Performance and Emission Characteristics of Pre-Heating Diesel by Using Shell and Coil Heat Exchanger in CI Engine

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ABSTRACT

Heat transfer enhancement is an important task in internal combustion engine. To improve the performance of compression ignition engine, the diesel fuel is to be heated by using a heat exchanger arrangement. Heat exchangers are widely used in various application such as engine exhaust gas heat recovery systems, power plants, refrigeration and air-conditioning systems, biomedical industries etc., in this work a shell and coil heat exchanger is to be fabricated to reduce the engine exhaust temperature and pre heat the diesel fuel in CI engine. The thermal analysis is carried out by considering the various parameters such as flow rate of diesel, flow rate of exhaust gases, exhaust temperature, effectiveness and overall heat transfer coefficient. In CI engine the ignition delay is occurring due to physical delay and chemical delay period it causes incomplete combustion. By reducing the ignition delay period we can obtain complete combustion. It is desirable to pre heat the diesel fuel in heat exchanger, ignition delay period will be reduced and complete combustion will occur. Due to pre heating of fuel, diesel engine can maximize the overall engine efficiency, volumetric efficiency, fuel injection pump work can be reduced. Finally the performance and emissions will be analyzed with the exhaust gases and compare with normal engine working conditions.

KEY WORDS: Diesel engine performance, shell and coil heat exchanger, preheating, engine emission.

1. INTRODUCTION

Normally desirable factors for diesel engine are higher efficiency, lesser specific fuel consumption and also lower emissions. But in diesel engine ignition delay is occurring due to physical delay and chemical delay period. It causes incomplete combustion phenomenon in compression ignition engine it means bigger diesel droplet sizes cause the for physical delay as well as chemical delay due to longer period chemical reaction occur. By heating the fuel, this can be reduced the diesel fuel droplet sizes furtherly. So smaller droplets ensure the thorough mixing of air and fuel which improve the complete combustion. So preheating the diesel is the reasonable method for enhancing the engine performance and decreasing the engine emissions.

2. METHODOLOGY

First, shell and coil heat exchanger is to be designed and fabricated with the help of gas welding. Shell is made by using cylindrical sheet metal and heat exchanger coil is made by using copper with10 turns. Then, the heat exchanger is to be fixed in the exhaust of CI engine setup. Fuel flow is connected with heat exchanger inlet through fuel filter. Heat exchanger outlet is connected to fuel injector through fuel pump. These connections are made by nylon tube.

- The temperature of pre heated diesel from shell and coil heat exchanger should be maintained at 60°c.By using regulated value in the exhaust pipe and to avoid the over preheating diesel, theregulating valve is used to control the exhaust gas for auto ignition temperature not exceeding 60°c by help of thermocouple sensor.
- The experiment is connected by varying the load to observe the speed, Mano meter deflection, Fuel consumption and engine temperatures. Simultaneously, observe the readings of emissions likeCO, HC, Co_2, O_2, NOx by using five gas analyzer and also observe smoke emission using smoke meter.
- From the experimental readings the brake power, brake specific fuel consumption, brake thermal efficiency, volumetric efficiency are calculated.
- Finally, the graphs were plotted such as BP Vs BSFC, BP Vs BTE, BP Vs EGT BP Vs CO,BP Vs HC,BP Vs NO_X,BP Vs SMOKE.

Parameters of Shell & Coil Heat Exchanger:

Table.1.Dimensional parameters of shell and coil heat exchanger.

Dimensional Parameters	Dimensions(cm)
Outer diameter of Steel cylinder (Do)	35
Inner diameter of Steel cylinder (Di)	33
Thickness of Shell (t)	0.2
Outer diameter of copper tube (do)	0.7
Inner diameter of copper tube (di)	0.6
Thickness of copper tube (t)	0.1

Table.2.Operating parameters range of shell and coil heat exchanger.

Operating parameters range of Shell & coil heat exchanger	Diesel	Exhaust gas
Mass flow rate (kg/s)	0.008	0.0208
Inlet Temperature (°c)	32	257.16
Outlet Temperature (°c)	60.5	199.16

Table.3.Properties of diesel and preheated diesel of coil heat exchanger

Properties	Diesel	Preheated diesel up to 60°c
Calorific value (KJ/kg)	42000	42000
Density (ρ) (kg/m^3)	830	804

Table.4.Engine Specification

Manufacturer	Kirloskar oil engines limited
Type of Engine Cylinder	VCR Type, Vertical, 4-Stroke Single
Model	TV1
Rated Output	5.2 kW
Speed	1500 rpm
Compression Ratio	17.5:1
Bore and stroke	87.5 x 110 (mm)

Experimental setup: The schematic layout of experimental test and its instrumentation is shown in Figure.1.This study is carried out to find the performance and emission characteristics of preheated diesel to diesel. These value is also compared with diesel values. The power developed by the engine is directly displayed by the engine control panel.

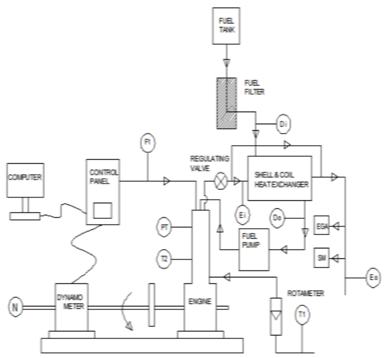

Figure.1.Experimental setup of Kirloskar compression ignition engine

T1- Inlet engine water temperature, PT - Pressure transducer, N - RPM Decoder, F1- Fuel Flow (Differential Pressure unit), T2 - Outlet engine jacket water temperature, Di-Dieselinlet, Do-Diesel outlet, Ei-Exhaust in, Eo-Exhaust out, EGA - Exhaust Gas Analyzer, SM – Smoke Meter.

Design Procedure for Shell and Coil Heat Exchanger: The analysis of the shell and coil heat exchanger is carried out through following procedure.

Step 1: Length of coil needed (L) = $\pi * D_C * N$

Dc= 8.2cm; N=10

On Substituting L = 260cm

Step 2: Shell side equivalent diameter

Here,

$$D_h = \frac{D_O{}^2 - \pi D_C\, do^2\, \gamma^{-1}}{D_O + \pi D_C\, do^2\, \gamma^{-1}}$$

Do = 35cm, Dc =8.2cm, do = 0.7cm

γ = 0.0455, on substituting the values

Dh = 30cm

Step 3: Calculating Pitch Ratio γ

$\gamma = \frac{b}{\pi\, D_C}$ On Substituting

b = 1.1715

Step 4: Heat carried by exhaust gas,

Qg= m_g x Cphg x ΔTg

=0.0208x1010x (257 - 199) = 1.2kW

Heat carried by preheated diesel,

Qd=m_d x Cphdx ΔTd

= 0.0208x2100 x (60 - 32) = 0.4704kW

The average of two readings Qavg,

Qavg = (Qg + Qd)/2

= (1.2+0.4704)/2

= 0.8352 kW

Qmax= min x Cpmin x (Thi - Tci)

= (0.0208) x 1010 x (257-60)

= 4.138 Kw

Step 5: Heat Exchanger effectiveness

Effectiveness (ϵ) = (Qavg / Qmax)

= (0.8352/4.138)

ϵ = 0.201

Step 6: Log mean temperature difference (LMTD)

$$LMTD = \frac{(Thi - Tc0) - (Tho - Tci)}{\ln\frac{(Thi - Tc0)}{(Tho - Tci)}}$$

$$\frac{(257.16 - 60.5) - (199.16 - 32)}{\ln\frac{(257.16 - 60.5)}{(199.16 - 32)}}$$

LMTD = 181.50°C

Step 7: Overall heat transfer coefficient (Uo),

The outer surface area of heat exchanger

Ao = π*do* L = π x 0.7 x 260 = 57.48cm^2

$U_O = \frac{Qavg}{Ao\ LMTD}$, on substituting the values

=0.0458 Kw / cm^2 k

3. RESULTS AND DISCUSSION

Performance and Emission Characteristics of Diesel – Preheated Diesel

Brake thermal efficiency: The Figure.2.shows the variation of brake thermal efficiency with brake power. The brake thermal efficiency (BTE) is increasing with increasing of load. From the figure shows that brake thermal efficiency is slightly less for preheated diesel when compared to normal aspirated diesel engine. Because of while preheating the diesel is phenomena in thermal loss.so that BTE is decreasing in preheated diesel engine than diesel engine.

Brake specific fuel consumption: The Figure.3.shows the variation of brake specific fuel consumption with brake power. Brake specific fuel consumption (BSFC) is decreasing with increasing of load. BSFC is decreasing for preheated diesel engine up to BP is 2.725 kw then BSFC is same for peak load.so that while preheated is BSFC is lesser than the normal diesel engine.

Exhaust gas temperature: The Figure.4.shows the variation of exhaust gas temperature with brake power. Generally exhaust gas temperature is increased with increasing of engine loads. At part load, the exhaust gas temperature is around 189℃ which increases to 345℃ at full load for normal diesel engine. But in preheated diesel engine the exhaust gas temperature at t part load, the exhaust gas temperature is around 125℃ which increases to 290℃ at full load can be decreased by means of EGT is 60℃ to 65℃ lower for preheated diesel engine than normal engine.

Emission Characteristics of diesel with preheated diesel: The variation of hydrocarbon (HC) emission with load for preheated diesel engine operation and with diesel engine is shown in Figure. 5. It can be observed that the formation of HC for preheated diesel operation is lower compared to that of diesel operation. In preheated diesel is HC emission is 5ppm to 7ppm lower than diesel fuel at full loads. This is believed to be due to the presence of oxygen in the fuel, which promotes the combustion process. As preheated diesel is droplet size is reduced caused inside the cylinder has more contains oxygen in the combustion chamber itself, so it is believed to enhance the combustion.

Carbon monoxide emission: The Figure.6.shows the variation of carbon monoxide (CO) emission with load for preheated diesel and diesel. It can be observed that the CO in the case of preheated diesel operation is lower in the entire load spectra compared to diesel. At full load the reduction in the concentration of CO emission is about 0.01

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to 0.012% compared to diesel operation. The presence of oxygen in the fuel, which helps to promote combustion processes, in turn reduces the exhaust emissions compared to diesel. Further the CO emissions reduced by the preheating diesel.

NOx emission: The variation in NOx concentration with load for preheated diesel and diesel is shown in Figure.7. The formation of NOx in the cylinder depends on the engine in-cylinder temperature and the rate of combustion. It can be observed that the formation of NOx for preheated diesel operation is 50 ppm to 80 ppm lower when compared to that of diesel operation. By preheating diesel can be chain breaking reaction and its droplets are reactive radicals, this leads to reduction of NOx emission.

Smoke opacity: The Figure.8 shows the variation of smoke opacity with load. Smoke is formed due to incomplete combustion of the fuel. This may be due to the presence of oxygen molecules in preheated diesel because of droplet size is reduced, which resulted in better combustion of the fuel; so preheated diesel resulted in lower smoke emission. Smoke emission is almost lesser to diesel at all loads.

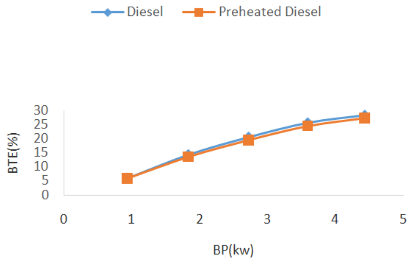

Figure.2.Variation of brake thermal efficiency with brake power

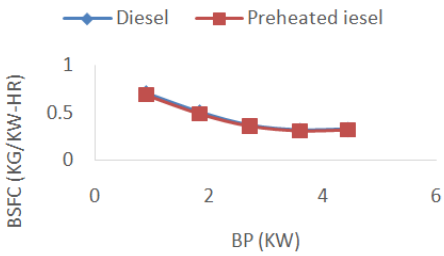

Figure.3.Variation of brake specific fuel consumption with brake power

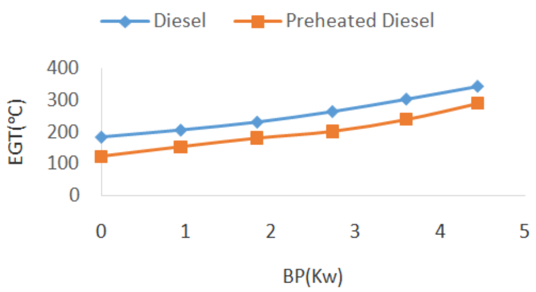

Figure.4. Variation of exhaust gas temperature with brake power

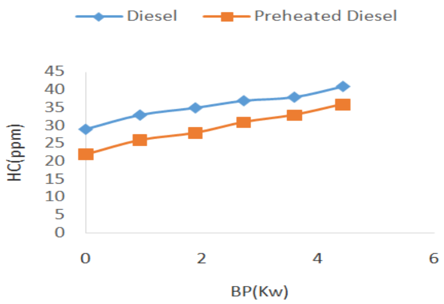

Figure.5.Variation of hydrocarbon with brake power for standard diesel with preheated diesel

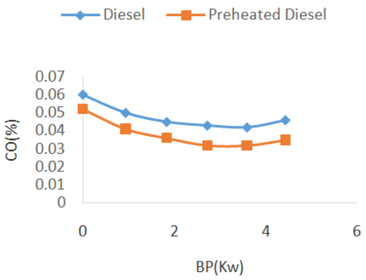

Figure.6.Variation of carbon monoxide with brake power

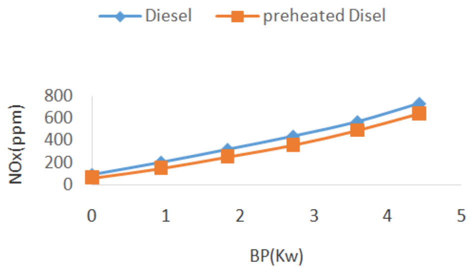

Figure.7. Variation of NOx emission with brake power

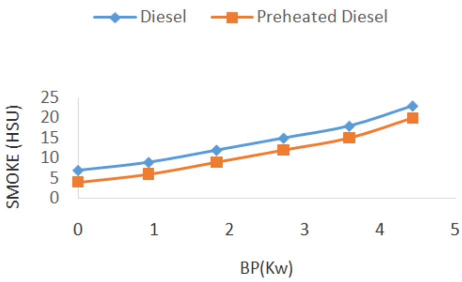

Figure.8.Variation of smoke opacity with brake power

4. CONCLUSION

By preheating the diesel with the help of shell and coil heat exchanger in diesel engine, the performance of the preheated diesel in the engine is higher than normal diesel engine and the emissions of the preheated diesel engine is lesser than normal engine. From the above results and discussion, the brake specific fuel consumption is significantly reduced while pre heating the diesel. Exhaust gas temperature is lesser for preheated diesel in diesel engine. From the emission characteristics curves, CO, HC, and SMOKE is very much lesser for preheated diesel compared to diesel whereas NOx is slightly lesser of them.

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