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Study of Alternative Fuel Extracted from Solid Waste

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ABSTRACT

Pyrolysis is the process of heating of an organic material in the absence of oxygen. A mini pyrolytic plant was made by using a pressure cooker as reactor. A external heating source had been used for heating purpose. 1 kg of plastic bottle cap and a mixture of bottle cap and tire (750g bottle cap, 250 gram tire) were processed. Around 200g liquid fuel had been extracted for both sample. Physical property of that extracted oils were checked. Density of the oil from only bottle cap sample was found 731 kg/m3 and of mixed sample was 743 kg/ m3, where density of conventional fuel such as diesel is 820 - 850 kg/m3 and gasoline is 719-780 kg/m3 . kinematic viscosity of pure bottle cap sample oil at 40°C was found 1.8 cSt and mixed sample was 2.2 cSt, where diesel has a value of 2-4.5 cSt and gasoline has 1.95-3.3 cSt. Gross calorific value of pure sample was found around 40.98 MJ/Kg and of mixed sample 39.5 MJ/Kg. Flash point of pure one was near around 63°C and of mixed one was 73°C. Diesel has a calorific value of 44-46 MJ/Kg and gasoline has a value of 43.2 MJ/Kg. The physical properties of pyrolytic oil is comparable with diesel and gasoline

Keywords: Pyrolysis, pyrolytic oil, kinematic viscosity.

1. Introduction

Bangladesh is a densely populated country in Asia. Crisis of power is one of the major problems in Bangladesh. Her per capita energy consumption is much below the world average. Energy consumption mix is estimated as: indigenous biomass 60%, natural gas 27.45%, oil 11.89%, coal 0.44% and hydro 0.23%. More than 77% of the country's population lives in rural areas and meeting most of their energy needs from traditional biomass fuels[1]. Pyrolysis is the process of heating of an organic material in the absence of oxygen. Biofuel can be extracted from solid wastes such as rubber, medical waste, rice husk and others which contain lignin. Researchers have been conducted for biodegradable and non-biodegradable waste materials. Rubber and plastics are non-biodegradable. About 20.50 million bicycle/rickshaw tires become scrap every year and wait for disposal which is about 37%(wt) of total tire waste production in Bangladesh. According to a estimation of every year, about 31,000 tons bicycle/rickshaw tires, 5160 tons motorcycle tires, and 28,900 tons bus/truck tires become scrap and are disposed and this amount is increasing [2]. Bangladesh generates about 3,36,000 tons of plastic wastes per year and and around 17,000tons/year is going to the landfill . Among them, 30% (2,01,600 tons) is solid waste and rest 60% is liquid 69% of that total amount is recycled. Basic purpose of that experiment is to recycle solid waste by pyrolysis and extract fuel from it. 1 kg of plastic bottle cap and a mixture of bottle cap and tire (750g bottle cap, 250 gram tire) were processed. Gross calorific value of pure sample was found around 40.98 MJ/Kg and of mixed sample 39.5 MJ/Kg. Flash point of pure one was near around 63°C and of mixed one was 73°C. Diesel has a calorific value of 44-46 MJ/Kg and gasoline has a value of 43.2 MJ/Kg. The physical properties of pyrolytic oil is comparable with diesel and gasoline.

2.Method:

Scrap tire and cap of plastic bottle was collected from local area of Khulna. Both waste materials was cut into pieces. Those materials were gently cleaned and dried carefully. Reactor is most important part of a pyrolysis plant. Here for this experiment a pressure cooker has been used to do the job of the reactor. A 3.5 Littre pressure cooker has been used. About more than 1 kg of bottle cap was able to feed at a time. As the pressure rises, the temperature of the material inside the sealed pot (the pressure cooker) also rises above the normal boiling point temperature. The outlet pipe is designed such that the vapor produced in the reactor can easily flow through them. The condenser pipe which is made of copper is of smaller diameter so that the vapor coming through the outlet pipes can easily condense as condenser is submerged in a biker filled with icy water. The collector pipe connected at the end of the condenser can collect the pyrolytic liquid fuel. A pressure cooker has been used as reactor so that advantages of both increased pressure and temperature can be used. It is effective as in a reactor with heater, there a film of melted material formed around heating surface, which might damage the heater and reduce efficiency. The reactor (pressure cooker) was externally heated by using a external heating source in one direction.

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3. Construction Parameters:

To construct the pyrolysis plant following items is being used.

- Pressure cooker
- Outlet pipe
- Condenser
- Collector
- Thermocouple
- Heater
- Temperature recorder
- Insulating material
- Necessary equipments for proper connection.

3. Design Specification

- A pressure cooker of 3.5 litter volume.
- Length of outlet pipe : 483 mm
- Diameter of condenser pipe: 13mm
- Diameter of outlet pipe: 25mm

4. Experimental Setup:

Here for pyrolysis of bottle cap a pressure cooker has been used to do the job of the reactor. The pyrolysis reactor is fed with biomass from top part. Inside the reactor the biomass is heated and undergoes chemical and physical processes being transformed into biochar. The reactor was insulated by using rope and mud. Outlet pipe has a total length of 483 mm . Actually it is a summation of two individual pipe of length 254mm . and 228mm. connected by a elbow joint. It collect the vapor from the pressure vessel and send it to the condenser. The condenser was made by copper pipe of 13mm diameter . Heat for the experiment was supplied by an external source to be exact a electric heater. The following figure shows the experimental sep up.

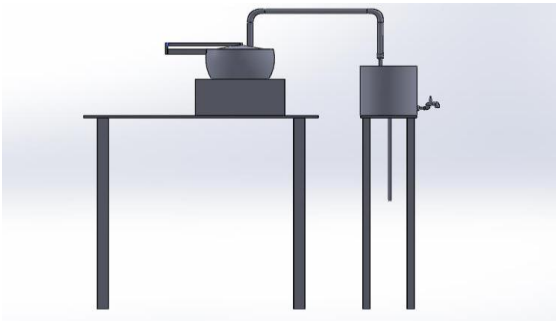

Fig 1: CAD model

Fig 2: Experimental setup.

5. Experiment Procedure:

In this experiment two different type material has been processed. One is waste bottle caps and other one is mixture of bottle caps and waste tires. The shredded waste was placed into the reactor. The total system was placed on a electric heater and heat was continuously supplied to the reactor. Around 1000g of waste was placed in the reactor. As heat is continuously supplied to the reactor the temperature inside the cylinder was increased gradually. A thermocouple is connected with the inner side of the reactor through which temperature reading was shown in the temperature recorder. The experiment was performed for different temperatures. For bottle cap, the experiment was done between the temperature range of 300°C to 350°C the flaring of white vapor began to come at 303°C through the condenser pipe. So, the volatile material began to form around this temperature. At a certain temperature the white vapor with high volatile material began to come out through the condenser. In the condenser the vapor is condensed and turned into liquid and this liquid is collected with the collector as the gravitational force works on it. There is a gateway for passing the uncondensed gas to atmosphere. It was noticed that as the temperature is increased, the time required to condense the vapor is decreased. The more increasing temperature increases more liquid oil from the material within a shorter time. In this way the heating process is carried out up to a certain time. At a point the white vapor stopped to flare. Then time is calculated through a stopwatch. The absence of white vapor indicates that pyrolysis process is completed and all the waste is converted into gas, liquid oil and char. The char was collected from the reactor and weighted. The amount of gas that passes to the environment is calculated by subtracting the weight of oil and char from the total weight of the bottle cap. Similar procedure was done for mixture of bottle cap and tires. For the mixed sample,750g bottle cap waste and 250g tire waste were mixed together and given to the reactor. The experiment was done between the temperature range of 287°C to 327°C. white gasses started to come out at 290°C.

6. Result and Discussion:

Total two sample was tested. Each sample was tested for three times to reach on a reliable conclusion. During the extraction of fuel from waste material following data was taken. Two materials were tested at different days. The data collected during pyrolysis process is shown in the appendix and the result obtained from the data is shown in Table.

Table no:1: data table for bottle cap sample

No of Obs	Mass of feed (kg)	Room temperature	Condenser temperature initial	Condenser final temperature	Starting temperature of pyrolysis	Final temperature of pyrolysis	Time (min)
1	20	18	18	30	303	350	145
2	20	21	21	32	300	344	130
3	40	21	21	33	304	348	150

Table no.2: data of collected output from the experiment

No of observation	Mass of feed material (kg)	Uncondensed gas (gm)	Amount of ash (gm)	Mass of liquid (gm)
1	1	350	450	200
2	1	366	484	150
3	1	256	520	224

Table no.3: data table for mixture of bottle cap and tire sample:

No of Obs	Mass of feed (kg)	Room temperature	Condenser temperature initial	Condenser final temperature	Starting temperature of pyrolysis	Final temperature of pyrolysis	Time (min)
1	1	22	19	31	287	327	135
2	1	23	20	32	290	325	140
3	1	21	20	35	292	350	155

Table no.4: data of collected output from the experiment

No of observation	Mass of feed material (kg)	Uncondensed gas (gm)	Amount of ash (gm)	Mass of liquid (gm)
1	1	350	400	250
2	1	330	470	200
3	1	280	500	220

Various properties of obtained pyrolytic oils have been tested in the laboratory. The extracted oils was brown in color. Both the oils has an acidic smell. All the properties have been tested carefully. Flash point was determined by using flash point measuring instrument. Density was measured in laboratory by digital weight measuring machine and volumetric beaker. . viscosity was measure at first by capillary tube method and then saybolt viscometer. Calorific value was measured by using oxygen bomb calorimeter . Comparison between conventional fuel and extracted fuel have been discussed below in table:

Table 6: physical properties analysis of obtained liquid product and commercial fuel:

Properties	Extracted Oil from bottle cap sample	Extracted Oil from mixed sample	Diesel	Gasoline
Density (ρ) (kg/m3)	731.11	743.33	820 - 850	719-780
Kinematic Viscosity (cSt)	1.8	2.22	2-4.5	1.95-3.3
Gross Calorific Value (MJ/Kg)	40.983	39.511	44-46	43.2
Flash Point °C	63	73	53-80	N/A

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