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Combine Effect of Injection Pressure and Increasing Inlet Air Pressure on the Performance & Emissions of CI Engine using Mahua oil blended with Diesel

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Abstract : *In the present experiment, the effect of increasing inlet air pressure on performance and exhaust gas emission of CI Engine using Mahua oil blended with diesel is taken. The test were conducted on Four stroke single cylinder water cooled diesel engine by using diesel at different engine load and at constant engine speed . Further the experimental were carried at normal atmospheric pressure and different supercharging pressure of 1.2bar and 1.5bar.It was observed that the increasing inlet air pressure performance parameter like Specific fuel consumption decreases, Brake Thermal efficiency and Mechanical efficiency increases. Emission parameters CO, HC emission reduces significantly with supercharging. In this experiment B10D90, B20D80 and B30D70 blend of Mahua oil are taken for experiment.*

Keywords – *CI Engine, Performance, Emission, Mahua oil, Supercharging, Injection Pressure*

I. INTRODUCTION

The energy depletion and environmental deterioration are the main problem world is facing today. The increasing population on the earth increased the energy needs. As per the world energy report, we get around 80% of our energy from conventional fossil fuels like oil (36%), natural gas (21%), and coal (23%). It is well known fact that these are non renewable sources of energy and they can't renewed at any cost once they are exhausted. This indicates that petroleum will become increasingly scared beyond the present rate of consumption. There are several initiatives to reduce the consumption of gasoline and Diesel, Solution to long term energy crisis will come only through research and developments in the field of alternative energy sources.

In this experiment we have taken B10D90, B20D80 and B30D70 as a fuel and results are compared with diesel fuel. After selecting the optimized blend results are obtained by varying the injection pressure by applying the taguchi method of parametric optimization.At a particular injection pressure and load it gives minimum specific fuel consumption and maximum brake thermal efficiency. Then at that injection pressure results are obtained by varying the inlet air pressure and results drawn are compared between that optimized blend and diesel fuel and effect of supercharging can be computed.[1] Damor et al Investigates the effect of supercharging on performance and exhaust gas emission of diesel engine fueled Pyrolysis oil and diesel blend. oil taken is tyre pyrolysis oil which was obtained by the waste automobile tyres. It was observed that the increasing supercharging pressure, the performance of the engine is gradually improving. Performance parameter like Specific fuel consumption is gradually Reduction with comparison Un-supercharging. Thermal efficiency is gradually increasing and Mechanical efficiency is also gradually increasing. Emission parameter CO, CO2 and HC emission are decreased significantly with supercharging.[2]Abdullah et al evaluated effects of air Intake pressure on Engine performance, fuel economy and exhaust emissions on a small gasoline engine. Higher air intake pressure increases the efficiency of combustion within a limited time to improve fuel economy, power output and exhaust emissions. Better combustion also leads to the reduced unburned components such as carbon (C), hydrogen (H2), carbon monoxide (CO) and hydroxide (OH) that resulted in cleaner emissions.[3] Kumar et al. investigated effect of Fuel Injection Pressure on Performance of Single Cylinder Diesel Engine at Different Intake Manifold Inclinations. From experiment it is found that engine at 60 degree manifold inclinations at 180 bars has given efficient performance and less pollution, cylinder flow structure is greatly influenced by the intake manifold inclination. It is found that at 60 degree intake manifold inclination, at 180bar gives the maximum brake thermal efficiency.[4] Gupta et al: studied Optimum Fuel Injection Timing of Direct Injection CI Engine Operated on Karanja Oil Investigation. The effects of karanja oil in the injection timing investigated and results are analyzed. The result of the karanja oil gives maximum efficiency which is obtained to at 25_ BTDC. [5]Pandya et al: Investigated effect of Compression ratio and Injection pressure on the performance and emission of C.I. Engine with Multiple Injection techniques - A Review Study. The study shows that the reduction in compression ratio will reduce the combustion peak temperature and that will reduce NOX but there will slight in-crease in CO and HC. By increasing compression ratio, it is possible to extract maximum possible mechanical efficiency from the engine. Increasing Compression ratio enhances Brake thermal efficiency increases from 27.3% to 29.1%, HC reduced , NOX level increases with increasing IOP (Injection Opening Pres-sure) due to faster combustion and higher temperatures . By Combination of variation in compression ratio and injection pressure shows that, the best effect is seen with the combination of injecting fuel at 250 bar while maintaining the compression ratio as 18:1, where the BSFC is minimum for whole of the load range with an improvement of about

10% over standard setting. [6] Anand et al: evaluated Performance and Emissions of a Variable Compression Ratio Diesel Engine Fuelled with Bio-Diesel from Cotton Seed Oil. Tests were conducted in a single cylinder variable compression ratio diesel engine at a constant speed of 1500 rpm. Highest brake thermal efficiency and lowest specific fuel consumption were observed for 5% biodiesel blend for compression ratio of 15 and 17 and 20% biodiesel blend for compression ratio of 19. The NO emissions increase proportionally with the mass percent of oxygen in the bio-fuel and compression ratio, at 17: 1. The visible smoke and carbon monoxide and unburned hydrocarbons emissions emerging from the biodiesel over all loads and compression ratios are lowered by up to 71.7% and 24% to 63.6%, respectively.[7] Kumar et al: (2014) studied effect of Injection Pressure on performance & emission characteristics Of DI Diesel engine running on Nelli Oil & Diesel fuel .The main objective of this study is to investigate the effect of injection pressures on performance and emissions characteristics of the engine. The brake thermal efficiency of the engine for Nelli oil-diesel blend of operations is high compared to diesel mode at 180, 200 and 220 bar. The exhaust gas temperature of Nelli oil diesel blend mode is less compared to diesel mode at fuel injection pressures of 180, 200 and 220 bar. HC and CO emissions of Nelli oil-diesel blend mode is lower compared to that of diesel fuel mode at all fuel injection pressures. [8]Kumar et al. (2013**)** studied Comparative Analysis of Performance and Emission of Diesel Engine by Varying Compression Ratio Using Different Fuels. Tests were carried out using three different CRs (14, 16 and 18:1) at 1500 rpm with varying load from 0 to 100%. The results showed that increasing compression ratio improves the burning characteristics of biodiesel. At higher compression ratio, brake specific fuel consumption (BSFC) increased while brake thermal efficiency decreased. However, slight increase in brake power is found especially at higher load. Steep decrease is recorded in smoke opacity (OP), carbon monoxide (CO), oxygen (O2) and hydrocarbon (HC) emissions, while increase in CO2 is also observed. [9]Dwivedi et al. (2013) evaluated performance of Diesel Engine Using Biodiesel from Pongamia Oil. The present study has dealt with the production of biodiesel from Pongamia oil, measurement of properties and performance evaluation on 2 KVA DG set with blends of biodiesel at various loads. The conclusions drawn are fuel properties like density, flash point, viscosity and calorific value of B10, B20 are very similar to diesel and therefore diesel may be well replaced by biodiesel in near future. The performance evaluation of engine has found that BSFC for B100 in case of Pongamia biodiesel was 30.4 % higher than diesel at full load, there by indicating that more amount of B100 produce power similar to diesel.

1.1 Introduction to Supercharging:-

The Supercharging can be defined as process of increasing charge (inlet Air) density in order to increasing power output and efficiency of the engine. The purpose of supercharging an engine is to raise the density of the air charge, before it is delivered to the cylinder. The greater the density of the compressed air in the combustion chamber, the greater the resistance offered to the travel of the fuel droplets across the chamber. This will result in better dispersion of the fuel .A Supercharger is an compressor used to increasing to pressure and density of air supplied to an internal combustion .Supercharger can be driven mechanically by belt , chain drive or by gear from the engine’s crankshaft, most of the supercharger driven by belt.

1.2 Mahua Oil

Mahua seeds are collected during May to July. During a bumper season a person can collect upto 15 kg per day. Local tribal extracts 250 ml of oil from 1kg of seed. Oil is usually kept for domestic consumption. In market they sell seeds at Rs 10/- per kg. The seeds should be de-shelled by pressing and then dried to get the kernel. The amount of oil extracted is 20-30 % of weight of kernels when crushed in ghanis, 34-37 % in expellers and 40-43% when extracted by solvents. The catalyst KOH is used, a homogeneous reaction takes place and the biodiesel is produced with the liberation of glycerin.

Figure1 Mahua Seeds

Properties	Diesel	Mahua Oil
Viscosity *(mm^2/s) (at 40^0C)*	4.3	24.58
Calorific Value(kj/kg)	42500	36100
Density(kg/l)	0.815	0.960
Flash point	58	232
Ash content	0.01	0.09
Cetane number	47	61.4

Table1 Properties of Mahua Oil

II EXPERIMENTAL SETUP

Experiment was performed on single cylinder four stroke water cooled diesel engine. Specifications engine are listed in table 2.Engine load was adjusted by eddy current type water cooled with loading unit dynamometer. Two stage reciprocating compressor has been used for supercharging.

Figure 2: Experimental Setup

No. of cylinder	Single cylinder

No. of stroke	4
Cylinder dia.	87.5 mm
Stroke length	110 mm
C.R. length	234 mm
Orifice dia.	20 mm
Dynamometer arm length	185 mm
Fuel	Diesel
Power	3.5 kw
Speed	1500 rpm
C.R. range	12:1 to 18:1
Inj. Point variation	0 to 25 Btdc

Table 2: Engine Specification

2.1 Methodology

- First Engine runs on diesel performance such as brake power, indicated power, break specific fuel consumption etc. find from the experiments.
- Then the blending of diesel and Mahua oil at different proportion like 10 %, 20% and 30% concentration in the diesel fuel takes, engine performance of the engine are measured for performance and emission parameters and are compared with diesel.
- Then we find optimum blend as by comparing performance & emission parameters for diesel, B10, B20, B30.
- After finding the optimized blend, we will investigate on different Injection Pressures and at different load by applying the taguchi method and find the optimized injection pressure and load for minimum SFC & maximum Brake thermal efficiency.
- Then we will compare the result of that optimized blend at that optimized injection pressure and load by varying the inlet air pressure against the diesel at same load and IP at different Inlet air pressure.

III OBSERVATION & RESULTS

Fuel: M30D70blend Density: 845.78 kg/m^3 Calorific Value:40705kj/kg

No.	Injection Pressure (bar)	Load (kg)	BP (kw)	FC (kg/hr)	SFC (kg/kwh)	BThEff (%)
1	160	2	0.57	0.40	0.7	12.6

1	180	6	1.72	0.45	0.26	33.80
2	200	10	2.81	0.35	0.12	71
3	160	6	1.69	0.45	0.26	33.21
4	180	10	2.79	0.60	0.22	41.12
5	200	2	0.54	0.35	0.64	13.64
6	160	10	2.82	0.70	0.24	35.62
8	180	2	0.5	0.42	0.48	10.52
9	200	6	1.69	0.5	0.29	29.89

Table 3: M30D70 blend as per Taguchi L9 Orthogonal array

Sr.No	Fuel	Air(mmWc)	I.A.P(Bar)	CO(%)	HC(PPM)	CO_2 (%)	NO_X (ppm)
1	Diesel	73.75	W/O SUP	0.05	48	2.5	6950
2	M30D70	73.75	W/O SUP	0.05	45	2.6	7051
3	Diesel	173.8	1.2	0.04	43	2.7	7150
4	M30D70	173.8	1.2	0.03	40	2.8	7288
5	Diesel	263.34	1.5	0.03	38	2.8	7295
6	M30D70	263.34	1.5	0.03	34	2.9	7388

Table 4: Effect of Inlet Air Pressure at (IP: 200 bars, Load: 10Kg) for performance parameters

Sr.No	Fuel	Fuel(cc/2min)	I.A.P(Bar)	FC(Kg/hr)	SFC(Kg/kw-hr)	BP(Kw)	Bthe(%)
1	Diesel	32	W/O SUP	0.8	0.28	2.84	30.3
2	M30D70	31	W/O SUP	0.77	0.27	2.84	32.6

3	Diesel	31	1.2	0.76	0.26	2.84	32.9
4	M30D70	29	1.2	0.72	0.25	2.84	34.9
5	Diesel	28	1.5	0.69	0.24	2.84	35.3
6	M30D70	27	1.5	0.67	0.23	2.84	37.5

Table 5: Effect of Inlet Air Pressure at (IP :200,Load:10Kg) for emissions parameters

3.1 Effect of Load on SFC: Shows the variation of a SFC for diesel and Mahua oil with different blend ratio at different load condition. From figure it is clear that SFC for diesel fuel reduced continuously for no load to full load condition. SFC reduced up to 0.25 & 0.23 kg/kw-hr for 20% and 30% blend ratio.The specific fuel consumption is depends on fuel consumption. For 30% blend, Up to 8kg load SFC reduced linearly after that SFC reduced very highly and from Figure it shows that for 30% blend SFC reduced better than other tested fuel.

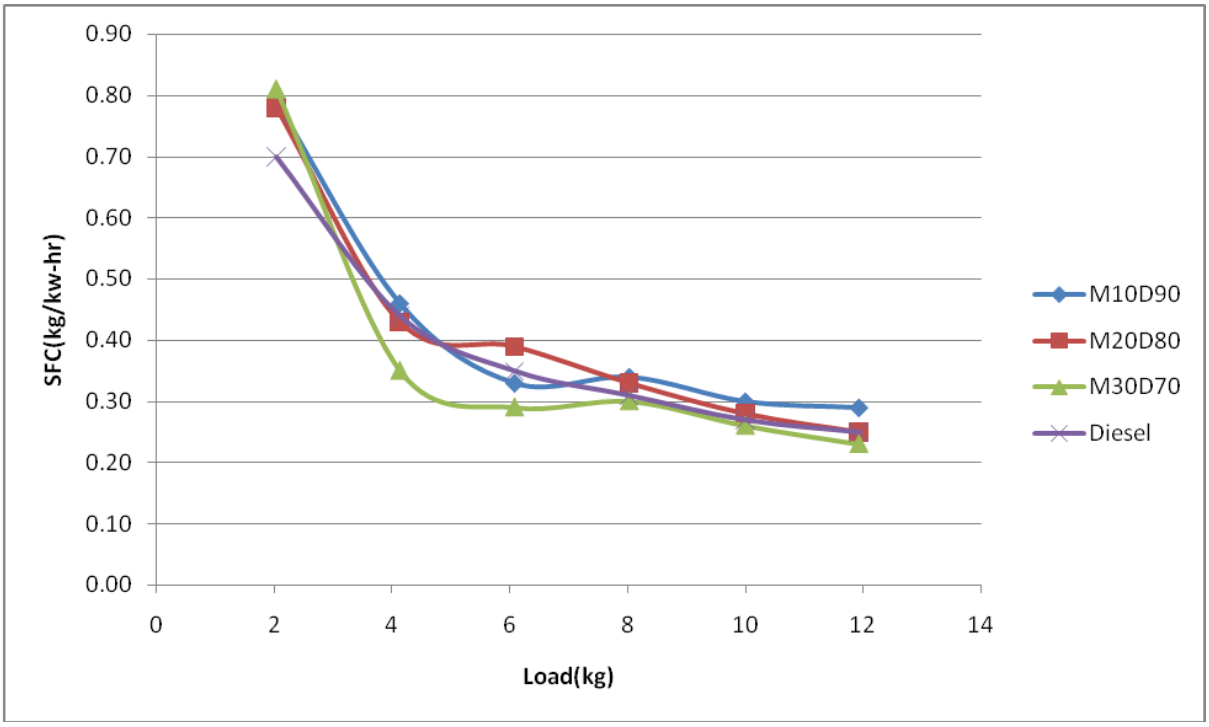

Figure 3 Load v/s SFC

3.2 Effect of Load on Brake thermal efficiency: Shows the variation of a brake thermal efficiency for diesel and Mahua oil with different blend ratio at different load condition. From figure it is clear that BTE For diesel increases continuously for no load to full load condition, for 10% of blend Brake thermal efficiency increased up to 30% but lower than diesel fuel. Highest Brake thermal efficiency is 38% for 30% blend ratio.

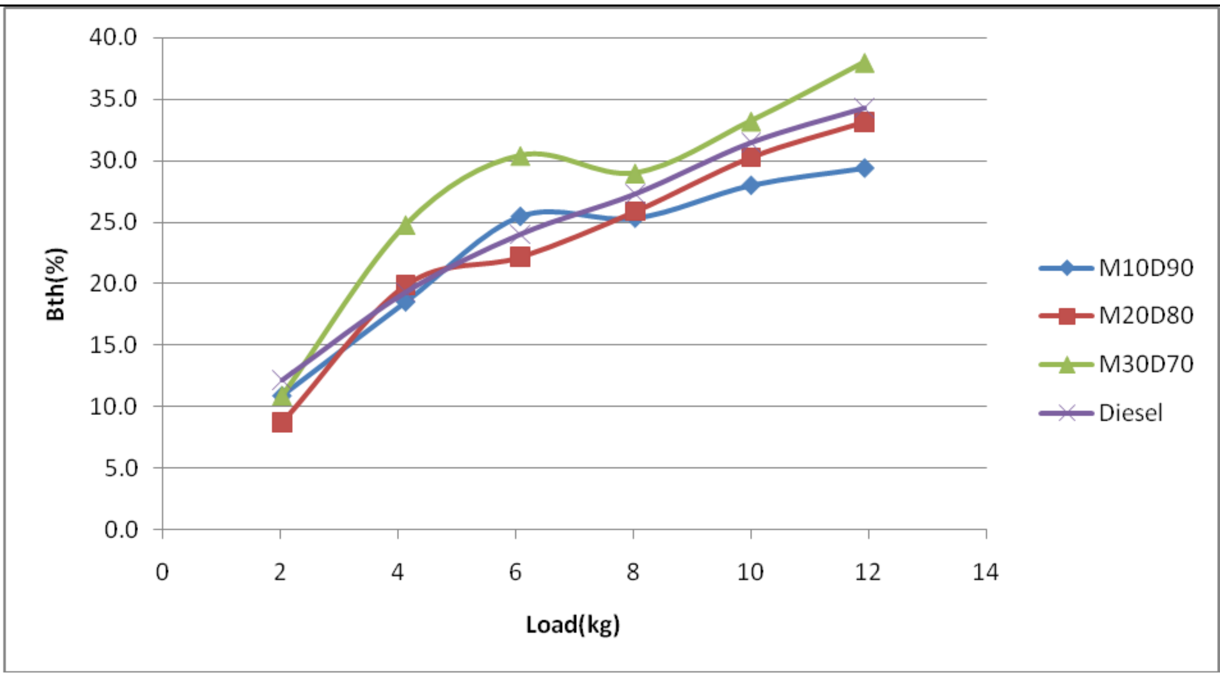

Figure 4:Load v/s Bth

The thermal efficiency of the engine is improved by increasing the concentration of the biodiesel, Brake thermal efficiency depends on calorific value of fuel which is used in engine. Calorific value of B-30 blend is lower than other fuel that's why it has highest brake thermal efficiency.

3.3 Effect of Load on CO Emissions: Shows the variation of a Carbon Monoxide for Mahua –diesel blend at different load condition. From figure it is clear that for 10% and 20% and 30% blend CO by %volume reduced lower than diesel fuel. For 20 & 30% of blend CO reduced up to 0.04 & 0.03% by volume of total exhaust gas respectively. For 30% blend emission of carbon monoxide is least.

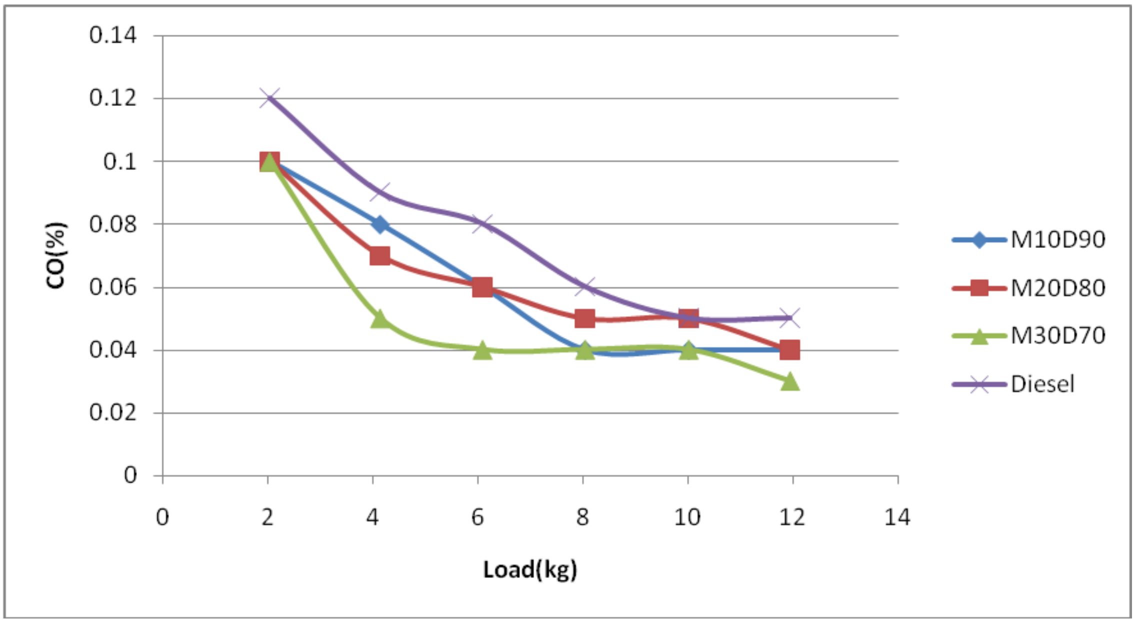

Figure 5:Load v/s CO(%)

3.4 Effect of Load on HC Emission: Shows the variation of Hydro Carbon for Mahua-Diesel blend at different load condition. From figure it is clear that HC for diesel fuel increased continuously for no load to full load condition and more compare to other test fuel. Above analysis of graphs shows that performance and exhaust emission characteristics for four stroke diesel engine was getting better result with 30% blend as compared to any other blend. So 30% was taken for optimization.

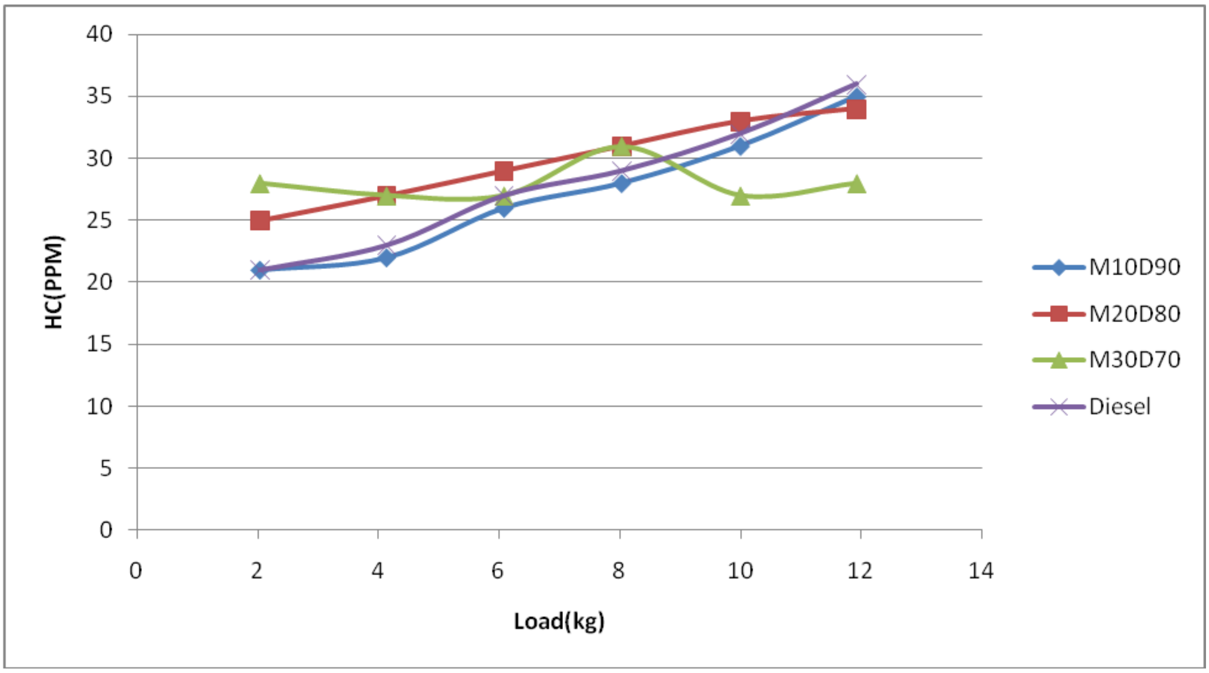

Figure 6:Load v/s HC(PPM)

3.5 Effect of Load on CO_2 shows the variation of a Carbon Dioxide for Mahua-diesel blend at different load condition. From figure it is clear that CO_2 by %volume for diesel fuel lower as compared to 10%,20% and 30% of blend .For 20 & 30% of blend CO_2 increased up to 2.8 & 2.9% by volume of total exhaust gas respectively. .

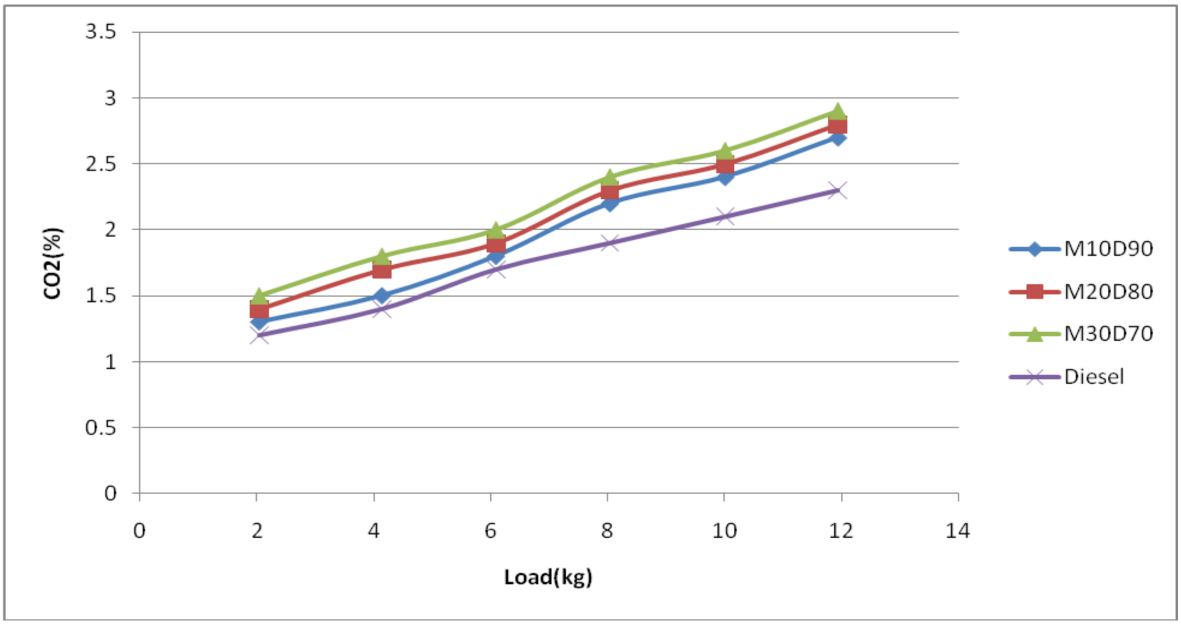

Figure 7:Load v/s CO_2

3.6 Effect of Load on No_x emissions: Shows the variation of NOx for Mahua blend at different load condition. From figure it is clear that NOx for diesel fuel increases continuously for no load to full load condition. And for 10% of blend NOx is 6259ppm higher than diesel fuel . And into 20 & 30% of blend NOx increased up to 6383 & 6580ppm respectively. The NOx of the engine is increase because biofuels has more oxygen content. Into 30% blend NO_X reduced than other test fuel.

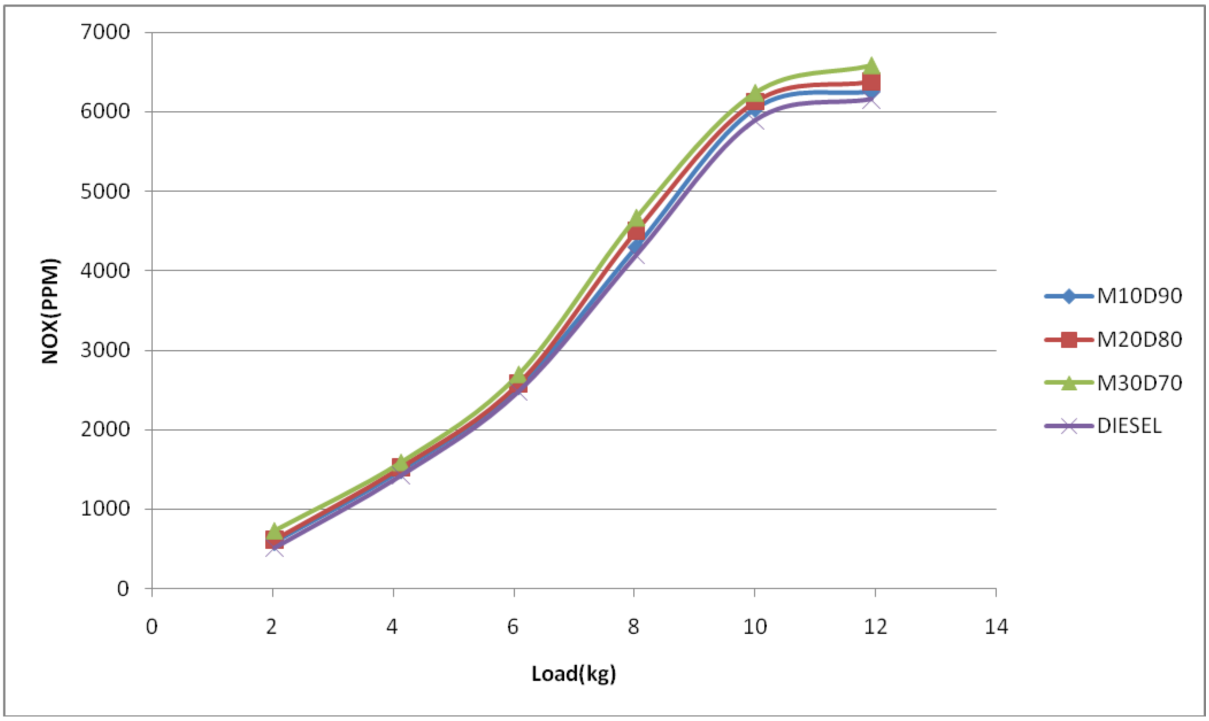

Figure 8:Load v/s NOx

IV CONCLUSION

- It is observed that with an increase in supercharging pressure, the performance of the engine improves**.**
- SFC (Specific fuel consumption) decreases and brake thermal efficiency increases as we increase the pressure as compare to without supercharging.
- As we increase inlet air pressure the content of carbon monoxide and hydrocarbons decreases as due to complete combustion as there is more oxygen available in biofuels.
- Due to higher percentage of oxygen content in biofuels Nitrogen oxide and carbon dioxide increases due to more availability of oxygen in biofuels.
- After analysis of graphs of Diesel, B10, B20 and B30 we can say that B30 gives the optimum performance as performance and emission parameters are concerned.
- At 200 bar, 10 Kg load we get maximum BTH (71%)& minimum Specific fuel(0.12kg/kw-hr) consumption for M30D70 as shown by taguchi method.

NOMENCLATURE

SFC: -Specific Fuel Consumption
ITH:- Indicated Thermal Efficiency
BTH : -BrakeThermal Efficiency
CO: Carbon Monoxide
HC : -Unburned Hydrocarbon
NOx: - Oxide of Nitrogen
PPM: - Part per million

I.A.P-Inlet Air Pressure
W/O SUP.-Without Supercharging

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