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Possibility Study of Pyrolysis Oil Produced from Pine Seeds as an Alternative of Fossil Oil and its Comparison with Pyrolysis Oil Produced from other Sources

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Possibility Study of Pyrolysis Oil Produced from Pine Seeds as an Alternative of Fossil Oil and its Comparison with Pyrolysis Oil Produced from other Sources

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Abstract- The conversion of pine seeds into pyrolytic oil by fixed bed reactor has been taken into consideration in this study. A fixed bed pyrolysis system has been designed and fabricated for obtaining liquid fuel from biomass solid wastes. The major components of the system are: fixed bed reactor, liquid condenser and liquid collectors. The reactor is heated by means of a cylindrical biomass source heater. Rice husk, cow dung and charcoal are used as the energy source. The products are oil, char and gas. The aim of the study was to compare the pyrolysis oil with fossil oil and to come up a decision about usage of pyrolysis oil as an alternative to fossil oil. By the experiment it is found that the pyrolysis oil can be used as fossil oil after some treatments.

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I. INTRODUCTION

Biomass has been recognized as a major renewable energy source to supplement declining fossil fuel sources of energy. It is the most popular form of renewable energy and currently biofuel production is becoming very much promising. Transformation of energy into useful and sustainable forms that can fulfill and suit the needs and a requirement of human beings in the best possible way is the common concern of the scientists, engineers and technologists. From the view point of energy transformation, fixed bed pyrolysis is more attractive among various thermo chemical conversion processes because of its simplicity and higher conversion capability of biomass and its solid wastes into liquid product.

In South Asian developing countries, especially in Bangladesh the generation of biomass waste is quite high. Along with other residues these waste accumulated is creating disposal problems. Also direct burning of these wastes creates a serious environmental problem. As carbonaceous solid wastes are the source of energy, therefore, the potential of recovering these

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wastes into useful form of energy by pyrolysis into liquid fuel should be considered. In this way the waste would be more readily useable and environmentally acceptable. This liquid of high heating value can easily be transported, can be burnt directly in the thermal power plant; can easily be injected into the flow of conventional petroleum refinery, can be burnt in a gas turbine or upgraded to obtain light hydrocarbon transport fuel. The solid char can be used for making activated carbon. The gas has high calorific value, sufficient to be used for the total energy requirements of the pyrolysis plant. Recently some work has been carried out with biomass solid waste as feedstock at the Fluid Mechanics Laboratory of Mechanical Engineering Department of Rajshahi University of Engineering & Technology (RUET), Rajshahi, to obtain liquid fuel using fixed bed pyrolysis technology.

II. PYROLYSIS TECHNOLOGY: A BRIEF OVERVIEW

a) Chemical Reaction of Pyrolysis Process

Pyrolysis an attractive method to recycle scrap tires has recently been the subject of renewed interest. Pyrolysis of tires can produce oils, chars, and gases, in addition to the steel cords, all of which have the potential to be recycled. Tire pyrolysis liquids (a mixture of paraffins, olefins and aromatic compounds) have been found to have a high gross calorific value (GCV) of around 41-44 MJ/kg, which would encourage their use as replacements for conventional liquid fuels [1, 2, 3]. In addition to their use as fuels, the liquids have been shown to be a potential source of light aromatics such as benzene, toluene and xylene (BTX), which command a higher market value than the raw oils [4, 5]. Similarly, the liquids have been shown to contain monoterpenes such as limonene [1-methyl-4-(1-methylethenyl)-cyclohexene] [6, 7].

Pyrolytic char may be used as a solid fuel or as a precursor for the manufacture of activated carbon [8, 9]. It was found that another potentially important end use of the pyrolytic carbon black (CBp) may be as an additive for crude bitumen [10]. Some of the previous research group studied the composition of evolved

pyrolysis gas fraction and reported that it contains high concentration of methane, ethane, butadiene and another hydrocarbon gases with a GCV of

approximately 37 MJ/m³, a value sufficient to provide the energy required by the pyrolysis process [11].

Pyrolysis can be presented by the following equation



b) *Selected Biomass Waste*

Pine seeds were selected as the feed material for this study. *Pinus longifolia* in the genus *Swietenia*, is extensively cultivated in India, Sri Lanka, Bangladesh etc as avenue tree. It is a semi evergreen tree, about 30-35m tall. Fruit shape is oval, fruit length is 1 to 3 inches, fruit covering dry or hard, the fruit color is brown.

c) *Reasons for selecting pine seeds as biomass waste*

- A large amount (250000 tons/yr) of pine seeds are not utilized which is grown in Bangladesh
- The production of oil from pine seeds may provide the use of a renewable resource, and at the same time adding value to agricultural products.

Table 1 : Approximate composition of pine seeds [19]

Moisture	5%
Crude Protein	31.6%
Oil	10-12%
Soluble sugar	5.15%
Fat	44.9%
Ash	4.5%

d) *Fixed Bed Pyrolysis System*

Pyrolysis may be either fixed bed pyrolysis or fluidized bed pyrolysis. In fixed bed pyrolysis, a fixed bed pyrolyser is used. The feed material in the reactor is fixed and heated at high temperature. As the feed is fixed in the reaction bed (reactor), it is called fixed bed pyrolysis. In this process, the feed material is fed into the reactor and heat is applied externally. Liquid petroleum or other inert gas is used for making inert condition and for helping the gaseous mixture to dispose of the reactor.

The losses in fixed bed pyrolysis are relatively less than fluidized bed pyrolysis. Moreover, fluidized bed pyrolysis is more complex. This project work is based on fixed bed pyrolysis.

e) *Feed Preparation*

The pine seeds are collected and dried. It is then crushed into smaller sizes. These are <1.18mm, 1.18mm, 2.36mm, and 4.75mm in dia. It is dried with the help of oven. Thus the feed material is prepared.

III. EXPERIMENTAL PROCEDURE

The following procedures are employed for experimental operation:

- Feed material was weighed and filled into the reactor.
- The experimental set-up was assembled.
- High temperature adjustable gaskets were used to seal the joints and fittings of the hot parts of the connecting pipe, reactor and condenser.
- Ice was placed into the condenser.
- The reactor was heated externally by a biomass heater at different temperatures and these temperatures were measured by thermometer.
- The N₂ gas was passed through reactor through a heated pipe and this flow was controlled by the use of a gas flow meter valve.
- The operation time was recorded by means of a stopwatch.
- When the operation was completed a small flow of N₂ gas was allowed to pass through the system to prevent back flow of air which might react with hot gases when the reactor was still hot.
- It is dismantle when the rig was cooled enough to be handled. The char was collected from the reactor bed and weighed. All data are recorded in tabular form.
- All the parts of the system were cleaned and the heating value of the liquid and char was measured by a bomb calorimeter before reassembling for the next run.

IV. EFFECT OF FEED PARTICLE SIZE

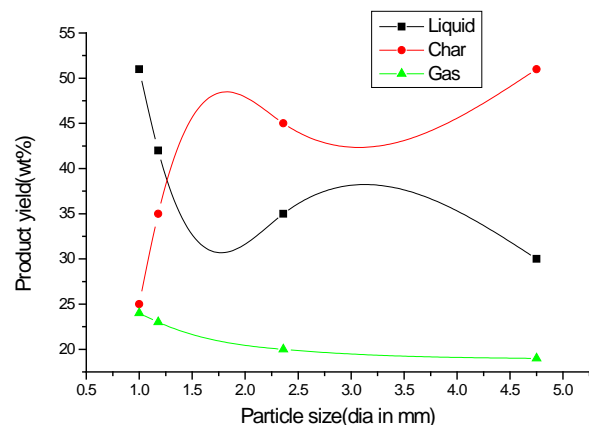


Figure 1 : Effect of feed particle size on product yield (<1.18 mm, 1.18 mm, 2.36 mm and 4.75mm) for reactor temperature 450~550oC

Figure 1 represents the percentage weight of liquid and solid char products for different particle size of feed at a bed temperature of 500oC and an operating time of 90 minutes. It is observed that at 500oC the percentage of liquid collection is a maximum of 51% of total biomass feed for particle size of <1.18 mm .A less amount of liquid is obtained from the larger particle size feed. This may be due to the fact that the larger size particles are not sufficiently heated up so rapidly causing incomplete pyrolysis that reduced liquid product yield.

V. EFFECT OF REACTION TEMPERATURE

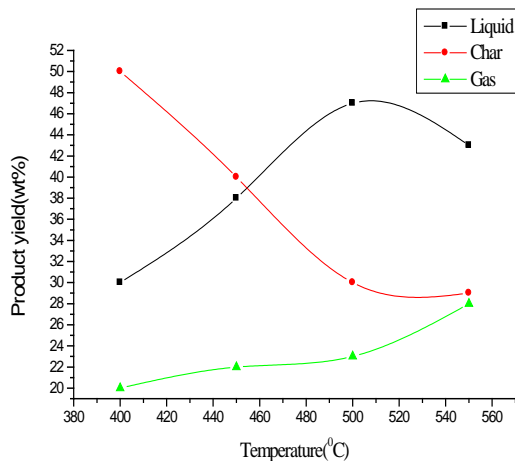


Figure 2 :The effect of operating temperature on product yield

Figure 2 shows the variation of percentage weight of liquid, char and gaseous products at different bed temperature with particle size of < 1.18mm. From this it is found that the maximum liquid products yield is obtained at a temperature of 500oC, and this is 47%wt of total biomass feed. At lower temperature the liquid product yield is decreasing while with the increase of temperature above 5000C, the liquid product yield is again deteriorating. With the increase of temperature the solid char yield is decreasing above 5000C and increasing below 5000C. It may be caused at lower temperature less than 5000C, complete reaction cannot be taken place.

Table 2 :Comparison of pine seeds pyrolysis oil with biomass derived pyrolysis oil

Analysis	Pine Seed oil	Date Seed oil [12]	Waste Paper oil [13]	Sugarcane bagasse oil[14]	Jute stick oil [15]
Kinematic viscosity at 35°C (cSt)	12.15	6.63	2.00	89.34	12.8
Density (kg/m³)	1240	1042.4	1205	1198	1224
Flash Point (°C)	60	126	200	105	> 70
HHV(MJ/kg)	24.22	28.636	13.10	20.072	21.091

VI. EFFECT OF RUNNING TIME

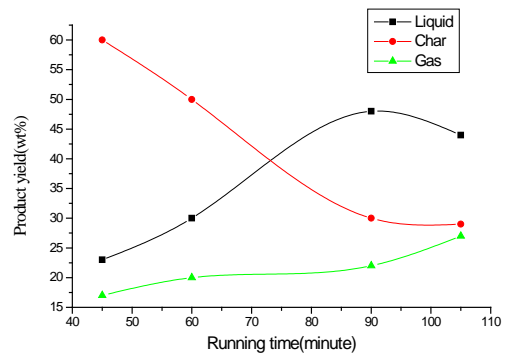


Figure 3 : Effect of running time on product yield for reaction bed temperature 450~5000C and for feed particle size 1.18 mm

Figure 3 shows the variation of product yield (wt %) of liquid, solid char and gas products at a temperature of 5000C for feed particle of size of < 1.18mm. The maximum liquid product is 48 wt% of biomass feed while the solid char product is 30wt% of dry feed at 90 minutes. It is observed that lower and greater running time than of that of 90 minutes the liquid product yield is not optimum that may be due to insufficient pyrolysis reaction and higher rate of gas discharge respectively. Secondary cracking reaction has taken place by which the amount of permanent gas product is increased. So, at temperature higher than 5000C liquid product is decreased.

VII. COMPARISON OF PINE SEEDS OIL WITH PETROLEUM PRODUCTS AND BIOMASS DERIVED PYROLYSIS OIL

The comparison of physical characteristics of pine seeds oil with other biomass derived pyrolysis oil and petroleum products is shown in Tables 3 and 4.

Table 3 : Physical characteristics of the pine seeds pyrolysis oil and its comparison

Analysis	Pine Seed oil	Fast Diesel [16]	Diesel [17]	Heavy Fuel Oil[18]	Wood Waste [17]
Kinematic viscosity at 35°C (cSt)	12.15	1.3-3.3.3 [#]	2.61 [*]	200 [#]	66.99
Density (kg/m ³)	1240	780	827.1 [*]	980 [*]	1180.2
Flash Point (°C)	60	75	53	90-180	59
HHV(MJ/kg)	24.22	45-46	45.18	42-43	19.80

#at 500C *at 200C

From the comparison it is shown that the viscosity of pine seeds oil is favorable than other pyrolysis oils. It has HHV of 24.22 MJ/kg.

VIII. CONCLUSION AND DISCUSSION

The objectives of the study are fulfilled by using the biomass waste in the form of pine seeds with fixed bed pyrolysis system. The fixed bed pyrolysis of solid pine seed has a maximum oil yield of 51wt% of biomass feed particle size of <1.18mm at a reactor bed temperature of 500oC and a gas flow of 5 liter/ minute with the running time of 90 minute. The physical properties analysis showed that the oil is heavy in nature with moderate viscosity. The oil possessed favorable flash point. The heating value of the oil is moderate. From the comparison it is shown that the viscosity of pine seeds oil is favorable than other pyrolysis oils. It has HHV of 24.22 MJ/kg.

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NOMENCLATURE

BTX benzene, toluene and xylene
CB pyrolytic carbon black
GCV gross calorific value
HHV higher heating value

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