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COAL BIOMASS-FUEL

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ABSTRACT

This paper reviews the literature on the co-firing of coal with biomass fuels. Brief summaries of the basic concepts involved in the combustion of coal and biomass fuels are presented. Different classes of co-firing methods are identified. Experimental results for a large variety of fuel blends and conditions are presented. Numerical studies are also discussed. Biomass and coal blend combustion is a promising combustion technology; however, significant development work is required before large-scale implementation can be realized. Issues related to the successful implementation of coal biomass blend combustion are identified.

Coal is commonly used as an auxiliary fuel in biomass fired co-generation power stations. The design of the boiler for these stations therefore required detailed knowledge of the properties of the biomass, the coal, and any interaction between the two.

A continuous ash discharge stoker is normally used for this combination of fuels. in assessing an acceptable grate rating for biomass fuel firing. The effective moisture of the biomass is the key parameter required, whereas the great rating for coal is a function of its reactivity.

The GCV of biomass fuels has been calculated using a formula involving their moisture and ash contents. in the case of bagasse. The values of the constants have been sufficiently defined to avoid the need to measure their GCV empirically. To size the flame for biomass fuel firing, the concept of effective moisture has to be introduced to overcome the distraction caused by any variation in ash content.

Keywords: Coal, Biomass Fuel, Bio-Briquette, Co-Firing.

I. INTRODUCTION

Coal is a type of biomass fuel.

Biomass and biofuels made from biomass are alternative energy sources to fossil fuels—coal, petroleum, and natural gas. Burning either fossil fuels or biomass releases carbon dioxide (CO_2), a greenhouse gas.

Globally, India is the fourth largest producer of agrochemicals after the United States, Japan, and China. India accounts for 16% of the world's production of dyestuffs and dye intermediates. The Indian colourants industry has emerged as a key player with a 15% global market share. The country's chemical industry is de-licenced, except for a few hazardous chemicals. India holds a strong position in the export and import of chemicals at a global level and ranks 14th in exports and eighth in imports at the global level.

Coal is a black or brownish-black sedimentary rock that can be burned for fuel or used to generate electricity. It is composed mostly of carbon and hydrocarbons, which contain energy that can be released through combustion (burning).

Burning biomass, however, does not increase the net amount of CO2 in the atmosphere because the amount of CO2 emitted during biomass burning is deemed equal to the amount of CO2 assimilated into the plants during their growth [4]. Thus, co-firing CO2-neutral biomass with coal is a possible means to lessen the global warming effect. Biomass generally had lower sulfur content when compared to coal and the alkaline ash produced at the end of the combustion process was capable of capturing some SO2 produced in the combustion process [5]. Biomass combustion could lead to low NOx emissions due to the higher volatility nature of biomass than coal [6]. Other minor pollutants like volatile organic compounds (VOC), polyaromatic hydrocarbons (PAH) and toxic organic compounds (TOC) could be reduced when coal was co-fired with biomass [7].

In this study, the simplest co-firing option of direct co-firing was considered. The 50% coal-50% biomass blend fuel briquette in this study was named bio-briquette. The 50% biomass had the same ingredients composition as the optimum 60S:40F(p) briquette. The fuel properties, combustion characteristics and carbon dioxide emission from combustion of the two types of briquettes – 60S:40F(p) briquette and bio-briquette were compared in this study.

Coal is often used as an auxiliary fuel in biomass fired co-generation power stations such as those installed in the cane sugar industry. These typically employ 10 to 75 mw turbo-alternators coupled to 75 t/h to 250 t/h boilers. Dual-fuel boilers are typically outfitted with both a continuous and a discharge stock.

II. LITERATURE REVIEW

According to Bassam (2010) and McKendry (2001), "biomass" is defined as "recent organic matter" that originates from the photosynthetic conversion process in plants. It can be derived from a number of sources and ultimately used for several purposes. Sources of biomass can be classified into four main categories: woody plants (forestry wastes), herbaceous grasses aquatic plants, and manures (Bush, 2015). Biomass crops have always been used as a major source of energy for a wide range of purposes, ranging from use as chemical feedstock to the production of electrical or heat energy (McKendry, 2001). For each function for which the crop is to be used, the properties differ. However, ideal energy crops are those that have more or less the following general characteristics, according to McKendry 2001):

- high yield of biomass
- A composition with a low percentage of contaminants
- Low energy input and, hence, low cost of production
- Low requirements in terms of additional nutrients

Therefore, when choosing a crop for use in bioenergy production, it is important to carry out tests to determine the extent to which the crop meets the characteristics above and can this be considered suitable for its purpose. In line with this, it is important to clearly figure out the bioconversion technique that is to be used and the final product desired.

Biomass and coal related to the gasification process are useful for understanding and predicting the gasification process. In this section, the relevant coal and biomass properties are presented and discussed.

first steps in evaluating the feedstock, solid fuels. Proximate analysis gives the fuel characteristics in terms of mass percentage of moisture, volatile matters, fixed carbon, and ash content in the solid fuel. It is performed by heating the raw material to a set temperature, and in the case of coal or biomass, the solid fuel decomposition takes place at this temperature to generate volatile gas substances. The moisture content is the number of water molecules that physio-chemically bond to the solid fuel material; however, for coal or biomass, the moisture content can be removed by heating without any chemical reactions occurring. The volatile materials that are released from coal or biomass decomposition reactions contain a series of gaseous molecules of hydrogen, carbon monoxide, carbon dioxide, and other hydrocarbons. Temperature and heating rate influence the rate of decomposition and the composition of the released gas. The decomposition reactions are also known as pyrolysis or devolatilization. The remaining solid from the devolatilization of the solid fuel (biomass or coal) is called char, which consists of fixed carbon and ash. The ash content is defined as the mass percentage of solids remaining in the char after complete combustion. The proximate analysis results for selected biomass and coals are listed in the table below:

- Data from typical proximate analyses of selected biomass and coals (wet base).
- Coal: the fundamental chemical classification of coal is based on the organic matter defined by standard proximate analysis (fixed carbon, volatile matter, moisture, and ash).
- Contents), ultimate chemical analysis (carbon, hydrogen, oxygen, nitrogen, and sulphur contents), and maceral contents. The abundance of fixed carbon classifies the rank of the coal, whereas the amount of ash in the coal defines its type (liu et al., 2005). Minerals are subdivided into inertinite, vitrinite, and liptinite.
- The inability of pulverised coal to ignite and completely burn in boilers is primarily attributed to the coal constituents (cloche et al., 2002). Maceral maturity can be estimated by vitrinite reflectance. The reactivity of vitrinite varies with its reflectance, and the inertinite content is considered a poor combustor, depending upon the
- Geological origin of the coal. Southern hemisphere coals are more likely to contain a large quantity of inertinite with a lower reflectance than northern hemisphere coals. Cloche and colleagues (1999) discovered a

link between coal combustion behaviour and total reflectance, but not with maceral composition. Inorganic matter contains various mineral classes (van alphen, 2005):

- Silicates: quartz, kaolinite, elite, chlorite, muscovite, montmorillonite, feldspars, etc.;
- Siderite (feco3), ferrous carbonate iron, calcite (caco3), calcium carbonate, and dolomite (caco3. X mgco3), calcium magnesium carbonate, are examples of carbonates.
- And ankerite (caco3, x mgco3, y feco3);
- Pyrite (fes2);
- Apatite

III. RESEARCH METHODOLOGY

1. Sampling design: secondary data
2. Sampling Technique: Many market research websites exist, as do blogs and other data analysis websites.
3. The following tools were used in the report rate: official websites.

The oil palm mill residues were taken from an oil palm mill in Bota, Perak whereas the coal was obtained from TNB Janamanjung, Perak. The briquetting process started with raw materials drying, then pulverizing of raw materials and powder in the range of 63 μm – 500 μm would be accepted for the following step of powder compaction. The powder densification was done using a hydraulic press and took place in an available 40 mm-diameter steel die with a load of 200 kN or 159 MPa [8,9] pressure. In order to get a 10 g 60S:40F(p) fuel briquette, 5.4 g PKS, 3.6 g PF and 1 g of waste paper were compacted whereas for bio-briquette, 2.7 g PKS, 1.8 g PF, 0.5 g waste paper and 5 g coal were compressed. In this study, the two briquettes, 60S:40F(p) briquette and bio-briquette had 40 mm-diameter and around 7 mm height, as shown in Fig. 1(a)-(b) repectively. Both types of briquette were left in ambient condition for 1 week upon removal from the die set and before any experiments [8,10]. The fuel properties tests that were vital for fuel characterization are calorific value determination, proximate and ultimate analyses. The combustion tests were done in a combustion chamber, where briquettes were burned in the chamber surrounded by water jacket connected to a thermocouple that showed water temperature. The combustion chamber is shown in Fig. 2. In all the properties tests, the arithmetic average result of three samples was taken. For calorific value determination, a bomb calorimeter (LECO AC-350) was used to obtain the high heating value (HHV) of the briquettes. The values for coal in ASTM E1131-98 Standard Test Method for Computational Analysis by Thermogravimetry were adhered to in proximate analysis for all the briquette materials in this study. The ultimate analysis was done using LECO CHNS 932 test equipment and before any analysis, it was calibrated with 51.78% carbon, 5.07% hydrogen, 20.13% nitrogen and 11.52% sulfur.

IV. DATA ANALYSIS AND INTERPRETATION

Calorific values, proximate and ultimate analyses of 60S:40F (p) briquette and bio-briquette The coal used as raw materials for bio-briquette had average calorific value of 23.03 kJ/g. The average HHV of bio-briquette was 22.66 kJ/g, which was higher than 18.63 kJ/g shown by 60S:40F(p) briquette. For each gram of fuel material, the bio-briquette was able to provide 4.03 kJ more energy than 60S:40F(p) briquette. The addition of coal with greater calorific value had increased the HHV of the fuel briquette, proven by the replacement of half the ingredients of the optimum biomass fuel briquette. On dry basis, the proximate analysis of 60S:40F (p) briquette showed higher volatile matter (VM) content and lower fixed carbon (FC) content when compared with bio-briquette. 60S:40F (p) briquette had 12.83 wt% more VM and 16.05 wt% less FC as compared to bio-briquette. The nature of higher VM of biomass than coal could probably reduce NOx emissions during combustion application [6]. Taking analogy to coal, as the coal rank gets higher, the heating value and FC content of coal increased and volatile matter in coal decreased. Comparing the 60S:40F(p) briquette and bio-briquette, the HHV of bio-briquette was higher than that of 60S:40F(p) briquette since the FC content of bio-briquette almost double the FC content of 60S:40F(p) briquette. The comparison of VM and FC contents for 60S:40F(p) briquette and bio-briquette is shown in Table 1. (a) (b) Advanced Materials Research Vol. 683 247 The ultimate analysis result is shown in Table 2. The carbon element in bio-briquette was 52.96 wt%, higher than that of 60S:40F(p) briquette. Similar to coal, as coal rank got higher, the calorific value and carbon content increased. The sulfur content of 60S:40F(p) briquette was only 0.11 wt%, a value which was lower than that of bio-briquette. Studies had found that when biomass was combusted, the SO2 emission usually decreased proportionally to the biomass thermal load since biomass generally had less sulfur content when compared with coal [4]. Table 1: VM and FC contents of two briquettes Table 2: Ultimate analysis of two briquettes Components [wt%] 60S:40F(p) briquette Biobriquette Volatile Matter 75.28 62.45 Fixed Carbon 17.68 33.73 Components [wt%] 60S:40F (p) briquette Biobriquette Carbon 45.70 52.96 Hydrogen 6.23 4.80 Nitrogen 0.81 0.89 Sulfur 0.11 0.18 Combustion of 60S:40F (p) briquette and bio-briquette The combustion chamber was used to simulate and compare the actual burning of the two types of fuel briquettes. Assuming an ideal case in which energy absorbed by water was equal to the energy released by briquettes burning, the energy released and the rate of energy released by briquettes combustion could be calculated. It was assumed that the energy provided by combusting ten fuel briquettes were all absorbed by water in the water jacket surrounding the combustion chamber. The water temperature could be tracked by the thermocouple connected to the water jacket and calculations could be done. A typical result obtained from the combustion test is illustrated in Fig. 3. When energy released from briquettes burning was absorbed by water, the water temperature increase from initial water temperature (Tinitial) to a steady state temperature (Tmaximum) which happened during steady state combustion of briquettes. The time taken to reach the steady state (tmaximum) was noted so that the rate of energy absorption could be calculated. Combustion test showed that bio-briquettes burning released more energy than combusting 60S:40F(p) briquettes. Combustion of ten bio-briquettes released 605.83 kJ energy, 204.98 kJ more compared to the 400.85 kJ released by burning ten 60S:40F(p) briquettes. The result of rate of energy absorption showed that bio-briquette was superior to 60S:40F(p) briquette. The rate of energy absorption when 60S:40F (p) briquettes were burned was only 0.1591 kJ/s, which was 0.0212 kJ/s less than 0.1803 kJ/s when bio-briquettes were combusted. Analyzing emitted gas components from 60S:40F (p) briquette and bio-briquette combustion The gases emitted from burning 60S:40F(p) briquette and bio-briquette were compared using a gas analyzer. The results from the gas analyzer as shown in Fig. 4, showed that CO2 emission from burning 60S:40F(p) briquette was 10.23% less than CO2 emission from bio-briquette combustion. The lower CO2 emission from 60S:40F (p) briquette combustion was because it was pure biomass but bio-briquette had coal as half its ingredients. It was also found that combustion of 60S:40F (p) briquette emitted 28.26% less NOx than combustion of bio-briquette. This showed that combustion of higher volatility pure biomass like 60S:40F(p) fuel briquette had led to lower NOx emission. This made the conversion of organically bound nitrogen in the fuel more easily controlled by the air-staged low-NOx combustion systems that were common in most boiler systems [6]. Combustion of 60S:40F (p) briquettes had managed to reduce CO2 and NOx emissions compared to bio-briquette combustion. However, the HHV of 60S:40F(p) briquette was 17.79% less than that of bio-briquette. The choice of using either 60S:40F(p) fuel briquettes or bio-briquettes as boiler fuel needed to be justified with further studies. For instance, whether or not the fuel chosen for combustion could reach the targeted temperature of boiler furnace and the ash quality yielded from combustion were important to be studied before deciding to use which of the two briquettes. 248 Advanced Materials and Engineering Materials II.

Natural gas contributed the second-largest share of the increase in energy consumption, accounting for 36% of the increase. Consumption came from coal (27%), natural gas (24%), hydropower (6%), renewables (5%), and nuclear power (4%). However, as an overall share of energy consumption, oil remained on top with 33% of all energy consumption. Cumulatively, fossil fuels — shown below in shades of grey —accounted for 84% of primary energy consumption.

V. FINDINGS

According to the study, the majority of fossil fuels are consumed. the majority of the gases in which the coal particles are found. The energy sector, in the scenario, faces a major challenge in providing energy at an affordable cost while also protecting the environment. The energy mix is primarily dominated by fossil fuels, with coal being the major contributor. The use of coal in conjunction with biomass as a supplementary fuel in combustion or gasification-based processes is a viable technological option for reducing harmful emissions. Today, power generation is dominated by fossil fuels, and the majority of power is consumed by the urban and industrial sectors. The rural area has to be electrified properly, so biomass power generation is the best way, as it has a renewable source of energy and the raw material for running the plant is abundant in nature.

VI. CONCLUSION

Generally, the 60S:40F(p) briquette showed lower fixed carbon and bio-briquette had higher calorific value than 60S:40F(p) briquette of pure biomass ingredients. This study showed that both 60S:40F(p) briquette and bio-briquette as fuel managed to reduce CO2 emission compared to coal during their combustions, with 60S:40F (p) briquette better than bio-briquette. Partial substitution of coal with biomass as fuel had proven to reduce CO2 emission. However, if the fuel consists of 50% biomass and 50% coal like the bio-briquette, higher calorific value and rate of energy released were shown. This study could be further extended to real application in power plants to check if 60S:40F(p) briquettes or bio-briquettes could replace or blend with existing coal as fuel. Nevertheless, other issues like ash quality has to be studied when combusting 60S:40F(p) briquettes or bio-briquette, instead of coal. The present study results are based on data analysis of the coal biomass. According to the According to the findings of the analysis, it is extremely difficult to provide energy at an affordable cost and without harming the environment.

Harming the environment.

Coal preparation is a highly developed, commercially available technology that is widely used in the coal industry but that offers only limited opportunities for R&D to significantly lower the cost of advanced coal preparation processes. Continued research with extensive industry participation should achieve further improvements in existing and emerging technologies. Liquid transportation fuels from coal and biomass have the potential to supply 2-3 mbpd of petroleum-equivalent fuels with significantly reduced CO2 emissions by 2035. And this plays an important role in addressing issues of energy security, supply diversification, and CO2 emissions. But their commercial deployment by 2020 will require aggressive large-scale demonstrations in the next few years. Investor confidence will most likely require a carbon price or fuel mandates that specify reductions in greenhouse gas emissions.

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