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Design and Fabrication Model is Used to Extract Waste Plastic to Bio Oil

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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.

I. INTRODUCTION

The world's annual plastic consumption has increased about 20 times from 5 million tons in the 1950s to nearly 100 million tons. Plastic is one such commodity that has been so extensively used and is sometimes referred to as one of the greatest innovations of the millennium. There is a numerous way in which plastic is and will continue to be used. Plastic has achieved such an extensive market because it is lightweight, cheap, flexible, reusable, do not rust, and so forth. Because of this, plastics production has gone up by almost 10% every year on a global basis since 1950.

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.

II. LITERATURE SURVEY

The cracking process breaks down the long polymeric chains into useful smaller molecular weight compounds. The products of this process are highly useful and can be utilized as fuels or chemicals in various applications [1]. Sequential pyrolysis and catalytic reforming system for municipal plastic wastes degradation using commercial and Indonesian natural zeolite catalysts. Our system will utilize all kinds of products as fuels including liquid, gaseous and solid products [2]. The technical evaluation of the potential to convert waste plastics to high-quality diesel fuel by an optimal combination of pyrolysis and catalytic hydrotreatment [3]. Setting up intermediate treatment plants for waste plastic, such as plastic incineration, recycle, or obtaining the landfill for reclamation is difficult. Therefore, it is necessary to use waste plastic to avoid such problems and convert them into useful biodiesel compounds by different methods [4]. Optimization of in-situ transesterification process parameters to increase the yield of biodiesel and further characterization of biodiesel using various analytical techniques. Finally, 5% of blended biodiesel properties were analyzed using ASTM standard methodology [5]. The transesterification method is commonly used for biodiesel production because of its higher yield and lower energy consumption. Transesterification is a chemical process of reacting triglycerides with alcohol in the presence of a catalyst [6]. Used frying oil (UFO) and polyolefin-based plastic wastes (PW) are waste materials that are abundantly available as household waste. This study was initiated with thermogravimetric and proximate analysis of the UFO and

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PW to examine their potential as feedstocks for pyrolysis conversion into fuel products. This was followed by microwave co-pyrolysis of a mixture of UFO and PW over a range of different ratios of PW added to UFO and different operating temperatures to assess the potential of using this co-pyrolysis approach to treat and convert these household wastes into an alternative fuel source [7]. Biodiesel production directly from wet algae assisted by Radio Frequency heating was investigated. Chlorella Vulgaris microalgae were chosen as the feedstock because of their high lipid and carbohydrate contents [8]. The optimal pyrolysis temperature required for biochar production was also optimized [9]. The catalytic pyrolysis of different types of plastics waste (PS, PE, PP, and PET) as single or mixed in different ratios in the presence of modified natural zeolite (NZ) catalysts in a small pilot-scale pyrolysis reactor was carried out [10]. To exploit the high efficiency of low-cost and stable pine wood-based biochar catalysts, impregnated with different chemical materials followed by lipase immobilization on calcite and glass-ceramic material, for the production of biodiesel via transesterification reaction [11]. Investigate the prospective use of secondary tannery sludge as an inexpensive feedstock for lipid extraction and biodiesel production via acid-catalyzed in-situ transesterification reaction under optimized conditions [12]. The bioconversion of fermented feeding medium into BSFL (Black Soldier Fly Larvae) biomass served as a key player in determining the true benefit of inoculating exomicrobes to ferment the feeding medium before BSFL offering [13]. To study the effects of the addition of biodiesel residue, glycerol in the epoxy resin, verifying the impact on its mechanical, thermomechanical, and adhesive properties. For that, a methodology of characterization of these materials was used, concerning its properties showing promising results with 1.0% of addition [14]. A study on the production of biodiesel with degummed used vegetable oil (collected from local food processing outfits in Nigeria) using eggshell, pineapple peel and cow bone calcined at a single temperature (700 ◦C) as a catalyst [15]. Integration of acidogenic fermentation with yeast fermentation for lipid biosynthesis is an attractive resource recovering strategy from both environmental and industrial points of view [16,17]. Most of the crude glycerin used in ruminant feed studies has been derived from vegetable oils (first-use oil), such as castor bean, soybean, cottonseed, sunflower, rapeseed, canola, and palm oil. Thus, at present, a limited number of studies have evaluated the effects of crude glycerin originating from waste vegetable oils (second-use oil) with high crude fat contents in animal diets [18]. The microstructure and porosity of different extrudate catalysts were analyzed by SEM and micro-CT to describe the relationship between the preparation conditions, pore structure, mechanical strength, and catalytic performance, which may be useful for the development of practical extrudate catalysts for commercial-scale production of biodiesel [19]. Pyrolysis waste oil (WPPO). Such findings are anticipated to better clarify the applicability and shortcomings of HDPE in the manufacture of substitute diesel fuel as a feedstock [20].

III. MATERIALS AND METHODS

PYROLYSIS PROCESS

Following two major pyrolysis methods are used to converting plastic wastes into useful bio-oil,

A. Thermal pyrolysis

B. Catalytic pyrolysis

A. Thermal pyrolysis

The non-catalytic or thermal pyrolysis of plastic is a high energy, endothermic process requiring temperatures of at least 350°C–500°C. Thermal cracking or Pyrolysis involves the degradation of the polymeric materials by heating in the absence of oxygen. The process is usually conducted at temperatures between 350° C and 500° C and results in the formation of a carbonized char (solid residues) and a volatile (Naveen Kumar P et al 2018).

In this paper, we are going to use the thermal pyrolysis method to convert waste plastic into bio fuel.

Pyrolysis is a chemical reaction in which large molecules are broken down into smaller molecules. The simplest example of pyrolysis is cooking in which complex food molecules are broken down into smaller & easy to digestible molecules.

Waste plastic and tire are long-chain molecules or polymer hydrocarbons. Pyrolysis technology is the industrial process of breaking down large molecules of plastic/tire into smaller molecules of oil, gas, and carbon black. Pyrolysis of waste plastic or tire takes place in absence of oxygen, at about 350-500 degree C and reaction time is about 15-90 minute.

Pyrolysis oil is sometimes known as bio-crude oil or bio-oil, is a synthetic fuel under investigation as a substitute for petroleum. It is extracted by biomass to liquid technology of destructive distillation from dried biomass in a reactor at a temperature of about 500 degree Celsius with subsequent cooling.

The oil produced in a pyrolysis process is acidic, with a PH of 1.5-3.8. The acidity may be lessened by the addition of readily available base components.

Little work has been done on the stability of bio-oil acidity that has been altered with base components while the exact composition of bio-oil depends on the bio mass source and processing conditions a typical composition is as falls water 20- 28 %, suspended solids, and pyrolytic lignin 22-36%,

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hydroxyl-acetaldehyde 8-12%, levoglucosan3-8 %, acetic acid4-8 %, acetol 3-6 %, sellubiosonl-2 %, glycol 1-2 %, formic acid 3-6 %. The water molecules are split during pyrolysis and held separately in other compounds within the complex with the pyrolysis liquid. The distinction is significant, as the "water" in pyrolysis oil does not separate like standard fossil fuels.

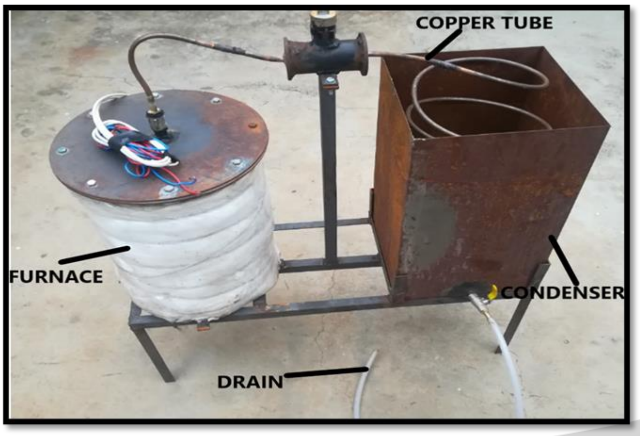

Figure 1: Working principle of bio-crude oil extraction from a waste plastic material.

In our experiments, the commercialization of usable shredded plastics was obtained and washed before pyrolysis. One of the most favorable and effective disposal methods is pyrolysis, which is environmentally friendly and efficient. Pyrolysis is the thermal degradation of solid waste at high temperatures (300-900^{0}C) in the absence of oxygen (and oxygen). Since the structure of the products and their yields can be significantly changed by catalysts, the results of pyrolysis in the absence of a catalyst have been presented in this article Pyrolysis of waste plastics was carried out in an indigenously designed and fabricated reactor.

The reactor is a stainless-steel tube of length 145mm, internal diameter 37mm, outer diameter 41mm sealed at one end, and an outlet tube at the other end. The reactor is to be placed inside the furnace for external heating with the raw material inside for internal heating. The reactor is heated by electrical heating to a temperature of about500^{o}C and more.

The furnace provides the heat the reactor needs for pyrolysis to take place, it has a thermocouple to control the temperature. A heating element converts electricity into heat through the process of resistive or Joule heating. Electric current passing through the element encounters resistance, resulting in heating of the element. Unlike the Peltier Effect, this process is independent of the direction of the current flow. Copper tubing is joined using flare connection, compression connection, or solder. Copper offers a high level of corrosion resistance but is becoming very costly. The condenser cools all the heated vapor coming out of the reactor. It has an inlet and outlet for cold water to run through its outer area. This is used for cooling the vapor. The gaseous hydrocarbons at a temperature of about 350^{o}C are condensed to about 30-35^{o}C.

Fig shows the scheme of the process involved in the experiments and the photograph of the experimental set up respectively. Waste plastics had been procured from the commercial source and stored in a raw material storage unit. The raw material was then fed into the reactor and heated using electrical energy. The yield commenced at a temperature of 350^{0}C. The gaseous products resulting from the pyrolysis of the plastic wastes are supplied through the copper tube. Then the burned plastic gas condensed in a water-cooled condenser to liquid fuel and collected for experiments.

IV. RESULTS

1.Lower reaction temperature of 350 to 500^{0}C: Lower operating cost, increased safety, and reduced maintenance.

2. Step energy recovery system: to ensure the energy efficiency of more than 80%.

3. Energy self-sufficient machinery: ensures more profits to investor & no of oil, stable can be used to external fuel for heating required during normal operations.

4. Effective Scrubbing system: to ensure that emissions are well below limits prescribed by environmental authorities.

5. Multiple layers of safety: to prevent machinery damage or health hazards.

6. Safe and automatic pyrolysis gas handling system.

V. CONCLUSIONS

Bio-oil production has become an important concern for the treatment of vehicle applications. Therefore, it is of special interest to boost thermal pyrolysis. The bio-oil production from waste plastic is examined in the present work and concluded in this study as below.

1. The pyrolysis reactor must be designed to meet the needs of mixed waste plastics and small and medium-scale development.

2. Waste plastic has a major potential to gain bio-oil and to alleviate environmental issues as a technological solution.

3. The cost of thermal pyrolysis is somewhat low relative to other methods.

4. If bio-oil blending with diesel can be used, the effective cost can be reduced even further.

5. If proper infrastructure and financial support are given, the approach is superior in all respects (ecological and economical).

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work.

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