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Investigation of Proximate Analysis of Coal and Coconut Shell

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Abstract: The power generation in Malaysia has grown so widely and they are dependance towards fossil fuel sources has invited harmful effects to the nature. This research is done to investigate the proximate analysis of coal and CSP via ASTM testing and their efficiency to generate power. In this experiment, coal and coconut shell are grounded into particles by a ball mill and went through ASTM E871, E872 and D1102 for proximate analysis. The findings showed the moisture analysis, volatile matter, ash content, fixed carbon and heating value of both coal and coconut shell. The efficiency evaluated showed that coal can be replaced with coconut shell for power generation as it is less harmful to the nature and has better combustion efficiency.

Keywords: Proximate Analysis, Coconut Shell

1. Introduction

Malaysia is a country that depends highly on power generation for its economic growth [1]. As we all know, Malaysia naturally confides in on mainly coal, natural gas and fuel oil as its fossil fuel sources for power generation [2].

Coconut shell can be listed down as an example of biomass source to replace coal in energy production. It is commonly utilized as a source of organic fertiliser due to its ability to preserve the farmlands' moisture and reduces the loss of nutrients when agriculture is done [3].

Coal is a resource that has been used widely in our country and it is also said to be easily available for a cheap price. This causes and effect of burning coal as it leads to emission of Greenhouse gases (GHGs) which causes degradation of environment and changes of climate.

In this case, we are considering the usage of coconut shell as biomass source to produce energy. This research focuses on proximate analysis of coal and coconut shell to identify the compatibility of coconut shell as source of fuel replacing coal.

1.1 Proximate Analysis

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PA is the most widely recognized & least complex type of coal/coconut shell assessment, which is utilized to figure design of fuel, its applicable properties and worth of its energy. Proximate analysis decides MA, AC, VM, FC, and HV. Customarily, the guidelines of proximate analysis are framed dependent on a couple of establishments which incorporates International Organization of Standardization (ISO), the American Society for Testing and Materials (ASTM), the German Institute for Standardization (DIN) and the British Standards Institution (BSI). Even though there are contrasts, the guideline applied, and methodology carried out are for the most part comparable. For the most part, proximate analysis is resolved gravimetrically after warming a sample under explicit conditions like atmosphere, temperature, and time.

1.2 Effects of Particle Size on Combustion

Particle size is a main consideration in deciding the restrictions during response [4]. The intra-molecule heat and mass exchange impacts are significant in devolatilization of millimetre-sized biomass particles. The coarser particles require more residence extra time because of its low dissemination rates. The little particles consume more rapidly than the coarser ones [5]

2. Materials and Methods

2.1 Materials

Materials used are coal and coconut shell. The sample preparation process is as the flowchart attached.

2.2 Methods

Proximate analysis consists of 5 elements which are MA, VM, AC, FC and HV. In this research, we have conducted 3 ASTM standard testing which are E871, E872 and D1102. Following is the procedure for each testing.

First is moisture analysis. Sample describes coal and coconut shell respectively. Sample is placed in airtight container to avoid gain/loss of moisture. Sample is then reduced by either coning & dividing or riffle. Sample container is dried for 30mins at 103 ± 1°C in oven and cooled to room temperature in desiccator. The container is weighed to nearest 0.2g and record as container weight, W_c. Sample of minimum weight, 50g is placed in the container, recorded as initial weight (W_i). Sample and container are placed in oven for 16 hours at 103 ± 1°C. Sample is removed and cooled at desiccator. It is weighed immediately to the nearest 0.01g. Sample and container are returned to the oven at 103 ± 1°C for 2 hours. Process continued until the total weight change between weighing varies less than 0.2% and record final weight, W_f

The second test is the analysis of volatile substances. The sample is placed in a sealed container to avoid the increase/loss of moisture. Reduce the sample by taper and split or shallow groove. The sample is further crushed into smaller particles by using a cutting/shearing laboratory grinder (the final product can pass through a sieve of 1 mm or smaller). The crucible and lid are weighed to the nearest 0.01 g and recorded as the crucible weight, Wc. Put approximately 1g of the sample in the crucible, close the lid and weigh it to the nearest 0.01g and record it as the initial weight Wi. Place the sample in a covered crucible on a platinum/nickel-chromium wire support, insert it directly into the furnace whose temperature is maintained at 950 ± 20°C, and immediately drop to the 950°C zone. Adjusting the temperature to within the specified range is crucial. After the rapid emission of volatiles has subsided as indicated by the disappearance of the glowing flame, inspect the crucible to verify that the lid is still properly seated. Replace the lid to prevent air from entering the crucible (if necessary). This can be done as quickly as possible by raising the crucible to the top of the furnace, replacing the lid to seal the crucible more perfectly, and then immediately lowering it back to the 950°C area. After heating for a total of 7 minutes, remove the crucible from the furnace and let it cool in a desiccator without breaking the lid. Weigh the crucible with a lid on the sample that has just cooled to the nearest 0.1 mg and record it as the final weight Wf.

The last procedure is for ash content analysis. The test specimen shall consist of approximately 2 g of coal and coconut shell particles respectively. Care should be taken to ensure that it represents the entire batch of materials being tested. The empty crucible is ignited and covered on a 600°C burner or muffle furnace, then cooled in a desiccator and weighed to the nearest 0.1 mg. Place 2g of the sample in a crucible, measure the weight of the crucible and the sample, then remove the crucible lid and place it in a dry box at 100°C to 105°C. After 1 hour, the crucible lid was replaced, cooled in a desiccator, and weighed. Repeat dry weighing until the weight is constant at 0.1 mg. During cooling and weighing, the crucible is kept well covered to prevent the absorption of moisture from the air. The weight (crucible plus sample minus crucible weight) is recorded as the weight of the oven dried sample. Place the crucible and contents in the muffle furnace, remove the lid, and ignite until all the carbon is removed. They are heated slowly at the beginning to avoid burning and always protect the crucible from strong air currents to avoid mechanical loss of the specimen. The recommended final ignition temperature is 580 to 600°C. Avoid heating above this maximum value. Move the crucible with its contents to the desiccator, cover loosely, cool and weigh accurately. Repeat the heating for 30 minutes until the weight after cooling is constant within 0.2 mg.

3. Results and Discussion

3.1 Results

Table 1: Proximate Analysis and Ultimate Analysis of Coconut Shell and Coal

Characteristics	Coal	Coconut shell	Rice husk	Palm kernel shell	Sugarcane bagasse	Hardwood
PROXIMATE ANALYSIS						
Moisture, M	9.34	5.56	8.40	4.00	5.25	7.80
Volatile Matter, VM	25.68	70.82	65.33	58.00	82.55	72.30
Fixed Carbon, FC	31.59	21.80	10.04	43.00	8.30	25.00
Ash, A	33.39	1.80	24.63	4.00	3.90	2.70
ULTIMATE ANALYSIS						
Carbon, C	72.15	40.08	31.60	51.00	46.60	48.60
Hydrogen, H	7.19	5.22	5.20	7.00	5.92	6.20
Oxygen, O	18.21	54.31	37.39	39.00	0.09	41.10
Nitrogen, N	1.55	0.22	0.70	3.00	0.14	0.40
Sulphur, S	0.89	0.17	0.09	0.48	43.35	-

Higher heating value, HHV (MJ/kg)	16.2	19.4	13.8	20.4	16.9	18.8
References	[6]	[7]	[8]	[9]	[10]	[11]

3.2 Discussions

The CSP has 5.56% of MC, 70.82% of VM, 21.8% of FC and AC of 1.8% respectively, which is almost like the values obtained for palm kernel shell [9]. Moisture can be interpreted as a proportion of water content existing in biomass which is ordinarily indicated by weight percentage (wet basis). Excessive measure of moisture influences the thermochemical change measures and the warming worth of the end-result. This then demonstrates the reasonableness of the biomass following the carbonization cycle intended to be used for cleaning, soil change and filtration by expanding soil carbon.

With the ignition of biomass, the VM depicts how fuel can be replicated with no issue. Its quality in an amazingly high whole conveys some inorganic blends [12], it commonly forecasts the reactivity of coal. The VM and the FC directly sway the combusting measure. The PA aids in understanding the introduction of the biomass during ignition. Therefore, CPS will emit higher energy during the process of combustion. The VM commonly grants to the increment of solid by-product by 10 to 20 wt% in pyrolysis process. It encounters a build-up response brought about by the all-encompassing holding season of the gases just as volatiles to shape solid items. The incredible value of volatiles displays the benefit of feedstock in going through an interaction of devitalization [12].

A high content of FC in biomass enables it to be apt for power generation as energy is reserved in FC and volatiles. The CSP has a 21.8% of FC. An important criterion that needs to be assessed is the AC of the biomass. It expects the presence of C and inorganic segment oxides and salt's structure. Generally, the AC in biomass is lower than 10% except if for certain biomass. Lower AC maintains a strategic distance from different challenges in furnaces and boilers regarding the improvement of combined solids and high release of dirty matter. Utmost biomass in Table 4.1 contains AC of less than a percentage of 10 wt% except for rice husk [8].

The trademark contrast among biomass might be because of the assortment and test planning of the feedstock, climate, and nature of the soil, technique and period of gathering, and the dampness of the environment. To survey the biomass properties, it was diverged from the aftereffects of other biomass as shown in Table 4.1. The thought about CSP biomass is comparable with those that have a critical worth of FC, VM, and less proportions of MC, and AC. Besides, from the characteristics conduct, the biomasses can replace bituminous coal and lignite.

The compound appraisal of biomass is pivotal for power creation and transformation into diverse components [13]. The values of UA for CSP are 40.08% of C, 5.22% of H, 0.22% of N, and 0.17% of S as displayed in Table 4.1. The composition of O (54.31%) which comprise of other inorganic particles was constrained by distinction. C, the foremost component discovered as it portrayed the most critical rate. Carbon is the critical constituent regularly found in the mentioned biomass. A high proportion of C content in biomass is invaluable on the grounds that its combustion builds the calorific worth [14]. Considering the hypothesis, materials with relatively high proportion of FC leads to a high worth of fundamental carbon. The value or proportion of O and VM has a significant affiliation. Incidentally, considering the results of coal and biomass, the association between O what is more, C on the solid development with volatiles content can be set up.

For example, the proportion of O in coal acquired a lower VM of 12%; however, by virtue of biomass, volatiles are found to be around 75% considering the extraordinary arrangement of oxygen. The CSP have an extraordinary level of H (5.22%) which is related with an amazing effect in a gas and water reactivity. Thus, the substance of nitrogen and sulphur creation said to be low. Appropriately, the CSP may convey a low proportion of SOx and NOx release during thermochemical change, accordingly, grows the ability of the CSP as an eco-accommodating ecologically replenishable source of power [12]. Low nitrogen and sulphur composition in biomass show lesser SOx and NOx that will be conveyed in heaters and boilers.

4. Conclusion

An all-around examination of the unquestionable data and accessibility of the CSP with respect to the probable for power generation, physiochemical, and morphological characteristics concerning the thermochemical change related properties were finished. It was done in order to inspect through and through the economical feasibleness and the enabling aspects of surveying the feedstock as a conceivable choice for charcoal creation. This study directed can possibly be an early phase of the formation of coconut shell charcoal and the assurance of biomass species for different utilizations of energy. CSP show a lower proportion of compound strong metals, functional groups and are said to have indistinct plans and all around required morphological attributes. The feedstock can fill in as an unquestionable asset of energy thinking about the incredible properties of solid fuel and C source. The high substance of FC at 21.8%, C at 40%, and high HV at 19.4% will yield a normal carbonaceous material, the charcoal. The CSP biomass presents dominating execution than the rest to the extent of energy and C composition. UA revelations like N (0.22%) and S (0.17%) proves that the biomass is practical with zero carbon transmissions. Accordingly, the use of CSP for charcoal creation could be viable and eco-obliging because of its abundant availability for an uncommonly minimal cost, and the broad quantitative depiction of the biomass shows its inert limit with respect to waste to energy applications through thermochemical development. As such, taking part in the preparing of coconut shells to charcoal is of mind-boggling financial significance.

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