Investigation on waste plastic oil as an alternative fuel for SI engine

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Abstract

Day by day the requirement of automobiles increases for people because every person tries to use their own vehicle to make their work easier and to save time. Increasing demand of automobiles also increasing the demand of conventional fuel, which are the non-renewable resources and their availability are reducing and becoming non-economical. Furthermore, these conventional sources are not eco-friendly. Therefore, it is necessary to search for an alternate fuel, which can be an effective substitute for conventional fuel. One interesting alternate fuel is plastic pyrolysis oil found in the pyrolysis process of waste plastics. The present work is aims to present the experimental investigation of 10% plastic pyrolysis oil with and without distillation is blended with gasoline. The performance and emission results of each are compared with pure gasoline. Finally experimental result shows that, the enhanced performance and emissions of CO, NO_x are controlled with distilled plastic oil blend compared to without distilled plastic oil blend.

Keywords: Waste Plastic Oil; SI engine; Performance; Emissions;

1. Introduction

Energy consumption rate and transportation sector improvement are one ago become the index of nation improvement. Dramatic raise in transportation field along with using the fossils at the critical rate also reduces the environmental sustainability. In this scenario, it is the high time to search for an alternative, which are renewable in nature and environmental friendly to replace conventional fuels without or little modifications in engine design. Some interesting alternate fuel is plastic pyrolysis oil are found by the pyrolysis process of waste plastics. Disposal of Plastic wastes are becoming challenging task. By appropriately treating, the energy can be tapped from these wastes to potentially meet the portion of fuel needs for transportation sector. Pyrolysis process was studied by [1,2,3] many investigators subsequently the process able to produce more amount of liquid fuel up to 80 wt. % at reasonable temperatures around 450^{o} C - 500^{0} C and also reviewed the reutilizing of solid wastes and proposed chemical reprocessing to regulate the environmental disputes. Chumsunti et al. [4] experimental investigations are carried out on CI engine fuelled with Distilled Waste Plastic Oil (DWPO) and different nozzle pressures. They reported that one can operate the engine fuelled with DWPO and also observed that the physico-chemical properties of DWPO are nearer to diesel fuel. Investigational study was carried out on a diesel engine using tyre oil blends and waste plastic oil blends with and without exhaust gas recirculation [5,6,7,8,9]. From the previous research articles, one can observed that the engines can run with tyre oil and plastic oil but releases more amount of NO_x emissions and which can control by using exhaust gas recirculation. The main aim of this research is investigation of spark ignition engine using waste plastic oil with and without distillation blends as an alternative fuel.

Waste plastic pyrolysis oil preparation

Waste plastic is a non-biodegradable hydro carbon material that consist toxic and harmful chemicals, which may cause for many ecological problems. According to the Central Pollution Control Board (CPCB), India produces 5.6 million tons of plastic waste per annum and solitary 60% of this waste is recycling for the energy generation [10]. Nevertheless, the usage of plastic becomes inevitable in daily life in one or other form. However, awareness among the people is increasing on reducing the plastic utilization rate. As a part of technological advancement, researchers introduced some effective ways to recycle the waste plastic. The process of converting waste plastic into useful petroleum grade fuel is methodically depicted in Fig. 1. This PPO fuel was purchased from GK industries Hyderabad. For further purification is carried on distillation apparatus to improve the physico-chemical properties like reduction of viscosity, increase in calorific value so on.

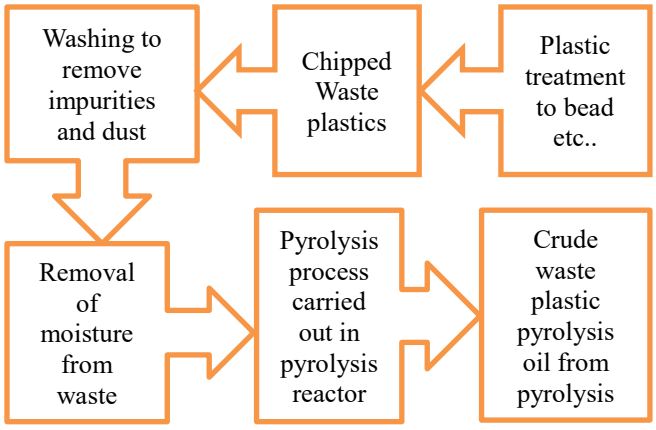

Fig. 1. Waste plastic pyrolysis process

2. Experimental Setup

Fig. 2. Experimental setup of Maruti 800 Petrol Engine

Experimental investigation was conducted on a multi cylinder 4-stroke water cooled Maruti 800 petrol engine as shown in Fig. 2. All the experiments are carried out at a fixed compression ratio of 8.7:1 at 1500 rpm under different load conditions. Stoichiometric air fuel ratio is maintained to assured complete combustion and to minimize emits from engine. In current study, a water brake dynamometer was used to load the test rig. The water brake dynamometer is couple to the engine by the rotor. While running the engine, a steady flow is maintained to well balance the centrifugal force developed during rotation. The amount of load and, hence, the torque absorbed by the dynamometer can be varied by controlling the water flow. From the principles of conservation, while carrying out experiments the applied load was converted into heat, which would dissipate to the water circulating in the dynamometer chamber. Test rig is attached with a digital indicator to apply and maintain the constant load on engine by creating a resultant trust in the form of reaction torque at the whirl chamber.

Blending Machine apparatus

The emulsifier is a blending apparatus which is used to prepare homogeneous mixture of PPO and DPPO in gasoline blends at desired proportions. The apparatus was supplied by Ormeroo Engineers Limited, England as shown in Fig. 3. The ingredients of blends at predetermined proportions are stirred in two stages to assure homogenous mixing. The prepared PPO and DPPO blends for investigating the performance and nature of emissions of a petrol engine.

Fig. 3. Blending Machine Apparatus

PPO and DPPO Blends preparation

The basic properties of PPO-PF and DPPO-PF were measured and compared to conventional petroleum fuel. In the present work 10%, 20% of PPO and DPPO blends were prepared PF on a volume basis. PPO blended in PF is indicated as 10PPO. For example, 10% of PPO blended by 90% of PF is denoted as 10PPO. DPPO blend with PF is denoted as 10DPPO. For example, 10% of DPPO blended by 90% of PF is denoted as 10DPPO. The estimated PPO fire point and flash point are 44 and 40 respectively. The basic properties of PPO and DPPO compared with petrol are presented in Table 1.

Table 1. Basic properties of fuels

S. No.	Characteristics	Petrol	PPO	DPPO
1	Specific Gravity	0.741	0.83	0.79
2	Kinematic Viscosity mm^2/sec	0.5	2.64	0.78
3	Calorific Value (MJ/kg)	43.44	42.8	44.41
4	Density (kg/m^3)	740.82	830	795

3. Results and discussions

The performance analysis were carried out on the maruti 800 petrol engine using PPO and DPPO fuel blends are blended with PF on a volume basis and emissions are measured with AVL 5 gas analyser.

From the Fig. 4, it is observed that the BSFC of PF varies from 1.46 kg/kW-hr to 0.35 kg/kW-hr, 10PPO varies from 1.55 kg/kW-hr to 0.37 kg/kW-hr and 10DPPO varies from1.44 kg/kW-hr to 0.36 kg/kW-hr. Nearly 2.9% of BSFC decreased for 10DPPO blend compared to 10PPO blend but it is 2.4%

increased than PF. This may be due to the calorific value of DPPO fuel more compared to PPO fuel.

Fig. 5 shows the difference between BTE and BP. The BTE of 10DPPO blend is 1% increase compared to 10PPO but it is less than PF. This reason may be due to the improved calorific value of DPPO fuel and this improved calorific value promotes the flame propagation compared to PPO fuel operation.

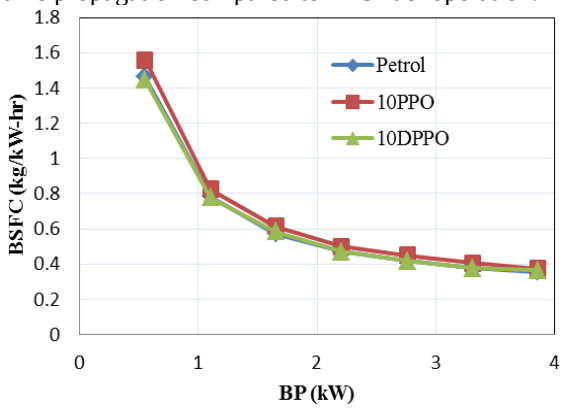

Fig. 4. Comparisons between BSFC and BP

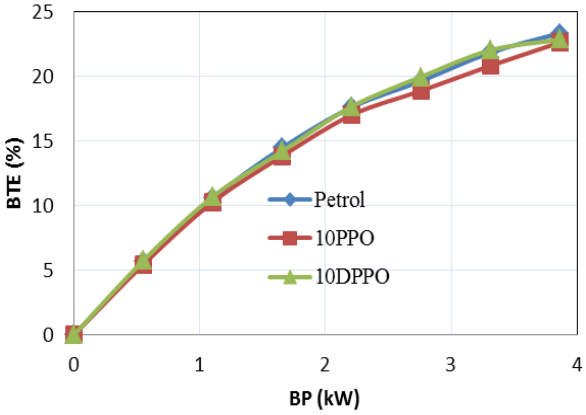

Fig. 5. Comparisons between BTE and BP

Major constituents of engine emissions are CO, O_2, CO_2, unburned HC, NO_x and particulate matter. The variation of Carbon Monoxide (CO) with BP is as shown in Fig. 6. The CO emissions of 10PPO and 10DPPO fuel operation decreased compared to PF. This reason may be due to the oxygenated characteristics of PPO and DPPO blends causes to decrease emissions than PF. The effect of 10DPPO and 10PPO blends on NO_x emissions is shown in Fig. 7. It is noticed that, NO_x emissions are uniformly increasing with BP. This is due to availability of higher oxygen and elevated combustion temperatures. Maximum NO_x emissions are noticed at 10PPO compared to PF and 10DPPO. This reason may be due to the self-ignition delay period which results higher in-cylinder temperatures.

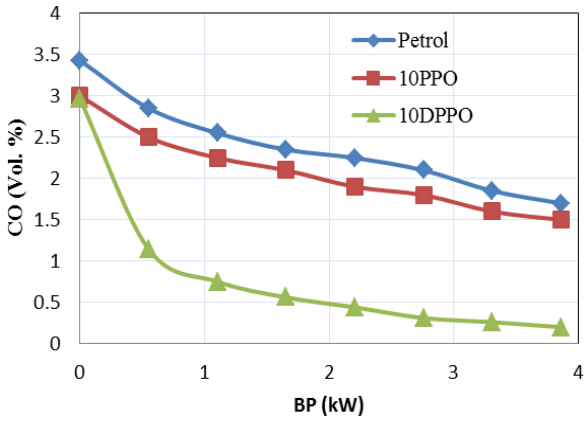

Fig. 6. Comparisons between CO and BP

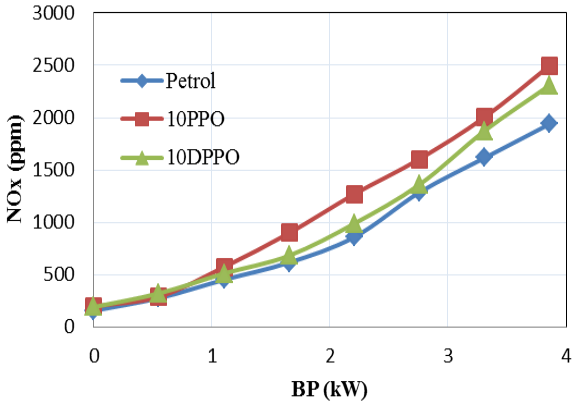

Fig. 7. Comparisons between NO_x and BP

4. Conclusions

The experimental investigation of SI engine using 10PPO and 10DPPO blends measured and presented. The BSFC of the engine fuelled with 10DPPO is 2.9% decreased compared to 10PPO and 2.4% higher than PF. The BTE of 10DPPO is 1% increase compared to 10PPO and 2.1% lesser than PF. The CO emissions is 86.6% decreased with 10DPPO compared to 10PPO and 88.2% lesser than PF. Nearly 19% of NO_x emissions was decreased compared to 10PPO but 28.7% increase compared to PF. The experiment results revel that, the engine performance improved and emissions controlled fuelled with DPPO blend compared to PPO blend. In the view of investigation engine able to run DPPO blends without altering the engine designs.

Abbreviations

PF	: Petrol Fuel
PPO	: Plastic Pyrolysis Oil
DPPO	: Distilled Plastic Pyrolysis Oil
DWPO	: Distilled Waste Plastic Oil
BSFC	: Brake Specific Fuel Consumption
BTE	: Brake Thermal Efficiency
CO	: Carbon Monoxide
NO_x	: Nitrogen Oxide

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