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Experimental Evaluation of Injection Pressure and Injection Timing on Diesel Engine

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***Abstract:** An attempt is made in this paper to conduct experiments to study the effect of different injection pressure with different injection timing of a Diesel Engine and evaluate performance and emission characteristics.*

The experiments are conducted at different Load conditions of 0%,,25% ,50%,& 75% and Full Load by varying injection pressures of 200 and 220 Bar with different injection timings at19°, 23° and 27° bTDC. Output results shows that engine operating at 220 bar pressure gives nearly 1% more brake thermal efficiency than lower pressure irrespective of the injection timing whereas brake specific fuel consumption is found to have significant changes at the initial conditions. It is also shows that the CO emissions decrease with increase in injection pressure and advancement in injection timings at 220 bar and 27º bTDC but also those conditions yield the lowest CO emission because of the NOx emissions increase with increase in injection pressure.

***Keywords:** Single cylinder, Brake Power, Performance Characteristics*

I. INTRODUCTION

Compression Ignition (CI) Engine is a type of IC Engine where the diesel fuel is injected into engine cylinder after end of compression stroke and combustion takes place due to elevated temperature of the air in the cylinder.

II. LITERATURE REVIEW

Bridjesh and Arun Kumar[1] have proved that as the fuel injection increases, performance characteristics. like Brake Thermal Efficiency and Brake Power increase. Rostami, et al., [2] have conducted experiments to study the effect of fuel injection timing on the performance of a Diesel Engine using diesel-biodiesel blends by running the engine at speeds of 1200, 1600, 2000 and 2400 rpm.. Hani Chotai [3] has explained that pollutant emissions and fossil fuel depletions from Diesel Engine after review on published research papers relating to varying injection pressure and timing and NOx emissions. Deva Kumar et al, [4] have proved that there are various that influence performance of Engine Rajendra Prasad [5] has conducted experimental study on a single cylinder Direct Injection Diesel Engine at 150 N/m^2, 170 N/m^2 and 190 N/m^2 injection pressure.

2.1 Objectives of the paper

An attempt is made in this paper to stud the effect of Fuel Injection Pressure with different fuel injection timings on a single cylinder Diesel Engine by conducting experimental work to evaluate the Engine performance characteristics at 200 bar 220 bar with different Injection Timings of 19º, 23º, 27º from bTDC.

III. EXPERIMENTAL WORK

Experimental setup is shown in Figure -2 followed by Engine specifications in Table -1 and experimental input conditions in Table-2.

IV. EXPERIMENTAL SETUP

Fig. 2: Single cylinder water cooled Diesel Engine

Table - 1: Engine Specifications

Manufacturer	Kirloskar Oil Engine Ltd.
Type	Single cylinder Diesel Engine
Model	TV1
Type of cooling	Water cooling
Arrangement of cylinder	Vertical
Bore	87.5 mm
Length	110 mm
Compression ratio	17.5:1
Speed	1500 rpm
Rated power	7HP
Lubricant	SAE 30/SAE 40

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Dynamometer Specifications:

Power output	–	7.5KW
Voltage	–	230 V
Current	–	Eddy current
Speed	–	1500 rpm
Power supply	–	3ϕ

Table-2: Experimental input conditions

S.No	Injection Pressure (bar)	Injection Timing (°bTDC)
1.	200	19°
2.	200	23°
3.	200	27°
4.	220	19°
5.	220	23°
6.	220	27°

1. Experiments are conducted to for the performance characteristics of a single cylinder Diesel Engine at the different injection pressure for different injection timings of fuel as per the conditions shown in Table-2. The experimental results obtained are: Carbon monoxide, Nitrogen oxide. Un-burnt hydrocarbon and Exhaust smoke.

V. RESULTS AND DISCUSSION

Results obtained from the experiments are shown in Tables – 3 to 8. The performance characteristics curves are drawn as shown in Figures – 3 to 9.

Table -3: Injection Timing at 200 bar pressure and 19^{O} bTDC

S.no	ITEMS	No Load	¼ Load	½ Load	¾ Load	Full Load
1	Brake Power (B.P)	0.00	1.30	2.57	3.79	4.99
2	Brake Specific Fuel Consumption (SFC)	-	0.43	0.31	0.27	0.25
3	Brake Thermal Efficiency	0.00	19.79	26.98	31.89	33.53
4	IMEP in bar	1.99	3.59	4.81	6.08	7.35
5	CO in %	0.029	0.051	0.061	0.078	0.227
6	UHC in ppm	29	54	74	103	137
7	NO_X in ppm	79	227	702	1016	1254
8	Smoke value in %	1.8	7.8	17.8	34.0	75.1

Table 4: Injection Timing at 200 bar Pressure and 23° bTDC

S.no	ITEMS	No Load	¼ Load	½ Load	¾ Load	Full Load
1	Brake Power (B.P)	0.00	1.30	2.56	3.80	5.03
2	Brake Specific Fuel Consumption (SFC)	-	0.47	0.31	0.27	0.26
3	Brake Thermal Efficiency	0.00	18.19	26.93	31.95	32.50
4	IMEP in bar	2.25	3.72	4.74	6.09	7.32
5	CO in %	0.043	0.046	0.041	0.050	0.169
6	UHC in ppm	23	33	54	94	128
7	NO_X in ppm	119	480	1136	1615	1803
8	Smoke value in %	3.2	8.1	19.0	32.4	66.7

Table 5: Injection Timing at 200 bar pressure and 27° bTDC

S.no	ITEMS	No Load	¼ Load	½ Load	¾ Load	Full Load
1	Brake Power (B.P)	0.00	1.29	2.54	3.79	4.98
2	Brake Specific Fuel Consumption (SFC)		0.47	0.32	0.27	0.26
3	Brake Thermal Efficiency	0.00	18.07	26.73	31.85	32.21
4	IMEP in bar	1.87	3.42	4.71	5.91	7.40
5	CO in %	0.039	0.034	0.042	0.069	0.238
6	UHC in ppm	26	31	61	97	135
7	NO_X in ppm	158	533	1264	1779	1950
8	Smoke value in %	2.6	7.6	20.7	34.0	66.5

Table 6: Injection Timing 220 bar Pressure and 19° bTDC

S.no	ITEMS	No Load	¼ Load	½ Load	¾ Load	Full Load
1	Brake Power (B.P)	0.00	1.29	2.55	3.79	4.99
2	Brake Specific Fuel Consumption (SFC)	-	0.47	0.32	0.27	0.25
3	Brake Thermal Efficiency	45.60	49.99	41.91	41.62	40.12
4	IMEP in bar	2.23	4.29	4.85	6.08	7.43
5	CO in %	0.048	0.054	0.057	0.069	0.198
6	UHC in ppm	30	39	61	83	126
7	NO_X in ppm	62	264	603	924	1210
8	Smoke value in %	2.1	9.4	24.1	37.6	78.0

Table7: Injection Timing 220 bar Pressure and 23° bTDC

S.no	ITEMS	No Load	¼ Load	½ Load	¾ Load	Full Load
1	Brake Power	0.00	1.29	2.56	3.79	4.98
2	Brake Specific Fuel Consumption (SFC)	-	0.43	0.31	0.27	0.25
3	Brake Thermal Efficiency	57.53	55.52	42.56	41.95	41.29
4	IMEP in bar	2.84	4.38	4.91	6.12	7.66
5	CO in %	0.069	0.065	0.063	0.067	0.173
6	UHC in ppm	71	67	77	91	127
7	NO_X in ppm	88	404	850	1228	1568
8	Smoke value in %	3.1	18.6	26.2	42.0	66.8

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Table 8: Injection Timing 220 bar and 27° bTDC

S.no	ITEMS	No Load	¼ Load	½ Load	¾ Load	Full Load
1	Brake Power (B.P)	0.00	1.29	2.54	3.77	4.99
2	Brake Specific Fuel Consumption (SFC)	-	0.47	0.32	0.27	0.25
3	Brake Thermal Efficiency	0.00	18.07	26.67	31.72	33.57
4	IMEP in bar	2.00	3.35	4.64	5.88	7.30
5	CO in %	0.051	0.036	0.029	0.043	0.126
6	UHC in ppm	18	29	47	69	114
7	NO_X in ppm	129	575	1174	1704	2019
8	Smoke value in %	2.4	6.8	17.6	31.1	56.3

Calculations

$$Break\ Power = \frac{2\pi NT}{60000}\ kW$$

$$Break\ Specific\ Fuel\ Consumption\ (BSFC) = \frac{TFC}{BP}\frac{kg}{kW} - hr$$

$$Brake\ Thermal\ Efficiency = \frac{B.P \times 3600}{TFC \times C.V}$$

$$Indicated\ Mean\ Effective\ Pressure = \frac{I.P \times 60}{LAnk}\ KN/m^2$$

Load Vs Brake Thermal Efficiency

The variation of brake thermal efficiency with respect to load for different injection pressures and injection timings are shown in Fig.3. It shows that Brake thermal efficiency greatly depends on the heat supplied from the fuel. From the graph, the engine operating at 220 bar pressure delivers almost 1% more at full load condition.

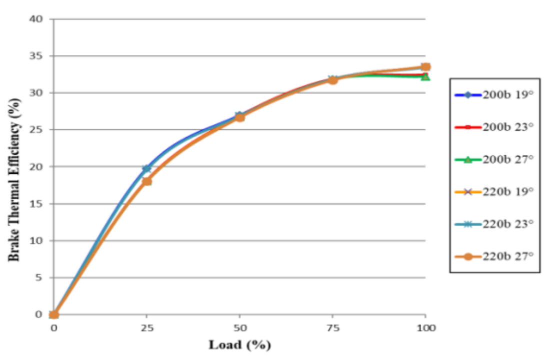

Fig.3: Variation Load Vs Brake Thermal Efficiency

Load Vs Brake Specific Fuel Consumption

The results for the variations in the brake specific fuel consumption (BSFC) with load are presented in the Fig.4. It is found minimum effect on BSFC at higher loads. Even the injection timing seems to have very negligible effect on the BSFC as the values seem to be similar at all different injection timings for a given pressure.

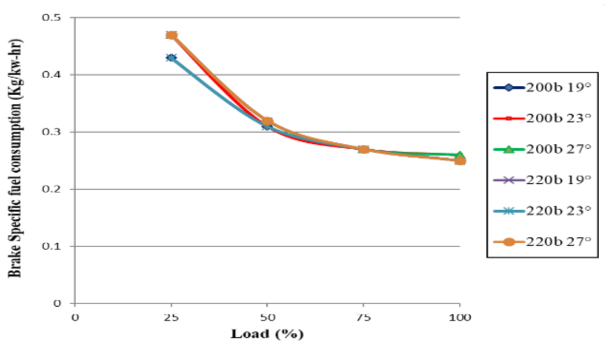

Fig. 4.: Variation of BSFC with load

Load Vs Indicated Mean Effective Pressure

Indicated mean effective pressure with respect to loads are shown in Fig.5. At full load, indicated mean effective pressure is observed to be similar with a variation of about 0.5 bar and the highest value acquired at 220 bar 23° of injection pressure and injection timing respectively. Whereas at lower loads the indicated mean effective pressure seems to raise and then fall with respect to advancing of the injection timing. At a injection pressure level the indicated mean effective pressure is higher at 23° bTDC than 19° bTDC the indicated mean effective pressure again drops.

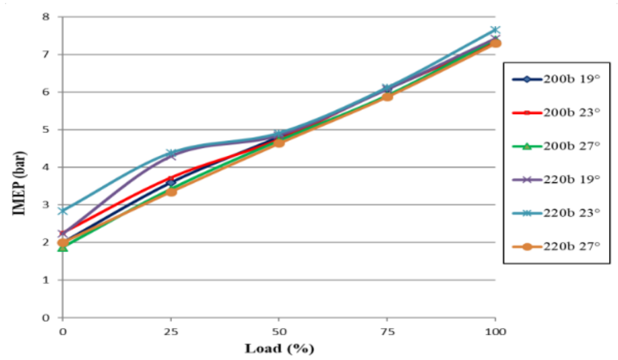

Fig. 5: Variation of IMEP with load

Load Vs CO Emissions

The Fig 6. shows the variation of carbon monoxide (CO) at various load conditions. It is also evident from the graph that retarded injection timing increases the CO emissions even at higher pressures. The CO emission at full load is observed to be lowest at 220bar injection pressure with 27° bTDC injection timing.

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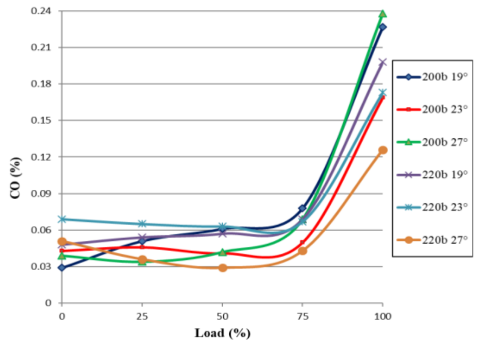

Fig. 6: Variation of CO emissions with load

Load VS UHC Emissions

The Fig.7 shows the variation of un-burnt hydrocarbons with respect to load for tested injection pressures and injection timings. It is also noticed that the UHC emission decreases. The engine running at 220 bar injection pressure with 27º bTDC injection timing produces minimum UHC emissions at all loads.

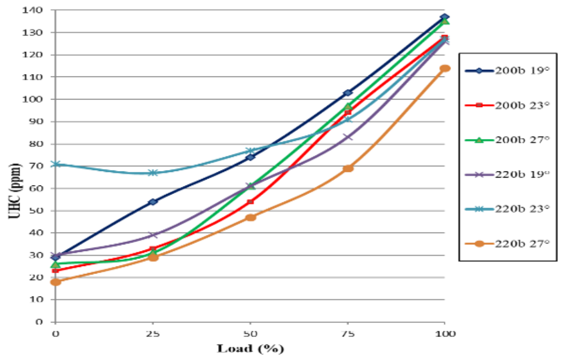

Fig.7: Variation of UHC emissions with load

Load Vs NOx Emissions

Variation of Nitrogen Oxides (NOx) emission at different loads are shown in Fig.8. The graph shows that the amount of NOx is increased with increase in injection pressure at all load conditions at specified injection timing. This is due to increase in temperature in combustion chamber.

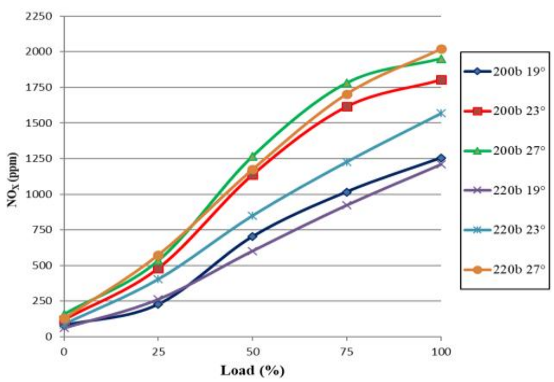

Fig.8: Variation of NOX emissions with load

Load Vs Smoke Value

The variations of smoke emission with respect to loads are shown in Fig. 9. From the graph, it is clear that the smoke value decreases as the pressure increases and also decreases with the advancement in the injection timing. It is evident that smoke density is lowest at 220bar 27º bTDC.

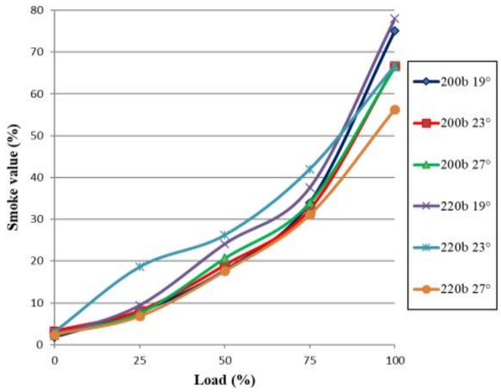

Fig. 9: Variation of Smoke value with load

VI. CONCLUSIONS

- The engine operating at 220 bar pressure gives nearly 1% more brake thermal efficiency than lower pressure irrespective of the injection timing.
- Brake specific fuel consumption and indicated mean effective pressure are observed that no significant changes at all injection pressures and injection timings.

EMISSION CHARACTERISTICS:

- The CO and UHC emissions are decrease with increase in injection pressure and advancement in injection timings at 220 bar 27º bTDC yields lowest CO emission compared to others.
- The NOx emissions increase with increase in injection pressure The smoke density values decrease at more advance injection timing.

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