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ORIGINAL ARTICLE

An Effect of Iridium Spark Plugs on SI Engine Performance and Exhaust Emissions by using Plastic Oil Petrol Blends

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ABSTRACT – The increasing population density of automobiles leads to demands more fuel consumption that leads to reducing the availability and also raises the cost. Therefore, it is necessary to search for an alternate fuel, which can effectively replace the conventional fuel without affecting the engine design. The objective of this paper is to discuss the influence of waste plastic oil blends from 0% to 25% at four different ratios fuelled in a multi-cylinder Maruti 800 SI engine by using two types of sparkplugs; the conventional type spark plug that consists of a centre electrode with a copper core, and a plug with an iridium based electrode tip. From the outcomes of the experiments, the engine efficiency is improved, and emissions are controlled by using iridium spark plugs compared to the conventional type spark plugs. At a higher blend of 25%, PPO performance and emissions are analysed and presented in this research. The oxides of nitrogen emissions of engine fuelled with 25% of the plastic oil blend are 13% reduced, and 4.5% brake thermal efficiency are enhanced by using iridium spark plugs compared to 25% of plastic oil by using the conventional type of spark plugs at full load conditions.

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Alternative fuel;
Spark ignition engine;
Exhaust emissions

NOMENCLATURE

BTDC	before top-dead center
WPO	waste plastic oil
PPO	plastic pyrolysis oil
PF	petrol fuel
SP	spark plug
BP	brake power
BSFC	brake specific fuel consumption
BTE	brake thermal efficiency
CO_2	carbon dioxide
NO_x	oxides of nitrogen
CO	carbon monoxide
HC	hydrocarbons
20PPO	20% PPO + 80% PF
20PPOSP	blends operated with iridium spark plugs

INTRODUCTION

In the present scenario, there is a vast demand and potential in the automobile sector. Day by day, increasing demand for the automobile sector causes to raise the dependence on various conventional energy sources. The non-renewable nature, which is declined with time, in addition to increasing the pollution of fossil fuels, causes to search for an alternative energy source. India imports 80% of its crude needs mainly from gulf nations, and we are in the third position in importing crude oil after US and Japan. The increasing population density of automobiles leads to demands more fuel consumption that leads to reduce the availability and also raises the cost. Therefore, it is necessary to search for an alternate fuel, which can replace the conventional fuel effectively without much affecting the engine design and operation. The advanced technology is utilised in automotive technology, and enhanced utilisation of automobiles allows running the engine with various kinds of alternative fuels. In addition, fossil sources utilisation in various engineering applications would contaminate the environment with their burning products. However, different control devices were utilised to decrease

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the emission rate, which led to diminishing the vehicle mileage by around 15%. It is advisable to look into the appropriateness of using 'clean-burning fuels to use in spark-ignition engines. The promotion of mankind's comfortable lifestyle, on the other hand, hastens the consumption and disposal of polymer waste. Waste plastic disposal management and recycling pose a technical challenge to the research community.

Pyrolysis is a way of turning the inherent chemical energy in plastic into usable fuel form, and it is one of many plastic recycling technologies. Pyrolysis is a thermos-chemical process that creates plastic oil by utilising the energy contained in polymer hydrocarbons. This can help mitigate some of the issues related to hazardous emissions caused by the disposal of discarded plastics. Many investigations are carrying by researchers on pyrolysis oil as an alternative to petroleum fuel [1]-[6]. The pyrolysis process is a waste plastic recycling process in which petroleum grade plastic oil is the critical by-product. A huge amount of plastic waste is being accumulated at geometric progression every year, which are creating serious environmental problems. Whereas investigating the energy needs in the light of plastic waste disposal together with the energy needs, developments in the creation of plastic oil produced by pyrolysis is an improved substitute fuel. In plastic pyrolysis, handling and processing of waste plastic are much more flexible and easier than the common recycling technique. It doesn't need any intense sorting procedure and hence it is less labour intensive. Kareddula et al. [7] investigated the influence of distilled plastic oil blends as a substitute fuel in a spark-ignition engine by varying blend percentage from 0 to 50%. From the outcomes, it is clear that the SI engine can run with a 50% blend. Mani and Nagarajan [8] investigated the influence of WPO as a fuel in a single cylinder CI engine by varying injection timing. From the outcomes, it is clear that the CI engine can operate at the retarded injection timing by using 100% plastic oil. Tests were performed at (23°, 20°, 17° and 14° BTDC) four injection timings. The retarded injection timing of 14° BTDC results compared to 23° BTDC at the standard injection timing resulted in increased thermal efficiency, smoke and carbon dioxide emissions while the carbon monoxide, hydrocarbons and nitrogen oxides are decreased at all the test conditions. The maximum brake thermal efficiency and lower cylinder peak pressure were found with retarded injection timing compared to all other injection timings. The engine operated by using waste plastic oil 35% of smoke intensity increased with retarded injection timing compared to standard injection timing.

Kalargaris et al. [9] have studied the multi-cylinder DI diesel engine at different pyrolysis temperatures by operation of fuels recovery from waste plastics. They suggested that recycling plastic waste by pyrolysis is one of the conventional approaches to dispose of the plastic waste and that can transform solid plastics into high-quality liquid fuel. From the results, it is noticed that the engine has a shorter ignition delay period and higher thermal efficiency at all loads by operating fuel produced from the pyrolysis process at lower temperatures. The engine exhausts CO, CO_2, HC and NO_x emissions are less compared to fuel produced from higher pyrolysis temperature. Many researchers [10]-[12] investigations are carried with and without exhaust gas recirculation to a compression ignition engine by using crude tyre waste and plastic waste pyrolysis oil blends. From the outcomes, the CI engine releases more NO_x emissions by operating with tyre and plastic pyrolysis oil blends, but it is observed by using exhaust gas recirculation NO_x emissions controlled. Kumar and Puli [13] conducted the experiments on an SI engine fueled with crude plastic oil blends without any alterations in the design of engine. From their results, it is observed that the engine can run with plastic oil blends, the thermal efficiency is slightly diminished while the oxides of nitrogen emissions are extensively augmented with increasing blend proportions compared to conventional fuel operation. In view of controlling the NO_x emissions and refining efficiency of the engine and also as an extension of earlier research, author's experiments are repeated with changing the spark plugs in the current research. Spark plug is a pivotal tool to ignite the compressed charge in SI engine. It delivers the electrical current from ignition system to compressed charge. The generated spark initiate the combustion in charge, which is at pre-requisite state in combustion chamber. In this current research paper aims to presents the examinations on three-cylinder spark ignition engine runs at 0%, 10%, 20% and 25% of plastic pyrolysis oil blends by using iridium spark plugs and results are compared with conventional type of spark plugs results.

METHODOLOGY

Iridium Spark Plugs

The spark plug is a pivotal tool to ignite the compressed charge in an SI engine. It delivers the electrical current from the ignition system to a compressed charge. The generated spark initiates the combustion in charge, which is at the pre-requisite state in the combustion chamber. Therefore, iridium spark plugs are introduced to serve this purpose. Two different types of spark plugs are used for the investigation; one is the conventional type spark plug, and the second type is iridium spark plugs. The iridium spark plug is as shown in Figure 1. It is used specifically due to extreme ignitability, augmented performance, minimal carbon deposits and improved throttle response. Physically, the spark plug is a metal threaded shell, electrically isolated from a central electrode by a porcelain insulator. The central electrode, which contains the resistor, is connected by a heavily insulated wire to the output terminal of an ignition coil. The metal shell of spark plug is screwed into the cylinder head and thus electrically grounded. The central electrode protrudes through the porcelain insulator into the combustion chamber, forming one or more spark gaps between the inner end of the central electrode and usually one or more protrusion structures attached to the inner end of the threaded shell.

Figure 1. Iridium spark plug

Blending Machine Apparatus

Figure 2 elucidates the blending apparatus, which is also known as an emulsifier. It is used to prepare homogenise mixing at desired proportions of petrol and plastic oil. The Ormeroo Engineers Ltd supplied the homogeniser apparatus. The performance and nature of emissions of various blends investigations are carried out on SI engines to enumerate in the current research work.

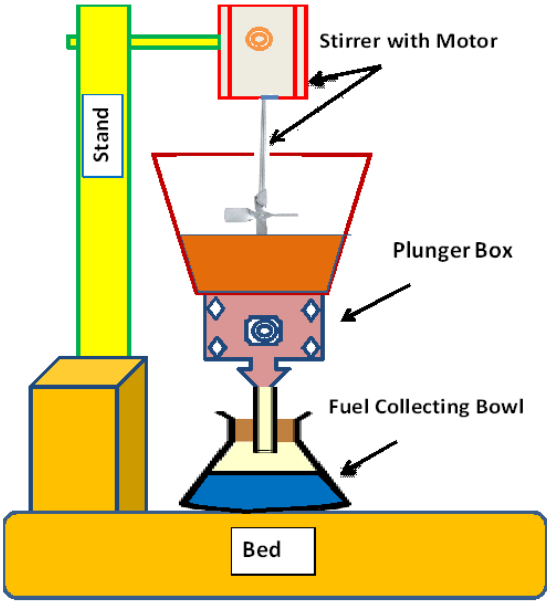

Figure 2. Schematic diagram of blending machine apparatus.

Table1. Basic properties of fuels

S. No.	Characteristics	Petrol	PPO
1	Specific Gravity	0.741	0.83
2	Kinematic Viscosity mm^2/sec	0.5	2.54
3	Calorific Value (kJ/kg)	43449.7	42807.5
4	Density (kg/m^3)	740.82	830
5	Octane Number	85	76
6	Hydrogen Content (wt.%)	15	14.02
7	Carbon Content (wt.%)	85	81.93
8	Sulphur Content (wt.%)	-	0.30
9	Nitrogen Content (wt.%)	-	1.35

Plastic Oil Blends Preparation

The oil used for the experimental analysis was acquired from GK industries, Hyderabad, India. The fundamental properties of the blends are measured and compared with petrol fuel and presented in Table 1. The flash and fire points are 40 ºC and 44 ºC, respectively. The C-H-N-S analysis was conducted at IICT Hyderabad, and the outcome of the test elucidates that test fuel and conventional fuels possess closer properties; however, have little enriched with nitrogen. Blending was carried out on volume basis by 0 %, 10 %, 20 %, 25 %. For instance, 10 % represents 10 % of PPO, and the rest is petrol and represented as 10PPO.

Experimental Setup

Figure 3 illustrates the schematic of the Maruti 800 petrol engine test rig used to conduct the experiments. Experiments are conducted at an 8.7:1 compression ratio and 1500 rpm. A water brake dynamometer is used to load the test rig in the current research. A digital indicator is attached to the test rig to collect the experimental data from the engine, and Table 2 gives the specifications of test rig.

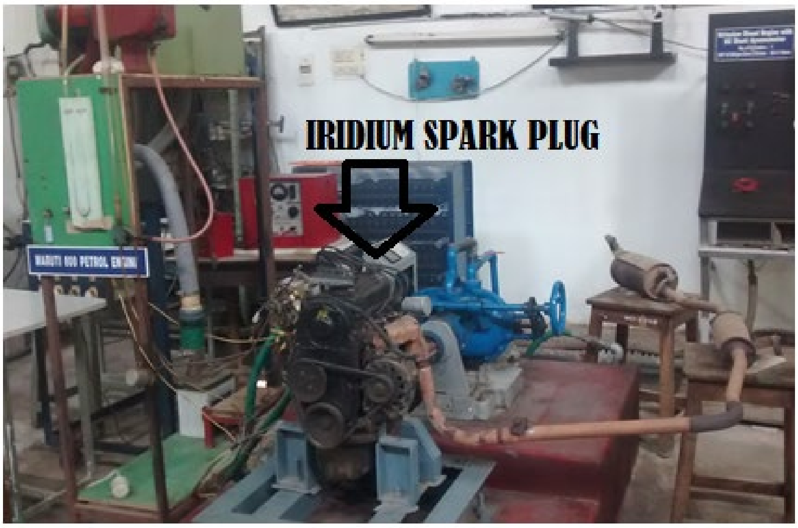

Figure 3. Maruti 800 petrol engine test rig.

Table 2. Maruti 800 petrol engine specifications.

Description	Specifications
Compression ratio	8.7:1
Stroke	72mm
Cubic capacity	796cc
Bore	68.55mm
Fuel delivery	carburettor type
Ignition	spark ignition
Number of strokes	4 strokes
Cooling Medium	water-cooled
Fuel type	petrol
Arrangement of valves	overhead
Engine make and model	Maruti 800
Orientation	vertical
Number of cylinders	three in-line

RESULTS AND DISCUSSION

The experimental investigation was carried out on the multi cylinders Maruti 800 petrol engine by using iridium spark plugs and operated with 0%, 10%, 20% and 25% of plastic pyrolysis oil blended in petrol fuel on a volume basis. The PPO blends by using iridium spark plugs results are compared with the conventional type of spark plugs results. The effect of changing the spark plugs of petrol-plastic oil blends with and without iridium on the brake specific fuel consumption was examined is as shown in Figure 4. The fuel consumption rate is increased uniformly by increasing the PPO blend proportions. As an alternative technique to improve the combustion quality, pilot test runs are conducted with the iridium spark plugs. The fuel consumption rate is decreased by using iridium spark plugs compared to conventional type spark plugs.

The BSFC for petrol is 1.39 kg/kWh at no load and 0.34 kg/kWh at full load, for 20PPOSP are 1.67 kg/kWh at no load, and 0.37 kg/kWh at full load, for 25PPOSP is 1.69 kg/kWh at no load and 0.38 kg/kWh at full load by using iridium spark plugs. This possible reason may be due to the improved material characteristics promoting anti-carbon deposition which leads to initiating the spark at right intervals in the combustion chamber. The effect of plastic-petrol oil blends operated in SI engine by using with and without iridium spark plugs on the BTE is as shown in Figure 5.

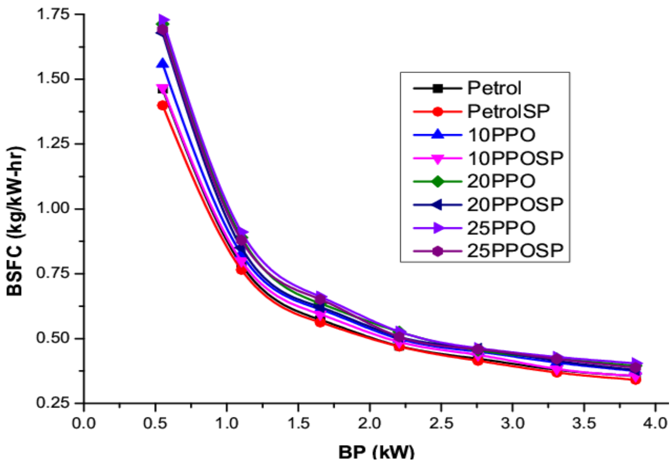

Figure 4. Variation of BSFC with brake power.

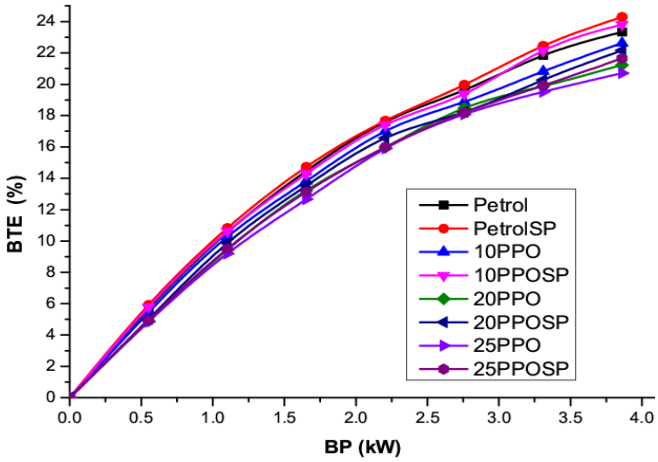

Figure 5. Variation of BTE with brake power.

The BTE of the engine decreases with an increase in the PPO blend proportion compared to petrol fuel by using with and without iridium spark plugs. The BTE of engine operated with pure petrol and 25PPO are 23.33% and 20.7% at full load by using the conventional type spark plugs, whereas for pure petrol and 25PPOSP are 24.28% and 21.65% at full load by using iridium spark plugs. A marginal increment of brake thermal efficiency is noticed with iridium spark plugs compared to without iridium spark plug results at all loads conditions. Because this BTE increment majorly depends on the enhanced combustion quality by using the iridium spark plugs [14].

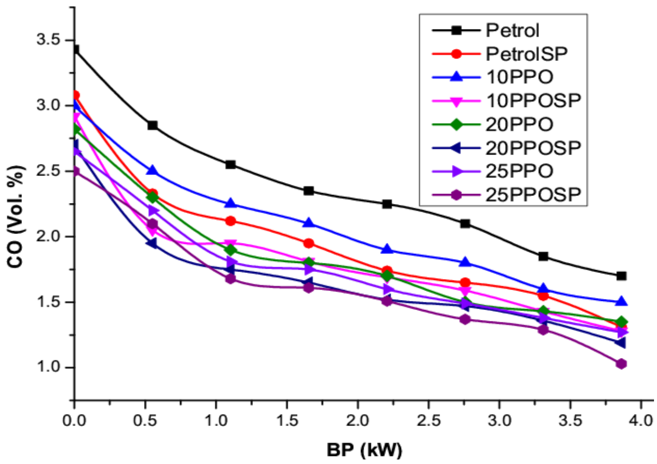

Figure 6. Variation of CO with brake power.

Major constituents of engine emissions are CO, O_2, CO_2, unburned HC, NO_x and particulate matter are measured by using an AVL five gas analyser. From Figure 6, it is observed that, as the emissions of carbon monoxide linearly decreases with brake power but, these emissions are diminishing with iridium spark plugs compared with conventional type of spark plugs. The CO emissions of the petrol engine run with pure petrol and 20PPO are 1.7 vol. % and 1.35 vol. % at full load by using the conventional type of spark plugs. But the petrol engine operated by using iridium sparkplugs at full load observed with pure petrol and 20PPOSP are 1.31 vol.% and 1.19vol. % respectively. From the outcome results at full load condition, compared to all other operated fuels, the minimum CO emissions are noticed at 25PPOSP. This possible reduction is by the oxygenated characteristics of plastic oil and improved combustion quality by using an iridium spark plug. The engine operating with PPO-PF inhibited oxygenation of the blend surpasses the combustion process and leads to the so-called leaning effect. Owing to that effect, CO emissions will diminution significantly. In the engine run with iridium spark plugs, a marginal decrease in carbon monoxide emissions was observed compared to conventional spark plugs with all operated fuels.

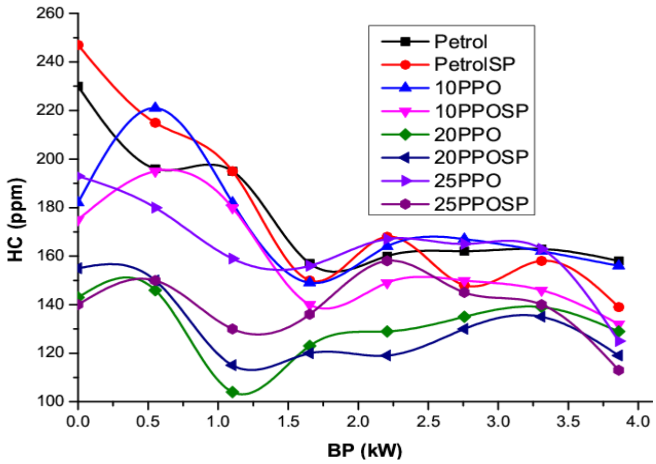

Figure 7. Variation of HC with brake power.

Figure 7 elucidates that PPO blends fuelled in SI engine by using iridium spark plugs would diminish the HC emission compared to the use of conventional type spark plugs. Unburned hydrocarbon emissions mainly depend on the incomplete combustion of the fuel-air mixture. The engine exhaust HC emissions at the 10PPOSP blend are 175 ppm, at no load and 132 ppm at full load. For 20PPOSP blend, is 155 ppm at no load and 119 ppm at full load that of 25PPOSP blend is 113 ppm at full load. It is observed from the results, at full load condition compared to all other operated fuels, the minimum HC emissions are noticed at 25PPOSP. While engine operated with iridium spark plugs, continuous flame propagation is possible in the combustion chamber. The formation of nitrogen oxides resulted from the reaction of oxygen and nitrogen with relatively high combustion temperatures [15].

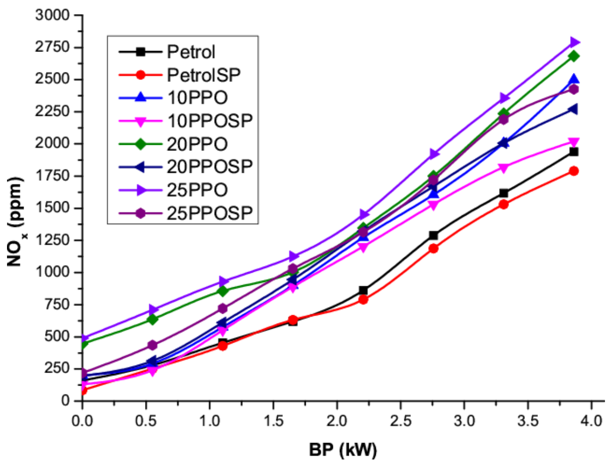

Figure 8. Variation of NO_x with brake power.

Figure 8 illustrates a comparison of all operated fuels, where the NO_x emissions are more for the 25PPO blend. This possible reason may be due to higher combustion temperatures and the availability of oxygen in PPO blends [16], [17]. As an alternative technique to reduce the combustion temperature, pilot test runs are conducted with the iridium spark plugs. The nitrogen oxides are 15.39% decreased with 20PPOSP operated fuel by using iridium spark plugs compared to conventional spark plugs. The NO_x emissions at 10PPOSP are 130 ppm at no load, and 2020 ppm at full load that of 20PPOSP blend is 196 ppm at no load and 2270 ppm at full load, for 25PPOSP blend is 220 ppm at no load and 2425 ppm at full load. The engine operated with iridium spark plugs, a substantial decrement of oxides of nitrogen is noticed compared to conventional type of spark plugs with all operated fuels.

CONCLUSION

The influence of PPO-PF blends by using with and without iridium spark plugs are experimentally investigated and reported.

i. The engine operated with 25PPOSP is 4.09% of BSFC decrement than that of the engine run with a fuel blend of 25PPO. By using iridium spark plugs, 3.9% of BSFC decreased the engine operated with pure petrol compared to conventional spark plugs fueled with PF operation.
ii. The BTE of the engine operated with 25PPOSP is 4.56% increase compared to the engine operated with 25PPO. The engine fueled with pure petrol by using iridium spark plugs 4% of BTE increased compared to conventional type spark plugs fueled with PF operation.
iii. The engine operated with 25PPOSP blend is18.89% of CO emissions decreased compared to the engine fueled with 25PPO. The CO emission at the 10PPOSP blend is 14.6% decreased compared to the engine operated with 10PPO.
iv. The engine exhaust HC emission at 25PPOSP operated fuel blend is 9.6% diminished compared to the engine fueled with 25PPO blend. The HC emission at the 10PPOSP blend is 15.38% decrement compared to the engine run with a fuel blend of 10PPO.
v. The engine exhaust NO_x emission at the 25PPOSP blend is 13.08% diminished compared to the engine run with a fuel blend of 25PPO. When the engine runs with pure petrol using iridium spark plugs, 7.7% of NOx emissions decreased compared to conventional spark plugs fueled with PF operation.

In the present work, the observations are revealed the usage of iridium spark plugs caused to improve the performance of the engine and reduction in oxides of nitrogen than the conventional type of spark plugs. It is noteworthy from the experimental results that the engine can operate beyond the 25PPO blend without any modification in engine design by using an iridium spark plug.

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