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Co-gasification of municipal solid waste and palm kernel shell in a fluidized bed gasifier

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Abstract - Biomass gasification is an interesting technology in future development of a worldwide sustainable energy system, which can help to decrease our current dependence on fossil fuels. the thermo chemical process known as gasification transforms biomass into producer gas, which is then used for a variety of purposes including the production of heat, power, and hydrocarbons. the thermal breakdown of mixtures of palm kernel shell and municipal solid waste in steam atmospheres was experimentally studied using a fluidized bed gasifier. in this work, a fluidized bed gasifier was used to co-gasify municipal solid waste with a palm kernel shell. the experiments were performed using a fluidized bed gasifier at co-gasification ratios of 0, 20 and 40%. the heating value and yield, hot and cold.

Keywords: Municipal solid waste, palm kernel shell, co-gasification, syngas, fluidized bed gasifier.

I. INTRODUCTION

The Paris Agreement's global action plan calls for reducing emissions in order to keep global warming well below 2°C [1]. Carbon dioxide (82% of the greenhouse gases), methane (10%), nitrous oxide (5%) and fluorinated gases (3%) are the main culprits behind global warming [2]. Carbon dioxide (CO_2) is primarily produced by burning fossil fuels including coal, natural gas, and oil as well as solid waste, trees, and wood products [2]. Hence, using MSW as an energy feedstock and switching from fossil fuels to renewable biomass will dramatically reduce the amount of waste that is disposed of in landfills. According to the World Bank, from the present MSW generation of 1.3 billion tones, with the majority consisting of organic waste, the worldwide MSW generation might reach above 2.2 billion tones in 2025 [3]. According to the EPA, over 258 million tones of MSW were generated in the United States in 2014, of which 136 million tones were disposed of in landfills [4]. Municipal solid waste (MSW) is a significant source of biomass. MSW is often disposed of in landfills, which is an environmentally harmful and unsustainable technique [5]. The thermal treatment approach has drawn increasing amounts of interest since it can convert MSW into useful energy [6]. Because to its high thermal efficiency, MSW gasification is a viable approach for producing syngas [7] and has become a research hotspot. The primary byproduct of MSW gasification is syngas, which is recognized as one of the most environmentally friendly alternative energies [8]. The efficiency of MSW gasification is influenced by a variety of variables, including feedstock characteristics, reactor layouts, and reaction conditions. There have been studies focusing on reaction circumstances including temperature, pressure, heating rate, and catalysts. He et al. [9] looked at how the catalyst and reactor temperature affected the yield and product composition of MSW steam catalytic gasification.

II. RELATED WORK

A. Indian palm kernel Shell

For co-gasification, the palm kernel shell and municipal solid waste are used. The palm kernel shell was shown below in Fig.1.

Fig.1.palm kernel shell

The dust present in biomass was washed with water and dried in sunlight for 4 days and also dried in an oven to remove moisture after it was sieved to 400µm.

B. Municipal solid waste

The municipal solid waste was shown below in Fig.2. The municipal solid waste, are taken for the experiment are collected from a local waste transfer station in Trichy, Tamilnadu. The moisture content of MSW is reduced by air which is dried for 4 days at 24°C.After drying process, the MSW is crushed manually to obtain the feedstock size of less than 2 mm. The ultimate and proximate analysis of municipal solid waste was shown in Table 1.

Fig.2. municipal solid waste

III. THE PROPOSED MECHANISM

The 10KW Bubbling fluidized bed is used for gasification process is shown below in figure.3. The various parts are gasification reactor, biomass feeding system, air supply system and syngas treatment section. The gasification reactor is made up of stainless steel. The wind box is attached at the bottom of the gasification reactor. The electric heater is used to preheat the air and supplied through the perforated plate distributor of 2mm stainless steel. Feeding system consists of hopper and screw feeders. It is located above the sand bed. The biomass is fed into gasifier continuously into the gasification reactor. The silica sand of mass size 0.5mm in diameter is used as bed material. The syngas contains ash and gaseous products. The syngas from gasifier entered into cyclone to remove as and gaseous products. Ash tank is used to collect the ash and unburned chars from cyclone which is attached at the bottom of the cyclone. The syngas from the cyclone entered into the tar sampling and analysis where gas chromatograph is used to analysis the syngas components.

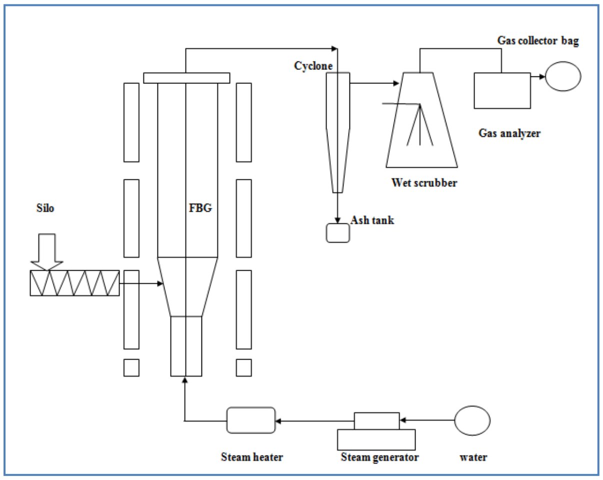

Fig.3.Scheme of the experimental system

IV. PERFORMANCE EVALUATION

The next sections summarize the experimental findings of the co-gasification of MSW and palm kernel shell, including the composition, calorific value, and production of syngas, gasification temperatures, cold and hot gas efficiency, and tar concentration.

A. Gasification temperatures

The gasifying agent, equivalency ratio, reactor type, size, type of biomass feedstock, and biomass properties are the main factors that affect the gasification temperatures, or combustion zone temperatures. Figure 4 displays the gasification temperatures for CGR of 0, 20, and 40. The gasifier reactor's combustion zone recorded the highest gasification temperatures. Figure 4 illustrates how the gasification temperatures ranged from roughly 700 to 900°C, with an average temperature of about 800°C. As can be seen, the temperatures of gasification somewhat decreased when the CGR climbed from 0 to 40%. Given that MSW has a high ash percentage, a rise in the overall ash content of the feedstock at high CGR may be the main cause of the drop in gasifier temperature with increase in CGR.

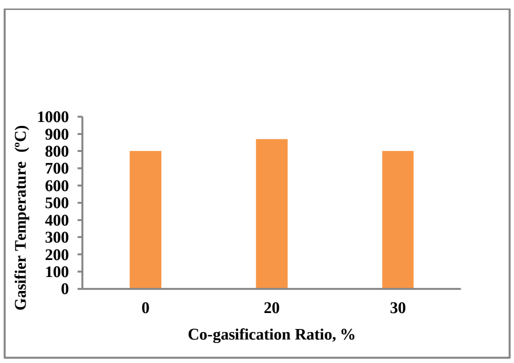

Figure4. Gasification temperatures for CGR of 0, 20 and 40% Compositions and calorific value of syngas

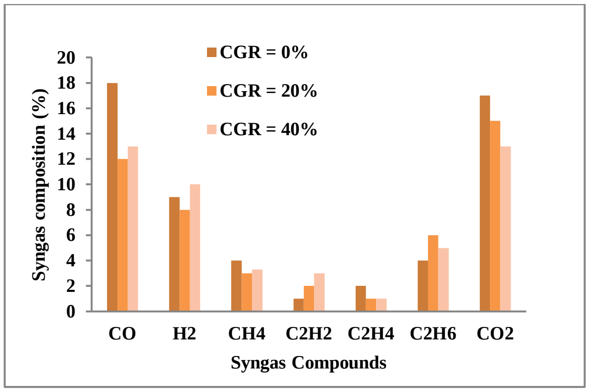

Figure 5. Syngas compositions at CGR of 0, 20 and 40%

Figure 5 reports the syngas compositions at various CGR. With CGRs of 20% to 40%, the carbon monoxide falls from 16.7% at 0% CGR to 12.6% and 14.1%, respectively. The decrease in the carbon content of the feedstock combinations at high CGRs results in a decrease in carbon monoxide. At high CGR, an increase in H` and hydrocarbon molecules counteracts the effects of CGR on CO. The stable gasifier temperatures (800°C) at CGRs of 0, 20, and 40% were principally responsible for the low variance in other important syngas components.

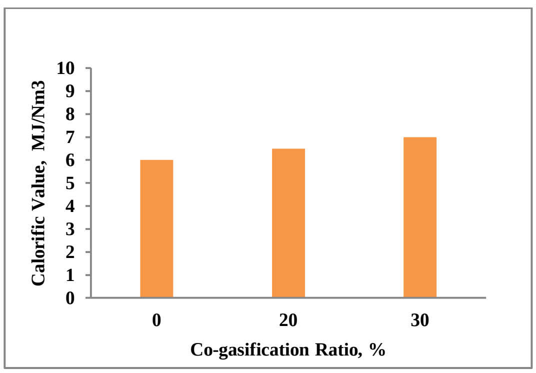

Figure6. Variation of syngas calorific value at various CGR

Together with other significant syngas elements, the increase in hydrocarbons led to a rise in the calorific value of syngas (Figure 6). The heating values of the syngas produced from 0, 20, and 40% CGR were 6.2, 6.5, and 6.7 MJ/Nm3, respectively. As previously mentioned, increasing hydrocarbon content at 20 and 40% CGR causes an increase in the heating value of syngas at higher CGR.

B. Gasification Efficiencies

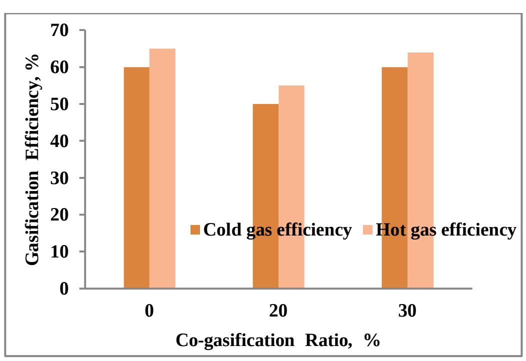

Figure7. Variation of gasification efficiencies at various CGR

The effects of co-gasification on cold and hot gas efficiencies are reported in Figure 7. As shown, the average hot gas efficiencies were 65, 55, and 64% and cold gas efficiencies were 60, 51, and 60% at CGR of 0, 20 and 40%, respectively.

C. **Syngas tar content**

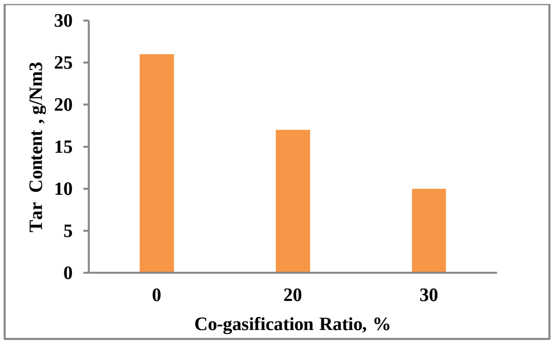

Figure8. Variation of syngas tar content at various CGR

Figure 8 shows the variation in syngas tar content at CGRs of 0, 20, and 40%. As demonstrated, the tar content of syngas significantly decreased from 26.1 to 9.9 g/Nm3 as CGR increased from 0 to 40%. This is because the cellulosic components of the feedstock decreased as CGR increased, and cellulose, hemi cellulose, and lignin are the primary substances responsible for tar generation in biomass gasification.

V. Conclusion

Using a fluidized bed gasifier, a feasibility study for employing MSW as a co-gasification feedstock was conducted.

1. The co-gasification ratios (CGR), or the proportion of MSW in the mixture of MSW and palm kernel shell, were studied for MSW as a feedstock at 0, 20, and 40%. Findings revealed that palm kernel shell gasification, or CGR of 0%, performed as well as CGRs of 20 and 40%.
2. The performance of CGRs of 20 and 40 is consistent with the results of various MSW that have been reported.
3. CO and H2 generation were 12.6 and 14.1%, and 8.6 and 10%, respectively, at CGR of 20 and 40%.
4. The syngas had a calorific value between 6.5 and 7.0 MJ/Nm3, and its hot and cold gas efficiency ranged from 51 to 60%.

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