Investigation on Conversion of Municipal Plastic Wastes into Liquid Fuel Compounds, Evaluation of Engine Performance and Emission Characteristics

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Abstract - *With a recent energy crisis, alternative fuel, especially for transportation, has been explored to reduce the consumption of gasoline, on the way of which use of alcohol & biodiesel have been successfully promoted to reduce this uneven diesel -gasoline consumption pattern; whereas, Diesel- Biodiesel blends was tested for performance and emission with acceptable results.*

Biodiesel is produced from waste plastic material. Natural State Research Inc. (NSR) has invented a simple and economically viable ***pyrolysis*** *process to decompose the hydrocarbon polymers of waste plastic into the shorter chain hydrocarbon of liquid fuel, Pyrolysis, involves the degradation of the polymeric materials by heating in the absence of oxygen. The process is usually conducted at temperatures between 350 and 500 °C and results in the formation of a carbonized char (solid residues) and a volatile fraction that may be separated into condensable hydrocarbon oil consisting of paraffin's, isoparaffins, olefins, naphthenes and aromatics, and a non condensable high calorific value gas.*

Diesel-biodiesel were blended at concentrations of DPF [100:0], DPF [80:20], DPF [60:40], by volume without any emulsifier additive to observe solubility and stability. Relevant physical and chemical properties were measured and compared with specification of diesel. Then blends were tested with unmodified single cylinder diesel engine for engine performance, fuel consumption and emissions, with comparison to commercially available diesel fuel.

Key Words**: Biodiesel, Butanol ,Pyrolysis,Single Cylinder diesel engine, DPF blends(diesel Plastic Fuel Blends)**

1.INTRODUCTION

Municipal plastic wastes (MPW) normally remain a part of municipal solid wastes as they are discarded and collected as household wastes. The various sources of MPW plastics includes domestic items (food containers, milk covers, water bottles, packaging foam, disposable cups,plates, cutlery, CD and cassette boxes. fridge liners, vending cups, electronic equipment cases, drainage pipe, carbonated drinksbottles, plumbing pipes and guttering, flooring. cushioning foams,thermal insulation foams, surface coatings, etc.), agricultural(mulch films, feed bags, fertilizer bags, and in temporary tarpaulin-like uses such as covers for hay, silage, etc.), wire andcable, automobile wrecking, etc. Thus, the MPW collected plastics waste is mixed one with major components of polyethylene,polypropylene, polystyrene, polyvinyl chloride, polyethylene terephthalate, etc.

The percentage of plastics in MPW has increased significantly . Waste plastics amount to around 20% of the volume and 8% of the weight of all MPW in USA during 2000 which increased to 11.7% by 2006 (Environmental Protection Agency (EPA) 2006 reports) and in Europe it is 15–25% (2004). In China (2000) and Japan (2001) plastics constitute 13% and 7% respectively in MPW . Similarly in India, of the total MPW, plastic waste increased from0.7% in 1971 to 4% in 1995 and 9% in 2003 .

2.Material and Method

Diesel Fuel for the present investigation was obtained from local Indian Oil Company's (IOC) retail outlet.

Biodiesel fuel sample used for present investigations was produced in the laboratory by employing **"Pyrolysis Process"** using Municipal Plastic Wastes.

Fig -1: Water bottles

Fig -2: Milk covers

The above **Fig -1**and **Fig -2**shows the municipal plastic wastes like water bottles and milk covers, these are used as feed stocks to produce liquid fuel compounds. Water bottles and milk covers are collected from local hotels and hostels.

2.1 Conversion of municipal plastic wastes into liquid fuel compounds in pyrolysis unit

Pyrolysis breakdown

The process Pyrolysis is generally defined as the controlled burning or heating of a material at higher temperature in the absence of oxygen. In plastics pyrolysis, the macromolecular structures of polymers are broken down into smaller molecule .

Thermal pyrolysis.

Thermal cracking or Pyrolysis, involves the degradation of the polymeric materials by heating in the absence of oxygen . The process is usually conducted at temperatures between 350° C and 500° C and results in the formation of a carbonized char (solid residues) and a volatile fraction that may be separated into condensable hydrocarbon oil consisting of paraffins, isoparaffins, olefins, naphthenes and aromatics, and a noncondensible high calorific value gas.

Catalytic pyrolysis

under catalytic conditions results in an increase in the conversion rates for a wide range of polymers at much lower temperatures than with thermal pyrolysis Narrows and provides better control over the hydrocarbon products distribution in Low density polyethylene (LDPE), High density polyethylene (HDPE), polypropylene and polystyrene pyrolysis.

Fig-3: Firing system

Fig.4:Gaseous product

Fig.5: Plastic liquid **f**uel

Fig-6: solid waste Residue

2. Results and Discussions

2.1Fuel Properties: All properties of plastic liquid fuel and its blends are tabulated in above tables Properties of plastic liquid fuel and its blends satisfy the ASTM standards of fuel properties. By considering these factors we can use this plastic liquid fuel blends as a fuel for diesel engines.

Table -1: Fuel Properties of Diesel and Plastic Fuel

Fuel Property	Diesel Sample	PlasticFuelsample
Density, kg/m3	819	819.2
KinematicViscosity,c.St	3.36	4.55
Calorific Value,MJ/Kg	44.8	42.98
Flash Point, °C	57	73

Table -2: Fuel Properties of various Blends of Diesel and Plastic Fuels

Parameters	PFO	PF20	PF40
Flash Point	55	56	60
Fire Point	62	63	66
KinematicViscosity,c.St	2.63	4.038	4.379
Density at 40°C, kg/m3	810	817.6	818
Calorific Value,MJ/Kg	44.93	44.35	43.96

2.2Engine Performance Methodology:

The entire engine experiments were conducted at a rated speed of 1500 rpm with an injection timing of 23^0 before Top Dead Center (TDC). The engine was allowed to run till the steady state is reached. Then the engine was loaded in terms of 0, 0.5, 1, 1.5, 2, 2.5, 3kw, by electrical loading. The first stage of experiments was performed with pure diesel at different loads from no-load to full load (3kw). The engine loads were adjusted by an electrical bulb switches.

The second stage of experiments was conducted using various blends of Diesel-and Plastic Fuel as an alternate fuel with same operating conditions. All the performance and combustion characteristics readings were recorded on computerized set up while exhaust emissions Carbon Monoxide (CO), Carbon Di-Oxide (Co2), UnburntHydrocarbons (UBHC) and Oxides of Nitrogen (NOx) were recorded by the flue gas analyzer (AVL444).

2.3 Engine Performance Characteristics:

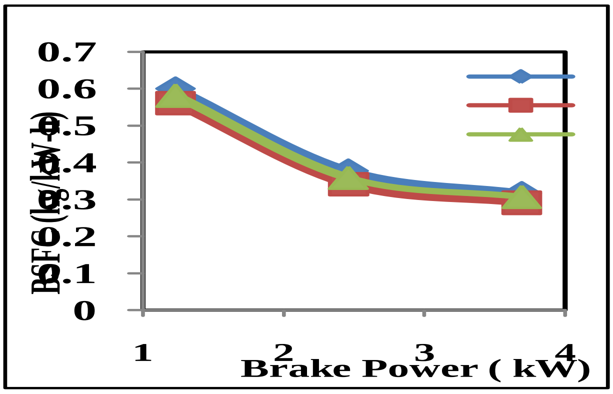

Chart -1: Variation of BSFC with Brake Power

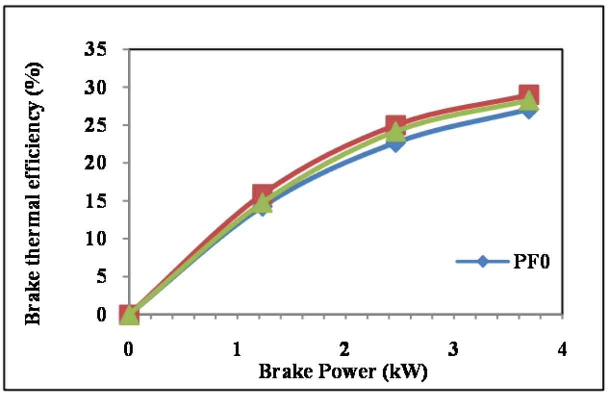

Chart -2: Variation of Brake Thermal efficiency with Brake

The variation of brake specific fuel consumption (BSFC) with BP for PF20, PF40 and diesel fuel. As the BP increases, BSFC decreases for both diesel and plastic fuel blends.

The brake thermal efficiency is maximum for the PF20 blend compare to diesel and PF40 Plastic fuels is a mixture of hydrocarbons varying from C_{10} to C_{30} having both low and heavy fractions with aromatics and oxygen. This results in smaller peak heat release rate and increases effective pressure to do work. Consequently, the work output is high and therefore the brake thermal efficiency increases.

2.4 Engine Emissions Characteristics:

The CO emission maximum with the operation of PF20 and PF40 than diesel,which may be attributed to poor mixture preparation.With increase in power output, the CO emission gradually reduces.

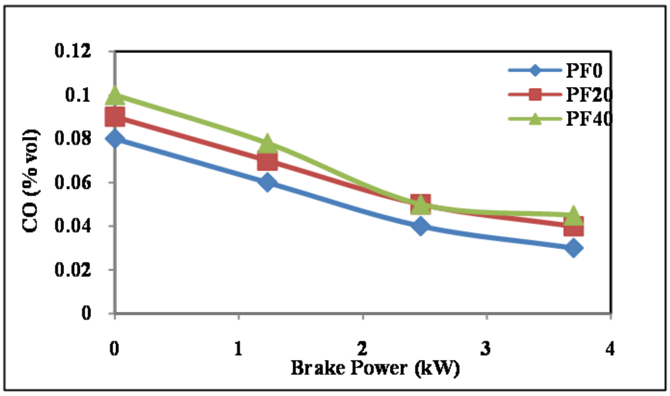

Chart -3: Variation of Carbon Monoxide with Brake Power

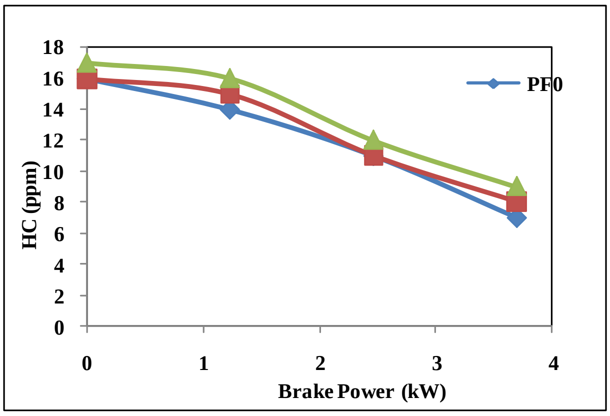

Chart -4: Variation of Hydro-Carbon with Brake Power

From the results, it can be noticed that the concentration of the hydrocarbon of PF40 blend is marginally higher than diesel and PF20. The reason behind increased unburned hydrocarbon is may be due to higher fumigation presents in plastic fuel blends.

3. CONCLUSIONS

- The fuel consumption of the engine was somewhat lower as compared to diesel fuel operation and brake thermal efficiency increases with PF20, PF40 blends operation.
- The emissions of engine like carbon monoxide (CO), hydrocarbon (HC) is increases when the engine runs with plastic fuel blends.
- The ability to recover valuable product and/or energy from wastes plastics.
- Perfect solution for waste plastic management.
- Raw material readily available for the process.
- Waste plastic pyrolysis liquid fuel can be used alternate fuel to the diesel.

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