ATLANTIS PRESS
Advances in Engineering Research, volume 208
Proceedings of the International Conference on Innovation in Science and Technology (ICIST 2020)

TGA and DSC Analysis Biomass and Coal as Co-Firing Solid Fuel

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***Abstract*—Indonesia has an energy mix target of 23% until 2025 in coal-fired power generation, a mixture of coal with biomass. The compound needs to be analyzed first to determine the combustion characteristics. This paper describes the characteristics of combustion of coal and sawdust (90%: 10%). In the TGA and DSC analysis, a blend of coal and sawdust 10%, C10, Tig C10 shows the highest value of 255.5 °C, linked to 100% coal with 294.6 °C, and 100% sawdust 247.9 °C. Furthermore, the peak area in the heat flow, C10, has the highest 7974.94 °C related to coal and sawdust. Besides such, the point reaction C10 at 383.1 °C has the highest value. Despite, the Tbo in C10 is the lowest associated with coal and sawdust, 581.5 °C, 632.6 °C, 775.4 ° C., While the Tmax C10 is at 409.7 °C between Tmax coal and T max sawdust. From the results of the Proximate and ultimate analysis, C10 reveals H: 4.59%, C: 59.3%, ash: 5.8%, Volatile matter 43.13%. This paper's analysis results show that the characteristics of C10 (90% coal and 10% sawdust) have an identical value with coal.**

***Keywords*—TGA and DSC analysis, biomass, and coal, co-firing solid fuel, alternative biomass**

I. INTRODUCTION

The energy parameter in Indonesia dominates the production of coal-fired electricity [1]. The projected power generation capacity will reach 56 GW by 2027, 48 percent of which insistence be generated by coal-fired power [2]. In addition, Indonesia plans to arrange the 23% renewable energy mix goal of RUEN by 2025 by designing roadmaps concerning each technology [3]. At this time, several coal-fired power generations have already blended coal with biomass, with a 5% percent biomass. In order to decide the form of combined combustion characteristics of biomass and coal as a fuel for co-firing power generation, the parameters are essential.

The biomass-coal combustion qualities are estimated employing a thermogravimetric analyser (TGA) and differential scanning calorimetry (DSC). The actual combustion temperature, the final reactivity-related temperature, the temperature of coal combustion, and the maximum combustion rate can be seen (Rmax) [4,5]. This study will also pursue the profile of coal combustion and its volatile profile, which is the variation/decomposition of volatile matter critical for solid fuels' thermal decomposition. With TGA and DSC, mass and thermal variations from coal and Biomass combustion to burnout can be studied [6,7]. The resulting results can represent the random process of coal combustion and the time of occurrence.

This paper demonstrates TGA and DSC coal and C10, embracing biomass with a sawdust mixing of 10% and 90% of coal. The sequence depicts the variations in the properties of the proximate and ultimate analysis. Additionally, temperature conditions and heat flux differences influence the time function between C10 (combining sawdust and coal) and the primary coal.

II. Experimental

A. Sample

The coal sample was obtained after sampling and checked for ASTM, and then it was primed for mixing with the Sawdust sample. As already stated, for the next TGA test parameter, the mixture between the sawdust and the coal is 10% sawdust and 90% coal with 200 mesh samples. Besides, the Proximate and ultimate analysis of the combination of sawdust and coal can be seen in table 1, from that table it can be seen the comparison between Coal, Sawdust and C10 (10% sawdust and 90% coal). Furthermore, the coal sample was obtained after sampling and checked for ASTM, and then it was primed for mixing with the Sawdust sample. As already stated, for the next TGA test parameter, the mixture between the sawdust and the coal is 10% sawdust and 90% coal with 200 mesh samples.

TABLE I. Proximate and Ultimate Analyses

			Coal	Sawdust	C10
Total Moisture	%	ar	24.13	5.16	22.23
Moisture in the analysis sample	%	adb	11.53	5.01	10.88
Ash content	%	adb	6.00	4.72	5.87
Volatile matter	%	adb	39.53	75.59	43.14
Fixed carbon by difference	%	adb	42.94	14.68	40.11
Total sulphur	%	adb	0.55	0.06	0.50
Gross calorific value	kcal/kg	adb	5,872.00	4,376.00	5,722.40
Gross calorific value	kcal/kg	ar	5,040.00	4,369.00	4,972.90
Gross calorific value	kcal/kg	db	6,638.00	4,607.00	6,434.90
Hardgrove grindability index	Index		42.00		
Carbon	%	adb	60.82	45.78	59.32
Hydrogen	%	adb	4.47	5.75	4.60
Nitrogen	%	adb	1.08	0.20	0.99
Oxygen by difference	%	adb	27.09	38.48	28.23

The Proximate and ultimate analysis of the combination of sawdust and coal can be seen in Table 1. The comparison between Coal, Sawdust and C10 (10% sawdust and 90% coal) can be seen from Table 1. Table 1 reveals no significant difference between coal and C10. The first is that the caloric importance of coal and C10 is not any different where coal is also high. C10 is lower in sulfur than coal. However, hydrogen C10 is larger than coal.

B. Pyrolysis Experiments

Analysis TGA-DSC for five samples using LINSEIS High-Pressure STA (Simultaneous Thermal Analysis) and TG-DTA/DSC (thermogravimetry/differential thermal analysis/differential scanning calorimetry) provides pieces of information about the material composition under the influence of temperature and very high pressure also as a function of temperature or time in a controlled atmosphere [8]. The initial time derivatives, particularly dTG/dt and the dDSC/dt, are recorded by TGA and DSC wherever relative mass loss, mass loss rates, relative heat flow and heat flow are monitored by temperature, the combustion properties are well examined for different solid materials by these methods.

The test results are from Tig, where Tmax is the peak temperature of combustion, at which the carbon fuel is used to intersect the steep weight loss curve (TGA) from the starting line. At the same time, Tbo is the ultimately highest temperature (DSC) while TB is the last heat flow temperature with zero (dDSC) the final Rmax (mg/s) (dDTG). Furthermore, the coal was pyrolyzed in situ after cooling to a flow rate of 10 °C/min to 50 ° C with the same temperature reduction requirements to generate the coal in DSC / TGA.

III. Results and Discussion

A. Analyse DSC/TGA

Each sample decreased at the beginning of heating, and the TGA graph means that the coal moisture content is high enough to allow the mass of the coal to drop rapidly. The initial temperature of combustion (Tig) indicates the temperature value when coal begins to burn and releases flying matter. In contrast, Tmax exhibits the reactivity of coal to low-temperature oxidation which causes self-burning. The lower the Tmax value's impact, the higher the reactivity of coal, the higher the propensity to self-combustion than that of higher Tmax coal.

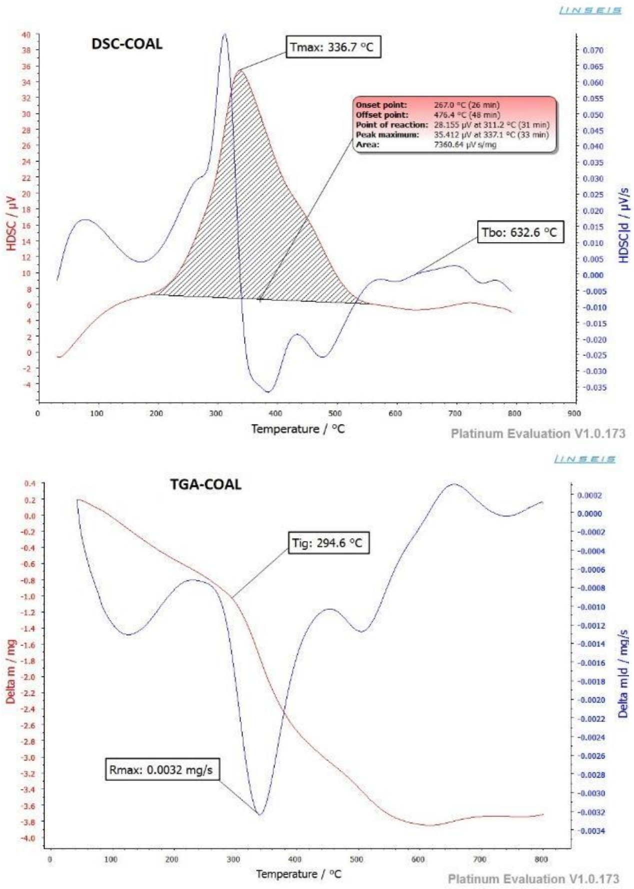

Fig. 1. Coal analyse DSC/TGA.

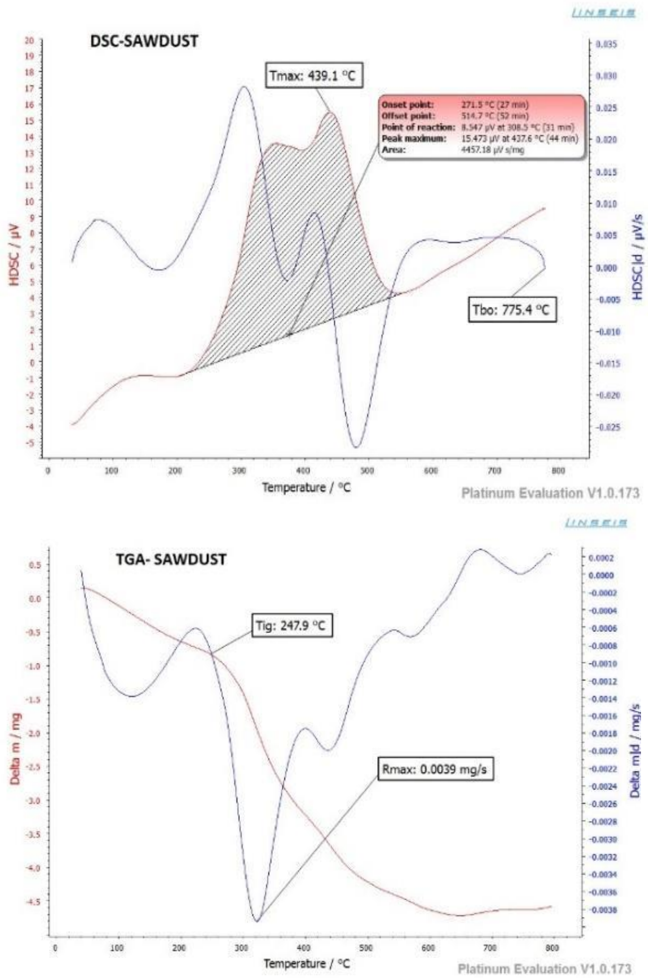

Fig. 2. Sawdust analyse DSC/TGA.

First, this paper will compare the results of DSC / TGA Coal, sawdust, and C10 (10% sawdust and 90% coal). Figure 1 presents the DSC / TGA analysis results on coal, and it can be seen that the Tmax is 336.7 ºC, Tbo 632.6 ºC, the maximum coal heat flow is 35,412 µV with an area of 7360.64 µV s / mg. Figure 1 shows that the Tig in coal is 294.6 ºC, and the Rmax is 0.0032 mg/s. Figure 2 describes the DSC / TGA sawdust analysis, which will later be used as a blender with coal. The picture below shows that the Tmax of sawdust is 439.1 ºC with a Tbo of 775.4 ºC, the DSC analysis shows that the maximum peak of sawdust is 15.473 µV with an area of 4457.18 µV s / mg.

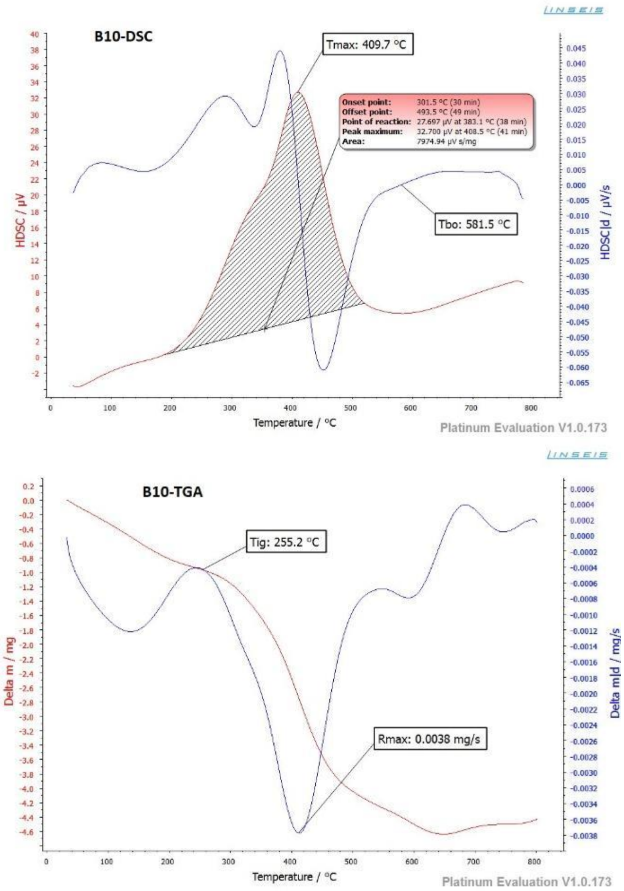

Fig. 3. C10 (10% sawdust, 90% coal) analyse DSC/TGA.

Figure 3 presents the DSC/TGA analysis at C10 where 10% sawdust and 90% coal, Tmax at C10 is 409.7 ºC and Tbo: 581.5 ºC, the maximum peak shows 32.7 µV with an area of 7974 µV s / mg. while Tig C10 shows 255.2 ºC and Rmax of 0.0038 mg/s. Figure 1 and Figure 3, analyse coal and coal, whether there is a variety of equivalent fitter for deciding solid-fuel combustion before entering the boiler power generation.

B. Comparison of Each Sample

From the DSC / TGA coal analysis, sawdust and C10 (10% sawdust and 90% coal) can recognize the changes in coal characteristics before mixing with sawdust. Table 2 is the difference in DSC / TGA analysis on the three samples after being integrated as a reference for combustion characteristics, which reveals that the difference between Coal and C10 is not much different.

TABLE II. COMPARISON SAMPLES

	Tig ºC	**Rmax (mg/s)**	**Tmax ºC**	**Tbo ºC**	**Peak area µV s/mg**	**Point of reaction (ºC)**
Coal	294,6	0,0032	336,7	632,6	7360,64	311,2
C10	255,2	0,0038	409,7	581,5	7974,94	383,1
Sawdust	247,9	0,0039	439,1	775,4	4457,18	308,5

Tig on coal shows that it is higher than C10 then sawdust, it means sawdust is easier to ignite and burn than C10 then coal. Rmax coal has the smallest mg / s and the highest is sawdust, it means that sawdust and C10 is easier to burn than coal. As Tmax, sawdust had the highest value and coal had the lowest value, it shows that coal is more reactive than C10 and sawdust. For Tbo, sawdust had the highest value and C10 the lowest. From the interval temperature (Tbo-Tig), sawdust has the biggest interval value with 527.5 ºC while C10 has lowest with 326.3 ºC and coal with 338.0 ºC, it shows that C10 is faster to burn out. It can be seen in Table 2 that the comparison between coal and C10 seems not to have a marked preference.

IV. CONCLUSIONS

The proximate and ultimate analysis results determined that there was no significant difference between C10 (sawdust 10% and coal 90%) and Coal, while the DSC / TGA results also explained that the burning characteristics of sawdust 10% mixtures with Coal 90% were not much different from burning attributes of 100% Coal so that it can be concluded that 10% sawdust and 90% coal is perfect for power generation fuel. Future research will increase the percentage of sawdust and could combining another biomass as an alternative.

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