Proceedings of the
International Conference on Mechanical Engineering and Renewable Energy 2017
(ICMERE2017) 18 – 20 December, 2017, Chittagong, Bangladesh

ICMERE2017-PI-147

PYROLYSIS OF RICE HUSK BY INFRARED WAVE

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Abstract-*Rice husk is one of the major agriculture wastes that has high potential as carbon and energy sources and has not been utilized well yet. When, the rice husk is burnt, bio-oil is produced. Pyrolysis is one of the methods for bio-oil production from rice husk. In this study, the pyrolysis of rice husk using infrared wave irradiation as a heating source, as an efficient and environmental valorization process was investigated. The effect of operating variables, namely infrared wave power (Watt), and reaction time (min) was studied. The highest yield of bio-oil produced from the rice husk pyrolysis process was about 20%, whereas it is about 60% for charcoal and about 20% for gas at the infrared wave power of 600 W, and 45 min reaction time. The produced bio-oil was analyzed by using Bomb calorimeter and was found that it has the calorific value of 31.7 MJ/Kg which is comparable with the commercial fuels such as diesel, gasoline and methane. The products obtained by pyrolysis technique are useful in many ways and can be suitable alternative to fossil fuels and natural gas.*
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Keywords: Rice husk, Pyrolysis, Bio-oil, Infrared wave.

1.INTRODUCTION

Rice husk is the outer covering of paddy and accounts for 20–25% of its weight. It is removed during rice milling. Lignocellulosic biomass residues have recognized as suitable species capable of high energy outputs to replace conventional fossil fuels. Rice husk is a lignocellulosic biomass which could be a potential alternative renewable and sustainable resource for production of bio-fuel and power generation. Rice husk has identified as one of the most viable renewable energy sources from agricultural biomass residues, because it is abundant, cheap and does not require significant effort to collect.

Pyrolysis differs from other processes like combustion and it usually does not involve reactions with oxygen, water, or any other reagents. In practice, it is not possible to achieve a completely oxygen-free atmosphere. Because some oxygen is present in any pyrolysis system, a small amount of oxidation occurs. Conventional heating methods using tube furnace or fluidized bed reactor used for pyrolysis of biomass; however, these heating methods spent long heating period that results in very low quality products due to secondary reaction [1]. Other disadvantages including more energy required for the heating process, heat transfer resistance and heat losses to the surrounding [2].Infrared wave pyrolysis is a relatively new process.Conventional thermal heating usually employs an external heating source to transfer heat to material through a surface .In contrast, infrared wave heating constitutes a unique way of heating where heating effect arises from the interaction of electromagnetic wave with the dipoles within the material being heated. By such heating mechanisms, heat is generated within the material rather than from an external source, thereby giving a more efficient heating process compared to conventional surface heating respect to even distribution of heat and easier controll over the heating. In addition, high temperatures and heating rates can be obtained through infrared wave heating, and it shows remarkably high convertion efficiency of electrical energy into heat (80%-85%) .

2. METHODS

2.1 Material Preparation

Rice husk of domestically available were used for the preparation of rice husk chips. Firstly, rice husk was carried into the machining process to make the chips. The chips produced from rice husk was of less than 0.05 mm in size in order to make the heating process much easier. The chips were then washed by using water to remove the impurities. After washing, to remove the moisture the chips were dried in the heater. Finally rice husk chips were ready for the pyrolysis. For every experiment, the amount of rice husk chips was weighted by a weight machine to get the accurate result of the experiment.

2.2. Experimental Setup and Procedure

For Infrared wave pyrolysis, rice husk scraps were fed directly into the quartz glass conical flask reactor with known weight, as the fixed bed system was employed. The schematic diagram of the experimental setup is showed in Fig. 1.

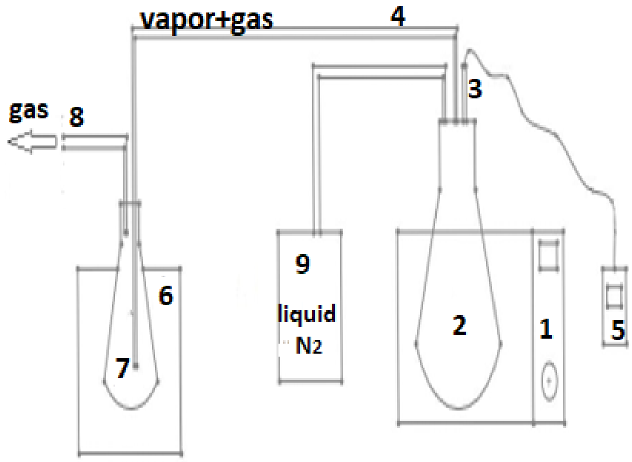

Fig.1: Schematic Diagram of Infrared assisted Pyrolysis System of Rice husk: 1. Infrared cooker (VISION VSN-INF 2083), 2. Quartz Glass Reactor, 3. Thermocouple, 4. Stainless Steel Pipe, 5. Temperature Monitor, 6. Ice Bath, 7. Condenser, 8. Vent Pipe, 9. Liquid N_2 tank.

When the microwave heating was started, the rice husk scraps was begun to pyrolysis after certain temperature elevation. Pyrolysis products (vapors and gases) was passed through the steel pipe to the iced water cooled condenser, where the condensable products was condensed in the bottom of the condenser flask and gaseous product passed throug the exhaust pipe. The temperature of the pyrolysed product was recorded after a certain time interval for several times. Nitrogen gas was used in this study to create the inert atmosphere inside the reactor. Ice cooled water used to condense the vapor in order to maximize the oil yield. The condensed oil was accumulated at the bottom of the condenser flask which was then stored for further analysis.

2.3 Analysis of Pyro-oil

The pyro oil obtained from the pyrolysis was stored for analysis. A digital bomb calorimeter was used for determining the higher calorific value of pyro-oil. A known mass of pyro-oil which was equal to or less than 1 gram was tested in the bomb calorimeter. After recording the temperature rise, the higher calorific value was calculated.

3. RESULT AND DISCUSSION

3.1 Effects of Reaction Time, Infrared Wave Power and Amount of Rice husk

Fig. 2 and Fig. 3 illustrate the effect of operating variables, namely infrared power (Watt) and reaction time (min). As shown Fig. 2, there is a large gap between the solid yield line and the liquid-oil yield line. Production of liquid oil rose with increasing reaction time (15 min to 45 min), however, after 45 min, with the augmentation of reaction time, production of liquid oil decreases. This is probably due to secondary cracking of volatile caused by longer reaction time during the process. The highest bio-oil yield production was about 20% at 45 min. As the highest bio-oil yield was obtained at this reaction time, it was used as a standard (for the experiment/process). 45 minute reaction time was also constant at the time of checking the effect of infrared power (watt). According to fig. 3, the effect of infrared power is similar to the effect of reaction time. Bio-oil yield increased gradually as infrared power was increased from 400 W to 600 W but with further increase of power, bio-oil yield decreased gradually. However, there was a decrease in solid yield as the power increased. Solid yield decreased gradually with the increase of power from 400 W to 600 W and after 600 W, it started to increase moderately up to 800 W. This is because at higher power, primary decomposition of the sample material increased. The highest bio-oil yield obtained was about 22% at 600 W. Thus the infrared power of 600 W and reaction time of 45 min were used for the experiment. Finally, the highest bio-oil yield was produced about 20% and the calorific value of the yield is 31.7 Mj/Kg. In addition, the highest charcoal yield was about 60%.

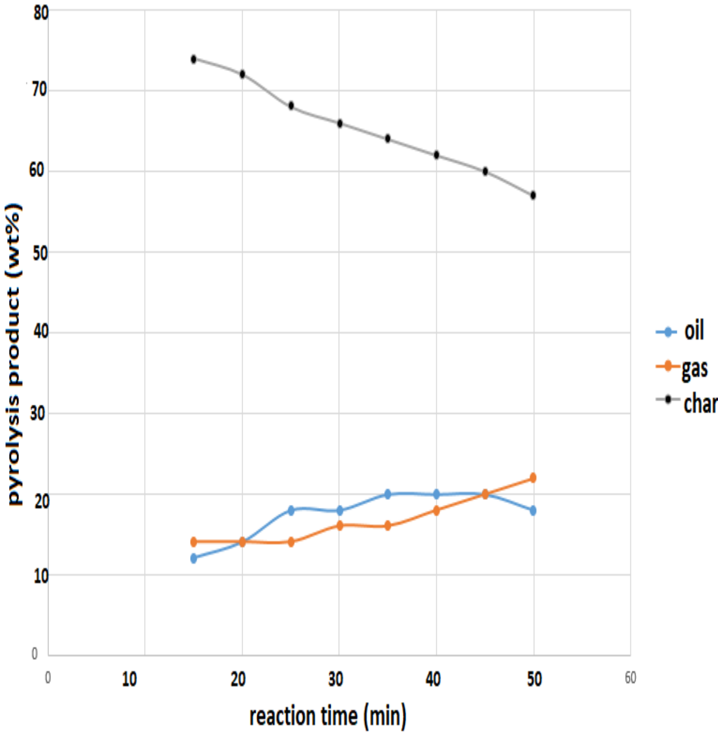

Fig. 2: Pyrolysis product (Wt %) Vs Time

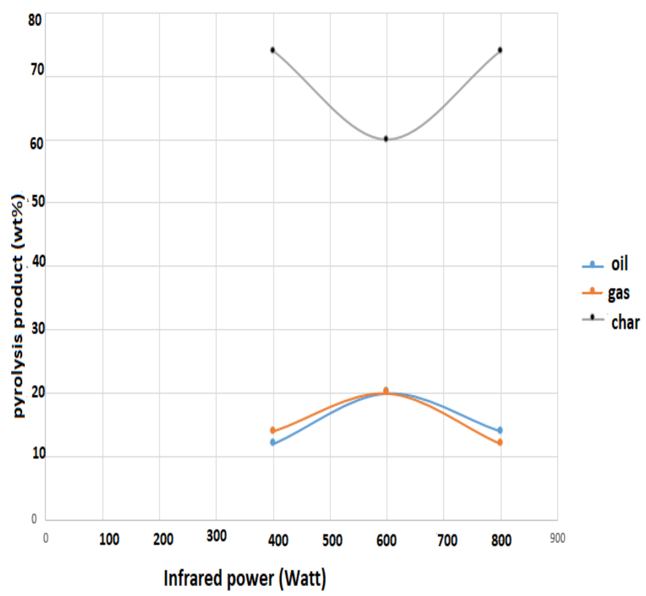

Fig. 3: Pyrolysis product (Wt %) Vs Power (Watt)

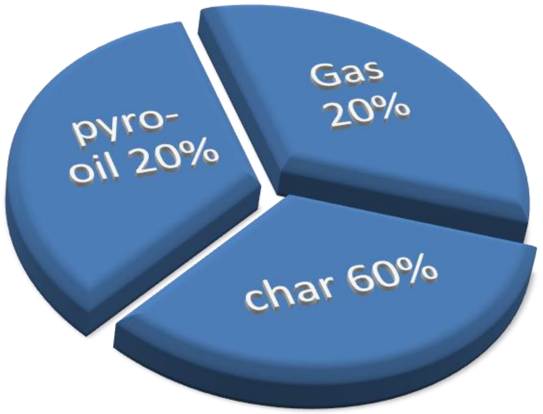

Fig. 4: Percentage of product yield

3.2 Calorific Value of Pyro-oil

The higher calorific value of the oil obtained is 31.7 MJ/Kg which is the highest for fuel substitute and 24.5 MJ/Kg which is highest for charcoal. The calorific value of mostly used fuel is shown in the fig. 5.

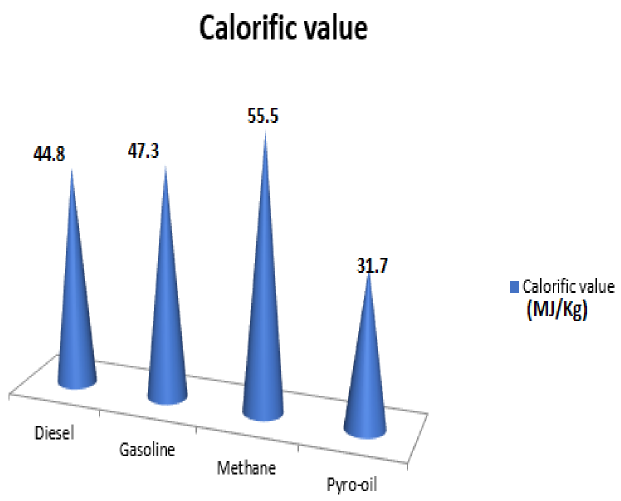

Fig. 5: Calorific value of different fuels

4. CONCLUSION

The infrared-assisted pyrolysis is a process that reduces the production cost whilst increasing the quality of products. This technique is a new pathway that can be enhanced to accelerate the pyrolysis process in comparison to conventional techniques. For the effect of reaction time, the higher the reaction time it will somehow reduce the bio-oil yield due to secondary cracking. The highest bio-oil yield was produced about 20% at microwave power of 600 W, 45 min reaction time, which have calorific value of 31.7 MJ/Kg with consistent flow of nitrogen gas. It is concluded that the infrared-assisted pyrolysis technique can provide selective and rapid heating, is a way to reduce the waste volume and can also be used to treat the waste in situ. In addition, it is a cleaner process in comparison to conventional techniques, which can enhance chemical reactivity, save the required processing energy, and consequently reduce cost.

5. REFERENCES

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