Pyrolysis Of Mustard De-Oiled Cake

Anil Kumar, S.K. Gandhi, Sewa Singh

Abstract: A fixed bed pyrolysis has been designed and fabricated for obtaining liquid fuel from mustard de-oiled cake. Thermal pyrolysis of mustard de-oiled cake were carried out in a semi batch reactor made up of stainless steel at temperature range from 450^{0}C to 600^{0}C and at a rate of 150C /min to produce bio-fuel. The maximum yield of oil was 51% on wt. % basis for mustard de-oiled cake, it was obtained at a temperature of 600^{0}C with a less completion time. The fuel analysis of oil reveals that this pyrolytic oil can be used as fuel.

Keywords: Renewable energy; Pyrolysis oil; fixed bed; mustard de-oiled cake.

Introduction

Biomass(agri. waste) is an indigenous, cheap, and above all renewable energy. The increasing availability of bio-mass combined with the recent development of technologies to use it efficiently and with low level of emissions promises to make biomass an increasingly attractive fuel option. Biomass, in contrast to fossil fuels, has a unique potential for making a positive environmental impact. That is, for sustainable biomass production and use, the carbon dioxide (CO_2) emitted would be absorbed by the fresh biomass (***Bridgwater, 2002)***. The different processes such as thermo chemical and bio chemical process are used to convert biomass to fuel (fig.1). Among these processes pyrolysis is one of the suitable thermo chemical conversion processes to get maximum liquid product from biomass. Any type of biomass can give liquid fuel after pyrolysis which can be used as energy fuel and also for production of different chemicals ***(Bridgwaterand Peacocke, 2004)***. In this process the oil produced by the cold pressing of different oil containing seeds is esterifies in presence of different catalyst to get bio diesel. During the process of cold pressing, after extraction of oil from seeds some amount of also remains in the de-oiled cake. So less amount of is extracted, which is again sent for trans-esterification purpose to produce bio fuel. But by the process of pyrolysis maximum liquid yield can be obtained from the seed directly. The yield and composition of pyrolysis products greatly depends on the reaction parameters: temperature, particle size of the fuel, heating rate and residence time (***Onay and Kockar, 2003).*** Here work has been carried out on mustard de-oiled cake to obtain fuel oil by the process of pyrolysis. The physical and chemical properties of pyrolytic oil shows that, the oil has a positive affinity towards the use of oil as transportation purpose

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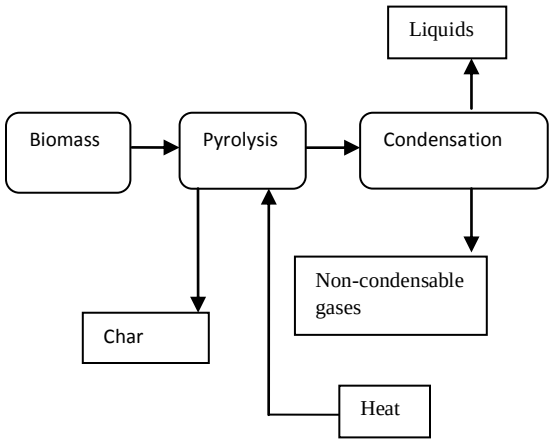

Fig1: Reaction pathway for the pyrolysis of biomass

2. Material

Experiments were carried out on different bio mass samples, mainly on oil containing seeds in order to study and fulfill the objective of the thesis. Mustard de-oiled cake is directly taken from the market. Proximate and ultimate analysis was used to characterize the raw material. The proximate analysis determines the Moisture, volatile matter, Ash, fixed carbon content in the fuel. It is a quick and practical way of assessing the fuels quality and type. The moisture content of biomass has a marked effect on the conversion efficiency and heating value.Volatile matter evolves in the form of gas, light, hydrocarbon and tars. CHNSO analysis (ultimate analysis) is conducted so as to predict the amount of carbon, hydrogen, nitrogen, sulphur and oxygen content in the raw material. Presentation of carbon, hydrogen and oxygen percentage show the resemblance with the hydrocarbon fuels and presentation of nitrogen and sulphur show the exhaust characteristics of the fuel.

3. Experimental setup

The raw material is pyrolyzed in an externally heated stainless steel fixed bed reactor system. The main components of the system are fixed bed reactor and liquid condenser. The reactor is cylindrical shaped vessel made up of stainless steel having capacity of ½ liter. The pyrolysis experiments were performed in an apparatus designed with a batch reactor of height 16.5cm, 4.7 cm ID and OD 5.0 cm. in diameter. The reactor is heated externally by a heater at different temperatures (450, 500, 540, 570 and 600^{0}C) and this temperature is measured by means of a mercury thermometer. Pyrolysis vapor is condensed into liquid in the

condenser and then is collected in the liquid collectors. The non-condensed gas is fed to the atmosphere.

4. Results and discussions

Proximate and ultimate analysis was used to characterize the raw material. The proximate analysis determines the Moisture, volatile matter, Ash, fixed carbon content in the fuel. Higher volatile matter of the biomass makes it more readily de-volatilized than solid fuel. Liberating less fixed carbon hence makes them more useful for pyrolysis and gasification. Ash content and moisture content affect the heating value. The ash content in the bio mass is an integral part of plant structure which consists of a wide range of mineral matter such as salt of calcium, potassium, silica and magnesium. The proximate and ultimate analysis of mustard de-oiled cake are given in Table:1 and Table:2 respectively which shows that the raw materials contains higher percentage of volatile matter and less amount of moisture and ash content and higher weight percentage of oxygen followed by carbon and hydrogen with a fewer amount of sulphur.

Table 1: Proximate analysis of raw materials

Raw materials	Moisture content (%) per kg	olatile matter	ash content (%)	carbon (%)
nustard de-oiled cake	**0.3**	**74.49**	**3.08**	**22.13**

Table 2: CHNSO analysis of mustard de-oiled cake

Carbon %	Hydrogen %	Nitrogen %	Oxygen %	Sulphur %	C/N %	C/H %
42.22	**6.7**	**3.35**	**46.91**	**0.815**	**12.0**	**6.3**

4.1 Product yield

Thermal pyrolysis of mustard de-oiled cake were carried out in a semi batch reactor made up of stainless steel at temperature range from 450^{0}C to 600^{0}C and at a rate of 15^{0}C/min to produce bio-fuel.

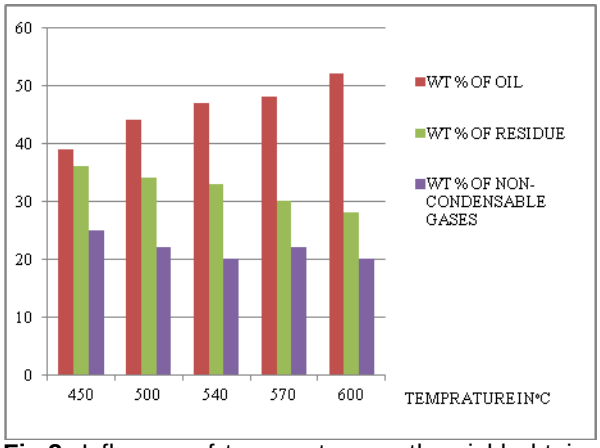

Fig.2: Influence of temperature on the yield obtained from mustard de-oiled cake at different temperatures when heated at the rate of 15^{0}C/Min.

The maximum yield of oil was 51% on wt. % basis for mustard de-oiled cake was obtained at a temperature of 600^{0}C. The effect of the temperature on the production of the char, oil and non-condensable gases from mustard de-oiled cake are shown in fig 2.

4.2 Effect of temperature on the completion time

Table3 shows the time consumed to complete the pyrolysis reaction for the different five temperatures. If we increase the temperature in the reactor the time consumed to complete the process is decreasing.

Table3: Effect of temperature on the completion time

Mustard de-oiled	
Temperature in ^{0}C	**Pyrolysis reaction completion time**
450^{0}C	27 Minutes
500^{0}C	25 Minutes
540^{0}C	22 Minutes
570^{0}C	20 Minutes
600^{0}C	19 Minutes

5. Analysis of the result

The fuel so obtained from the pyrolysis of the biomass is compared with the conventional fuels (liquid as well as solid).

Table 4: Calorific value of pyrolytic char

Pyrolytic char	Calorific value, Kcal/kg
de-oiled cake char	5201.2
Cattle dung	3800
Dry wood	4800

The calorific value of the char obtained from the mustard de-oiled cake is compare with the available common solid fuel. The calorific values of the char are quite good as compared with the available fuel as shown in table 4.

Table 5: Physical properties of pyrolytic oil and diesel

Pyrolytic oil	Mustard de-oiled cake	diesel
Appearance	Dark brown free flowing liquid	Yellowish
Order	Distinctive smoky smell	Aromatic
Calorific value	9467 Kcal/kg	10700 Kcal/kg
Flash point	42^0C	76^0C
Viscosity	14 CST@ 40^0C	2.5 CST
PH value	4.1	---

The comparison of the various necessary properties of the oil obtained from the mustard de-oiled cake and diesel is shown in table 5.

6. Conclusion

Pyrolysis of mustard de-oiled cake were carried out in a semi batch reactor made up of stainless steel at temperature range from 450^0C to 600^0C and at a rate of 15^0C/min to produce bio-fuel. The maximum yield of oil is 51% on wt. % basis for mustard de-oiled cake, was obtained at a temperature of 600^0C with a less completion time. The fuel analysis of oil reveals that these pyrolytic oils can be used as fuel. The liquid as well as solid fuel obtained from this raw material is a low sulphur fuel which is environment friendly in nature that is discussed in the literature also.

7. References

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