Investigation on diesel engine performance with design modifications of the piston by using a plastic fuel

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***Abstract*- The depletion of world petroleum reserves results in two crises: rising fuel prices and global warming problems. Energy security can be maintained by improving the efficiency of energy-producing components. Efforts are being made to find alternatives. In the present work, the modification of the CI engine, for inducing Turbulence to improve the combustible mixture, a rotating blade has been provided in the cavity (bowl) of the reciprocating piston in the main combustion chamber. The strip designs the piston crown at an angle of 90°. This arrangement induces the turbulence incombustible mixture during engine operation, through which better combustion can be achieved. With the increase in energy expenditure, stringent emission norms, depletion of petroleum fuels and the undulate cost of petroleum products in India, it has become vital to use alternative fuels for diesel engines. The energy conversion from waste plastics has been an intelligent way to tackle the environmental pollution problem of waste plastic management in landfills. Plastics being derived from the petrochemical source has a higher amount of hydrocarbon, which yield oil with a high calorific value. In this review, performance combustion and emission characteristics of a diesel engine using a blending of waste plastic oil and pure diesel. It is concluded that it is possible to use plastic oil derived from plastic wastes as an alternative fuel for diesel engines.**

Keywords- Turbulence, welded strips, modified piston

I. INTRODUCTION

Internal combustion engines have been a relatively inexpensive and reliable source of power for applications ranging from domestic use to large scale industrial and transportation applications for most of the twentieth century. DI Diesel engines, having the evident benefit of higher thermal efficiency than all other machines, have served both light-duty and heavy-duty vehicles. The in-cylinder fluid motion in internal combustion engines is one of the most important factors controlling the combustion process. It governs the fuel-air mixing and burning rates in diesel engines.

A better understanding of fluid motion during the induction process is critical for developing engine designs with the most desirable operating and emission characteristics. This requires matching the fuel sprays with combustion chamber geometry to effectively make use of the gas flows.

In DI diesel engines, swirl can increase the rate of fuel-air mixing, reducing the combustion duration for re-entrant chambers at retarded injection timings. Swirl interaction with compression induced squish flow increases turbulence levels in the combustion bowl, promoting mixing. The combustion Chamber flow develops from the interaction of the intake flow with the in-cylinder geometry; this work aims to characterize the role of combustion chamber geometry on in-cylinder flow. The effect of geometry is negligible, impacting the airflow during the intake stroke and early part of the compression stroke. But when the piston moves towards Top Dead Centre (TDC), the bowl geometry has a significant effect on airflow, resulting in better atomization, better mixing, and better combustion.

II. LITERATURE REVIEW

Jaichandar and Annamalai Investigated the combined effect of high injection pressure and toroidal combustion chamber (TCC) on CI engine and found that engine performance and emissions were improved with TCC and high injection pressure combination. However, an increase in injection pressure was found responsible for NOx emissions increment due to increased HRR and peak in-cylinder pressure during combustion. Therefore, in the current research one of the key engine design parameters, combustion chamber modification, was done.

Sagaya Raj Studied the air motion for four different geometries for a single cylinder CI engine. They reasoned out that combustion bowl profile played a key role in air-fuel mixing. Performance, combustion and emission characteristics of a diesel engine depend on operating parameters and fuel properties because this diesel engine has to achieve better air movement squish, swirl and Turbulence. This work would also make the existing engine ready to implement HCCI retrofit to attain BS-VI emission norms. Experiments were conducted to investigate the combined effect of compression ratio and piston geometry on a single-cylinder direct injection CI engine with two different combustion chambers, HCC (default geometry) and TCC (modified). The engine was run with three compression ratios (CRs) 16:1, 17:1 and 18:1 and 10% exhaust gas recirculation (EGR).

V. Sreenath and N. Raman Studied the agreement between the liner and rings of an indoor combustion engine and located that it depends chiefly on the linear wear dimensional loss throughout running-in. Running-in wear studies exploitation the factorial style of experiments on a compression ignition engine showed that at bound position locations of piston rings, the linear wear of the cylinder liner would increase with the initial surface roughness of the liner.

Brijeshetal. Investigated numerically and achieved the high turbulence intensity in various combustion chambers such as double

lip, Mexican hat, bow and toroidal. It was found that the toroidal combustion chamber created better turbulence out of all the combustion chambers.

Peter Andersson, JaanaTamminen, Carl-Erik Sandstrom. Piston ring tribology in 2002 The material of the ring ought to be capable of resisting fracture even in extremity conditions. the fabric of the ring ought to be elastic and corrosion resistance to serve its purpose inappropriate means. Ring material ought to even have a sensible thermal physical phenomenon to conduct heat from the piston to the cylinder walls. The fabric of the ring ought to be such it ought to stand up to the mechanical stresses because of combustion of fuel additionally because the thermal stress because of heat generation within the cylinder. Ring form ought to give minimum friction between ring and liner.

Amol B Gunjal.“Waste plastic used in petrol Engine”, By using the extracted fuel oil in 100 cc Bajaj Discover bike, it increases the efficiency of the bike by 15 to 20% as compared to petrol used in the bike. They concluded by comparing the density of HDPE oil with petrol, it gives approximately the same value. Also, comparing the density of LDPE oil with diesel oil gives approximately the same value.

Arun Kumar B .“Conversion of waste plastic into fuel oil in the presence of Bentonite as a Catalyst”, they got two issues, one of the expansive plastic oceans, and the other of the fuel deficiency. Then after pyrolysis oil extracting testing, they concluded. The oil that has been created by the LDPE plastic by the endorsed test process demonstrates that the properties are especially practically identical to the oil. Properties are especially practically identical to the oil.

Aditya Machiraju “Extraction of Liquid Hydrocarbon Fuel from Waste Plastic” concluded that the Pyrolysis method is both Ecological and Economical.1Kg of Waste plastics is converted into 75% of useful liquid hydrocarbon fuels without emitting any pollutants. It would also take care of hazardous plastic waste and reduce the import of crude oil. The properties of produced plastic liquid fuel are almost similar to that of Diesel fuel, hence plastic fuel represents a good alternative fuel for diesel engine and therefore it can be used for diesel engine vehicles.

III. MODIFICATION OF PISTON

The base piston has a bowl-shaped structure on the crown. In the present work modified piston is made with four strips at an angle of 90^0 to each other in a piston bowl. The strip consists of the same material as the piston fabricated by the use of aluminium welding; the piston crown is turned on the lathe machine



Fig 1: Piston with the rotating blades inside the bowl.



Fig 2: Arrangement of the modified piston inside the engine cylinder

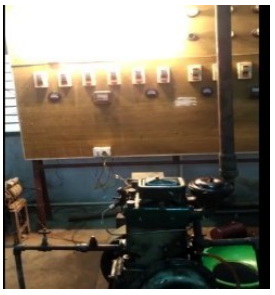

Fig 3: View across the engine side With electrical dynamometer

IV. EXPERIEMENTAL DETAILS

Experiments are conducted on a 4-stroke single cylinder 37.6 Kw Anil Engine, water-cooled Diesel engine. All these tests are conducted at a rated speed of 1500 RPM. The experimental setup, as shown in fig 3. From the experiments observed that combustibility of the fuel is very important in order to get a good power output and good thermal efficiencies. The Turbulence was played an important role here. The present work can be obtained by arranging the strips inside the piston bowl of the engine.

	Performance result for Normal piston with pure diesel					**Performance result for the modified piston with diesel**					**Performance result for the modified piston with plastic diesel B20**				
	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5	Trail 1	Trail 2	Trail 3	Trail 4	Trail 5
Load (Kw)	0	0.1	0.2	0.3	0.4	0	0.1	0.2	0.3	0.4	0	0.1	0.2	0.3	0.4
Voltage (V)	220	206	200	200	190	220	206	200	200	190	220	206	200	200	190
Current (A)	0	2.5	3.5	5	6.8	0	2.5	3.5	5	6.8	0	2.5	3.5	5	6.8

Time for 10 cc of fuel consumption(sec)	59.41	51.30	45.27	38.45	33.51	58.41	50.29	44.21	37.44	32.21	60.28	57.27	48.45	42.38	35.05
Brake power (Kw)	0	0.5	0.7	1	1.29	0	0.5	0.7	1	1.29	0	0.5	0.7	1	1.29
Brake specific fuel consumption kg/(kW-hr)	0	1.25	0.94	0.78	0.68	0	1.16	0.95	0.79	0.71	0	1.16	0.94	0.77	0.68
Brake thermal efficiency%	0	7.27	8.95	11.49	10.8	0	7.2	8.88	11.82	10.67	0	7.7	9.18	12.25	11.47
Indicated thermal efficiency%	7.9	14.55	15.34	16.21	15.56	8.09	14.26	14.86	15.79	16.22	6.8	13.4	14.8	16.41	16.43
Mechanical efficiency %	0	50	58.3	66.66	72.1	0	51.02	59.32	67.56	72.88	0	53.76	61.94	69.93	75
HC(ppm)	31	31	42	57	61	31	32	42	58	64	29	30	40	56	60
CO(%Vol)	0.11	0.12	0.11	0.21	0.3	0.17	0.15	0.18	0.21	0.32	0.1	0.11	0.11	0.19	0.28
CO2(%Vol)	2.9	5.8	7.8	10.5	13.5	3.1	6.2	8.1	10.8	14.1	2.5	5.5	7.4	10.3	13.11

TABLE 1 Performance characteristics values

V. RESULTS ANS DISCUSSIONS

A variable load test is conducted on the Diesel engine by arranging the modified piston inside the cylinder. The better combustibility of fuel is obtaining by better Turbulence due to the modified piston. The performance and emission characteristics are explained below in detail.

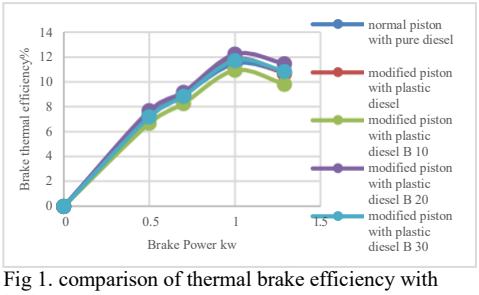

Fig 1. comparison of thermal brake efficiency with brake power

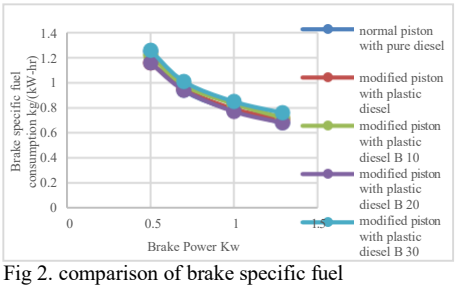

Fig 2. comparison of brake specific fuel consumption with brake power

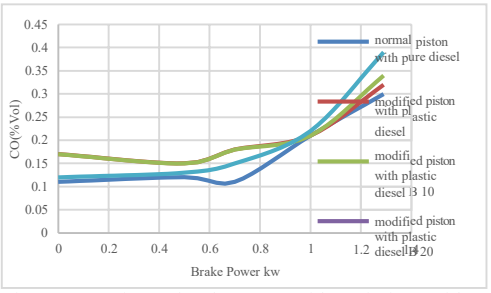

Fig 3. comparison of carbon monoxide emissions with brake power

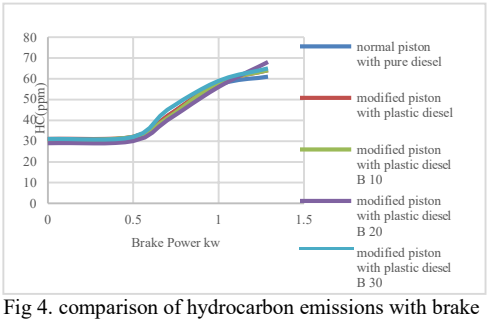

Fig 4. comparison of hydrocarbon emissions with brake power

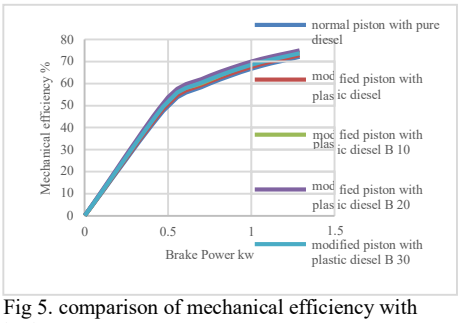

Fig 5. comparison of mechanical efficiency with brake power

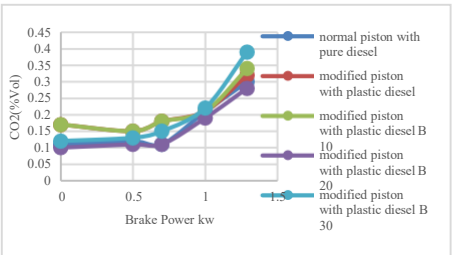

Fig 6. comparison of carbon monoxide emissions with brake power

BRAKE THERMAL EFFICIENCY: The variation of brake thermal efficiency with respect to brake power applied for regular piston and modified piston, as shown in figs 1. The modified piston causes turbulence. Turbulence enhances mixing and probably produces a leaning effect. The Turbulence in the combustion chamber makes the charge homogeneous and increases the combustibility of fuel. So brake thermal efficiency of the modified piston is 0.76% more than the regular piston at brake power 0.3kw. Brake thermal efficiency is increasing with the load applied.

BRAKE SPECIFIC FUEL CONSUMPTION: The variation of brake specific fuel consumption with respect to brake power applied for regular piston and modified piston as shown in fig 2. brake specific fuel consumption is a measure of the fuel efficiency of any prime mover that burns fuel and produces rotational or shaft power. It is typically used for comparing the efficiency of internal combustion engines with a shaft output. The brake specific fuel consumption of the modified piston is the same as the regular piston. At the brake power, 0.4 kW is the lowest fuel consumption; as the load increases, the fuel consumption decreases.

CARBON MONOXIDE (CO) EMISSIONS: The amount of Carbon monoxide (CO) emissions present in the exhaust with respect to b r a k e p o w e r for normal and modified pistons, as shown in fig 3. As more amount of oxygen is available in the cylinder results in a reduction in CO emissions. Due to the Turbulence, there will be a good amount of oxygen supply to the cylinder. The modified piston causes Turbulence. So that carbon monoxide emissions are reduced by 0.2% vol with the modified piston. Carbon monoxide emissions are reduced with the load applied. Compared to a regular piston, the CO emissions are reduced by 0.2% vol for the modified piston with a 0.4 kW load. CO emissions are got minimum at 250 bar pressure and the standard injection timing for 20.1 compression ratio.

HYDROCARBON (HC) EMISSIONS: The amount of Hydrocarbon (HC) emissions present in the exhaust with respect to the load applied for 0.3 kW for regular and modified pistons shown in fig. 4. Here, some lean mixture present in the cylinder. Turbulence can be obtained by the modified piston. The turbulence rich mixture is obtained. This causes the reduction of hydrocarbons in the exhaust. The hydrocarbon emissions are increased with the modified piston so that HC emissions are increased by 8% with the modified piston.

MECHANICAL EFFICIENCY: The variation of mechanical efficiency with brake power applied for regular piston and modified piston, as shown in Fig 5. Mechanical efficiency measures the effectiveness with which a mechanical system performs. It is usually the ratio of the power delivered by a mechanical system to the power supplied to it. Because of friction, this efficiency is always less than one. The modified piston's mechanical efficiency is 3% more than the regular piston at brake power 0.3kw. Mechanical efficiency is increasing with the load applied because its slip increases and rotor speed falls.

CARBON DIOXIDE (CO_2) EMISSIONS: The amount of Carbon dioxide (CO_2) emissions present in the exhaust stroke with respect to b r a k e p o w e r regular and modified pistons, as shown in fig.6. As more amount of oxygen is available in the cylinder results in a reduction in CO_2 emissions. Due to the Turbulence, there will be a good amount of oxygen supply to the cylinder. The modified piston causes Turbulence. The carbon dioxide (co_2) emissions are reduced by 0.3% vol with a modified piston at a 0.2 kW load. Carbon dioxide emissions are reduced with the load applied. CO_2 emissions are got minimum at 250 bar pressure and the standard injection timing for 20.1 compression ratio.

VI. CONCLUSIONS

Based on the above results and discussions, the following conclusions as drawn. The rotating blades inside the piston and Turbulence are generated inside the combustion chamber. This further increases the combustibility of the mixture. The homogeneous mixture inside the combustion chamber increases the modified piston's thermal brake efficiency by 2% compared to the regular piston. The combustion chamber's Turbulence provides the homogeneous mixture, increasing the mechanical efficiency by 3% with a modified piston. Turbulence in the combustion chamber increases the oxygen present in it. With this, emissions reduced are drastic. The HC emissions are increased due to the high temperatures in the combustion chamber caused by the Turbulence.

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