Experimental Performance Analysis of Diesel Engine without Ceramic Coating on Cylinder Liner

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Abstract— Automobile industries faces big problem related to fuel economy, engine efficiency and emission which is harmful to the environment as well as human. In diesel engine one–third fuel energy is converted into the useful work otherwise diesel engine rejects about two third of heat energy of fuel i.e. one third to exhaust and one third to coolant. Due to rise of fuel cost major challenges for automobile industry is to decrease the fuel consumption, exhaust emissions without compromising efficiency. The performance of internal combustion engine can be improve by reducing frictional losses as well as reduction in specific fuel consumption of fuel during the engine operation. Exhaust emission can be reduced by complete combustion of fuel which is obtained by complete combustion of fuel due to high combustion temperature inside the combustion chamber. These things can be obtain by ceramic materials which have low thermal conductivity, less weight, corrosion resistance, wear resistance and shock resistance etc. the objective is to improve the performance of four stroke single cylinder diesel engine by providing ceramic coating on cylinder liner to know the effect of coating on the performance of diesel engine.

Keywords: *Thermal efficiency, Fuel economy, Ceramic, Emissions*

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NOMENCLATURES

1	FP	Friction Power	KW
2	BP	Break Power	KW
3	IP	Indicated Power	KW
4	T	Torque	Nm
5	SFC	Specific Fuel Consumption	Kg/kwhr
6	BSFC	Break Specific Fuel Consumption	Kg/kwhr
7	ISFC	Indicated Specific Fuel Consumption	Kg/kwhr
8	L	Engine Load	Kg
9	g	Gravitational Acceleration	m/s^2
10	D	Diameter Of Drum	meter
11	N	Number Of Revolution Per Minutes	rpm
12	CV	Calorific Value	kJ/kg
13	ηb	Brake Thermal Efficiency	%
14	ηm	Mechanical Efficiency	%
15	hp	Horse Power	KW
16	mf	Fuel Flow Rate	kg/hr
17	ρd	Density Of Diesel	Kg/m^3
18	m	Mass	Kg
19	R	Break Drum Radius	meter
20	ηth	Thermal Efficiency	%
21	ηith	Indicated Thermal Efficiency	%
22	ηbth	Break Thermal Efficiency	%
23	TBC	Thermal Barrier Coating	

I. INTRODUCTION TO DIESEL ENGINE

Diesel engine becomes more popular than S.I (Spark Ignition) engine because of limitation of engine size and less operating cost. Petrol engine cylinder bore diameter cannot be increased beyond 150mm. diesel engine is require for large power requirement.

Diesel engines are widely used because of following reasons.

- It can be manufactured in large range of sizes (50 mm to 1200mm).
- Large speed range is available (100rpm to 4500rpm).
- Large range of power output is available (5kw to 50000kw).
- Due to higher compression ratio thermal efficiency of diesel engine is higher compared to petrol engine.
- Diesel fuel is less expensive than petrol.
- As diesel has higher specific gravity than Petrol. Fuel is sold on the volume basis so more kg of diesel per litre is available compare to petrol.

Generally diesel engines are not used in two wheeler and small cars because of following drawbacks as compare to petrol engine.

- It is heavier in weight for same output.
- More noise and vibration therefore less comfort.

More exhaust smoke and odor.

II. CALCULATIONS:

To measure the performance characteristics of diesel engine for different load conditions 2kg, 4kg, 6kg, 8kg, and 10kg respectively. We calculate [3] [4]torque, break power, friction power, and indicated power, mass of fuel consumption, break specific fuel consumption, indicated fuel consumption, mechanical efficiency and indicated thermal efficiency as well as break thermal efficiency for each load.

A. *Torque Calculation:*

Here I have calculated torque for five different load conditions respectively 2kg, 4kg, 6kg, 8kg, 10kg loads.

1) 2-load:

$T=m*g*R$
$T=2*9.81*0.141$

T=2.77Nm

2) 4-load:

T=m*g*R
T=4*9.81*0.141
T=5.53Nm

3) 6-load:

T=m*g*R
T=6*9.81*0.141
T=8.30Nm

4) 8-load:

T=m*g*R
T=8*9.81*0.141
T=11.07Nm

5) 10-load:

T=m*g*R
T=10*9.81*0.141
T=13.83Nm

B. Break Power calculation:

Here I have calculated break power for five different load conditions respectively 2kg, 4kg, 6kg, 8kg, 10kg loads.

1) 2-load:

$$B.P = \frac{2\times3.14\times1485\times2.77}{60\times1000} = 0.4299kw$$

2) 4-load:

$$B.P = \frac{2\times3.14\times1451\times5.53}{60\times1000} = 0.8402kw$$

3) 6-load:

$$B.P = \frac{2\times3.14\times1419\times8.30}{60\times1000} = 1.2326kw$$

4) 8-load:

$$B.P = \frac{2\times3.14\times1342\times11.07}{60\times1000} = 1.5543kw$$

5) 10-load:

$$B.P = \frac{2\times3.14\times1319\times13.83}{60\times1000} = 1.9095kw$$

C. Mass of Fuel Consumption (mf) Calculation:

Here I have calculated mass of fuel consumption for five different load conditions respectively 2kg, 4kg, 6kg, 8kg, 10kg loads.

1) 2-load:

$$mf = \frac{6.70\times3600\times0.832}{60\times1000} = 0.3344kg/hr$$

2) 4-load:

$$mf = \frac{7.9\times3600\times0.832}{60\times1000} = 0.3943kg/hr$$

3) 6-load:

$$mf = \frac{9.8\times3600\times0.832}{60\times1000} = 0.4892kg/hr$$

4) 8-load:

$$mf = \frac{10.7\times3600\times0.832}{60\times1000} = 0.5341kg/hr$$

5) 10-load:

$$mf = \frac{11.8\times3600\times0.832}{60\times1000} = 0.5890kg/hr$$

D. Break Thermal Efficiency Calculation:

Here I have calculated Break thermal efficiency for five different load conditions respectively 2kg, 4kg, 6kg, 8kg, 10kg loads.

1) 2-load:

$$\eta_{bth} = \frac{0.430\times3600\times100}{0.334\times42630} = 10.85\%$$

2) 4-load:

$$\eta_{bth} = \frac{0.840\times3600\times100}{0.394\times42630} = 17.99\%$$

3) 6-load:

$$\eta_{bth} = \frac{1.23\times3600\times100}{0.489\times42630} = 21.27\%$$

4) 8-load:

$$\eta_{bth} = \frac{1.55\times3600\times100}{0.534\times42630} = 24.57\%$$

5)10-load:

$$\eta_{bth} = \frac{1.91\times3600\times100}{0.584\times42630} = 27.61\%$$

E. Indicated Thermal Efficiency Calculation:

Here I have calculated indicated thermal efficiency for five different load conditions respectively 2kg, 4kg, 6kg, 8kg, 10kg loads.

1) 2-load:

$$\eta_{ith} = \frac{1.93\times3600\times100}{0.334\times42630} = 48.72\%$$

2) 4-load:

$$\eta_{ith} = \frac{2.34\times3600\times100}{0.394\times42630} = 50.11\%$$

3) 6-load

$$\eta_{ith} = \frac{2.73\times3600\times100}{0.489\times42630} = 47.17\%$$

4) 8-load:

$$\eta_{ith} = \frac{3.05\times3600\times100}{0.534\times42630} = 48.28\%$$

5) 10-load:

$$\eta_{ith} = \frac{3.41\times3600\times100}{0.584\times42630} = 48.88\%$$

F. Mechanical Efficiency:

Here I have calculated Mechanical efficiency for five different load conditions respectively 2kg, 4kg, 6kg, 8kg, 10kg loads.

1) 2-load:

$$\eta_{mech} = \frac{0.4299\times100}{1.93} = 22.27\%$$

2) 4-load:

$$\eta_{mech} = \frac{0.840\times100}{2.34} = 35.90\%$$

3) 6-load:

$$\eta_{mech} = \frac{1.232\times100}{2.73} = 45.10\%$$

4) 8-Load:

$$\eta_{mech} = \frac{1.554 \times 100}{3.05} = 50.88\%$$

5) 10-load:

$$\eta_{mech} = \frac{1.909 \times 100}{3.41} = 56.00\%$$

G. Break Specific Fuel Consumption Calculation:

Here I have calculated Break Specific Fuel consumption for five different load conditions respectively 2kg, 4kg, 6kg, 8kg, 10kg loads.

1) 2-load:

$$\text{BSFC} = \frac{0.334}{0.429} = 0.78\text{Kg/kwh}$$

2) 4-load:

$$\text{BSFC} = \frac{0.394}{0.840} = 0.47Kg/kwh$$

3) 6-load:

$$\text{BSFC} = \frac{0.489}{1.232} = 0.40\text{Kg/kwh}$$

4) 8-load:

$$\text{BSFC} = \frac{0.534}{1.554} = 0.34\text{Kg/kwh}$$

5) 10-load:

$$\text{BSFC} = \frac{0.589}{1.909} = 0.31\text{Kg/kwh}$$

H. Indicated Specific Fuel Consumption Calculation:

Here I have calculated indicated Specific Fuel consumption for five different load conditions respectively 2kg, 4kg, 6kg, 8kg, 10kg loads.

1) 2-load:

$$ISFC = \frac{0.334}{1.93} = 0.173kg/kwh$$

2) 4-load:

$$ISFC = \frac{0.394}{2.34} = 0.168kg/kwh$$

3) 6-load

$$ISFC = \frac{0.489}{2.73} = 0.179kg/kwh$$

4) 8-load:

$$ISFC = \frac{0.534}{3.05} = 0.174kg/kwh$$

5) 10-load:

$$ISFC = \frac{0.589}{3.41} = 0.172kg/kwh$$

III. EXPERIMENTAL SETUP

A single-cylinder, 4-Stroke, water-cooled diesel engine of 5 HP rated power is considered for the experimentation. The engine is coupled to a rope brake dynamometer through a load cell. It is integrated with a data acquisition system to store the data for the off-line analysis. The schematic layout of the experimental set up is shown in below Figure

Figure 1.1 Experimental Setup of Diesel Engine [2]

A stationary, 5 HP direct injection diesel engine is used to conduct experiments. Its specifications are given in Table. Concentrations of CO and UHC are measured using Exhaust gas analyser. Air suction rate and exhaust airflow rates are measured with the help of an air velocity meter. Temperatures at the inlet and exhaust valves were monitored using thermocouples.

Parameter	Details
Engine	Single Cylinder High Speed Diesel Engine
Cooling	Water cooled
Bore × Stroke	80 mm × 110 mm
Compression ration	16 : 1
Maximum Power	5 hp or 3.7 Kw
Rated speed	1500 rpm
Capacity	553

Table 1.1: Engine Specification [1]

IV. RESULT AND DISCUSSION

A. Performance Characteristic of with coated Diesel Engine

1. Friction Power for Coated Cylinder Liner:

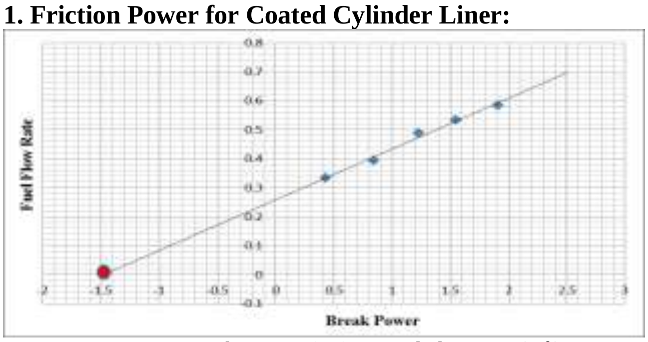

Figure 1.2 Brake Power (BP) v/s Fuel Flow Rate (mf) [5]

Experiment is perform on the single cylinder diesel engine so we use Willan's line method to determine the frictional power which is difference of indicated power and break power. Friction power can be determine by extending the line to zero fuel consumption line which cut the break power axis which gives friction power. From the graph of break power v/s fuel flow rate (mf), frictional power of non-coated diesel engine is 1.5kw as shown in figure.

2. Mass of fuel consumption vs. load:

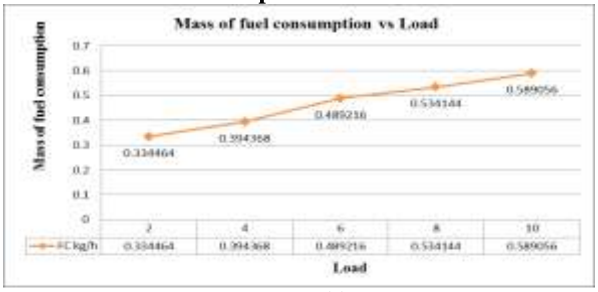

Figure 1.3 Mass of fuel consumption v/s Load

From the above figure, we found that as the load increases the mass of fuel consumption increase with respect to load.

3. Break thermal efficiency vs. Load:

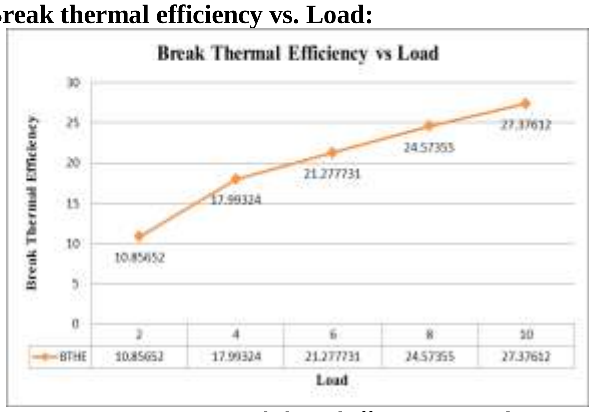

Figure 1.4 Break thermal efficiency v/s Load

From the above figure, we can say that as the load increases the break thermal efficiency increase from 10.85% to 27.37% with respect to load.

4. Break Specific Fuel Consumption:

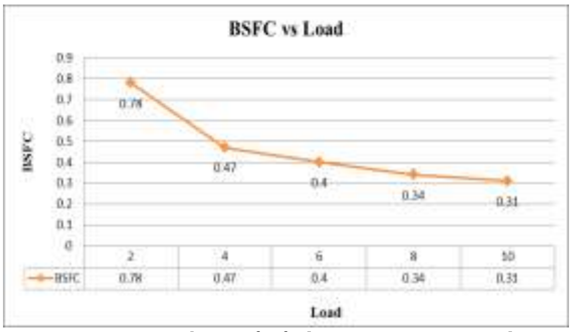

Figure 1.5 Break Specific fuel consumptions v/s Load

From the above figure, load v/s break specific fuel consumption graph indicates that as load increase the break specific fuel consumption decreases with respect to load.

5. Indicated Specific fuel consumption:

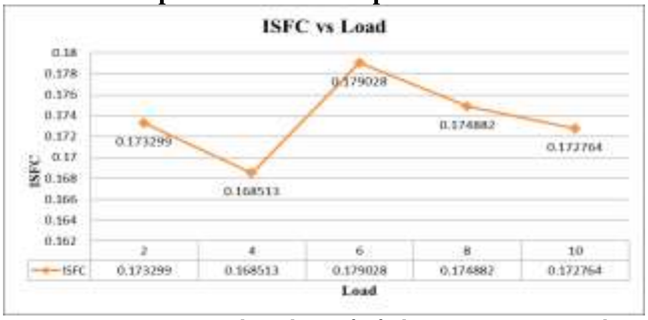

Figure 1.6 Indicated Specific fuel consumptions v/s Load

As shown in figure, Load v/s indicated specific fuel consumption graph indicate that indicated fuel consumption decreases for 2kg to 4kg while it increases for 4kg to 6kg then again it decreases from 6kg to 10kg.

6. Indicated thermal efficiency:

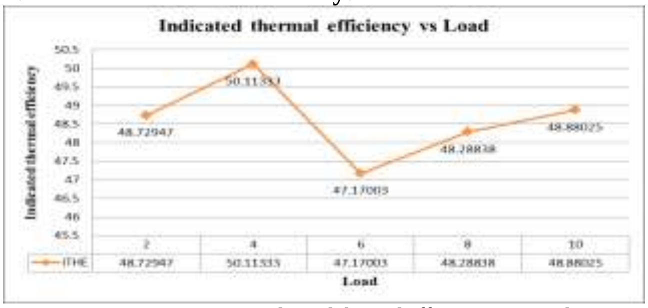

Figure 1.7 Indicated thermal efficiency v/s Load

As shown in figure, Load v/s indicated thermal efficiency graph indicate that indicated thermal efficiency increases for 2kg to 4kg while it decreases for 4kg to 6kg then again it increases from 6kg to 10kg.

7. Mechanical efficiency:

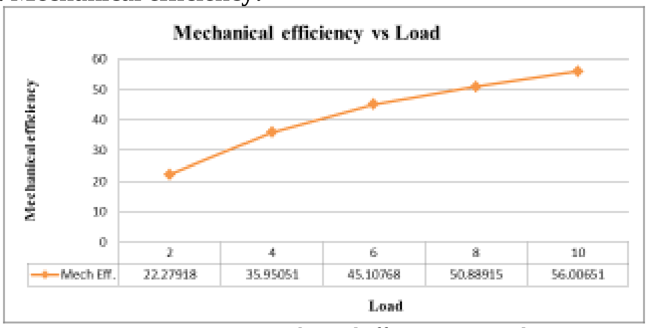

Figure 1.9 Mechanical efficiency v/s Load

As shown in figure, load v/s mechanical efficiency graph indicated that as the load increases from 2 kg to 10kg the mechanical efficiency increase from 2 kg to 10kg.

V. CONCLUSION

By performing experiment on single cylinder water cooled diesel engine we found following things.

- Friction Power is about 1.5.
- Break thermal efficiency increase from 10.85% to 27.37% with respect to load.

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- Variation in indicated Power.
- Mechanical efficiency continues increases.
- Mass of fuel consumption increases

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