, which also causes lower engine noise. Easy vaporization and better mixing of air and fuel occur due to warm up of inlet air, which causes lower CO emission.

**Index Terms-** Pre heater, Exhaust gases heat recovery, Techniques for increasing the Efficiency of an engine.

## I. INTRODUCTION

Engines convert's chemical energy from fuel to thermal and then thermal energy is converted into Mechanical Energy. The lightweight petrol internal combustion engine, operating on a four-stroke Otto cycle, has been the most successful for light automobiles, while the more efficient Diesel engine is used for trucks and buses. However, in recent years, turbo Diesel engines have become increasingly popular, especially outside of the United States, even for quite small cars.

Continuance of the use of the internal combustion engine for automobiles is partly due to the improvement of engine control systems (onboard computers providing engine management processes, and electronically controlled fuel injection). Forced

air induction by turbo charging and supercharging have increased power outputs and engine efficiencies. Similar changes have been applied to smaller diesel engines giving them almost the same power characteristics as petrol engines. This is especially evident with the popularity of smaller diesel engine propelled cars in Europe. Larger diesel engines are still often used in trucks and heavy machinery, although they require special machining not available in most factories. Diesel engines produce lower hydrocarbon and CO<sub>2</sub> emissions, but greater particulate and NO<sub>x</sub> pollution, than gasoline engines. Diesel engines are also 40% more fuel efficient than comparable gasoline engines.

Generally, in Diesel engine air enters into the combustion chamber at atmospheric temperature. But if the temperature does not reach the flash point the ignition doesn't takes place. Generally, this problem can be seen in winters. By pre – heating the inlet air the air that enters into the chamber gives an effective combustion and engine starts faster.

Now – a – days in a practical diesel engine “glow plugs”, some kind of “heater plugs” are used in order to attain flash point of diesel and to start engine faster. This ‘glow plugs’ or other kind of heater plugs use the external energy source to heat the inlet air entering into the chamber. Exhaust gases carries all the remaining heat after the expansion stroke. The heat carried away is useless.

An air-preheater (APH) is a general term to describe any device designed to heat air before another process (for example, combustion in a boiler) with the primary objective of increasing the thermal efficiency of the process.

The object of the intake system is to deliver the proper amount of air and fuel accurately and equally to all cylinders at the proper time in the engine cycle. Flow into an engine is pulsed as the intake valves open and close, but can be generally modeled as

quasi-steady state flow. The intake system consists of an intake manifold, a throttle, intake valves, and either fuel injectors or a carburetor to add fuel.

Fuel injectors can be mounted by the intake valves of each cylinder (multipoint port injection), at the inlet of the manifold (throttle body injection), or in the cylinder head (CI engines and modern two-stroke cycle and some four-stroke cycle SI automobile engine).

The concept of increasing the fuel efficiency of an engine is to pre-heat the intake air which is flowing through the combustion chamber. The humidity in the atmospheric air affects the vaporization in the chamber. Therefore, by pre-heating the inlet air before going to the combustion chamber for a considerable amount, the vaporization can be ease and in turn complete combustion is achieved. Moreover by reducing the water vapor to the engine, the steam formation in the engine can be reduced pitting of the engine cylinder, piston and exhaust pipe.

In other words, it says that exhaust NOx can be reduced by in-cylinder combustion improvement. This study investigated the effect of inlet air preheating on in-cylinder combustion and exhaust NOx. The influence of improved fuel properties on the exhaust NOx is also discussed. Inlet air preheating induces higher level of excitation of air particles and there is good evaporation of fuel particles and consequently ignition delay become shorter. Due to better evaporation and shorter ignition delay, there is less fuel adhering to the combustion chamber wall and therefore small amount of fuel accumulated in the combustion chamber before ignition is started which may produce low NOx as well as low noise and vibration.

In transportation, an exhaust heat recovery system turns thermal losses in the exhaust pipe into energy. This technology seems to be more and more of interest by car and heavy-duty vehicle manufacturers as an efficient way to save fuel and reduce vehicles' CO<sub>2</sub> emissions. This technology can be used either on a hybrid vehicle or a conventional one: it produces either electric energy for batteries or mechanical energy reintroduced on the crankshaft. The 2016 Chevrolet Malibu Hybrid car features an Exhaust gas Heat Recovery (EGHR) system to accelerate coolant heat up time. This gives faster heat up of the engine coolant which in turn heats up the

engine faster. Less fuel is used giving reduced emissions. This will also quicken cabin heating warm up for passenger comfort and window defrosting. For hybrid applications it also can warm the battery pack. The cooling system is connected to a heat exchanger placed in the exhaust gas transferring the thermal energy from the exhaust gas to the cooling system. When the engine is warmed up the exhaust gas is diverted to a by-pass pipe.

## II. DESIGN OF AIR PREHEATING SETUP

The design is to attach a shell and tube type heat exchanger to the exhaust and intake manifold. The design is to attach the cross-flow type heat exchanger and perform the performance test on the diesel engine.

*Components of Pre-heating chamber:*

Mild steel plate – 1 mm thickness.

Copper tubes – 5/8inch specification.

Mild steel tubes – 1inch diameter\* 2mm thickness.

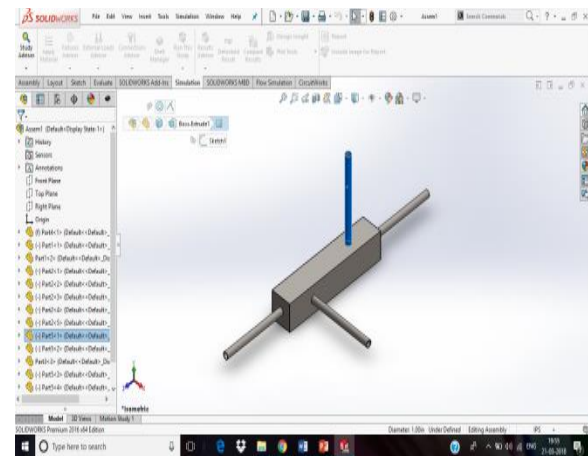


Fig 1: Design of preheating chamber using

*Fabrication of shell:*

Shell is made in the form of square by using machine bending operation and enclosed into square of dimension 9.5 cm \*9.5 cm and welded it by using gas welding operation.

*Fabrication of Heating Coil:*

1. Plate of dimension 9.5\*9.5 cm<sup>2</sup> is made and holes are made on it at required places.
2. Now copper tubes of 1 feet length are attached to plate and are joined by using copper welding.

3. Now the Heating coil is placed inside the shell and is both are joined by using arc welding.
4. Finally, the shell is enclosed with two plates and now the tubes are attached in required places for according to design of engine.

A. Design And Analysis of Pre-Heater:  
 Outer pipe = 1 inch; Thickness = 2 mm

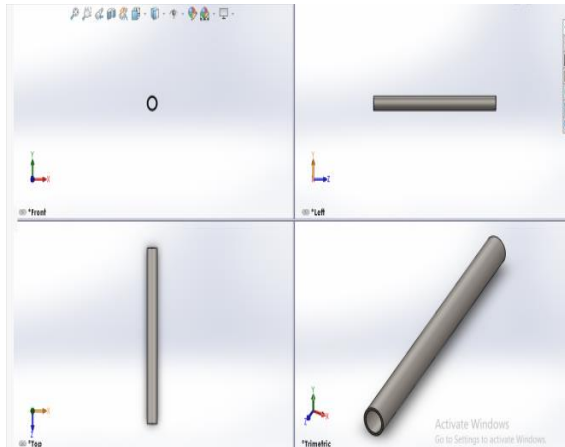


Fig 2: Design of M.S Pipe Shell:

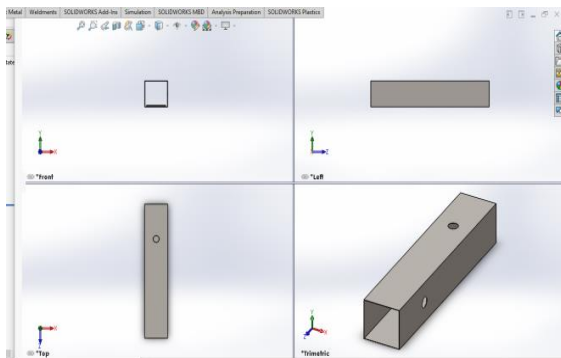


Fig 3: Perspective views of design of the shell  
**Copper Tubes:**

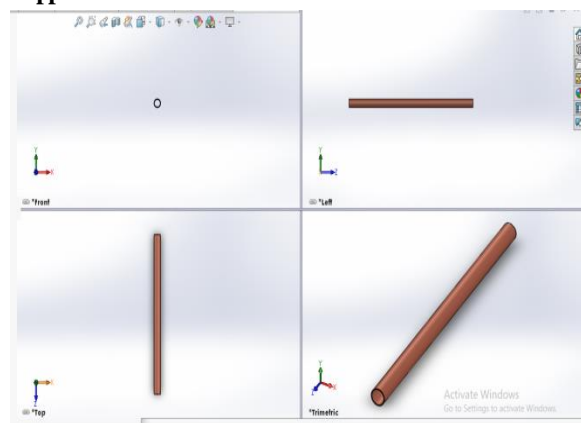


Fig 4: Different views of copper tubes

Heater Coil:

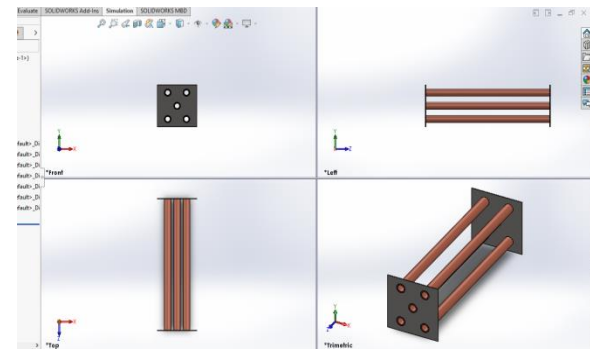


Fig 5: Different views of design of heater coil

B. Analysis of the shell:

1. Analysis is done on the according to the pressure exerted by the exhaust gases produced inside the engine.
2. Accordingly, we applied the pressure of 100 N/mm<sup>2</sup>.
3. We have attained a factor of safety of 1.8.

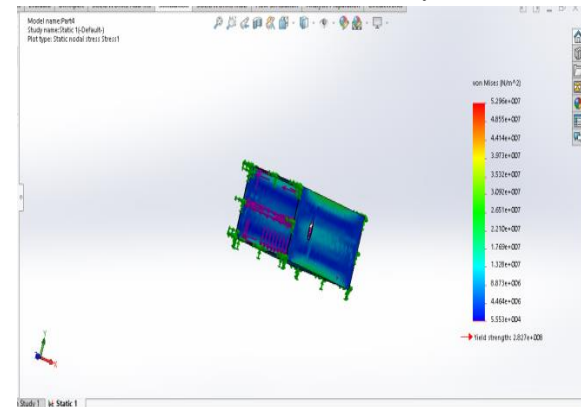


Fig 6: Analysis in solid works

Analysis of copper heating coil:

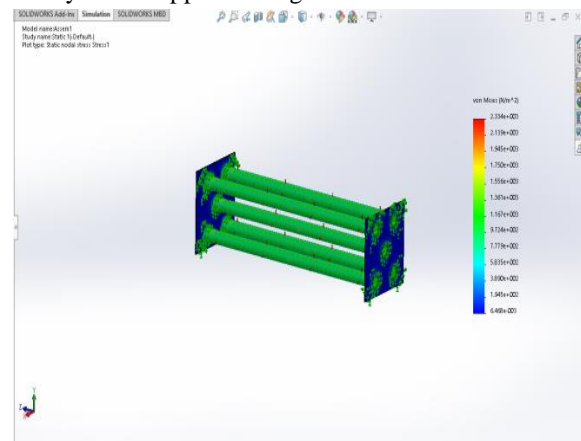


Fig 7: Analysis of heater coil

### III EXPERIMENTAL SETUP & PROCEDURE

A. Performance test has been done on the Diesel Engine Setup



Fig 8: The Pre-Heating Chamber Set Up on the Diesel Engine

Procedure:

1. Connect the instrumentation power input plug to a 230V, single phase power source. Now the digital meters namely, RPM and Temperature indicators display the respective readings.
2. Connect the water line to the engine jacket and brake drum.
3. Check the lubricating oil in the oil sump.
4. Start the engine and allow it to stabilize rated speed (1500 rpm).
5. Now load the engine in steps of ¼, 1/2, 3/4, full load & 10% over load and allow the engine to stabilize at each load.

#### IV RESULTS AND DISCUSSIONS

Table.1: Engine Specifications:

Engine	Four stroke single Cylinder
Make	Kirloskar
Bhp	5 hp
Rpm	1500
Fuel	Diesel
Bore	80 mm
Stroke length	110 mm
Starting	Cranking
Working cycle	Four stroke

Method of cooling	Water cooled
Method of ignition	Compression ignition

Table.2: Results for single cylinder water cooled diesel engine without Pre-Heating

Sl. No.	Load (S1-S2) Kg	Speed (N) Rpm	Time for 20cc fuel consumption. (sec)	Brake Specific Fuel Consumption	B.P kW	$\eta_{B.Th}$ %
1	0	1502	160	$\infty$	0	0
2	1	1560	124	0.492	0.96	16.32
3	2	1554	89	0.343	1.92	22.87
4	4	1536	72	0.282	2.28	29.21
5	5	1523	56	0.246	3.34	32.61

Table.3: Results for single cylinder water cooled diesel engine with Pre-Heating

Sl. No.	Load (S1-S2) Kg	Speed (N) Rpm	Time for 20cc fuel consumption. sec	Brake Specific Fuel Consumption kg/kWh	B.P kW	$\eta_{B.Th}$ (%)
1	0	1520	164	$\infty$	0	0
2	1	1580	128	0.487	0.96	14.62
3	2	1550	95	0.328	1.92	21.16
4	4	1545	77	0.270	2.28	28.73
5	5	1535	65	0.242	3.34	33.79

Graphs:

The variation of brake power with brake specific fuel consumption is shown in figure below. It is observed that the brake specific fuel consumption was decreased by 2% when compared without air preheating of incoming air.

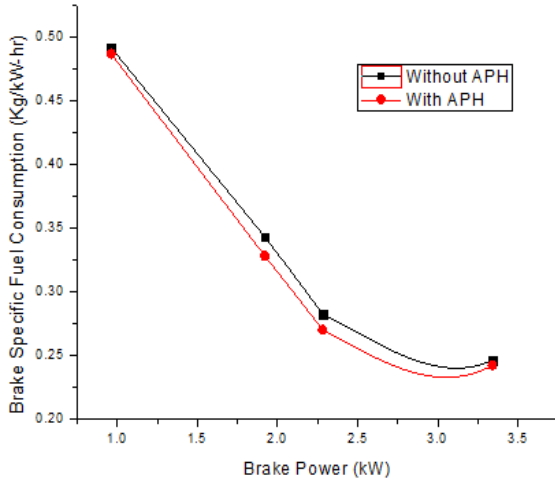


Fig.9: Variation of BSFC with B.P

The variation of brake power with brake thermal efficiency is shown in figure below. It is observed that the brake thermal efficiency was increased by 3.61% when compared without air preheating of incoming air.

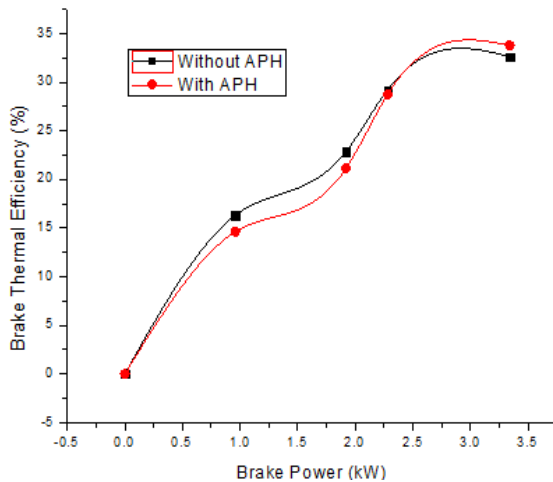


Fig.10: Variation of  $\eta_{bth}$  with B.P

### V. CONCLUSION

- Performing the test and attaining the values, we observed that there is an increase in the Brake power.
- Brake specific fuel consumption is decreased (2%) with air preheating.
- There is increase in brake thermal efficiency.
- The maximum brake thermal efficiency for diesel with air pre heating (33.79%) was higher than that of diesel without air preheating. The brake thermal efficiency increased in 3.61%.

- Increase in the brake power indicates that combustion of the fuel is done completely, and this reduces the toxic emissions from the engine.
- Effective combustion of fuel takes place and reduced temperature of exhaust gases emitting in to the atmosphere.

### VI SCOPE OF FUTURE WORK

In the present investigation the performance parameters are evaluated with constant operating parameters such as injection pressure, injection timing, compression ratio and crank angle.

In the future work the investigation will be carried out by varying the operating parameters like injection pressure, injection timing and compression ratios by using ankola oil ethyl esters blends. With varying these parameters to be finding inside cylinder pressure, combustion analysis and heat release rate. Major modification in engine design will be change to evaluate performance and emissions.

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