International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 03 | Mar-2018 www.irjet.net p-ISSN: 2395-0072

PRODUCTION OF ALTERNATE FUEL FROM WASTE PLASTIC MATERIALS

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Abstract – *Plastic in reason time has merged a major damage for the environment and government has taken steps to illuminate the use of plastics, but plastic become an internal part off our life. So, we have come up with a new concept where we can produce alternate fuel (diesel) from waste plastic material. Though, the process of converting waste plastics into resource is carried out on Thermal Pyrolysis in the absence of oxygen at high temperature of about 400°C-500°C and runs without the addition of a catalyst. In this experiment plastics used for pyrolysis to get alternate fuel (diesel) are Mixed Plastics (High Density Polyethylene, Low Density Polyethylene, Polypropylene, Polystyrene, Poly Vinyl Chloride, Polyurethane, Polyamide, etc.) in which it contain the same physical properties as the fuel like petrol, diesel, etc. Further, the process is subjected to distillation for purifying the oil to obtain fuel. Thus the problems faced by the increasing in plastic waste and increasing fuel crisis can be eliminated by making a system which can decrease the pollution due to plastic and increasing the availability of the alternate fuel.*

Keywords-Plastic waste, Pyrolysis oil, Alternate fuel (Diesel)

1. INTRODUCTION

Over 280 Million tons of plastics have been producing by a human which affects marine life. Plastics are said to be non-biodegradable in nature. To dispose this plastic, every year it costs US$ 2 Billion and for Honk Kong it costs US$ 14 Million. Most of the plastic waste in landfills result in the formation of carbon sink and it takes 1000 years to decompose which also affects soil and water. A carcinogen, polychlorinated dibenzo-p-dioxins has been produced by the uncontrolled incineration of plastic. There are two benefits in converting waste plastic to pyrolysis. At first, hazards caused by plastics will be reduced (minimized). Secondly, domestic fuel obtained from it will be used for automobiles and industries [1]. Hence KHAN (2015), recycling of plastic solid waste is a better option to convert the waste material to useful resource. The Thermal pyrolysis of plastic waste [Faravelli(2001),dolezal(2001),Cha(2002),Kim(2004)] is an endothermic process that does employ any catalyst[2]. The advantages of plastics are lightweight, durability and energy efficiency. Recycling, regenerating and utilizing of waste plastics have become a hot spot of research at home and abroad [3].

Plastic waste does not degrade or degrades at a very low pace. The pyrolysis of plastic yield on average 45-50% of oil, 35-40% of gases, and 10-20% of tar, depending on the pyrolysis technology. Through optimal combustion of pyrolysis the conversion of waste plastic to high-quality diesel fuel takes place [4]. The process of collecting the plastic bags is known as pyrolysis. Based on the level of the plastics, the conversion of the plastic to the fuel varies.[5] Because of its high heat of combustion and due to the increasing availability in local communities, waste plastics are one of the most promising resources for fuel production[1][5]. Feed stocks which are non-hazardous and combustible are the major requirements for the conversion of waste plastic into fuel [6].During the use phase, plastic save energy and co_2 emissions. Due to the wide-spread littering of plastics on the landscape of India, plastic waste has attracted wide spread attention in India [7].

The fossil fuel is replaced by alternatives fuel technologies such as biogas, gasification, dimethyl ether, pyrolysis, waste oil recycling, derived bio-fuel, bio-ethanol and bio-diesel lipid. Based upon the types of plastics and its properties the oil is prepared. The extraction of oil from waste plastics are processed based on various conversion technologies

Pyrolysis process becomes an option of waste-to-energy technology in order to deliver alternate fuel (diesel) to replace fossil fuel. Pyrolysis is non-environmental harmful emission or non-toxic unlike incineration [8].

1.1 Plastic

Plastic is material consisting of any of a wide range of synthetic or semi-synthetic organic compound that are malleable and so can be molded into solid object.

The plastics are classified into three types namely Thermoplastic, Thermosetting and Elastomer.

1.1.1 Thermoplastic

Thermoplastic which are repeatedly soften and melt in enough heat and hardened on cooling.

Common thermoplastic range from 20,000 to 50,000 amu, while thermosets are assumed to have infinite molecular weight

Illustration:

Polyethylene (PE), Polypropylene (PP), Polystyrene (PS) and Poly Vinyl Chloride (PVC)

1.1.2 Thermosetting

Thermosetting can melt and made shape only once. They will stay solid after they have solidified and not suitable for repeated heat. In the thermosetting process a chemical reaction occurs that is irreversible.

Illustration:

Polyester, Phenol formaldehyde, Urea Formaldehyde

1.1.3 Elastomer

Elastomer materials that are made of polymers that are joined by chemical bonds, acquiring a final slightly cross-linked structure.

Depending on the distribution and degree of the chemical bonds of the polymers, elastomeric materials can have properties or characteristic similar to thermosets or thermoplastics

Illustration:

Natural rubber, Polyurethane, Polybutadiene, Silicone

2. METHODOLOGY

2.1 Pyrolysis

Pyrolysis process is a heating of organic materials in the absence of oxygen and it involves the change of chemical composition and is irreversible. In plastic pyrolysis, the longer molecules are breakdown into smaller molecules in presence of heat through three forms like carbon black atoms, pyrolysis oil and pyrolysis gas molecules. The process runs in a cylinder chamber at high temperature of about 400^{o}c-500^{o}c and without the addition of catalyst. The pyrolysis gas is converted into liquid form in cooling tower.

2.2 Condenser

Condenser is a cooling process in which gas phase is converted into liquid phase. The heat vapour from reactor is condensed by cold water and the temperature drops to 35^{o}c-40^{o}c nearly at room temperature.

2.3 Reactor

It is mild steel tube of length 145mm, internal diameter 37mm, outer diameter 41mm completely sealed at one end and an outlet at the other end. The reactor is heated by electrical heating at high temperature of about 400^{o}c and more. Tungsten is used as heating element which is coated by ceramic material in order to control electricity. The reactor is covered with glass wool for absorbing the heat without releasing into atmosphere.

2.4 Process Vignette

Fig.1 Experimental Setup

Raw material are fed into the reactor of about 6kg and the experiment runs with all types of plastic i.e. high density polyethylene, low density polyethylene, polypropylene, polystyrene, poly vinyl chloride, etc. The collected waste plastics are cleaned and shredded into 3-5cm size to fit into the reactor. The process is carried out at high temperature in the absence of oxygen and without catalyst. Heat is applied by electrical energy of heating coil to melt the waste plastics. When temperature is gradually increased the melted plastic turns into liquid slurry form. At the temperature of 270^{o}c or above that liquid slurry turns into vapour and pass through a condenser unit for cooling process. In condenser heated vapour are cooled by cold water and the temperature drops from 400^{o}c to 35^{o}c-40^{o}c.At the end pyrolysis oil are collected.

Fig.2 Collected Pyrolysis oil

During thermal cracking process plastic are not broken down immediately. When heat is applied the short chain

hydrocarbons break down at the first stage and slowly carbon-carbon bond break down as the temperature increased. At last while increase in temperature step by step long chain hydrocarbon are break down. The remaining carbon black inside the reactor can be used for brick manufacturing.

2.5 Distillation

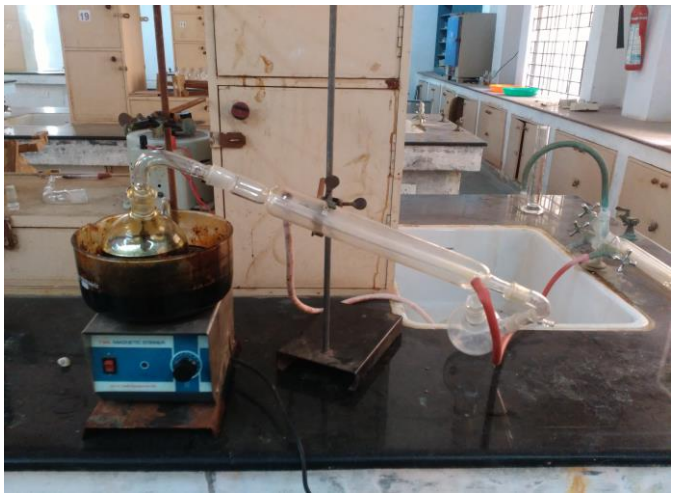

Fig.3 Distillation process setup

Pyrolysis oil is purified by converting gas into liquid and also removing impurities through simple distillation process. The impurities are removed inorder to avoid corrosion in separating system. The oil is heated with light burner (heating mantle) and the gases re-circulated around the cartridge. Now the gases are moved from cartridge into condensing system for converting i.e. transforming the plastic from a solid to a liquid to gas. In condensing system, the gases are cooled and condensed into liquid fuel. Through stream the waste impurities are removed and transfer the fuel from condensing unit to storage container.

3. RESULT AND ANALYSIS

3.1 Quality of Fuel

The quality of alternate fuel obtained has distilled with residuum. The physical properties of alternate fuel (diesel) are compared with diesel and petrol.

3.2 Physical Properties

3.2.1 Density

Density is a measurement of comparing the amount of matter an object has to its given volume and it is qualified with the ratio of mass(m) per unit volume(v).Using hydrometer instrument the density is measured. The SI unit is kg/m^3

$$P=m/v$$

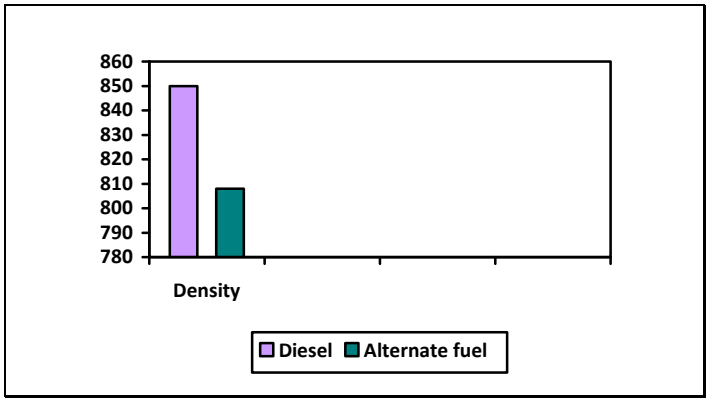

Fig.4 Graphical presentation of density for diesel and alternate fuel

3.2.2 Viscosity

Viscosity is a measure of a fluids resistance to flow. It describes the internal friction of a moving fluid. A fluid with large viscosity resists motion because its molecular makeup gives it a lot of internal friction. By using viscometer the viscosity is identified and expressed by the unit centistokes.

Kinematic viscosity= $(0.22*T - 135/T)*10^{-6}$

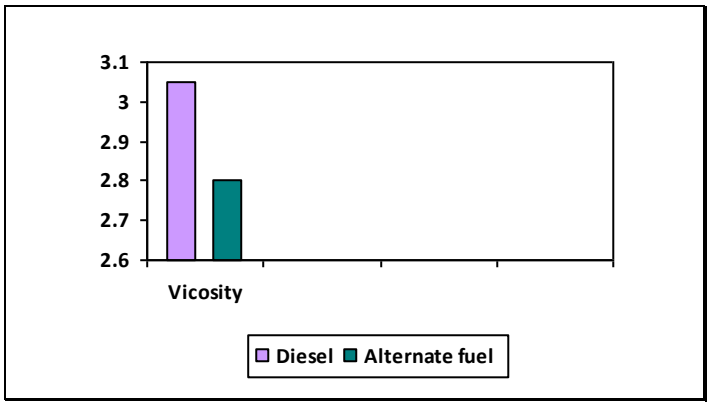

Fig.5 Graphical presentation of viscosity for diesel and alternate fuel

3.2.3 Calorific value

The calorific value is the total energy released as heat when a substance undergoes complete combustion with oxygen under standard condition. The chemical reaction is typically a hydrocarbon or other organic molecules reacting with oxygen to form carbon-dioxide and water and release heat. Hence calorific value is measured by using bomb calorimeter and expressed by the unit kJ/kg.

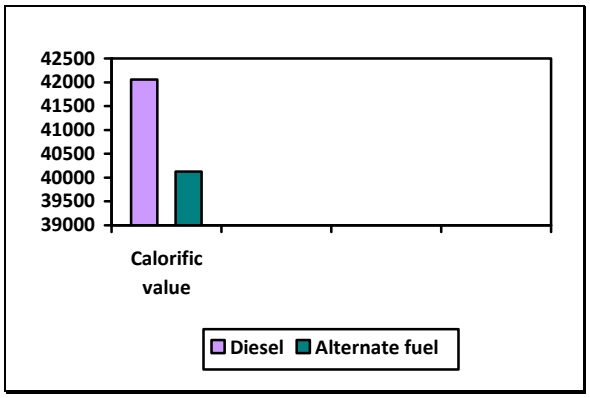

Fig.6 Graphical presentation of calorific value for diesel and alternate fuel

3.2.4 Flash Point & Fire Point

The flash point of a fuel is the lowest temperature at which it can vaporize to form an ignitable mixture in air. If a source of ignition is given then its starts burning. If a source of ignition is not given it remains as an ignitable mixture.

The fire point is defined as the lowest fuel temperature at which the diffusion flame is sustained longer than five seconds above the fuel pool without any external heat supply. And hence both the fire point and flash point is identified by the apparatus called Cleave land open cup. It is expressed by the unit ^{o}c.

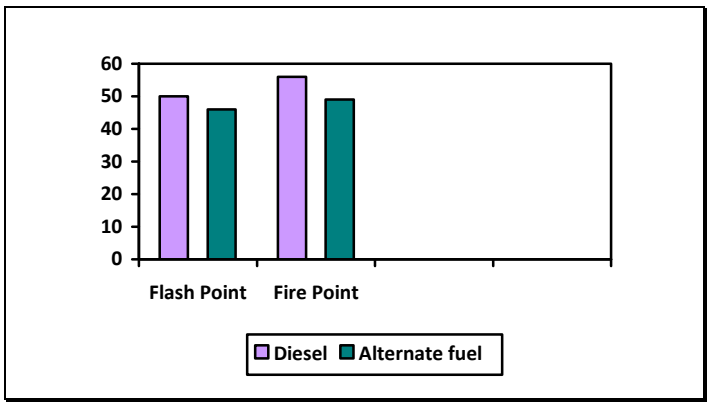

Fig.7 Graphical presentation of flash & fire point for diesel and alternate fuel

Table.1 Characteristics of diesel and alternate fuel

S.no	Properties	Diesel	Alternate fuel (Diesel)
1.	Density (kg/m^3)	850	808
2.	Viscosity	3.05	2.8
3.	Calorific Value (kJ/kg)	42060	40125
4.	Flash point (^{o}c)	50	46
5.	Fire Point (^{o}c)	56	49

4. CONCLUSION

According to the present condition the plastic plays a vital role in the modern world. Last year 260 million tons of plastic is produced all over the world in that 75% of plastic are turned as waste

In that 75% of waste plastic 14 million tones of plastic waste is dumped into the seas as a result more than one lakh of sea species are killed

By using diesel it produces pollution and that affect the natural environmental condition. To reduce the pollution and usage of crude oil we have produced alternate fuel (Diesel). By comparing the properties of plastic fuel (Diesel) and diesel fuel we found that all the properties are near to the diesel. And hence we concluded that waste plastic fuel (Diesel) becomes a good alternate fuel for the diesel engine instead of using diesel. Hence we can reduce plastic waste, pollution level and raise our country economic status.

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