Extraction of Waste Plastic Oil as a Replacement for Diesel

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Abstract – To satisfy the increasing population dependence on transportation, plastic oil is extracted and added along with petroleum products. Plastics which are considered as hazardous to environment pose severe threat to the living beings. In order to reduce the waste plastics and prevent the environmental damage plastic recycling is being done. Blending up of plastic oil with diesel makes the transportation process as more feasible one. Waste polyvinyl chloride (PVC) has been collected and made to undergo thermal pyrolysis which is being maintained at temperature of 450°c in the absence of oxygen. The oil collected by this process was found to be less when compared with the oil which is being collected using the catalyst $BaCO_3$ .The percentage amount of oil extracted by using the catalyst was found to be 20% higher than that of the oil extracted without using catalyst. In the catalytic pyrolysis the increase in the quantity of catalyst increases the amount of the liquid products obtained and reduces the time required. The obtained oil by this process was made to undergo for property test and the results were compared with property test of diesel.

Index Terms – Plastic Recycling, Thermal Pyrolysis, Petroleum Products.

1. INTRODUCTION

The rapid increase in population has led to the complete utilization of available energy. This led to dependence on secondary resources like coal, biomass, tidal etc., in order to satisfy the thirst of energy dependence many alternative methods have been developed. Simultaneously, optimum utilization of energy, recycling of waste products will proportionally help to satisfy the energy dependence. One such efficient method of obtaining energy is plastic recycling. A plastic material is any of a wide range of synthetic or semi-synthetic organic solids that are mouldable. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. The plastics are classified into two types as thermoplastics and thermo sets.

Plastics are durable and degrade very slowly, the chemical bonds that make plastic so make it equally resistant to natural processes of degradation. So, to prevent the environment from pollution and to utilize the waste optimizing plastic recycling is being done. The greatest challenge to the recycling of plastics is the difficulty of automating the sorting of plastic wastes, making it labour intensive.

1.1 Need for Alternative Fuel

Fossil fuels are in limited supply. Global consumption of fossil fuels is increasing, and much of that increase is from the transportation sector. While automobile fuel efficiency has improved over the last 30 years, improvements have been fairly level since the mid 1980's. Efforts to improve fuel efficiency are limited by the increased use of heavy vehicles such as sport utility vehicles and light trucks for personal use. Fossil fuel combustion releases large amounts of greenhouse gases, the most significant being carbon dioxide. Every one of us should have a positive impact on the environment by making appropriate choices in our daily lives – mostly with respect to transportation, home energy use, and waste disposal.

1.2 Plastics

The word plastic is derived from the Greek (plastikos) meaning capable of being shaped or moulded, from (plastos) meaning molded. It refers to their malleability, or plasticity during manufacture that allows them to be cast, pressed, or extruded into a variety of shapes. Such as films, fibre plates, tubes, bottles, boxes, and much more. Most plastics contain organic polymers. The vast majority of these polymers are based on chains of carbon atoms alone or with oxygen, sulphur, or nitrogen as well. The backbone is that part of the chain on main "path" linking a large number of repeat units together.

The properties of PVC as follows,

- Weathering stability. PVC is resistant to aggressive environmental factors is therefore the material of choice for roofing.
- Versatility. PVC can be flexible or rigid.
- Fire protection. PVC is a material resistant to ignition due to its chlorine content.
- Longevity. PVC products can last up to 100 years and even more.
- Hygiene. PVC is the material of choice for medical applications, particularly blood and plasma storage containers.
- Energy recovery. PVC has high thermal power; when utilized in incinerators PVC provides power and heat for homes and industries, and all that without any environmental impact
- Barrier properties. PVC can be made impervious to liquids, vapours and gases.
- Eco-efficiency. Only 43% of PVC's content comes from oil (57% comes from salt); it therefore contributes to the preservation of that highly valuable natural resource.
- Recyclability. PVC is very recyclable, more so than many other plastics.
- Public Safety. PVC has often fallen under unfounded attempts so that today it is one of the best explored materials in the world due to serious scientific researches carried in order to disprove accusations.
- Economic efficiency. PVC is the cheapest of large-tonnage polymers providing many products with the best quality-price ratio.

1.3 Physical Properties

Physical properties	Value
Tensile strength	2.60 N/mm^2
Notched Impact Strength	2.0 – 4.5 KJ/m^2
Thermal Coefficient of Expansion	80 x 10^{-6}
Max. Continued Use Temperature	60 ^oC (140^oF)
Melting Point	212 ^oC (413 ^oF)
Glass Transition Temperature	81 ^oC (178 ^oF)
Density	1.38 g/cm^3

Table 1.1 Physical properties of PVC

1.4 Characteristics of PVC

- Light and robust.
- Resistant to rust and corrosion.
- Transparent and freely colourable.
- Mass producible excellent electrical and electronic properties.
- High heat-insulation efficiency.
- Hygienic with a strong gas barrier.

2. PROJECT METHODOLOGY

The equipment required for the process of oil extraction are listed below.

1) Raw plastics (waste PVC plastics).
2) Catalyst.
3) Thermal reactor.
4) Cut off regulator.
5) Thermocouple.
6) Condenser.
7) Submersible pump.
8) Collector.
9) Weight balance.

2.1 Fabrication Process

The various components required for the extraction of oil from the wastes of poly vinyl chloride are fabricated. They are as follows

- Reactor.
- Cut-off regulator.
- Thermocouple.
- Condenser.
- Submersible pump.
- Collector.

2.2 Experimental Procedure

The experimental sets up of the components are shown below.

Figure 2.1 Experimental Procedures

2.3 Thermal Pyrolysis

Pyrolysis is the chemical decomposition of organic substances by heating the word is originally coined from the Greek-derived elements pyro "fire" and lysys "decomposition". Pyrolysis is usually the first chemical reaction that occurs in the burning of many solid organic fuels, cloth, like wood, and paper, and also of some kinds of plastic. Anhydrous Pyrolysis process can also be used to produce liquid fuel similar to diesel from plastic waste. Pyrolysis technology is thermal degradation process in the absence of oxygen. Plastic waste is treated in a cylindrical reactor at temperature of 300ºC – 350ºC. The plastic waste is gently cracked by adding catalyst and the gases are condensed in a series of condensers to give a low sulphur content distillate. All this happens continuously to convert the waste plastics into fuel that can be used for generators. The catalyst used in this system will prevent formation of all the dioxins and Furans (Benzene ring). All the gases from this process are treated before it is let out in atmosphere. The flue gas is treated through scrubbers and water/ chemical treatment for neutralization. The non-condensable gas goes through water before it is used for burning. Since the Plastics waste is processed about 300ºC - 350ºC and there is no oxygen in the processing reactor, most of the toxics are burnt. However, the gas can be used in dual fuel diesel-generator set for generation of electricity.This process is used heavily in the chemical industry, for example , to produce charcoal, activated carbon,methanol,and other chemical from wood ,to convert ethylene dichloride into vinyl chloride to make PVC, to produce coke from coal, to convert biomass into syngas and bio char, to turn waste into safely disposal substances ,and for transforming medium-weight hydrocarbons from oil into lighter ones like gasoline. These specialized uses of pyrolysis may be called by various names, such as dry distillation, destructive distillation, or cracking. Pyrolysis also plays an important role in cooking procedures, such as baking, frying, grilling, and caramelizing. In addition ,it is a tool of chemical analysis ,for example, in mass spectrometry and in carbon-14 dating . indeed, many important chemical substances, such as phosphorus and sulphuric acid, were first obtained by this process. Pyrolysis has been assumed to take place during cytogenesis, the conversion of buried organic matter to fossil fuels. It is also the basis of pyrography. In their embalming process, the ancient Egyptians used a mixture of substances, including methanol, which they obtained from the pyrolysis of wood.Pyrolysis differs from other high-temperature processes like combustion and hydrolysis in that it does not involve reactions with oxygen ,water, or any other reagents. In practice, it is not possible to achieve a completely oxygen –free atmosphere .because some oxygen is present in any pyrolysis system, a small amount of oxidation occurs.The term has also been applied to the decomposition of organic material in the presence of superheated water or steam(hydrolysis pyrolysis),for example ,in the steam cracking of oil.

2.4 Extraction Procedure by Thermal Pyrolysis Method

The raw material, crushed wastes PVC plastics is used to fill the electrical heater. The wall of the thermal reactor is connected with thermocouple. The thermocouple. The thermocouple is connected with cut-off regulator. Top part of the reactor connected with condenser. The condenser has two internal and two external ports.

- Water inlet
- Water outlet

In that water inlet port water taken into the condenser by using submersible pump. Water is used to circulate inside the condenser tube. Then the water is expelled through the outlet port and the water falls into the bucket. The condenser tube also has two external ports for the vapour to flow through it.

- Vapour inlet
- Vapour outlet

The vapour which comes out from the reactor is allowed to flow into the inlet port of the condenser .Vapour which is cooled inside the condenser by circulating water is collected in the collector through the outlet port. The cut-off regulator is set to the temperature of around 400°c. The waste PVC plastics melt inside the thermal reactor. After 10 mins, the reactor temperature will reach a temperature range of 370°c.since the cut-off regulator was set to this maximum temperature , the current supply will be stopped .At that mean time the water is circulated to the condenser by using the submersible pump. The vapour coming from the thermal reactor is condensed by the circulating water, and hence the vapour is transformed to oil in the condenser tube .The condensed oil is then collected in the

beaker kept below the vapour outlet. It is observed from the study that 130 g of waste polyvinyl chloride (PVC) plastics and 1% of catalysts namely $BaCO_3$ which yield about 10-15 ml of PVC oil .The entire process was completed in 20 mins. The waste sludge obtained is found to be light in nature. It is observed that sludge once obtained cannot be reused and even if it is recycled ,yields obtained through the recycling is about 2-3 ml.The amount of oil extracted by using the catalyst is tabulated in table 2.1

S. No	Amount of PVC	Temperature	Oil extracted with 1% catalyst	Oil extracted without catalyst
1	130 grams	450°c	20 ml	5 ml

Table 2.1: Extracted oil

2.5 Property Analysis

The extracted oil is made for property analysis. The following are the properties,

- Flash point.
- Fire point.
- Density.
- Kinematic viscosity

2.6 PROCESS IN THE EXPERIMENT

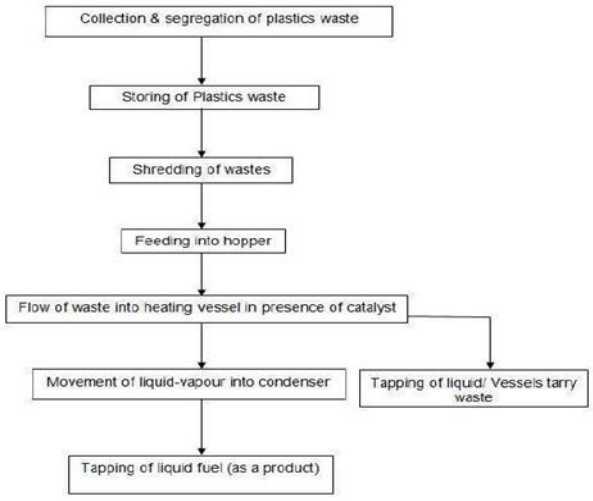

Figure 2.2 Experimental process

3. RESULTS AND DISCUSSION

The following results were obtained from various observation from the experiment:

3.1 Physical Observation

This wastes could be obtained from rubbish household wastes and industrial wastes. These collected wastes are crushed into small chips to enhance the plastic oil extraction. The pictorial representation of the raw plastic The physical appearance of the source PVC before and after the thermal pyrolysis is shown in figure 3.1

Figure 3.1 Physical observation of PVC

3.2 Comparison of the Property Test with Diesel Oil

The properties like flash point, fire point density, and kinematic viscosity were determined for both the plastic oil and diesel. The values were plotted with diesel and plastic oil as X-axis and temperature range values on Y-axis. The result shows that the properties of plastic oil approximately equals with that of the diesel.Property analysis test on flash and fire point in diesel and waste plastic oil is shown in the figure 3.2

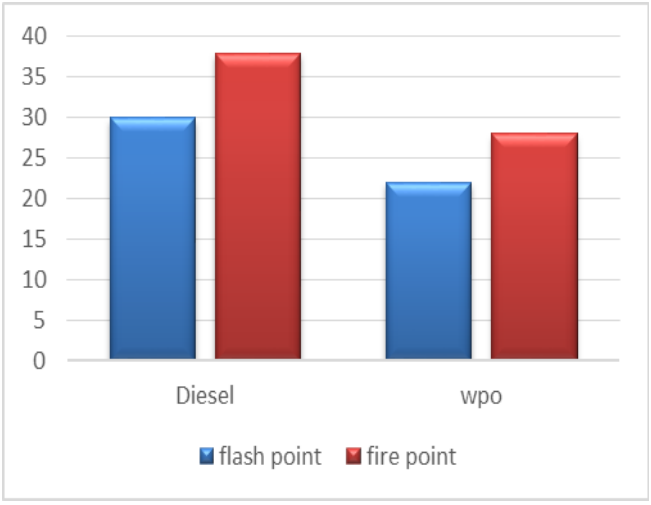

Figure 3.2: Analysis on flash and fire point

It is obtained from the above graph that flash and fire point of the plastic oil is found to equals with that of the diesel with oil on X-axis and the flash and fire point on Y-axis.Graph showing density variation on diesel and waste plastic oil is in the figure 3.3

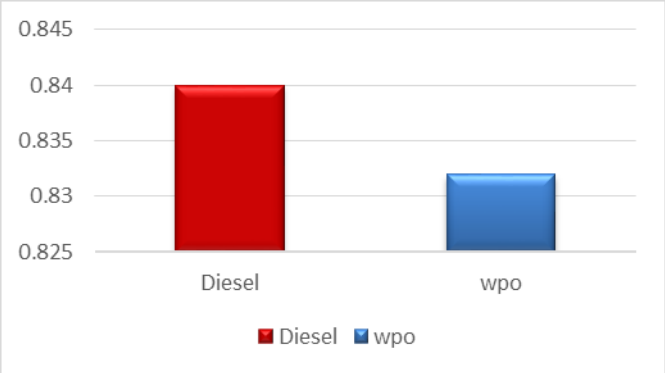

Figure 3.3 Analysis of density variation

3.3 Property Analysis

S.No	Property	Diesel	90% WPO	80% WPO	70% WPO	60% WPO
1	Density(kg/m3)	840	848	834	826	822
2	Specific gravity	0.840	0.848	0.834	0.826	0.822
3	Flash point	50	46	43	39	36
4	Fire point	56	59	53	48	44
5	Viscosity at25˚C	3.80	5.56	5.12	4.84	4.26
6	Kinematic Viscosity at 30˚C	2.999	3.236	4.431	1.52	1.364
7	Sulphur content %	0.01	0.0085	0.0091	0.010	0.035
8	Carbon residue %	0.016	0.009	0.010	0.013	0.015

Table 3.1 Property analysis of diesel and wpo

S.no	Load in (kg)			Time taken for 10cc	Speed (rpm)	Manometer reading in(cm)	
	W1	W2	W1 – W2			h1	h2
1	5	1	4	83	1350	6	9
2	10	3	7	67	1210	4	7
3	15	4	11	55	1130	3	8
4	20	6	14	48	1020	5	7

Table 3.2 Load test on four strokes diesel engine

Sample	BP (KW)	TFC (Kg/hr)	SFC (Kg/KW hr)	IP (KW)	ηmech (%)	ηBT (%)	ηIT (%)
P.oil 60%; Diesel 40%	0.534	0.357	0.668	1.834	29.33	12.23	42.03
P.oil 70%; Diesel 30%	0.935	0.442	0.449	2.235	41.86	17.31	41.37
P.oil 80%; Diesel 20%	1.469	0.539	0.367	2.769	53.44	22.29	42.03
P.oil 90%; Diesel 10%	1.869	0.617	0.330	3.701	58.34	24.78	42.97

Table 3.3 Load test on four strokes diesel engine contd

4. CONCLUSION

From this work it is observed that, thermal pyrolysis of plastic is used for the extraction of the oil. The temperature is maintained to about 450˚c.The yield obtained by this method was 5 ml. In order to increase the plastic oil yield various catalysts were used. In thiswork, $BaCO_3$ is used as the catalyst. The pyrolysis process occurs at the temperature of450˚C and water is made as the cooling medium. The oil is obtained by condensing the vapours produced from the reactor to the liquid products. The yield obtained by this process is 20ml which is found to be 20% higher than that of the yield obtained without catalyst. This extracted oil is made the undergo property test. Properties like kinematic viscosity, density, flash and fire point which are obtained using PenSky Martens apparatus (closed cup) and Redwood Viscometer. The flash and fire point of the plastic oil are found to be 42˚c and 45˚c.The density and the kinematic viscosity are 0.8355 gm/cm^3 and 2.52. The obtained values were compared with the property test of diesel and the values were found to be approximately equals with that of the diesel.

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