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Pyrolysis of Animal Manure

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Abstract - *The massive consumption of fossil fuels and the difficulty of achieving energy and environmental sustainability, a serious search for new and cleaner energy has gained attention in recent years. The front line is moving towards the production of clean, ecologically friendly energy from locally accessible raw resources. In this research, pyrolysis-based conversion of the combined biomass (cow dung) has been studied. It has been modelled how temperature affects the yield and energy content of fuels for energy generation, including bio-oil, char, and biogas. The investigation's findings generally showed that the product output and energy recovery were not considerably impacted by the quantities of the various biomass. The outcome of energy recovery shows a significant influence on temperature, with greatest conversion for char, syngas, and bio-oil. After pyrolysis, a total energy conversion efficiency of was attained.*

Key Words: *Pyrolysis, Animal Manure, Cow-dung, Char.*

1. INTRODUCTION

Animal wastes in the form of manures are produced in large quantities by agricultural activities. Although some of the manure can be used as fertiliser, not all of it can, and the excess is bad for the environment. The use of the manure as a direct or indirect source of fuel for distant power generation is another option. There are several advantages to burning animal manure as fuel:

- Cheaper than electricity, most natural gas, and propane

- Saves on disposal costs

- Decreases the smell and other annoyances brought on by large livestock and poultry operations.

Space heating, steam, and electricity are a few potential uses for the energy from manure concept.

Combustion, gasification, pyrolysis, and anaerobic digestion are the possible conversion processes. Biogas, which is created through anaerobic digestion, has a heating value between 60 and 80 percent that of natural gas. This gas has several uses, including powering refrigeration equipment, boilers, and furnaces. Biogas that has been gasified can have a heating value between 10 and 20 percent that of natural gas. Any gas-fired appliance can use it. Although most fresh manures typically have too much moisture content to burn and must first be dried, direct combustion is another option. For small-scale operations, a direct combustion process can be used to generate space or process heat. If the fuel is burned in a boiler and a steam turbine is used to generate the electricity, large-scale operations can be used to do so.

The use of a staged pyrolysis process to create a medium for remote biomass power generation was examined in the current study. Comparing this method to more traditional ones has a number of benefits:

- Its process throughput is higher than that of anaerobic digestion.

It can be used with poultry litter, an abundant resource, which is not as well suited to digestion due to its high lignocellulosic content. It does not consume large amounts of water that must be treated, as in the case of anaerobic digestion.

- In comparison to traditional gasification processes, it can produce more butane gas.

- It doesn't convert as much of the nitrogen in manure to NOx as direct combustion and is easier to use with small-scale power generation technologies.

Even though there have been a lot of pyrolysis studies on biomass materials, the majority of these have concentrated on plant biomass rather than animal manures and on the creation of liquid fuels, chemicals, or hydrogen rather than fuel gas mixtures (H_2, CO, CH_4). India produces a lot of animal manure from a variety of sources. Farm animal production has gradually shifted in favour of larger units due to the economics of scale. These densely populated animal populations produce large amounts of manure or litter, but frequently lack the capacity to use these materials as plant nutrients locally. Manure actually ceases to be a benefit, as it once was on smaller farms, and instead becomes a liability for the large-scale animal production facility. On larger farm operations, manure management has lost importance, which has resulted in environmental issues like water pollution and odour.

2. MARERIAL AND EXPERIMENTS

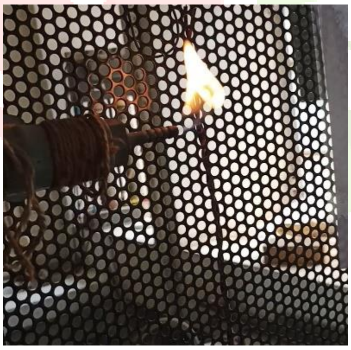
Dried cow dung was employed in this experiment as the pyrolysis's starting ingredient. At Vijay Dairy in Katraj, the excrement was collected, and 3 mm of dried cow dung was screened for usage. The goal preparation temperatures were chosen at 313 K, 323 K, 333 K, 343 K, 353 K, 363 K, and 873 K for the semi-coke preparation treatments.

The semi-coke sample burnt in pure oxygen and produced CO_2, H_2O, N_2, and SO_2 as byproducts. The specimen's C, H, N, and S constituents were identified. Pyrolysis in a He environment was also used to determine the composition of CO and other gases. Using far-infrared heating equipment and an electronic balance, the mass of the semi-coke specimen during the heating process was calculated under certain atmospheric, temporal, and climatic parameters. The specimen's moisture, ash content, and volatile content were then determined.

3. EXPERIMENTAL RESULTS AND DISCUSSION

By contrasting the severe variations of the four factors—gasification temperature, water mass percentage, heating rate, and feed temperature—the best process parameters for the pyrolysis yield were identified.

The gasification temperature and water mass fraction had the greatest impact on the hydrogen yield.



Obtained Gas Flame

1.Effect of gasification temperature on the gasification process of cow dung.

The gasification temperature was the key variable affecting the gasification of cow manure. The gasification process and the increased gaseous output were supported by raising the gasification temperature. Due to the endothermic nature of the in situ gasification of biomass for obtained gas production, intermediate byproducts from the pyrolytic gasification of cow dung, such as volatile compounds, are cracked at higher temperatures and reformed to enhance the quantity of gas.

2. Effect of water mass fraction on the gasification process

The acquired gas yield and moisture mass fraction had a positive correlation; as the moisture mass fraction grew, so did the obtained gas yield. As the moisture mass fraction grew, the pyrolysis process produced more water vapour. The increase in moisture mass fraction is advantageous to the increase in gas yield because the water vapour created reacts with the pyrolysis product carbon at high temperatures to form carbon monoxide and hydrogen whereas carbon monoxide combines with water to produce carbon dioxide and hydrogen.

By-product after pyrolysis (Char)

ANALYSIS OF GASIFICATION

The highly complicated process of gasifying cow dung may be broken down into three broad stages: hot drying and dehydration, high temperature carbon pyrolysis, and hydrogen synthesis by gasifying the pyrolysis byproducts with water vapour. In the in situ gasification of cow dung tests, these three steps take place in order but not independently of one another, and the reactions cross over.

The following are the primary reactions:

$$\text{dry biomass} \rightarrow H_2 + CO_2 + CO + C_nH_m + \text{tar} + \text{char}$$

$$C + H_2O \rightarrow CO + H_2$$

$$C + 2H_2O \rightarrow CO_2 + 2H_2$$

$$C + 2H_2 \rightarrow CH_4$$

$$CH_4 + H_2O \rightarrow CO + 3H_2$$

$$C_nH_m + H_2O \rightarrow CO + H_2 + CO_2$$

$$CO + H_2O \rightarrow CO_2 + H_2$$

The water on the surface of the cow dung evaporates and exists as water vapour when the temperature rises. The pyrolysis process of cow dung starts when the temperature hits 473 K. As the temperature rises, the pyrolysis reaction rate keeps accelerating.

4. SYSTEM ARCHITECTURE:

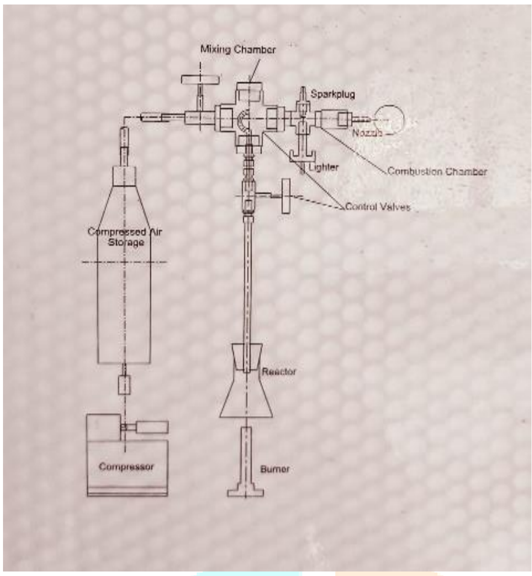


Fig.1 Schematic diagram of Experimental Set-up

5. CONCLUSIONS

In this experiments, two processes—in situ gasification of cow dung and gas production from semi-coke—were examined. The ideal experimental conditions for the in situ gasification of cow dung were established in light of the test. This gives theoretical support and references for the large-scale generation of gas produced from cow manure.

The following are the primary conclusions:

The gasification temperature, water mass fraction, heating rate, and feed temperature are the ideal process parameters for in situ gasification of cow dung.

The semi-coked cow dung preparation's tiny particle size and high temperature promote the gasification reaction, which raises the hydrogen output.

The semi-coking process separates the gasification of water vapour from the pyrolysis of cow manure. This raises the coke concentration in the cow dung and lowers the amount of volatile chemicals that block the gasification reaction. It also enhances the conditions for the secondary cracking and reforming reactions. These factors encourage the gasification of water vapour and increase gas generation.

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