Waste Plastic Pyrolysis Oil alternative Fuel for an IC Engine

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Abstract—**The use of Plastics is increasing drastically and the disposal of waste plastics has been a major concern. Plastics are processed from Crude Oil. The objective of this work is to reverse the process and obtain the flammable fuel from Plastic waste. Besides helping in removal of Tons of waste plastic, which makes a Tidy environment, the Pyrolysis of waste plastics also helps in generating an alternate fuel, a convenient form of fuel to replace Diesel or Gasoline. Waste Plastic from scrap were collected and these Plastic wastes are heated in a closed chamber (Similar to a process called Pyrolysis) to attain temperatures up to 150°C - 600°C. The Plastic waste is melted and evaporated at this temperature; these evaporated gases are condensed into to liquid state. Both, Condensed and Uncondensed gases can be used as fuel to engines. The obtained plastic pyrolysis oil is tested for its thermal properties and compared with petrol and Diesel Fuel. The performance tests are also conducted on an IC Engine and the results obtained are tabulated.**

Keywords—Waste Plastics, Pyrolysis, Alternative Fuel.

I. INTRODUCTION

Use of Plastics is increasing day by day and the disposal of waste generated from plastics has been a major concern. Plastics are processed from crude oil. The objective is to reverse the process and from flammable fuel from plastic waste. Besides helping in removal of tons of waste plastic, which makes a tidy environment, the pyrolysis of waste plastics also helps in generating an alternate fuel, a convenient from of fuel to replace diesel or gasoline. With the alarming levels of increase in consumption of Petrol, Diesel which are not only non-replenish able but also are the source for major hazardous pollutants that damage the environment, Innovation and search for alternative fuels falls in its natural order and this liquid hydrocarbon obtained from waste plastics might as well save the day and meets the growing demand for alternative fuels.

Plastics have become common materials of our everyday lives, and many of their properties, such as durability, versatility and light-weight, can be a significant factor in achieving sustainable development. However, plastic applications also contribute to the growing amounts of solid waste generated, as plastic products are often used only once before disposal. The disposal problem is not simply technical, but it also has social, economic and even political aspects. This is the reason why several different methods have been explored and applied for solving the problems associated with polymer waste handling and disposal.

Management of plastic waste is a big issue in India. According to Central Pollution Control Board (CPCB), India generates 5.6 million tons of plastic waste annually and approximately only 60% of collected plastic waste is re-cycled. Tons of Plastic waste is dumped on land and huge amounts are disposed of into the water bodies. These plastic wastes could be used for producing fuel. Pyrolysis of waste plastic could provide a better way to dispose of the waste plastic which causes environmental pollution.

1.1 Plastics

As a brief introduction to plastics, it can be said that plastics are synthetic organic materials produced by polymerization. They are typically of high molecular mass, and may contain other substances besides polymers to improve performance and/or reduce costs. These polymers can be extruded into desired shapes.

There are two main types of plastics
1)Thermoplastics
2)Thermosetting plastics

1.1.1 Thermoplastics

Thermoplastics can repeatedly soften and melt if enough heat is applied and hardened on cooling, so that they can be made into new plastics products.

Illustration: Polypropylene, Polyethylene, Polystyrene, Nylon, and so forth.

Applications: Low Density Polyethylene (LDPE) utilized as a part of plastic packs and adaptable compartments. High

Density Polyethylene (HDPE) utilized as a part of channelling, cleanser bottles, oil bottles. Polyethylene is utilized as a part of basins and sustenance compartments, Nylon ropes; Polystyrene is utilized as a part of glasses and plates, and so on.

1.1.2 Thermosetting Plastics

Thermosets or thermosetting can melt and take shape only once. They are not suitable for repeated heat treatments; therefore, after they have solidified, they stay solid.

Illustration: Polyester, Phenol formaldehyde, Melamine Formaldehyde, Urea Formaldehyde, and so forth.

Applications: Melamine cutlery for electrical protections, Electrical switches, Formica table tops, and so on.

1.2 Waste Plastics

Waste plastics are one of the most promising resources for fuel production because of its high heat of combustion and due to the increasing availability in local communities. Unlike paper and wood, plastics do not absorb much moisture and the water content of plastics is far lower than the water content of biomass such as crops and kitchen wastes. The conversion methods of waste plastics into fuel depend on the types of plastics to be targeted and the properties of other wastes that might be used in the process.

The composition of the plastics used as feedstock may be very different and some plastic articles might contain undesirable substances (e.g. additives such as flame retardants containing bromine and antimony compounds or plastics containing nitrogen, halogens, sulphur or any other hazardous substances) which pose potential risks to humans and to the environment. The types of plastics and their composition will condition the conversion process and will determine the pre-treatment requirements, the combustion temperature for the conversion and therefore the energy consumption required, the fuel quality output, the flue gas composition (e.g. formation of hazardous flue gases such as NOx and HCl), the fly ash and bottom ash composition, and the potential of chemical corrosion of the equipment, Therefore the major quality concerns when converting waste plastics into fuel resources.

1.2.1 Municipal Plastic Wastes

Municipal plastic wastes (MPW) normally remain a part of municipal solid wastes as they are discarded and collected a household waste. 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, drinks bottles, plumbing pipes and guttering, surface coatings, etc.), agricultural (feed bags, fertilizer bags etc.), wire and cable, 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.

1.2.2 Industrial Plastic Wastes

Industrial plastic wastes are those arising from the large plastics manufacturing, processing and packaging industry. The industrial waste plastic mainly constitutes plastics from construction and demolition companies (e.g. polyvinylchloride pipes and fittings, tiles and sheets) electrical and electronics industries (e.g. switch boxes, cable sheaths, cassette boxes, TV screens, etc.) and the automotive industries spare-parts for cars, such as fan blades, seat coverings, battery containers and front grills). Most of the industrial plastic waste has relatively well physical characteristics i.e. they are sufficiently clean and free of contamination and are available in fairly large quantities.

1.3 Fuel Demand

The present rate of economic growth is unsustainable without saving of fossil energy like crude oil, natural gas or coal. International Energy Outlook 2010 reports the world consumption of liquid and petroleum products grows from 86.1 million barrels per day in2007 to 92.1 million barrels per day in 2020 and 110.6 million barrels per day in 2035 and natural gas consumption increases from 108 trillion cubic feet in 2007 to 156 trillion cubic feet in 2035. This way, the oil and gas reserve available can meet only 43 and 167 years further. Thus, mankind has to rely on the alternate/renewable energy sources like biomass, hydropower, geothermal energy, wind energy, solar energy, nuclear energy, etc.

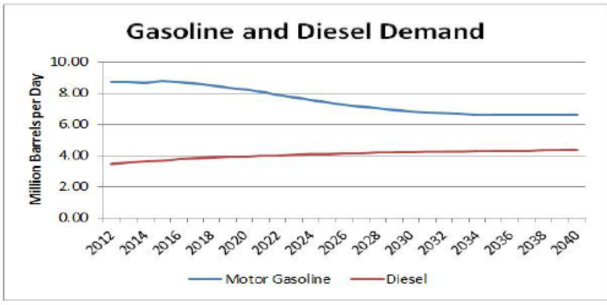

Fig. 1.1. Gasoline and Diesel Demand

1.4 Pyrolysis

Pyrolysis is a thermochemical decomposition of organic material at elevated temperatures in the absence of oxygen. Pyrolysis of organic substances produce gas and liquid products which are termed as bio-fuels and leave a solid residue.

In the process of plastic pyrolysis macromolecular structure of polymer are broken into smaller molecules and sometime monomer units. Further degradation is of these subsequent molecules depends on a number of different conditions including temperature, residence time, presence of catalyst and other process conditions. The pyrolysis reaction is carried out with and without catalyst. Accordingly, the reaction will be thermal and catalytic pyrolysis. Plastic waste is continuously treated in a cylinder chamber.

Types of pyrolysis process are as follows,

Cracking processes break down polymer chains into useful lower molecular weight compounds at high temperature in absence or limited supply of oxygen. Three different cracking processes such as hydrocracking, thermal cracking and catalytic cracking are reported.

Hydrocracking of polymer waste typically involves reaction with hydrogen over a catalyst in a stirred batch autoclave at moderate temperatures and pressures to yield gasoline range products.

Thermal cracking, or Pyrolysis, involves the degradation of the polymeric materials by heating in the absence of oxygen at a temperature between 500 - 800ºC 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, naphthene's and aromatics, and a non-condensable high calorific value gas.

In order to have a proper background study on technologies available for conversion of waste plastics to fuel, literature survey is carried out to know its various applied method throughout the globe, they are summarized below. From this crude oil various products petrol, diesel and kerosene etc. can be obtained by distillation. This process can convert all HDPE waste plastic to different grade fuels. After reviewing these various literatures, we can see that different forms of Pyrolysis processes have been employed for the conversion of plastic wastes to efficient fuels and also successfully tested as well.

Vijaykumar B Chanashetty et al. [1], "Fuel from plastic waste", Plastics present a major threat to today's society and environment. Over 14million tons of plastics are dumped into the oceans annually, killing about 1,000,000 species of oceanic life. They got two issues dumping of plastic in ocean, shortage of fuel for this problem they extracted fuel from waste plastic using catalytic pyrolysis method the result obtained has similar properties as the petrol.

PawarHarshal R et al. [2], "Waste plastic Pyrolysis oil Alternative fuel for CI Engine", from the extracted pyrolysis oil they have runned an engine with 100% of extracted fuel and got the result that CO emission increased by 5% in waste plastic oil compared to diesel operation.

Amol B Gunjal et al. [3], "Waste plastic used in petrol Engine", By using the extracted fuel oil in 100 cc Bajaj Discover bike it increases efficiency of 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 same value. Also comparing the density of LDPE oil with diesel oil itsgives approximately same value.

Dr.D.Subramanyam et al. [4], " Performance Investigation of Diesel Engine using Waste Plastic Pyrolysis oil and Diesel Blends" Performance investigation of single cylinder four stroke diesel engines was run with waste plastic oil and diesel blends as alternative fuel. Waste to energy is the recent trend which will focus new interest on research. Brake thermal efficiency of waste plastic oil blend 26.24% at 3.67 kw bp was more than that of diesel (24.85%).

Arun kumar B Y et al. [5], "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 endorsed test process demonstrates that the properties are especially practically identical to the oil.

Aditya Machiraju et al. [6], "Extraction of Liquid Hydrocarbon Fuel from Waste Plastic" they concluded that, 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.

II. METHODOLOGY

The methodology consists of the following steps

- Collection of waste plastic from scrap.
- Preparation of pyrolysis setup.
- Extraction of fuel from the waste plastic.
- To calculate the different properties of this extracted fuels.
- Performance testing on an IC engine with this extracted fuel.

2.1 Collection of Waste Plastic from Scrap

The collection of waste plastic is quite an easy task as compared to other wastes, the plastic wastes are abundant and can be obtained in large quantities from the households, roadsides, hospitals, hotels etc. Which are collectively obtained from scrap. These plastics are usually termed as Polyethylene (PE); Polypropylene (PP); High density Polyethylene (HDPE); Low density Polyethylene (LDPE).

2.2 Preparation of Pyrolysis Setup

The figure below shows Schematic Representation of pyrolysis process. The main parts of pyrolysis setup are described below.

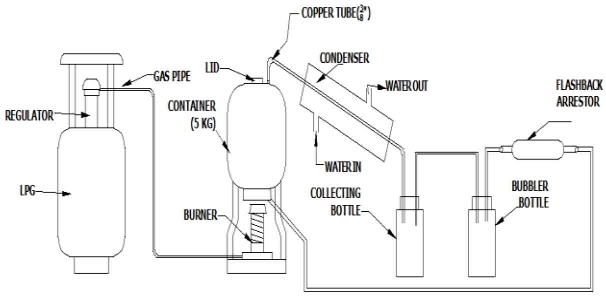

Fig. 2.1. Schematic Representation of pyrolysis process

The main parts of pyrolysis setup are as follows,

Reactor: Cylinder of 5kg capacity, which is used as container is made of low carbon steel which can resist up to 760ºC and has capacity to hold up to 2kg of waste plastic.

Burner: It is used to burn the plastic in the reactor using LPG for producing flame at required temperature up to 600ºC.

Vent Port: It is used to pass heated vapour from reactor to the outlet copper tube. It is made of mild steel having some holes for the easily passage of heated vapour which is connected to the copper tube using washer and nuts.

Nut, Bolt and Washer: The material used for nut bolt and washer is made of Brass, which can resist a temperature about 1080ºC.

LPG Cylinder: It is used for burning the plastic in the reactor through the burner which is inside the reactor.

Copper Tube (3/8"): Copper tubing is most often used for supply of hot and cold tap water, and as refrigerant line in HVAC systems. It is used for passing the liquid fuel which is extracted by burning the plastic in the reactor as the plastic gets melted in the reactor the liquid fuel from the vent port passes through this copper tube.

Condenser: It cools the entire heated vapour coming out of the reactor. It has an inlet and an outlet for cold water to run through its outer area. This is used for cooling of the vapour. The heat produced by the reactor passing through the copper tube is condensed to 50% of the heat produced in the reactor. It holds up to 3ltr of water.

Water Tank: It is used for storage of water. Which is used to pass in to the condenser through its inlet to condense the heat formed in the copper tube.

Collecting Bottle: It is used for collecting the oil from the copper tube which is condensed. The collecting bottle should be transparent in nature to observe the filling of the fuel in the collecting bottle.

Pipes: The pipes are used to convey water from water tank to the condenser and from condenser to the outlet. Then to convey gas from collecting bottle to bubbler and from bubbler to the flash back arrestor. Then from flash back arrestor to mild steel rod which is fitted near burner to produce flame. For all these purposes a transparent pvc pipe of quarter inch diameter is used.

Flashback Arrestor: It is a device which reduces the backfire of the gas which is produced in bubbler bottle. It helps to provide the gas to the burner for producing flame in controlled way.

2.3 Extraction of Fuel from the Waste Plastic

Thermal cracking process without catalyst is used in converting waste plastic into liquid fuel. Collected waste plastic are cut pieces of 3-5 cm size to fit into the reactor conservatively. It is cleaned using caustic soda and water and then after dried for 2-3 hours. For the experimental purpose we use 2 kg of waste plastic in a batch process system because conversion temperatures for these plastics are relatively low. Heat is applied from 100°C at the starting to begin melting the waste plastics, the melted waste plastic turn into liquid form when temperature is increased gradually up to 150°C-500°C. When temperature is increased, the liquid passes through the copper tube and then it passes through a condenser unit which condenses the heat of the liquid fuel.

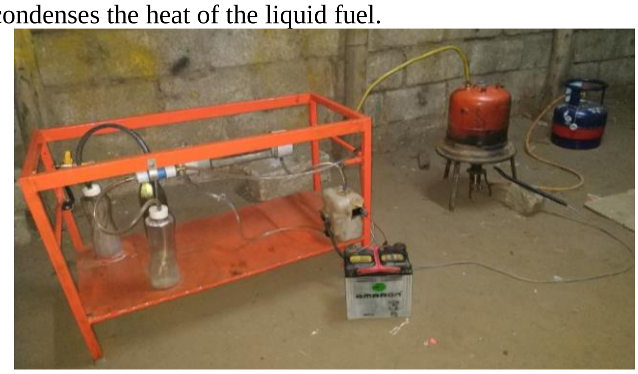

Fig. 2.2. Pyrolysis Setup

Then we collect liquid fuel which is called as plastic pyrolysis oil in the collecting bottle. Gases which are formed in the collecting bottle is transferred to the bubbler bottle. The gasses from bubbler bottle is passed through the pipe to the flashback arrestor and from the arrestor, which is used to provide the gas to the burner for producing flame in controlled way. The flame produced from pyrolysis oil is again used for burning plastic in the reactor.

2.4 To Calculate the Different Properties of this Extracted Fuel

The physical appearance of the extracted fuel is Viscous fluid with Brown shading with a repulsive smell. Some physical properties which we have tested for the extracted plastic pyrolysis oil are given below,

2.4.1 Density

It is the ratio of mass of fuel to volume of fuel. The S I unit is (kg/m3). To determining the density value, we tested the fuel in our college Energy Laboratory. Thus, we get density of the plastic pyrolysis oil as 760 kg/m3.

2.4.2 Kinematic Viscosity

It is the ratio of two physical properties of fluid. It is defined as the ratio between the dynamic viscosity and density of a fluid. The S I unit is centistoke. To determining the kinematic viscosity value, we sent a sample of fuel to laboratory at Bangalore. The kinematic viscosity is measured using the viscometer. Thus, we get the kinematic viscosity of the plastic pyrolysis oil as 2.8 centistokes.

2.4.3 Gross Calorific Value

The amount of heat produced by combustion of unit quantity of fuel. The S I unit is KJ/kg. To determining the kinematic viscosity value we sent a sample of fuel to the laboratory at Bangalore. Thus, we get gross calorific value of the plastic pyrolysis oil as 10800.00 Kcals/Kg or 45.226 MJ/kg.

2.4.4 Flash Point

Flash point is the lowest temperature at which a liquid can form an ignitable mixture in air near the surface of liquid. The S I unit is °C. To determining the flash point value, we tested the fuel in our college Energy Laboratory using pensky marten’s setup. Thus, we get fire point of the plastic pyrolysis oil as 35°C

2.4.5 Fire Point

Fire point is the lowest temperature where the vapour of a liquid will initiate and sustain a combustion reaction. The S I unit is °C. To determining the fire point value, we tested the fuel in our college Energy Laboratory using pensky marten’s setup. Thus, we get fire point of the plastic pyrolysis oil as 45°C

2.5 Performance testing of an IC engine with this extracted fuel

For the performance test of the plastic pyrolysis oil we tested the oil in four stroke variable compression ratio petrol engine test rig in our college Energy Lab and we obtained results of brake thermal efficiency, fuel consumption, air consumption, engine output, heat input and other reading were calculated and tabulated below. And we performed emission test on a four stroke, 2-Wheeler, Splendor plus engine with pyrolysis oil supply to it.

III. RESULTS AND DISCUSSION

After extraction of the fuel from waste plastics, through pyrolysis process, certain tests were performed onto the fuel to test its properties and compare them to conventional fuels. These tests include thermal properties, performance characteristics on an IC Engine, and emission tests on a vehicle. The results obtained from these tests have been discussed below.

3.1 Thermal Properties

The thermal properties of the plastic pyrolysis oil are well and good, which is similar to the petrol. The comparison of the thermal properties such as density, gross calorific value, viscosity, Flash point, Fire point is tabulated below.

TABLE 1. Comparing Properties of plastic pyrolysis oil with petrol and diesel

Sl. No.	Properties	Plastic pyrolysis oil	Petrol	Diesel
1	Density (kg/m^3)	760	742	850
2	Gross calorific value (MJ/kg)	45.226	45.5	42.6
3	Viscosity (cst) @ 25°C	2.8	2.42	3.05
4	Flash point (°C)	35	23	50
5	Fire point (°C)	45	29	56

3.2 Performance Test on Four Stroke Variable Compression Ratio Petrol Engine Test Rig

The extracted plastic pyrolysis oil has been tested in Four Stroke Variable Compression Ratio Petrol Engine Test Rig. The speed was set to 2000Rpm and reading were noted which is tabulated below. The calculation and results of plastic pyrolysis oil and petrol are also tabulated below.

Specifications of VCR Setup

Type of Engine : 4 Stroke Vertical Petrol VCR Engine
Make : Crompton greaves MK-25
Power : 2.2 kW (3 HP)
Rated speed : 2300 rpm
Bore : 70 mm
Stroke : 66.7 mm
Compression Ratio : 4.56 Standard
Starting : Manual Rope Start
Loading : By Electric Alternator
Orifice Diameter : 15 mm

Observation:

Compression Ratio = 4.67

TABLE 2. Four Stroke Variable Compression Ratio Petrol Engine readings tabular

Sl No.	Engine speed in RPM	Electric Load in KW	Monometer Reading h_w in cm	Time 't' for 10cc fuel in 10 sec	Voltage (V_g)	Current In Amps (I_g)	Temperature in °C	
							Air inlet	Air outlet
1	2000	0.5	1	25	141	1.33	36	314
2	2000	1	1.3	22	141	2.70	36	332
3	2000	1.5	1.6	20	131	3.79	38	346

Calculation: For 0.5 KW

1.Brake Power (BP):

$BP=Vg \times I_g/1000\times\eta_g$ (1)

$BP=141\times1.33/1000\times0.7= 0.2675$ KW

2.Mass of Fuel Consumed (m_f):

$m_f=V_{cc}\times Spetrol/1000\times t$ (2)

$m_f=10\times0.76/1000\times25= 3.04\times10^{-4}$ kg/s

3.Brake Specific Fuel Consumption (BSFC):

$BSFC=m_f\times3600/BP$ (3)

$BSFC=3.04\times10-4 \times3600/0.2675= 4.091$ kg/KW hr

4.Brake Thermal Efficiency (ηbth%):

$\eta_{bth}\%=(BP/mf\times cv) \times100$ (4)

$\eta_{bth}\%=(0.2675/3.04\times10-4 \times45226) \times100= 1.945$ %

5.Air Head Capacity Flow (ha):

$ha=((\rho w/\rho a)-1)\times hw$ (5)

$ha=((1000/1.142)-1) \times1\times10-2= 8.74$ m

(Where $\rho_a=P_a/R_a\times T_a$

$\rho_a=1.01325\times102/0.287\times(36+273)=1.142$ kg/m3)

6.Velocity of Air (V):

$V=\sqrt{2gha}$ (6)

$V =\sqrt{2 \times 9.81 \times 8.74} = 13.09$ m/s

7.Discharge (Q):

$Q=Cd\times a\times V$ (7)

$Q =0.6\times1.767\times10-4\times13.09= 1.387\times10-3$ m3/s

8.Mass Flow Rate of Air (m_a):

$m_a=Q\times\rho_a$ (8)

$m_a=1.387\times10-3\times1.142= 1.5839\times10^{-3}$ kg/s

9. Fuel Air ratio (F/A ratio):

F/A ratio$=m_f/ m_a$ (9)

F/A ratio$=3.04\times10^{-4}/1.5839\times10^{-3}=$ 0.190228

TABLE 3. Four Stroke Variable Compression Ratio Petrol Engine final tabular using plastic pyrolysis oil for an Engine speed of 2000 RPM

Sl No.	Electrical Load in KW	Fuel Consumed in kg/s	Air Consumed in kg/s	F/A Ratio	Engine O/P BP in KW	Heat I/P in KW ($m_f\times c_v$)	Brake Thermal Efficiency in %	BSFC in kg/KW hr
1	0.5	3.04×10^{-4}	1.583×10^{-3}	0.190228	0.2675	13.748	1.945	4.091
2	1	3.45×10^{-4}	1.807×10^{-3}	0.190860	0.5438	15.602	3.48	2.283
3	1.5	3.8×10^{-4}	1.997×10^{-3}	0.190228	0.7092	17.18	4.122	1.928

TABLE 4. Four Stroke Variable Compression Ratio Petrol Engine final tabular using petrol for an Engine speed of 2000 RPM

Sl No.	Electrical Load in KW	Fuel Consumed in kg/s	Air Consumed in kg/s	F/A Ratio	Engine O/P BP in KW	Heat I/P in KW (mf×cv)	Brake Thermal Efficiency in %	BSFC in kg/KW hr
1	**0.5**	**2.51×10-4**	**1.98×10-3**	**0.12**	**0.265**	**11.31**	**2.34**	**3.410**
2	**1**	**2.76×10-4**	**2.23×10-3**	**0.123**	**0.633**	**12.44**	**5.09**	**1.571**
3	**1.5**	**3.3×10-4**	**2.86×10-3**	**0.115**	**0.921**	**14.94**	**6.16**	**1.297**

3.3 Performance characteristic

The performance test of the plastic pyrolysis oil was tested in a four-stroke variable compression ratio petrol engine test rig in our college Energy Lab. Comparing the Brake Specific fuel consumption, Brake thermal efficiency, Air fuel ratio of the plastic pyrolysis oil with the petrol. The performance characteristic of the engine is plotted below.

3.3.1 Brake Specific fuel consumption

Brake specific fuel consumption is a measure of the fuel efficiency of the fuel burnt and produces shaft power. Variations in Brake specific fuel consumption (BSFC), with respect to engine brake power. These graphs are shown in Brake power v/s Brake Specific Fuel Consumption. Plastic pyrolysis oil content increased further due to Plastic pyrolysis oil has similar calorific value and also has higher viscosity compared to the petrol.

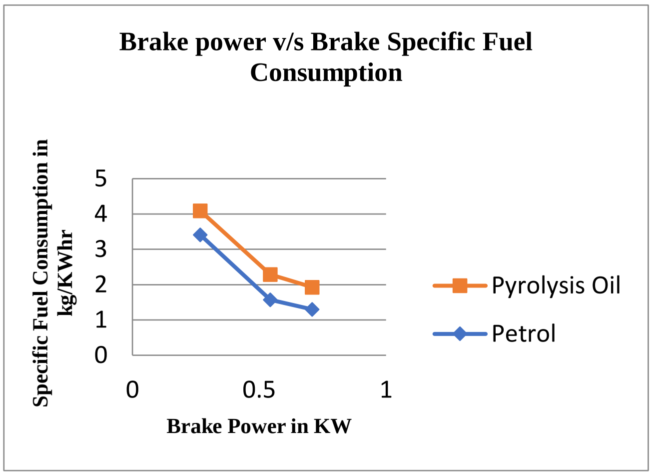

Fig. 3.1. Brake power v/s Specific Fuel Consumption

5.3.2 Brake thermal efficiency

The experimental study on a Four Stroke Variable Compression Ratio Petrol Engine using plastic pyrolysis oil. At different electric load, the efficiency goes on increasing. The graph comparing Brake thermal efficiency of the plastic pyrolysis oil with the petrol is plotted below. Comparing to the petrol the plastic pyrolysis oil has less brake thermal efficiency as shown in Fig. 3.2. Brake Power Brake v/s Thermal Efficiency.

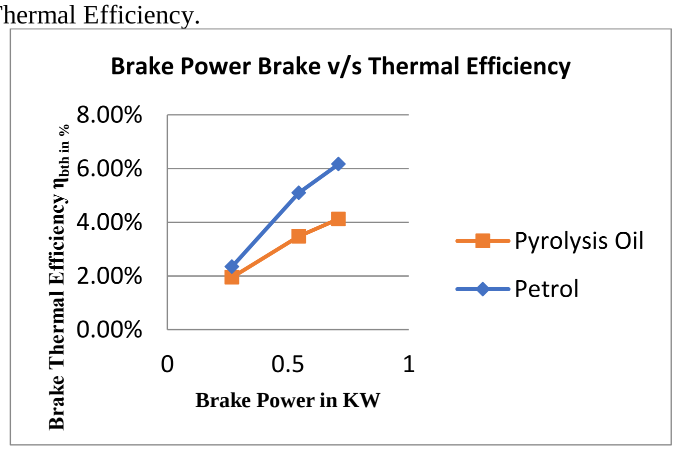

Fig. 3.2. Brake Power Brake v/s Thermal Efficiency

5.3.3 Air fuel ratio

Air fuel ratio is the mass ratio of the air to a solid, liquid, or gaseous fuel present in a combustion process. The air fuel ratio determines whether the mixture is combustible at all, how much un wanted pollutants are produced in the reaction. The graph comparing the plastic pyrolysis oil with petrol. The plastic pyrolysis oil has less air fuel ratio as shown in Fig. 3.3. Air fuel ratio v/s Brake power.

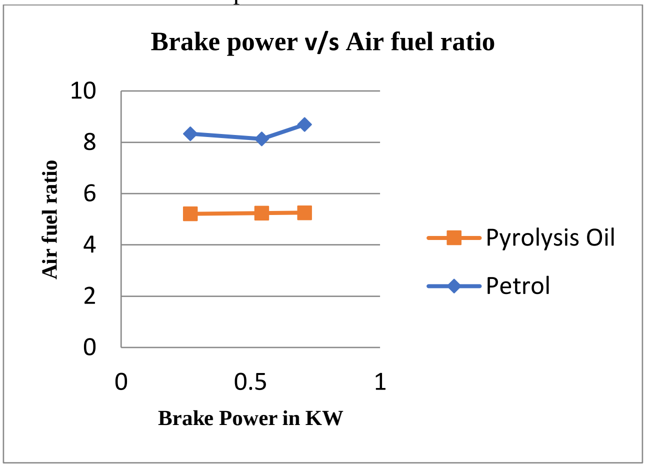

Fig. 3.3 Air fuel ratio v/s Brake power

5.4 Emission Test

Specifications

Type of vehicle : 2-Wheeler
Type of engine : 4 strokes
Model : SPLENDOR plus
Fuel : Petrol

TABLE 5. Comparison of Emission Test

	Unit	Pres STD		Measured level	
		Petrol	Plastic Pyrolysis Oil	Petrol	Plastic Pyrolysis Oil
CO	% Vol	3.5	3.5	0.41	0.08
HC	PPM	4500	4500	97	75
CO2	%Vol	--	--	1.30	1.00
O2	PPM	--	--	11.8	2.7

IV. CONCLUSION

Though mankind has awoken to this threat and responded with developments in creating degradable bio-plastics, there is still no conclusive effort done to repair the damage already caused. In this regard, the Pyrolysis studied here presents an efficient, clean and very effective means of removing the debris that we have left behind over the last several decades. By converting plastics to fuel, we solve two issues, one of the large plastics which is thrown in to sees, and the other of the fuel shortage. This dual benefit, though will exist only as long as the waste plastics last, but will surely provide a strong platform for us to build on a sustainable, clean and green future. By taking into account the financial benefits of such a project, it would be a great boon to our economy. So, from the studies conducted we can conclude that the properties of the fuel obtained from plastics are similar to that of petrol and further studies on this field can yield better results.

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