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Increasing Amount of Pyrolysed Oil Using Modification of Reactor and Condenser of Pyrolysis Setup

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ABSTRACT

There is a need to find alternative fuels in order to meet the demand of crude oil and to reduce the rate of environmental pollution. The alternative fuels can be extracted by a process called Pyrolysis. Pyrolysis is a process of extracting oil from the solid wastes like Vellikathan seeds, coconut shell, cashew shell, etc. The extraction process is carried out by heating the waste in a reactor between 100°C to 600°C. In order to withstand this temperature the material of the reactor should have high melting point and should be light in weight. The vapour coming out of the reactor needs to pass through a condenser where it can be converted into liquid. In order to collect more amount of oil the material of the condenser should have high thermal conductivity and high melting point in order to withstand the temperature of the vapour. There is a large amount of vapour which is not converted into liquid due to the low thermal conductivity of the material of the condenser and due to some discrepancies in the condenser. The reactor also takes a more time to convert the solid waste into vapour. This leads to the considerable amount of reduction in the oil collected after the Pyrolysis process. To overcome the above mention difficulties a condenser and reactor whose thermal conductivity is more and melting point is more is selected. Copper is selected over mild steel and stainless steel. Copper has more thermal conductivity than stainless steel and mild steel so more amount of heat will exchange from the from the pyrolysed gas and the condensation of Pyrolysis gas into oil will also be more.

KEY WORDS: pyrolysis reactor, condenser, oil separator, Nitrogen cylinder, pyrolysis oil, charcoal, pyrolysis gas.

1. INTRODUCTION

Pyrolysis is a process of thermal degradation of the solid waste. The Pyrolysis process is an endothermic process. This process takes place in the absence of oxygen. The Pyrolysis is classified into three categories, Slow Pyrolysis, Flash Pyrolysis and Vacuum Pyrolysis. The Slow Pyrolysis is a process in which solid waste is heated slowly between temperatures 300°C to 400°C. The Flash Pyrolysis is also known as Fast Pyrolysis which takes place in less than 2 seconds with in temperature 300°C to 550°C. The vacuum Pyrolysis technique is a combination of slow and flash Pyrolysis, as the solids are heated relatively slowly and the gas is removed from the hot temperature zone very quickly by a vacuum pump.

2. EXPERIMENTAL

Pyrolysis setup used for oil extraction: The reactor is placed on the floor with temperature indicator. The outlet of the reactor is directly connected to the condenser using a stainless steel tube which can withstand high temperature. Another one of inlet is connected to the reactor from the nitrogen cylinder. The condenser is firmly connected with the help of alloy gasket. Counter flow condenser here selected. The flow of water is directed against to the direction of Pyrolysis gases. The condensate drips into the gas liquid separator. The non-condensable gases rise to the neck of other tube and pass through the exhaust tube to gas burner. To measure the temperature outside the reactor the thermocouple is connected to the digital temperature indicator.

Figure.1. Pyrolysis set-up

Using apparatus button set the temperature level. While the specified temperature is attained at the apparatus, it's automatically off the supply to the reactor. When the temperature is tend to reduce, it's automatically gets switched on and power supply were applied. In this Pyrolysis apparatus, chipped material is filled in the reactor initially, and then reactor has closed with the help of bolt. Here gasket was used to prevent leakage. Then supply nitrogen gas from the cylinder to reactor for the time period of 3 to 4 min, after it's closed. Switch on the electrical supply, initially set the temperature up to 600°C in the temperature controller. For condenser water is supplied from inlet to outlet. Gases are collected in the balloon. Finally note the time taken to reach the temperature up to 600°C. Cooling time of the reactor is 11 to 12 hours. Finally we have collected the Pyrolysis oil, char and syngas's. The schematic diagram of the apparatus is shown in above figure.

Various components of the setup:

Reactor body: The reactor is made of stainless steel material, in the shape of rectangle and thickness is 10mm. the top side is closed with the help of nuts and bolts. The one inlet and outlet are made. Inlet used to supply the nitrogen gas and outlet transfers the volatile gases.

Condenser: The condenser is made up of stainless steel and it's connected to the gas liquid separator. The outlet of the reactor is directly connected to the condenser using a stainless steel tube which can withstand high temperature. Another one inlet is connected to reactor from the nitrogen cylinder. The condenser is firmly connected with help of alloy gasket. Counter flow condenser here selected. The flow of water is directed towards the direction of Pyrolysis gases. The condensate drips into the gas liquid separator.

Gas and liquid separator: The gas liquid separator is made up of stainless steel. The condensate drops into gas liquid separator. The non-condensate gases rise to the neck of outer tube and pass through the exhaust tube to gas burner.

Thermocouple and digital temperature indicator: The thermocouple used is a line type (chromal - alunmel) thermocouple which can withstand temperature up to 1200°C. It is inserted outside of the reactor, to measure the temperature outside the reactor the thermocouple is connected to the digital temperature indicator. Using setup button set the temperature level. The setup gets specified temperature means it gets switched off automatically. The thermocouple is connected a digital temperature indicator that can display up to 999°C.

Heater: The heater is a U shaped heating element and is made up of nichrome wire. Only one heater has 3kW heating capacity and 240V supply. The heater is inserted outside of reactor is in the shape of U.

Nitrogen cylinder: Nitrogen cylinder is used to supply the N_2 gases observe in the reactor and also exhaust the oxygen which presents inside the reactor. This gas also acts as a shield of the reactor.

Pictorial view of existing condenser:

a) The condenser is made up of stainless steel.
b) Counter flow is selected i.e. liquid and vapour will flow in opposite directions to each other.
c) Diameter of the inner stainless steel: 20mm
d) Diameter of the outer stainless steel pipe: 50mm
e) Total length: 1000mm

Fig.2. Modified condenser

Pictorial view of existing reactor:

- It is made of up copper.
- Its thermal conductivity is more than existing reactor.
- It can withstand temperature up to 1083°C
- Thickness of copper plate used is 1mm.

Fig.3. Modified Reactor

Table.1.Comparison of oil extraction for different seeds

Reactor model	Seeds	Initial Temp (C)	Final Temp (C)	Oil Collected (ml)
Existing Setup	**Cashew Nut shell**	117	750	500
	Coconut Shell	93	450	174
	Vellikathan seeds	72	450	313
Modified Setup	**Cashew Nut shell**	117	750	550
	Coconut Shell	93	450	200
	Vellikathan seeds	72	450	350

3. RESULTS AND DISCUSSION

Time and temp graph for Cashew Nut shell: The initial temperature for both modified and existing condenser was 200ºC. The time taken to reach 400ºC for modified setup is 96 min whereas for existing setup is 128 min. To reach 600ºC the time taken by the modified setup is 128 min and for the same temperature the existing setup took 160 min.

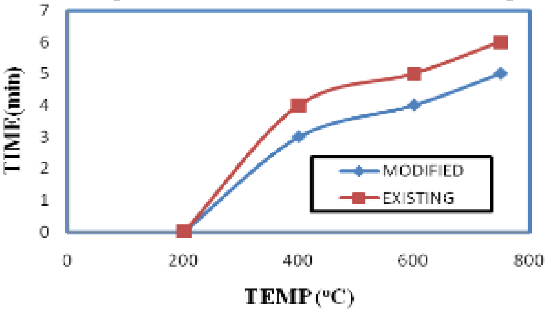

Figure.4. Cashew nut shell pyrolysis oil extraction

In the existing setup the time consumption was 190 min to reach 750ºC and for modified setup it is 160min. Oil extracted is 500 ml from existing setup after modifying the oil obtained is 550ml.

Time and temp graph for Coconut Shell: The initial temperature for both modified and existing condenser was 100ºC. The time taken to reach 220ºC for modified setup is 78 min whereas for existing setup is 87 min. To reach 350ºC the time taken by the modified setup is 109 min and for the same temperature the existing setup took 124 min. In the existing setup the time consumption was 186 min to reach 450ºC and for modified setup it is 180min. Oil extracted is 176 ml from existing setup after modifying the oil obtained is 200ml.

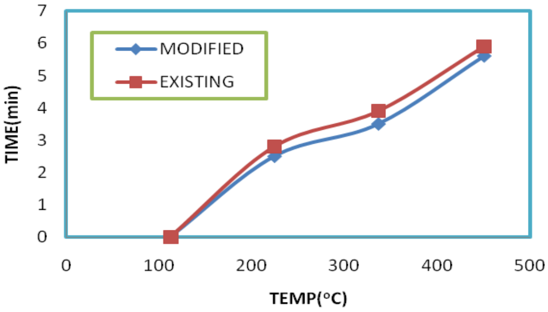

Figure.5. Coconut shell pyrolysis oil extraction

Time and temp graph for Vellikathan seeds: The initial temperature for both modified and existing condenser was 100ºC. The time taken to reach 230ºC for modified setup is 63 min whereas for existing setup is 70 minute reach 350ºC the time taken by the modified setup is 80 min and for the same temperature the existing setup took 100 min. In the existing setup the time consumption was 150 min to reach 470ºC and for modified setup it is 140min.Oil extracted is 313 ml from existing setup after modifying the oil obtained is 350ml.

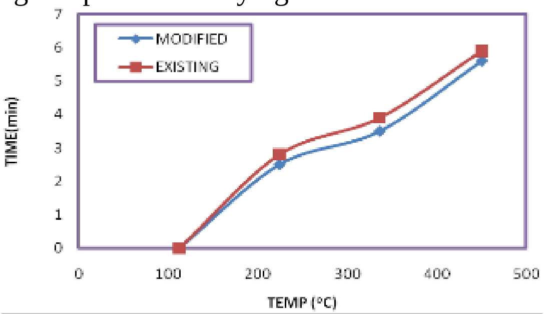

Figure.6. Vellikathan seeds pyrolysis oil extraction

4. CONCLUSION

Copper has more thermal conductivity than stainless steel and mild steel so more amount of heat will exchange from the from the pyrolysed gas and the condensation of Pyrolysis gas into oil will also be more. The modified setup takes less time compared to existing setup. The oil collected is quite more. Cashew nut shell proves to be the best among the three samples. Pyrolysed oil can be the best alternative fuel.

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