The extraction of Pyrolytic oil from Biomedical Plastic Waste to Use as a Fuel in Diesel Engine

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College ***:*** *PDA College of Engineering, Kalaburagi*
Branch ***:*** *Mechanical Engineering*
Guide(s) ***:*** *Dr. M C Navindgi*
Student(S) ***:*** *Mr. Saikumar S Hodalur*
Mr. Rahul
Mr. Ranjeetreddy
Mr. Vishal

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Introduction:

Waste plastic disposal and excessive use of fossil fuels have caused environment concerns in the world. Both plastics and petroleum derived fuels are hydrocarbons that contain the elements of carbon and hydrogen. The difference between them is that plastic molecules have longer carbon chains than those in LPG, petrol, and diesel fuels. Therefore, it is possible to convert waste plastic into fuels. Pyrolysis can act as the residue management option because bio-oils derived from biomass pyrolysis could act as feedstocks for producing hydrocarbons that may be readily integrated into the existing petroleum refineries or future bio-refineries. Pyrolysis is the thermal degradation of biomass by heat in the absence of oxygen and results in the production of charcoal (solid), bio-oil (liquid) and fuel gaseous products. The bio-oil obtained from pyrolysis could not be used in diesel engine. Due to the presence of oxygenated compounds in the bio-oil, it cannot be blended with the conventional oil. Bio-oil can be combined with diesel fuel directly through emulsification method by the aid of surfactant. bio-oil would not auto-ignite without an ignition additive and therefore a nitrated alcohol is added in various concentrations to the bio-oil. A minimum of 5 vol. % additive was required for stable engine.

Objectives:

1. Design and fabricate the Pyrolytic equipment to extract the oil from biomedical plastic waste or any other plastic waste.
2. Up gradation of pyrolytic-oil by emulsification.
3. Determine the basic fuel properties of upgraded pyrolytic-oil diesel blends
4. Conduct an experiment to determine performance and emission characteristics of DI diesel engine fuelled with upgraded pyrolytic-oil to find its suitability to use as fuel in diesel engines.

Methodology:

The steps involved in pyrolytic process is as shown in flow chart diagram.

Fig. 1 Pyrolytic process flow chart

Collection of Biomedical/Plastic waste: There are many major sources of the plastic waste such as household waste, hospitals, blood bank, nursery, autopsy centres, laboratories and minor sources such as clinics dental clinics, home cares, institutions, cosmetic shops etc. In this project it is planned to use solid plastics waste. These wastes are treated and subjected to pyrolysis process to extract oil.

Pyrolysis Process: Pyrolysis is the thermal decomposition of biomass occurring in the absence of oxygen. It is the fundamental chemical reaction that is the precursor of both the combustion and gasification processes and occurs naturally in the first two seconds. The products of biomass pyrolysis include biochar, bio-oil and gases including methane, hydrogen, carbon monoxide, and carbon dioxide. Depending on the thermal environment and the final temperature, pyrolysis will yield mainly biochar at low temperatures, less than 4500C, when the heating rate is quite slow, and mainly gases at high temperatures, greater than 8000C, with rapid heating rates. At an intermediate temperature and under relatively high heating rates, the main product is bio-oil.

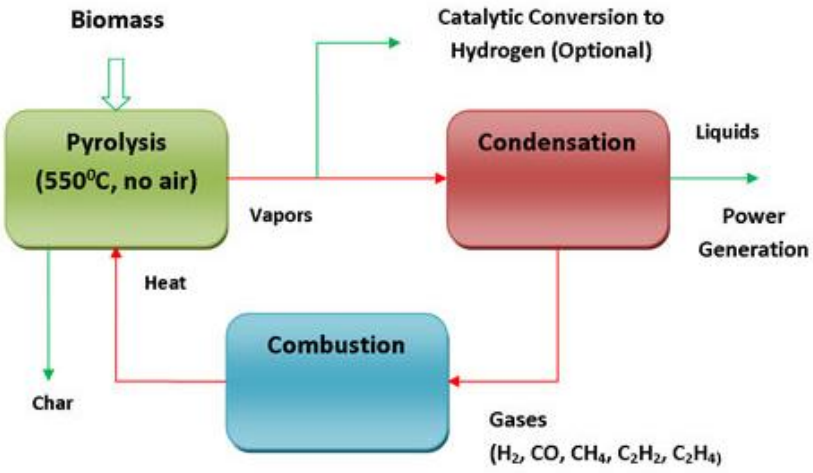

Fig.2. Plastic waste liquification via pyrolysis

Design and Fabrication of pyrolysis equipment:

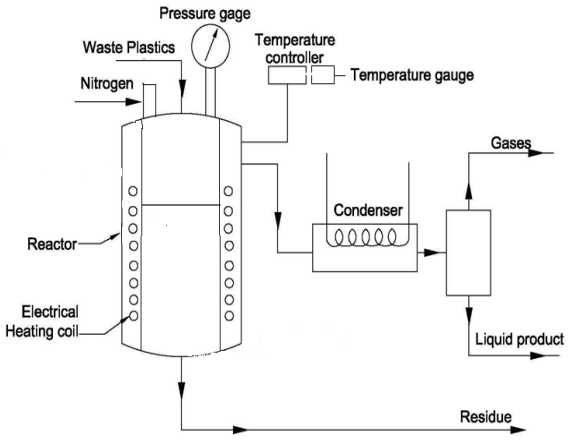

Fig 3: Pyrolytic equipment

Fig 4: Fabricated Pyrolysis Unit

The pyrolytic equipment consists of: Reactor: The reactor consists of electrical heating coil and bricks around the reactor where the combustion takes place.
Condenser: In condenser the change of phase takes place i.e.vapour to liquid.
Temperature controller: The temperature controller controls and sets the temperature which is required for reactor to carryout combustion.
Pressure Gauge: Pressure gauge indicates the pressure in the reactor.
Upgradation of extracted oil: Up gradation of extracted pyrolytic-oil by emulsification process (adding ignition improver and surfactant). To determine the basic fuel properties of emulsified bio-oil as per IS standard.
Performance Test: The performance and emissions of single cylinder four strokes DI diesel engine fuelled with bio-oil diesel blends will be carried and the results will be compared with diesel fuel.

Fig 5: Photograph of the experimental setup

Conclusion:

1. Pyrolysis process was the best methods to treat waste plastic under solid waste management technique.
2. A pyrolysis batch reactor was successfully designed and fabricated with a handling capacity of 10 kgs per cycle and the overall yield of WPPO was found to be 42% yield WPPO was noticed at higher levels with the increase in temperature above 500oC
3. Diesel engine was able to run with 100% waste plastic oil.
4. Engine fuelled with waste plastic pyrolysis oil exhibits higher thermal efficiency up to 75% of the rated power for diesel engine.
5. With waste plastic pyrolysis oil there was increase in CO emission level compared to diesel operation.
6. Waste plastic pyrolysis oil can be used alternate fuel to the diesel.

Scope for future work:

1. The current batch feeding system is to be converted to continuous feeding system with some modification. Better and effective distillation columns should be applied on the plant for refining of the pyrolysis products.

2. The non-condensable gases were flared off in the experiment. It would be valuable to collect some of the gases and investigate its composition. The diesel range product should be separated out of the condensed products in the small-scale plant.