Extraction of Bio-Diesel From Waste Plastic Through Pyrolysis Process

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***Abstract*—The long-term ambition of energy protection and cooperation, combined with environmental issues of problematic waste accumulation, is tackled through the proposed waste-to-fuel technology. The need to control plastic waste is becoming more evident. This leads to pyrolysis, which is a way to make it very useful to us by recycling them for the production of fuel oil. In this work, plastic waste is used as a source for the production of automotive bio-diesel fuel via a two-step thermochemical process based on pyrolysis and hydro-treatment. As many environmental and social problems arise from plastic waste, re-use technologies are of vital importance in achieving the Sustainable Development Goals (SDG). A potentially cost-effective solution can be accomplished by using waste plastics processed into bio-oil. Thus, the problems faced by the rise in plastic waste and the rising fuel crisis can be avoided by developing a system that can minimize hydrocarbons dependence due to plastics and increase the availability of alternative fuels.**

Keywords—Bio-oil, Furnace, Heater, Pyrolysis, Waste plastic, Wastewater.

INTRODUCTION

The consumption of plastics has increased from 4000 tons/annum (1990) to 4 million tons/annum (2001) and it is expected to rise 8 million tons/annum during the year 2009.Nearly 50 to 60% of the total plastics are consumed for packing. Once used plastic materials are thrown out. They do not undergo bio-decomposition. Hence, they are either land filled or incinerated. Both are not eco-friendly processes as they pollute the land and the air. Waste tyres in India are categorized as solid waste or hazardous waste. It is estimated that about 60% of (retreated) waste tyres are disposed via unknown routes in the urban as well as rural areas. The hazards of waste tyres include- air pollution associated with open burning of tyres (particulates, odour, visual impacts, and other harmful contaminants such as polycyclic aromatic hydrocarbon, dioxin, furans and oxides of nitrogen), aesthetic pollution caused by waste tyre stockpiles and illegal waste tyre collecting and other impacts such as alterations in hydrological regimes when gullies and watercourses become waste sites.

Plastics have now become indispensable materials, and the demand is continually increasing due to their diverse and attractive applications in households and industries. Mostly, thermoplastics polymers make up a high proportion of waste, and this amount is continuously increasing around the globe. Hence, waste plastics pose a very serious environmental challenge because of their huge quantity and disposal problem as thermoplastics do not biodegrade for a very long time. All the reasoning and arguments for and against plastics finally land upon the fact that plastics are nonbiodegradable. The disposal and decomposition of plastics have been an issue that has caused several types of research works to be carried out in this regard. Currently, the disposal methods employed are landfilling, mechanical recycling, biological recycling, thermal recycling, and chemical recycling. Of these methods, chemical recycling is a research field which is gaining much interest recently, as it turns out to be that the products formed in this method are highly advantageous.

I. OBJECTIVE

- This project attempts to show how human has been utilizing the energy and explore prospects of optimizing the same one of the alternative fuels is household plastic waste oil. Fuel obtained from pyrolysis process shows nearly same properties as that of diesel fuel. So we can use plastic oil as alternative fuel.
- To collect the household plastic waste from different places.
- To develop and fabricate the pyrolysis unit to produce liquid fuel from plastic waste.
- Conversion of household plastic waste in to liquid fuel.
- To purify the produced liquid fuel by water washing method.
- To conduct the different experiments to determine the different properties of liquid fuel.

II. METHODOLOGY CARRIED OUT

Design concept generation refers to the actual conceptual design where the design concept is an approximate description of the technology, working principles and form of the product. It has a detailed description on how the product will satisfy and meet customer requirements. Existing design constraints may even be solved by having a good development in the design concept.

For this project, many alternative concepts have been generated. The various generated concepts were then individually evaluated to find the most appropriate concept for the product. The concepts that gave the most advantages were considered as the best concept and a wait further evaluation. The product sketch for the chosen concept was further drafted.

Design concept generation is usually expressed in the form of sketches or rough 3-D model sand often accompanied by a brief textual description for the overall design concepts.

- Literature review
- Identification of the problem
- Finding solution of the problem
- Data collection
- Design of product
- Market survey for required components
- Purchase of required components system

- Manufacturing and assembly
- Testing and experimentation.
- Evolution of result of the project.

III. TECHNICAL DETAILS,SPECIFICATIONS AND CALCULATIONS

In our experiments, commercialize available shredded plastics were procured and washed before pyrolysis. One of the most favorable and effective disposing method is pyrolysis, which is environmentally friendly and efficient way. Pyrolysis is the thermal degradation of solid wastes at high temperatures (250-350nC) in the absence of air (and oxygen). As the structure of products and their yields can be considerably modified by catalysts, results of pyrolysis in the absence of catalyst were presented in this report. Pyrolysis of waste plastics was carried out in an indigenously designed and fabricated reactor. Fig shows the scheme of the process involved in the experiments. Waste plastics had been procured form the commercial source and stored in a raw material storage unit. Raw material was then fed in the reactor and heated by means of electrical energy. The yield commenced at a temperature of 350^0C. The gaseous products resulting from the pyrolysis of the plastic wastes is supplied through the copper tube. Then the burned plastic gas condensed in a water-cooled condenser to liquid fuel and collected for experiments.

IV. WORKING PRINCIPLE

There are many methods to extract fuel from waste plastic but the most commonly preferred is Pyrolysis process. It is an easy process which provides more effective results compared to other methods. The process extraction of fuel from waste plastic is divided into three stages which are as follows.

- Cleaning and Shredding.
- Pyrolysis Process.

- Distillation. The basic plastic waste preferred for Pyrolysis is Polyethylene Terephthalate (PET) bottles or Polyethene (PE) bags which are cleaned and shredded into small pieces.

This helps to easily melt the plastic and to form hydro-carbons in the form of liquid state or gaseous state depending on the output required.

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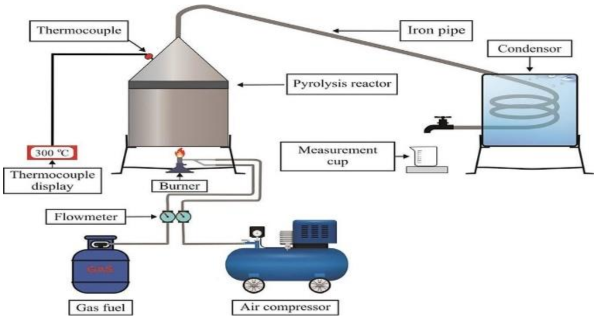
- A metal container.
- A condenser.
- A vessel to store the fuel. The metal container which will be used should withstand high temperature as the pyrolysis process starts at 450oC [4]. The metal container should be provided with suitable heat source, the heat source should be good enough to attend high temperature in very short time as all the above conditions are satisfied, the cleaned and shredded plastic waste are transferred inside the container for further process. As the Cleaned and Shredded plastic waste is transferred into the container, the container is then heated by the preferable source of heat in the absence of oxygen. When the waste plastic is burnt in the absence of oxygen it will not catch fire, instead it will burn and forms gaseous state. From the container the gaseous fuel is then sent to condenser to cool down the temperature, when the temperature cools down the gaseous state changes to liquid state which is partial fuel. After the extraction of partial fuel from waste plastic the fuel is then sent to the container where distillation process takes place. Distillation process is done because the partial fuel which we get after pyrolysis process does not have similar properties as Diesel or Gasoline, to get the properties of the fuel approximate similar to Diesel or Gasoline this process is done. In this process the partial fuel which we get again undergoes heating at lower temperature compared to pyrolysis process [5]. At last the fuel produced from the container after distillation process is contained in a Vessel for storage. This vessel can be of any material.

A. Specifications,Lengths and Others

LIST OF MATERIALS

SL.NO	NAME OF PARTS	MATERIAL	QUANTITY
1	FRAME	Mild Steel	1
2	REACTOR UNIT	M.S	1
3	CONDENSER UNIT	M.S	1
4	PRESSURE GUAGE	BRASS	1
5	TEMPERATURE SENSOR	M.S	1
6	COPPER TUBE	CU	2 mts
7	GATE VALVE	M.S	2
8	GAS BURNER	-	1
9	LED	GI	2

Table 1. List of materials



V. IMPLEMENTATION AND FINAL OUTCOME

- Pyrolysis of waste plastics to liquid fuel a suitable method for plastic waste management and conversion of waste plastic into liquid hydrocarbon by using new technology we can convert all types of waste plastic into hydrocarbon fuel at the temperature profile 150ºc to 200ºc.
- Addition of catalyst enhances the conversion and fuel quality. As compared to the purely thermal pyrolysis, the addition of catalyst in polyolefin pyrolysis. Significantly lowers pyrolysis temperatures and time. A significant reduction in the degradation temperature and reaction time 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.

- Fuel obtained from pyrolysis process shows nearly same properties as that of diesel fuel oil. So, we can use plastic oil as alternative fuel.

- Cleaned and chopped HDPE and LDPE plastic samples of 1.5 kg each were put into the reactor. The plastic is heated using the pyrolysis method at temperature of 150-200°C without any catalyst for 4 hours for HDPE and 3 hours for LDPE. The gas produced from the reactor were condensed into a liquid phase using a condenser. Products from plastic pyrolysis in the form of naphtha, gasoline, and diesel fuel and produced residues (activated carbon) were analyzed at the Laboratory.

- The product conversion calculation produced is used as follows:

Liquid Products (L/Kg %) = (Litre of product/Mass of raw (1) *material) x 100%*

Solid Product or Residue ($^{Kg}/_{Kg}$ %) = ($^{Kg\ of\ product}$ (2) *$_{Mass\ of\ raw\ material}$) x 100%*

Gas Products = 100% - {Liquid Products ($^{L}/_{Kg}$ (3) *%) + Solid Products (%)}*

VI .PERFORMANCE TEST ON WASTE PLASTIC OIL

Engine Performance

The diesel engine is made to run up to 50% blend ratio. Upon increasing the blend rate, the noise and vibrations increased that affects the performance. The parameters like brake thermal efficiency, exhaust gas temperature, brake specific fuel consumption are considered as testing factors with 10-50% blended oil.

Brake Thermal Efficiency

BTE is calculated to identify the calorific value of WPO-diesel blend. It is found that the calorific value of WPO-diesel oil is high than WPO, even though the exhaust gas temperature is marginally higher in WPO-diesel. At full load, the exhaust temperature of the WPO is marginally higher than the diesel oil. This leads to higher head loss, then the BTE value is low in case of WPO-diesel blend (Fig.13).

Emission Analysis

The IC engine emissions analysis is carried out with two fuels: Pure Diesel and WPO (10%) and DF (90%). Here, the emission test is carried out to find the presence of CO, NOx and HC in both the test fuels. It is found from the results that the blended fuel provides marginally low emission than the pure petrol, shown in Table 3 and 4.

The other results related to Brake power comparison (Fig. 10), TFC comparison (Fig. 11) and Comparison of Mechanical Efficiency (Fig. 11) is evaluated between the test fuels. It is found that the blended mixture performs better than the pure diesel.

Performance Test Calculation for Plastic Oil

Table 2 Observation Reading on Pure Diesel

Load %	Calculation Load (amp)	Applied Load(amp)	Time of 10cc fuel		
			T1	T2	T
0	0	0	60	65	62.5
20	2.5	2.5	55	54	54.5
40	5.2	5	50	49	49.5
60	7.70	7	39	38	38.5

Table 3 Pure Diesel Performance

Load (amp)	BP (kw)	TFC (Kg/hr)	SFC (Kg/kwhr)	I.P (kw)	ηmech %	ηBT %
0	0	0.478	0	0.8	0	0
2.5	0.718	0.548	0.762	1.518	47.32	10.53
5	1.437	0.625	0.435	2.237	64.25	18.47
7	2.012	0.776	0.385	2.812	71.55	20.83

Brake Power (*BP*) = *VI*cos /(*AE*□1000)
= (230□2.5□1)/ (0.8□1000) = 0.7187kw

Total Fuel Consumption (*TFC*) = 3.6*x*/*t*□ specific_gravity
=(3.6□10/54.5) □0.83 =0.548kg/hr

Specific fuel consumption=TFC/BP
=0.548/ 0.787
=0.7623kg/kWhr.

Mechanical efficiency (η_{mech}) = (*BP*/*IP*)□100
= (0.7187/1.518)□100 =47.32%

Brake thermal efficiency (η_{bt})
=((*bp*□3600)/(*tfc*□44800))□100
=(0.718□3600)/(0.548□44800)□100 =10.53%.

Performance Test on Mixture of WPO (10%) And diesel (90%):

Table 4 Observation reading on Mixed WPO10% and Diesel 90%

Load %	Calculation Load (amp)	Applied Load (amp)	Time of 10cc fuel		
			T1	T2	T
0	0	0	76	71	73.5
20	2.5	2.5	59	54	56.5
40	5.2	5	52	50	51
60	7.70	7	41	41	41

Table 5 Performance on WPO (10%) and Diesel **(90%)**

Load (amp)	BP (kw)	TFC (kg/ hr)	SFC (kg/kw hr)	I.P (kw)	ηmech %	ηBT %
0	0	0.372	0	0.7	0	0
2.5	0.727	0.484	0.665	1.427	50.94	12.19
5	1.455	0.537	0.369	2.155	67.51	21.99
7	2.037	0.668	0.327	2.737	74.45	24.76

Brake Power (*BP*) =*VI*cos /(*AE*□1000)
= (230□2.5□1)/ (0.7□1000)
= 0.727kw

Total Fuel Consumption (*TFC*)
= 3.6*x*/*t*□ specific gravity
= (3.6□10 /54.5) □ 0.76
= 0.484 kg/hr

Specific fuel consumption (*SFC*)

$= TFC / BP$

$= 0.548 / 0.787 = 0.7623$ kg/kW-hr

Mechanical efficiency (η_{mech})

$= (BP/IP) \times 100$

$= (0.727/1.427) \times 100$

$= 50.94\%$

Brake thermal efficiency (η_{bt})

$= ((bp \times 3600)/(tfc \times 44800)) \times 100$

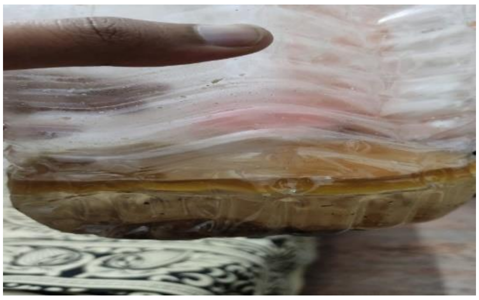
$=(0.727 \times 3600)/(0.484 \times 44800) \times 100 = 12.19\%$.

Fig. Oil Collected

Fig . pyrolysis experimental setup

Fig . Residues in the Reactor .

Fig 20. oil collected at end of pyrolysis.



VII CONCLUSION

We gained a lot of practical knowledge regarding, planning, purchasing, assembling and machining while doing this project work. We are proud that we have completed the work with the limited time successfully. The "EXTRACTION OF BIO-DIESEL FROM WASTE PLASTIC THROUGH PYROLYSIS PROCESS. "Is working with satisfactory conditions. We are able to understand the difficulties in maintaining the tolerances and also quality.

We have done to our ability and skill making maximum use of available facilities. Thus, we have developed an "design and fabrication of biodiesel by using plastic waste" which helps to know how to achieve extraction of bio fuel from plastics. By using more techniques, they can be modified and developed according to the applications.

The solution for environmental and energy issues are fulfilled by pyrolysis, which has been found the most effective technique of conversion of waste plastic to fuels. It has the potential to convert most energy from plastic waste to liquid, gas and char. Since the amount of plastic wastes available in every country is reaching millions of tons, the sustainability of this process is not questionable. This solves the problem in energy demand and also the dependence on fossil fuel as the non- renewable energy can be reduced. The use of this oil in diesel engine in the aspect of technical and economical is compared and found that the oil is able to replace the diesel oil. The liquid obtained in this process has relatively higher volume and low boiling range. It is noticeable that the fuel obtained in this process is cleaner compared to the conventional fuels.

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