Effect of Injection Pressure on the Performance of Single Cylinder CI Engine Fuelled with the Blend of 30% Plastic Pyrolysis Oil and 70% Diesel

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Abstract- *Depleting quantity of Conventional Fuel has been focused as a greater problem these days. Day by day, quantity of Petroleum, Crude Oil has more utilization and lesser production. Increasing use of Petrol & Diesel has made the people of the world to think for some alternative way for energy resources. At the same time. Other rising problem against the people of the world is increase in plastic waste and recycling of the same. Both of the issues are focused and efforts are made to get optimum solution.*

An experimental setup has been prepared for Blended Fuel of 30% Plastic Pyrolysis oil and 70% Diesel Fuel to be used in single cylinder, 4-stroke CI engine. Plastic Pyrolysis oil is obtained from plastic waste by pyrolysis process. Pyrolysis process is a thermo-chemical decomposition of organic matter in absence of oxygen. Blending of pyrolysis oil with diesel helps to reduce the consumption of diesel fuel. The variation in the Injection Pressure of the Engine, fuelled with above stated Blended Fuel, affects the engine performance as well as exhaust emission data. To understand the variation in Engine performance, Experiments were performed by setting different values of injection pressure individually on single cylinder CI Engine, fuelled with above stated blended fuel, at different loading conditions. Selected Injection Pressures were 160 bar, 180 bar, 200 bar and 220 bar. Effect of Engine performance of each were compared by Graphical representation of different performance parameters. It was found to have increase in Engine Performance with increase in Injection Pressure. HC and CO2 emissions were found to be decreased, while NOX were found to be increased with increase in Injection Pressure.

Keywords- Plastic Pyrolysis Oil, Injection Pressure, Blend ratio, Diesel Fuel, CI Engine, Performance of Engine

I. INTRODUCTION

Use of plastic in our daily activities seemed to be increased from years. In an online article, dated April 4, 2013 of the daily newspaper The Times of India of the author Dhananjay Mahapatra it was stated that ‘"We are sitting on a plastic time bomb," the Supreme Court said on Wednesday after the Central Pollution Control Board (CPCB) informed it that India generates 56 lakh tonnes of plastic waste annually, with Delhi accounting for a staggering 689.5 tonnes a day. "Total plastic waste which is collected and recycled in the country is estimated to be 9,205 tonnes per day (approximately 60% of total plastic waste) and 6,137 tonnes remain uncollected and littered," the CPCB said. [1]

The energy crisis as well as the environmental degradation are the major problems mankind is facing today. Demand of energy has been increased day by day because of the increased population on the earth. By the year 2100, the world population is expected to be in excess of 12 billion and it is essential that the demand of energy will be increased by five times of what it is now. According to 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 that the time is not so far when all these sources will be completely exhausted.

To overcome both of the issues stated above, the alternative fuel i.e. Plastic Pyrolysis Oil can be used in CI Engine. As the CI Engine generally available are designed to work effectively with Diesel Fuel only, to use Plastic Pyrolysis Oil in the CI Engine, one need to blend it with Diesel Fuel. Past work related to Plastic Pyrolysis Oil shows that this fuel does not give as comparable performance as Diesel Fuel or other Pyrolysis Oil like Tyre Pyrolysis Oil. So, one need to either improve in Engine Design or make changes in Engine parameter to get noticeable performance of Engine with Plastic Pyrolysis Oil blends with Diesel Fuel. To achieve that, experimentations have been carried out with variation in Injection Pressure in this research.

II. LITERATURE SURVEY

A. Research work regarding performance and emissions of engine with the blended fuel of Plastic Pyrolysis Oil along with other parametric variation has been stated below.

C. Wongkhorsub & N. Chindaprasert [2] made a comparison of the use of pyrolysis oils (Pyrolysis oils from waste tire and waste plastic) in diesel engine in the assessment of engine performance, and feasibility analysis. It was concluded that with Engine modification tire pyrolysis oil gives better performance than the diesel fuel, while plastic pyrolysis oil was found to be have high heating value. On economical aspect it was found that plastic pyrolysis oil could have much efficient if it’s price is not more than 85% of diesel fuel and it can reduce a great amount of solid plastic waste, which is advantageous on environmental aspects, too. M. Mani et al [3] performed an experimental investigation on four stroke, single cylinder, and direct-injection (DI) diesel engine using 100% waste plastic with cooled exhaust gas recirculation. Experiments showed a comparative reduction in NOX, smoke, HC, CO along with comparable Brake Thermal Efficiency with 20% EGR level. M. Mani & G. Nagarajan [4] studied the influence of injection timing on performance, emission and combustion characteristics of a DI diesel engine running on waste plastic oil at four injection timings (23°, 20°, 17° and 14° bTDC). Compared to standard injection timing of 23° bTDC, the injection timing of 14° bTDC was having reduction in NOX, CO and HC emissions with increase in brake thermal efficiency, CO2 and smoke.

B. Effect of variation in Injection Pressure on Engine with different Fuels has been stated in following rese3arch work.

Author Avinash Kumar Agarwal et al [5] used a single cylinder diesel fuelled CI engine to experimentally determine the effects Avinash Kumar Agarwal et al [5] used a single cylinder diesel fuelled CI engine to experimentally determine the effects of fuel injection strategies and injection timings on engine combustion, performance and emission characteristics at constant speed (2500 rpm) with two FIPs (500 and 1000 bars respectively) and different start of injection (SOI) timings. Cylinder pressure, rate of heat release (ROHR), exhaust gas temperature and brake mean effective pressure (BMEP) were found to be higher for lower FIPs (i.e. 500 bars), while Brake Thermal Efficiency (BTE) increases at higher FIPs. For advanced SOI, ROHR, BMEP and BTE increased, while brake specific fuel consumption (BSFC) and exhaust gas temperature reduced significantly. Wenming Yang et al [6] researched with fuel injection strategies to strike an optimum solution between engine performance and emissions in CI engines. They concluded that increasing the fuel injection pressure can improve the fuel atomization and thus improving combustion process with a higher brake thermal efficiency, producing less HC, CO, PM emissions, but more NOx emission. Pilot injection help in reducing combustion noise and NOx emissions and immediate post injection may help in soot oxidation and late post injection helps in regeneration of diesel particulate filter. Kyunghyun Ryu [7] observed the effects of pilot injection pressure on the combustion and emissions characteristics in a diesel engine using biodiesel–CNG dual fuel. In a Dual Fuel Combustion (DFC) mode, with increase in pilot-fuel injection pressure, the combustion begins and ends earlier with reduce in ignition delay, exhaust smoke and CO emissions. While the same increases NOX emissions. Özer Cana et al [8] observed the effects of ethanol addition (10% and 15% in volume) with 1% isopropanol on performance and emissions of a turbocharged indirect injection Diesel engine running at different injection pressures (150, 200 and 250 bar) at full load. It was found that the ethanol addition reduces CO, soot and SO2 emissions, with increase in NOx emission and approximately 12.5% (for 10% ethanol addition) and 20% (for 15% ethanol addition) power reductions. It was also found reduction in CO, smoke emissions and in Power with increase in injection pressure especially between 1500 and 2500 rpm. R. Anand and G.R. Kannan [9] used a blend of 30% waste cooking palm oil (WCO) methyl ester, 60% diesel and 10% ethanol (called as Diestrol) in the experimental evaluation of DI diesel engine at varying injection pressure and injection timing. Maximum brake thermal efficiency of 31.3% was obtained at an injection pressure of 240 bar and injection timing of 25.5° before TDC. Compared to diesel, diestrol fuel showed reduction in CO, CO2, NOx and smoke emission by 33%, 6.3%, 4.3% and 27.3% respectively with increase in unburnt hydrocarbon (UHC), cylinder gas pressure and heat release rate. Minimum ignition delay of 12.7° CA was observed with diestrol fuel which was similar to diesel at same operating condition.

III. PLASTIC PYROLYSIS OIL

Pyrolysis is a thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen (or any halogen). It involves the simultaneous change of chemical composition and physical phase, and is irreversible. The word is coined from the Greek-derived elements pyro "fire" and lysis "separating".

Pyrolysis differs from other high-temperature processes like combustion and hydrolysis in that it usually does not involve reactions with oxygen, water, or any other reagents. In practice, it is not possible to achieve a completely oxygen-free atmosphere. Because some oxygen is present in any pyrolysis system, a small amount of oxidation occurs.

Bio-oil is produced via pyrolysis, a process in which biomass is rapidly heated to 450–500°C in an oxygen-free environment and then quenched, yielding a mix of liquid fuel (pyrolysis oil), gases, and solid char. Variations in the pyrolysis method, biomass characteristics, and reaction specifications will produce varying percentages of these three products. Several technologies and methodologies can be used for pyrolysis, including circulating fluid beds, entrained flow reactors, multiple hearth reactors, or vortex reactors. The process can be performed with or without a catalyst or reductant.

The original biomass feedstock and processing conditions affect the chemical properties of the pyrolysis oil, but it typically contains a significant amount of water (15%–30% by weight), has a higher density than conventional fuel oils, and exhibits a lower pH (2–4). The heating value of pyrolysis oil is approximately half that of conventional fuel oils, due in part to its high water and oxygen content, which can make it unstable until it undergoes further processing. Bio-oil can be hydro-treated to remove the oxygen and produce a liquid feedstock resembling crude oil (in terms of its carbon/hydrogen ratio), which can be further hydro-treated and cracked to create renewable hydrocarbon fuels and chemicals. Hydro-treating stabilizes the bio-oil preventing molecule-to-molecule and molecule-to-surface reactions and eventually produces a finished blend-stock for fuels. Bio-oil can be deoxygenated from its high initial oxygen content of 35-45 percent by weight (wt%) on a dry basis all the way down to 0.2 wt%. [10]

Donglei Wu et al. [11] produced experimental setup for low temperature conversion of plastic waste into light hydrocarbons. For this purpose 1 litre volume, energy efficient batch reactor was manufactured locally and tested for pyrolysis of waste plastic. The feedstock for reactor was 50 g waste polyethylene. The average yield of the pyrolytic oil, wax, pyrogas and char from pyrolysis of PW were 48.6, 40.7, 10.1 and 0.6%, respectively, at 275 ◦C with non-catalytic process. Using catalyst the average yields of pyrolytic oil, pyrogas, wax and residue (char) of 50 g of PW was 47.98, 35.43, 16.09 and 0.50%, respectively, at operating temperature of 250 ◦C.

The steps involved in conversion of plastic waste into liquid fuel are given below:

- Mechanical segregation of plastic waste from mixed MSW dump yard/storage.
- Transportation of segregated plastic waste through conveyor belt for optical segregation. Optical segregation of plastic waste is done (only HD, LD, PP and multilayer packaging except PVC). Shredding of plastic waste and dislodging dust and impurities.

Following Fig.1 shows all the processes of production of Plastic Pyrolysis Oil.

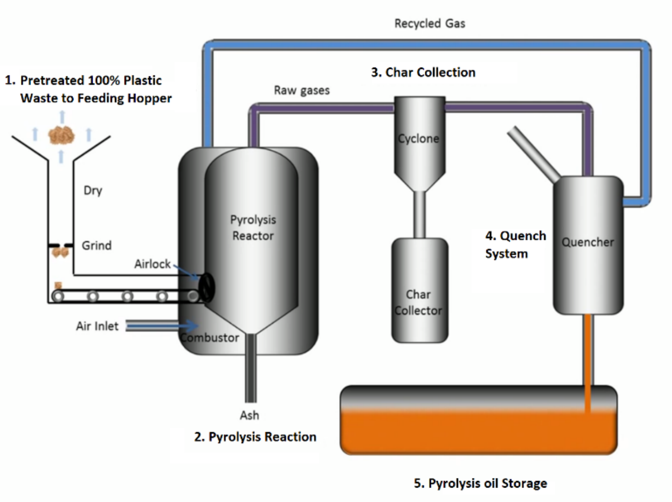

Fig. 1 Production of Plastic Pyrolysis Oil

- Transportation of segregated (100% plastic waste) into feeding hopper (reactor). Feeding of plastic waste into reactor for random depolymerisation in presence of additives.
- Produced raw gases are sent to char collector where solid char particles are separated from gases. Char collector contains a cyclone coil to separate char particles from gases.
- After that, raw gases are sent to quench system or condenser to separate recycled gases and Pyrolysis oil.

Plastic Pyrolysis Oil used for this research work was tested in certified laboratory for its properties and test results are stated in the table 1 given below.

Table 1 Properties of Plastic Pyrolysis Oil

SR NO	TEST TYPE	TEST RESULT	UNIT
1	Acidity, Inorganic	NIL	N/A
2	Appearance	DARK RED	Visual
3	Kinematic Viscosity cSt at 40 ^{o}c	1.69cSt	cSt
4	Flash point ^{o}C	22	^{o}C
5	Fire Point ^{o}C	26	^{o}C
6	Gross Calorific Value	10980	Cal/kg
7	Density	0.788	gm/ml
8	Oil Impurity	0.01%	% by Wt.
9	Water %	40 ppm	% by Wt.
10	Pour Point	Above -2	^{o}C
11	Sulphur	0.01	% by mass

12	Ash	0.001	% by mass
13	Sediment	0.001	% by Wt.

IV. EXPERIMENTAL SETUP

The setup consists of single cylinder, four stroke, multi-fuel, research engine connected to eddy type dynamometer for loading. The operation mode of the engine can be changed from diesel to Petrol or from Petrol to Diesel with some necessary changes. In both modes the compression ratios can be varied without stopping the engine and without altering the combustion chamber geometry by specially designed tilting cylinder block arrangement.

Fig. 2 Overview of Experimental Setup

The injection point and spark point can be changed for research tests. Setup is provided with necessary instruments for combustion pressure, Diesel line pressure and crank-angle measurements. These signals are interfaced with computer for pressure crank-angle diagrams. Instruments are provided to interface airflow, fuel flow, temperatures and load measurements. The setup has stand-alone panel box consisting of air box, two fuel flow measurements, process indicator and hardware interface. Rotameters are provided for cooling water and calorimeter water flow measurement. A battery, starter and battery charger is provided for engine electric start arrangement

The engine specifications used in above stated setup are given below in table 2.

Table 2 Engine Specifications

Number of Cylinders	Single cylinder
Number of Strokes	4
Swept Volume	552.64 cc
Cylinder Diameter	80 mm
Stroke Length	110 mm
Connecting Rod Length	234 mm
Orifice Diameter	20 mm
Dynamometer Rotor Radius	141 mm
Fuel	Diesel
Power	3.7 kw
Speed	1500 rpm
Compression Ratio Range	12 to 18
Inj. Point variation	0 to 25 BTDC

The Experimental setup is utilised to observe Variable Compression Ratio (VCR) engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio, heat balance and combustion analysis. Lab view based Engine Performance Analysis software package “Engine soft” is provided for on line performance evaluation.

V. EXPERIMENTAL METHODOLOGY

The steps involved in Experimental methodology are given below:

1. Before starting of Experiment with any of the selected Injection Pressures, necessary overhauling and reconditioning practice were done including replacement of piston rings by the authorised service executive provided by manufacturer.
2. Water supply was initiated along with the starting of Engine. Water Head was kept maintained at 7.5 cm and Fuel supply line was checked for any leakages.
3. According to IS: 10000 Part V, Constant speed engine was kept running at idling condition for 2 hours with Blended fuel, before taking the readings.
4. After completing Engine running at idling conditions, Injection Pressure was checked whether it is as per the reading conditions or not.
5. Load was set to desired condition and Exhaust Probe of Fire Gas Analyser was inserted into the Exhaust pipe of Engine. Exhaust Gas Analyser was kept initially ready by completing fresh air purge and Leak test. The procedure was continued approximately 10 minutes on the same load and then readings of Exhaust gas Analyser were taken.
6. Meanwhile Engine RPM were measured by Tachometer along with measurement of Temperature and

Relative Humidity by digital Hygrometer. Atmospheric pressure was assumed to be 100 kPa.

7. At the end of the 10 minutes measurement, FC was measured by setting stop watch for 2 minutes.
8. Steps 4 to 7 were repeated for another load. The whole procedure was repeated for the experiments with another Injection Pressure range.

Calculated performance parameters from the experiments performed for each of the Injection Pressure range i.e. 160 bar, 180 bar, 200 bar and 220 bar with Blended fuel of 30% Plastic Pyrolysis Oil and 70% Diesel has been stated below in table 3, table 4, table 5 & table 6 respectively.

VI. RESULT DATA

Table 3 Performance Data of Engine Experiment with Injection Pressure 160 bar

IP (kW)	BP (kW)	FP (kW)	IMEP (bar)	BMEP (bar)	FMEP (bar)	IThEff (%)	BThEff (%)	SFC (kg per kWh)	Fuel (kg/h)	Torque (Nm)	Mech Eff. (%)
2.372	0.000	2.372	3.552	0.000	3.552	62.958	0.000	NA	0.314	0.000	0.000
2.577	0.205	2.372	3.864	0.307	3.557	64.848	5.155	1.676	0.332	1.382	7.949
2.779	0.407	2.372	4.194	0.614	3.579	70.991	10.399	0.831	0.327	2.764	14.649
2.979	0.607	2.372	4.523	0.921	3.602	68.380	13.930	0.620	0.364	4.145	20.372
3.183	0.811	2.372	4.847	1.235	3.612	67.585	17.219	0.501	0.393	5.527	25.477
3.381	1.009	2.372	5.173	1.543	3.630	68.366	20.398	0.423	0.413	6.909	29.836
3.579	1.207	2.372	5.492	1.852	3.640	65.726	22.165	0.389	0.454	8.291	33.724
3.776	1.404	2.372	5.811	2.161	3.650	67.522	25.108	0.344	0.467	9.673	37.185
3.980	1.608	2.372	6.143	2.482	3.661	67.612	27.319	0.315	0.491	11.054	40.405
4.176	1.804	2.372	6.463	2.792	3.671	66.924	28.911	0.298	0.521	12.436	43.200
4.371	1.999	2.372	6.818	3.118	3.700	65.996	30.179	0.285	0.553	13.818	45.729
4.564	2.192	2.372	7.176	3.447	3.730	66.265	31.826	0.270	0.575	15.200	48.029

Table 4 Performance Data of Engine Experiment Injection Pressure 180 bar

IP (kW)	BP (kW)	FP (kW)	IMEP (bar)	BMEP (bar)	FMEP (bar)	IThEff (%)	BThEff (%)	SFC (kg per kWh)	Fuel (kg/h)	Torque (Nm)	Mech Eff. (%)
1.998	0.000	1.998	2.994	0.000	2.994	57.042	0.000	NA	0.292	0.000	0.000
2.207	0.209	1.998	3.309	0.313	2.996	59.504	5.631	1.524	0.310	1.382	9.463
2.414	0.416	1.998	3.637	0.626	3.011	63.567	10.947	0.784	0.317	2.764	17.221
2.618	0.620	1.998	3.967	0.939	3.028	62.192	14.723	0.583	0.351	4.145	23.674
2.826	0.828	1.998	4.297	1.259	3.038	60.379	17.687	0.484	0.391	5.527	29.294
3.026	1.028	1.998	4.628	1.573	3.055	62.694	21.304	0.402	0.403	6.909	33.981
3.227	1.229	1.998	4.955	1.887	3.068	60.905	23.194	0.369	0.442	8.291	38.082
3.437	1.439	1.998	5.286	2.213	3.073	60.819	25.464	0.336	0.472	9.673	41.869
3.642	1.644	1.998	5.604	2.529	3.075	60.645	27.371	0.313	0.501	11.054	45.133
3.837	1.839	1.998	5.934	2.844	3.090	60.069	28.788	0.297	0.533	12.436	47.925
4.028	2.030	1.998	6.270	3.160	3.110	61.366	30.926	0.277	0.548	13.818	50.397
4.214	2.216	1.998	6.606	3.474	3.132	59.649	31.365	0.273	0.590	15.200	52.583

Table 5 Performance Data of Engine Experiment Injection Pressure 200 bar

IP (kW)	BP (kW)	FP (kW)	IMEP (bar)	BMEP (bar)	FMEP (bar)	IThEff (%)	BThEff (%)	SFC (kg per kWh)	Fuel (kg/h)	Torque (Nm)	Mech Eff. (%)
1.692	0.000	1.692	2.525	0.000	2.525	62.483	0.000	NA	0.226	0.000	0.000
1.903	0.211	1.692	2.848	0.316	2.532	66.649	7.387	1.159	0.238	1.382	11.084
2.112	0.420	1.692	3.174	0.631	2.543	60.810	12.095	0.708	0.290	2.764	19.890
2.319	0.627	1.692	3.502	0.947	2.555	60.606	16.388	0.522	0.319	4.145	27.040
2.524	0.832	1.692	3.827	1.262	2.566	63.055	20.788	0.412	0.334	5.527	32.967
2.729	1.037	1.692	4.152	1.577	2.575	62.635	23.794	0.360	0.364	6.909	37.989
2.931	1.239	1.692	4.476	1.893	2.584	60.360	25.522	0.335	0.405	8.291	42.282
3.159	1.467	1.692	4.838	2.247	2.591	63.138	29.323	0.290	0.418	9.673	46.444
3.365	1.673	1.692	5.164	2.568	2.596	61.803	30.730	0.277	0.454	11.054	49.723
3.565	1.873	1.692	5.495	2.887	2.608	60.870	31.984	0.266	0.489	12.436	52.544
3.763	2.071	1.692	5.828	3.208	2.621	63.926	35.184	0.242	0.491	13.818	55.039
3.951	2.259	1.692	6.168	3.527	2.641	63.022	36.034	0.236	0.523	15.200	57.177

Table 6 Performance Data of Engine Experiment Injection Pressure 220 bar

IP (kW)	BP (kW)	FP (kW)	IMEP (bar)	BMEP (bar)	FMEP (bar)	IThEff (%)	BThEff (%)	SFC (kg per kWh)	Fuel (kg/h)	Torque (Nm)	Mech Eff. (%)
1.628	0.000	1.628	2.426	0.000	2.426	61.455	0.000	NA	0.221	0.000	0.000
1.841	0.213	1.628	2.751	0.318	2.433	66.542	7.702	1.108	0.231	1.382	11.575
2.052	0.424	1.628	3.078	0.637	2.441	60.636	12.540	0.681	0.282	2.764	20.681
2.262	0.634	1.628	3.408	0.955	2.453	60.029	16.818	0.507	0.314	4.145	28.017
2.468	0.840	1.628	3.739	1.272	2.467	63.035	21.448	0.398	0.327	5.527	34.026
2.680	1.052	1.628	4.075	1.600	2.476	62.797	24.652	0.346	0.356	6.909	39.257
2.885	1.257	1.628	4.406	1.920	2.486	60.884	26.531	0.321	0.395	8.291	43.575
3.091	1.463	1.628	4.733	2.240	2.493	62.876	29.756	0.286	0.410	9.673	47.326
3.297	1.669	1.628	5.053	2.558	2.495	61.551	31.161	0.273	0.447	11.054	50.626
3.497	1.869	1.628	5.381	2.876	2.505	60.303	32.227	0.264	0.484	12.436	53.442
3.698	2.070	1.628	5.708	3.195	2.512	63.142	35.348	0.241	0.489	13.818	55.982
3.896	2.268	1.628	6.055	3.525	2.530	63.023	36.685	0.232	0.516	15.200	58.209

VII. GRAPHICAL REPRESENTATION AND DISCUSSION

A. Fuel Consumption

From the graph of Fuel Consumption vs load, given in fig. 3, we can conclude that Fuel consumption for lower and medium loads is lesser for higher injection pressure of 220 bar. For all loading conditions, fuel consumption decreases with increase in injection pressure and this is due to more atomisation of fuel particles at higher injection pressure. After 180 bar injection pressure there is sudden more increase in atomisation and fuel consumption decreases to a greater value after that.

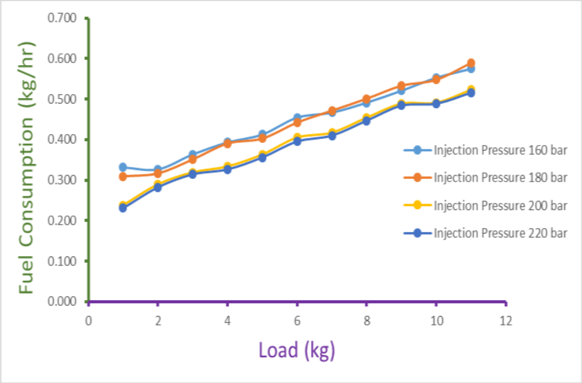

Fig. 3 Fuel Consumption vs Load

B. Indicated Mean Effective Pressure & Brake Mean Effective Pressure

Fig. 4 & 5 shows variations in IMEP & BMEP respectively, with changes in load for different Injection pressures. Both BMEP & IMEP increases with increase in load. BMEP does not show major variation for different Injection Pressure at lower loads. At higher loads, there is minor difference in BMEP values for different Injection Pressures. BMEP increases for much lower value with increase in Injection Pressure. BMEP value is highest for Injection Pressure 220 bar and lowest for Injection Pressure 160 bar, at higher loads. IMEP shows vast variation for different Injection Pressure at all loading conditions. IMEP value decreases with increase in Injection Pressure at same loading conditions. These shows that with higher Injection Pressure, we can achieve full loading condition with lower peak pressure than the same at lower Injection Pressures. So higher Injection Pressure shows good significance in terms of IMEP.

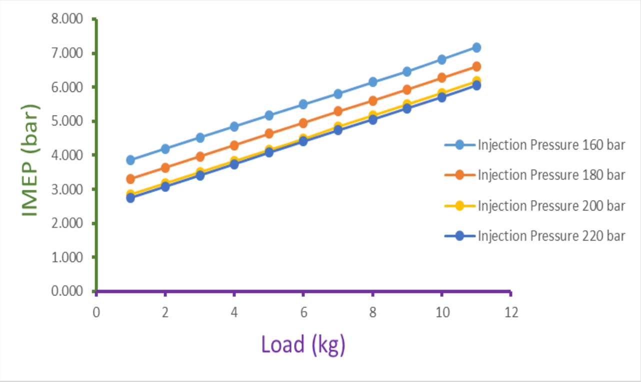

Fig. 4 IMEP vs Load

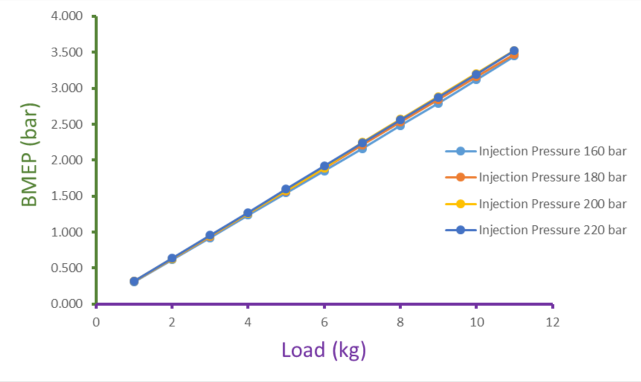

Fig. 5 BMEP vs Load

A. *Indicated Thermal Efficiency & Brake Thermal Efficiency*

Variation in IThEff and BThEff with load are shown in Fig. 6 & 7 respectively for various Injection Pressures. IThEff remains almost constant with increase in load. For higher Injection Pressure, IThEff value is bit higher than the IThEff value at lower Injection Pressure. BThEff increases with increase in load. BThEff value also increases with increase in Injection Pressure for the same loading conditions. After 180 bar injection pressure, there is sudden large peak in BThEff value.

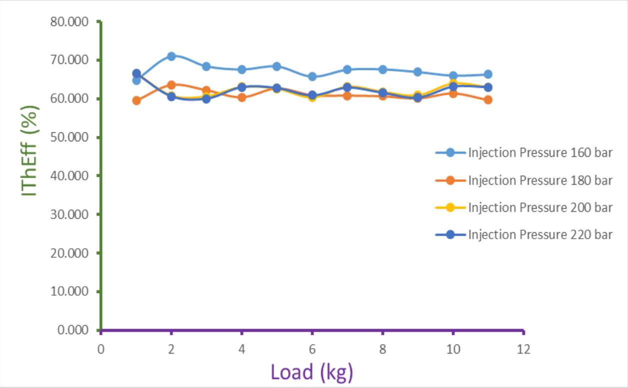

Fig. 6 IThEff vs Load

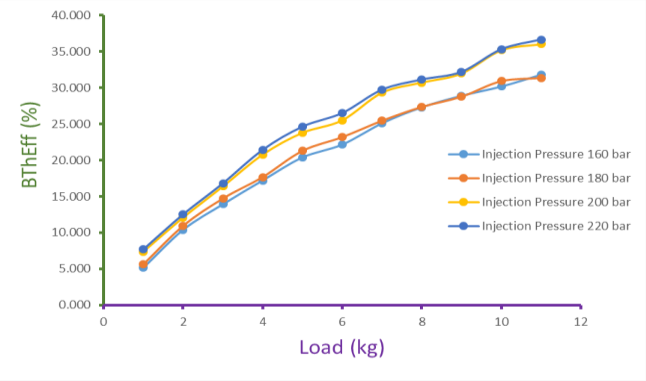

Fig. 7 BThEff vs Load

B. *Specific Fuel Consumption*

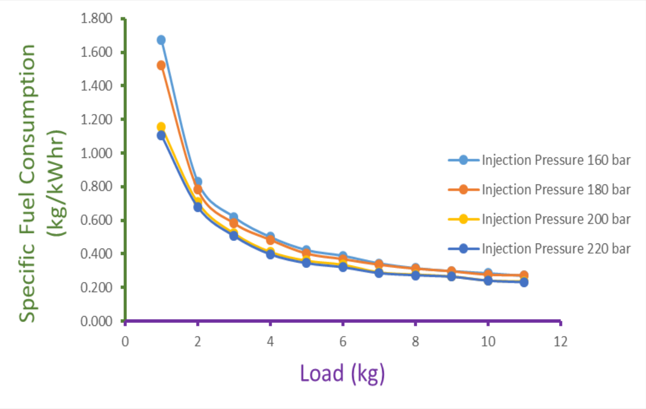

Fig. 8 SFC vs Load

Variation in SFC can be understood by the Fig. 8, which is showing that SFC decreases with increase in load. Up to the load of approximately 9 kg, SFC is decreasing with increase in Injection Pressure for the same loading conditions. After 9 kg load, at full loading conditions there is no major variation in SFC with Injection Pressure for the same load and even at higher loads, SFC does not show major variation with changes in load, too. So, up to the load of 9 kg, SFC is minimum for the Injection Pressure 220 bar than any lower injection Pressure.

C. Mechanical Efficiency

Fig. 9 shows the plot of Mechanical Efficiency variation along with varying load for different Injection Pressure. Mechanical Efficiency increase with increase in loads. For the same loading condition Mechanical Efficiency increases with increase in Injection Pressure. For Injection Pressure 220 bar, we get maximum Mechanical Efficiency at high loading condition and that is nearly 60%. This parameter shows great significance of increase in Injection Pressure.

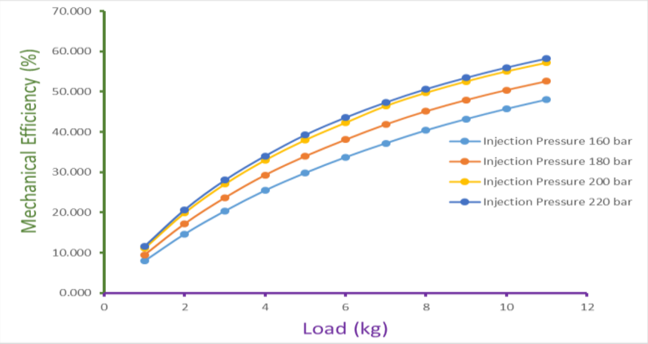

Fig. 9 Mechanical Efficiency vs Load

D. HC, CO_2 & NO_X Emissions

Fig. 10, 11 & 12 shows HC, CO_2 & NO_X Emissions respectively with variation in load for different Injection Pressure.

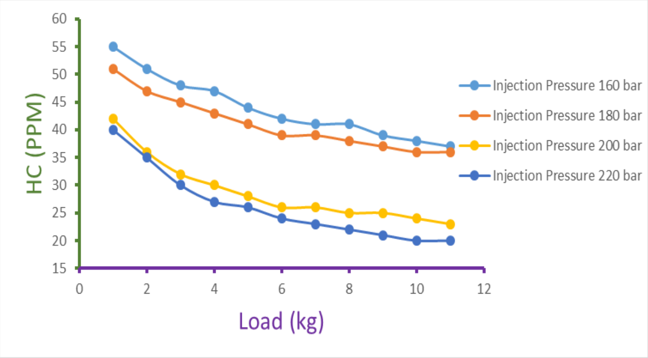

Fig. 10 HC Emissions vs Load

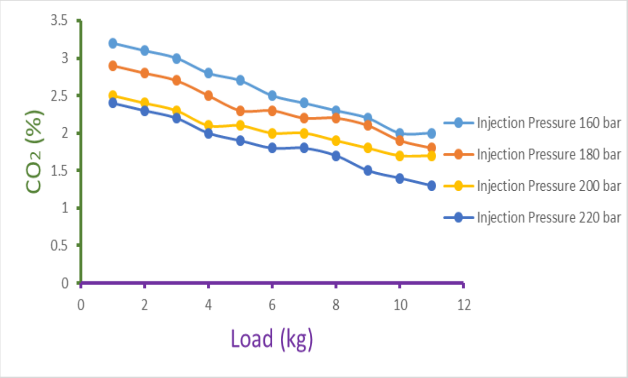

Fig. 11 CO_2 Emissions vs Load

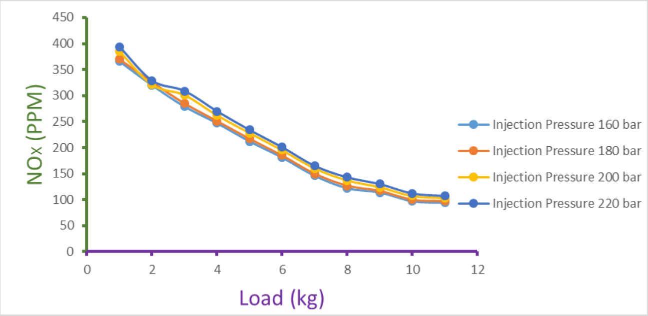

Fig. 12 NO_X Emissions vs Load

HC and CO_2 Emissions are relatively lower for higher Injection Pressure than lower Injection Pressure values. While NO_X Emissions are increasing with increase in Injection Pressure. These significance of Exhaust emissions are clearly visible and understood from the graphs provided. With increase in injection pressure and atomisation, there is complete combustion of fuel and it creates lesser value of HC emissions. Further most of the oxygen content gets utilised in combustion process and thus, there is lesser oxidation of CO with oxygen, which reduces CO emissions as well.

VIII. CONCLUSION

- Fuel Consumption & Specific Fuel Consumption decreases with increase in Injection Pressures. So higher injection Pressures are said to have positive impact on Fuel Consumption & Specific Fuel Consumption.
- Peak pressures in IMEP are quite lesser for higher Injection Pressures than for lower Injection Pressures.
- IThEff and BThEff increases with increase in Injection Pressures.
- Mechanical Efficiency increases with increase in Injection Pressure and it is maximum for Injection Pressure of 220 bar.
- HC and CO2 Emissions are decreasing for Injection Pressure from 180 bar to 220 bar. NOX Emissions are quite higher for higher Injection Pressure i.e. 220 bar than the lower ones.owing to lack of energy resources. In lasts, certain decade miniaturization of the

REFERENCES

[1] An online article of the daily newspaper The Times of India dated April 4, 2013 of the author Dhananjay Mahapatra. http://timesofindia.indiatimes.com/home/environment/

pollution/Plastic-waste-time-bomb-ticking-for-India-SC-says/articleshow/19370833.cms

[2] C. Wongkhorsub, N. Chindaprasert. March, 2013. A Comparison of the Use of Pyrolysis Oils in Diesel Engine. Energy and Power Engineering, 2013, 5, 350-355. doi:10.4236/epe.2013.54B068 Published Online July 2013 (http://www.scirp.org/journal/epe)

[3] M. Mani a, G. Nagarajan, S. Sampath, November 2009. An experimental investigation on a DI diesel engine using waste plastic oil with exhaust gas recirculation. Fuel 89 (2010) 1826–1832.

[4] M. Mani a, G. Nagarajan, August 2009. Influence of injection timing on performance, emission and combustion characteristics of a DI diesel engine running on waste plastic oil. Energy 34 (2009) 1617–1623.

[5] Avinash Kumar Agarwala, Dhananjay Kumar Srivastavaa, Atul Dhara, Rakesh Kumar Mauryaa, Pravesh Chandra Shuklab, Akhilendra Pratap Singha, March 2013. Effect of fuel injection timing and pressure on combustion, emissions and performance characteristics of a single cylinder diesel engine. Fuel, Volume 111, Pages 374–383

[6] Balaji Mohan, Wenming Yang, Siaw kiang Chou, September 2013. Fuel injection strategies for performance improvement and emissions reduction in compression ignition engines - A review. Renewable and Sustainable Energy Reviews, Volume 28, December 2013, Pages 664–676.

[7] Kyunghyun Ryu, August 2013. Effects of pilot injection pressure on the combustion and emissions characteristics in a diesel engine using biodiesel–CNG dual fuel. Energy Conversion and Management Volume 76, December 2013, Pages 506–516

[8] Özer Cana, İsmet Çeliktenb, Nazım Ustac, January 2004. Effects of ethanol addition on performance and emissions of a turbocharged indirect injection Diesel engine running at different injection pressures. Energy Conversion and Management. Volume 45, Issues 15–16, September 2004, Pages 2429–2440.

[9] G.R. Kannan, R. Anand, August 2011. Experimental evaluation of DI diesel engine operating with diestrol at varying injection pressure and injection timing. Fuel Processing Technology, Volume 92, Issue 12, December 2011, Pages 2252–2263.

[10] A report on Technical Information Exchange on Pyrolysis Oil: Potential for a Renewable Heating Oil Substitution Fuel in New England, Report prepared by Energetics Incorporated Columbia, Maryland For Bioenergy, Technologies Office Washington, DC Contact Info: Bioenergy Technologies Office Energy Efficiency and Renewable Energy U.S. Department of Energy 1000 Independence Avenue, SW Washington, DC 20585. eere.energy.gov/biomass, May 9-10, 2012.

[11] Sajid Hussain Shah, Zahid Mahmood Khan, Iftikhar Ahmad Raja, Qaisar Mahmood, Zulfiqar Ahmad Bhatti, Jamil Khan, Ather Farooq, Naim Rashid, Donglei Wub, February 2010. Low temperature conversion of plastic waste into light hydrocarbons. Journal of Hazardous Materials 179 (2010) 15–20.