Advanced Journal of Science, Technology and Engineering
Volume 4, Issue 1, 2024 (pp. 1-15)
www.abjournals.org

ASSESSMENT OF OVBIOMU COAL FOR INDUSTRIAL APPLICATION

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Cite this article:

Alabi O. O., Adakole S., Osaghae O. S. (2024), Assessment of Ovbiomu Coal for Industrial Application. Advanced Journal of Science, Technology and Engineering 4(1), 1-15. DOI: 10.52589/AJSTE-EWGVMPJK

Manuscript History

Received: 6 Sept 2023

Accepted: 13 Nov 2023

Published: 7 Feb 2024

ABSTRACT: *This research is to assess the quality of Ovbiomu lignite coal deposited for optimum utilization in metallurgical industries in Ovbiomu. Samples of coal were collected for analysis and sample was collected from five different stationary lots until 10 kilograms of the sample was collected and 500g was taken for characterization. The sample was reduced using jaw crusher and ball milled to a size of 1400µm and 1 kilograms of 1400µm was further reduced to 1100µm and was classified into various sieve sizes using mechanical sieve shaker. CalK2 bomb calorimeter was used to determine the calorific value of the head sample, the economic liberation size and the actual liberation size. The proximate analysis of the head sample and all the sieve sizes was done using Furnace, oven, porcelain crucibles, analytical balance, and desiccator to ascertain the individual carbon content. Ultimate analysis was done using XRD and concentration was done using froth flotation method. Result from sieve analysis shows that at 1000 µm, 710 µm, 500 µm, 355 µm, 250 µm, 180 µm, 25 µm, 90 µm, 63 µm, and -63 µm, the following weight was retained 1.45 g 1.86 g, 3.73 g, 3.5 g, 14.61 g, 48.28 g, 0.15 g, 0.17 g and 0.20 g respectively. The economic liberation size was found out to be 180um where most of the sample is retained and the actual liberation size was found out to be 125um but with a very small quantity retained. The results of the calorific value of the head sample and each of the sieve sizes of 250µm, 180µm, and 125µm, was determined to be 24.51MJ/Kg, 25.86MJ/Kj, 18.57MJ/Kg and 38.07MJ/Kg respectively, the following are result of percentage carbon content, for the Head sample (40.65%), 1000µm (29.55%), 710µm (38.53%), 500µm (42.43%), 335µm (35.42%), 250µm(43.07%), 180µm (30.92),125µm (63.40%) 90µm (0.56%) 63µm (0.62%) and -63µm (9.91%). The result of ultimate analysis of the sample shows Nitrogen (1.15%), Hydrogen (4.80%), Sulphur (0.13%) and Oxygen (29.56%).*

Article DOI: 10.52589/AJSTE-EWGVMPJK
DOI URL: https://doi.org/10.52589/AJSTE-EWGVMPJK

INTRODUCTION

Coal has long been a part of daily life, according to a number of authors, including Jennifer *et al.* (2013) and Rasheed *et al*. (2015). In the past, coal has been used to heat homes, cook, and even to make art. Coal is the most prevalent fossil fuel of plants. Energy sources known as fossil fuels are thought to have developed millions of years ago and are non-renewable. They also contain natural gas and oil. The fossil fuel known as coal was created from many types of extinct planets.

According to Rahman *et al.* (2019), humankind and coal have a long history of interacting. Even though the Roman Empire utilized it extensively first, the fossil was employed as lacing by cavemen. Chukwu *et al*. (2016) describe coal as combustible black porous brownish-black sedimentary rock. In recent years, coal has had the world's fastest rate of energy growth. Rasheed *et al.* (2015) describe the coal in India's Cambay basin as a significant tertiary hydrocarbon belt with a NNW-SSE trend and an intracratonic graben. They also describe the discovery of the coal deposit's proximate and ultimate locations. According to Pavel *et al.* (2018) and Cody *et al*. (1993), coal is an organic rock (as opposed to the majority of other rocks in the earth's crust, like clays and sandstone, which are inorganic); it is primarily composed of carbon (C), but it also contains hydrogen (H), oxygen (O), sulfur (S), nitrogen (N), and some inorganic components (minerals), as well as water (H2O). Moreover, they added, the calorific value, which can be either gross or net, is a measurement of the amount of heat or energy produced. The latent heat of condensation of the water vapor created during combustion accounts for the difference. Gross calorific value (GCV) entails the full condensing of all combustion-related vapours. Net calorific value (NCV) is based on the supposition that the combustion product does not completely condense before it is expelled. Fuels should be compared based on their net calorific value and other factors, says Jeffrey (2005).

The calorific value of fuel oils is far more stable than that of coal, which fluctuates significantly depending on the amount of ash, moisture in the ore, and kind of coal. According to Misra (1992), proximate analysis has been used for a long time to separate volatile, fixed carbon, and inert components to assess the rank of coals. According to Aina *et al.* (2009) and Mahapatra (2016), the quantity of heat emitted during the burning of a specific amount of a substance—typically a fuel or food—is the heating value or calorific value of that substance. Each substance has a feature known as the calorific value. Energy per unit of the substance, typically mass, is quantified using units like kcal/kg, kJ/kg, J/mol, and Btu/m3. The Gross Calorific Value is relevant for gas burned in condensing boilers, which condense the water vapor created by combustion, recovering heat that would otherwise be lost. Heating value is often evaluated by using a bomb calorimeter. Coal was classified by Davis (1978) as Peat coal, Lignite, Sub-bituminous, Bituminous, and Anthracite. According to Liu *et al*. (2006), the types of samples taken depend on the mining process and the goals of the coal testing. Samples could be necessary for business transactions, process control, quality control, and/or technical evaluation. In order for the sample to be objective and appropriately representative for the intended use, it is crucial to define what the sample's purpose will be before it is collected. The beneficiation of coal encourages uniformity in the size of the pulverized coal after comminuting and aids in the removal of contaminants that cause the generation of ash and sulfur when coal is burned. Gravity separation, which involves screening coal particles through sieves of progressively smaller mesh sizes, is one way of beneficiation. Size

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reduction, grinding, screening, and handling are all components of coal preparation (Sujeet *et al*., 2019).

METHODOLOGY

Study Area

Ovbiomu coal deposit is located in Owan East Local Government, with coordinates 7°06'04"N, 6°05'34"E in Edo State, Nigeria. Nigerian geotechnical consult, Jidet Nigeria, revealed that a group of indigenous mineral explorers have identified 196 million metric tonnes of coal in Edo State, western Nigeria and is able to generate 1200MW for 50 years and Ovbiomu coal deposit accounts for 36.12 million metric tonnes which is 18.43%. Figure 1 is a map showing the coal seam in Edo State.

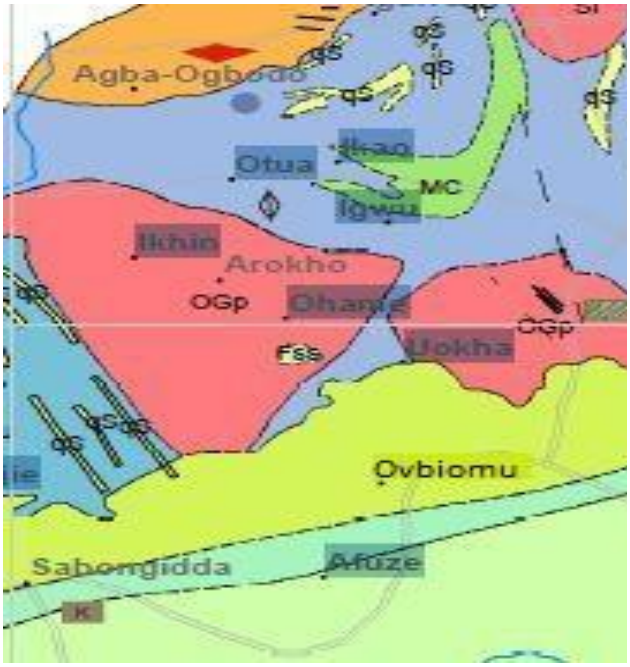

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Figure 1: Showing the geological map of the study area and its environment (Sourced and extracted from geological survey of Nigeria 2006).

Sample Collection and Preparation

A total of 10 coal samples were collected for examination. The samples were picked at random from 10 distinct lots, totaling 10 kilograms. Five hundred (500) grams sampled out from 10 kilograms was taken for characterization. This sampling process was carried out from the top soil at a depth of 0 and 2 meters and at intervals of 5 meters horizontally from each sample lot. The samples were properly gathered and placed in sample bags. They were then appropriately tagged before being transported. Coal was extracted from the Ovbiomu coal open cast project for the experiments, and lumpy coal was first put through a jaw crusher. The coal was well mixed before sampling, which was then divided into separate pieces using a sample splitter. This was done to further uniformize the coal sample that was acquired. For proximate analysis, a portion of the coal was set aside, while the remainder was pulverized in a ball mill. A small amount of the coarser coal was discovered; it was filtered, re-crushed, and mixed with the sample of the finer coal.

Sieve Analysis

Take a 100g subsample from the coal sample. Weigh the subsample, charged into a screen deck, and then run the screen deck through standard sieves of 1000 μm, 710 μm, 500 μm, 355 μm, 250 μm, 180 μm, 125 μm, 90 μm, 63 μm and -63 μm. Then keep track of the particle retention weight for each sieve size.

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Proximate Analysis Operations

According to Rasheed *et al.* (2015), this operation comprises Moisture Content, Volatile Matter, Ash Content and Fixed Carbon Content determinations.

(i) Moisture Content

One gram of coal sample from each sieve size and the head sample is measured and put in a porcelain crucible; the sample in the crucible is heated in an electrical hot air oven at 100–110 for one hour and then cooled in a desiccator and weighed. This process is repeated until the weight of the crucible containing anhydrous coal becomes constant. Loss of weight is reported as moisture content. Moisture (%) = loss in weight due to removal of moisture in gram / weight of coal sample taken in gram x 100.

$$\frac{M_1-M_2}{M_1} \times 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 1$$

where M_1 is the initial mass of the coal sample and M_2 final mass of the coal sample.

(ii) Volatile Matter

One gram of moisture-free coal sample from each sieve size and the head sample is measured and put in a crucible covered with lid and placed in a muffle furnace; the sample in the crucible is preheated at 950^0C for seven minutes. The crucible is taken out, cooled first in air, then inside the desiccator and weighed again. This process is repeated until the weight of the crucible containing coal becomes constant. Loss of weight is reported as volatile matter (%) = loss in weight due to removal of volatile matter in gram / weight of coal sample taken in gram x 100%.

$$\frac{M_1-M_2}{M_1} \times 100\% \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 2$$

where M_1 is the initial mass of the coal sample and M_2 final mass of the coal sample.

(iii) Ash Content

One gram of coal sample from each sieve size and the head sample is measured and put in an open crucible and placed in a muffle furnace; the sample in the crucible is heated at 750^0C for one and a half hours (90 minutes). The crucible is taken out, cooled first in air, then inside the desiccator and weighed again. This process is repeated until the weight of the crucible containing coal becomes constant. Loss of weight is reported as ash content (%) = weight of ash formed in gram / weight of coal sample taken in gram x 100.

$$\frac{M_2}{M_1} \times 100\% \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad 3$$

where M_1 is the initial mass of the coal sample and M_2 is the final mass of the coal sample.

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(iv) Carbon Content

Carbon (%) is reported as (100% - (Moisture Content (%) + Volatile Matter (%) + Ash Content (%) ………………………………………………………………………………………. 4

Ultimate Analyzer

The most practical way to report coal's primary organic constituent makeup is through ultimate analysis. An ultimate analyzer, used for this analysis, burns a coal sample to determine its weight percentages of carbon, hydrogen, nitrogen, sulfur, and ash. The analyzer simultaneously calculates the total carbon, hydrogen, and nitrogen from the same sample. The other numbers are used to determine total oxygen. In ASTM D3176-09, best practices for final analysis are displayed.

Calorific Value Determinations Using Bomb Calorimeter (CAL 2k)

One gram of the coal sample was weighed and placed inside the vessels; the firing wire was placed on the sample inside the vessel and closed with the cap thread. The vessel was filled with 3000 KPA oxygen gas from the filling station by placing it under the filling station. The bomb calorimeter lid was opened. Prepared vessel was inserted into the well of the bomb calorimeter using the Handling Hook. It is preferable not to insert the vessel with your hand as you may affect the temperature of the vessel. The HEAP records were pressed and scrolled until the required records, i.e., MASS and SID, were located. It was pressed until required Mass and SID were displayed. ENTER key was pressed and the selected record was transferred to line 1 of the display, when the vessel was in the well. The MASS and SID were entered through the keyboard into the monitor. When the HEAP was empty, the MASS and SID were entered. The calorimeter's lid was closed. No fault was detected then the INITIAL status was displayed and the pilot light was ON. Drift and time was displayed during this period depending on the initial parameters of the calorimeter. The initial period criterion was met, then the vessel was fired. The FIRE status was briefly displayed in 6 seconds. Immediately after firing, the FINAL status was displayed. Drift or time was displayed during this period depending on the final parameters of the calorimeter. The result was displayed as it developed during the final period. The final period criterion was met, then the determination ended. The DONE status was displayed and the pilot light flashed until the lid was opened.

NOTE: $CV = KCC$ ……………………………………………………………………… 5

$$K = \frac{CV}{CC} \quad \text{……………………………………………………………………} \quad 6$$

where: CV is calorific value and CC is carbon content.

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RESULTS AND DISCUSSION

Result of Sieve Analysis

Table 1: Showing the result of the particle size analysis

SIEVE SIZE (µm)	MASS RETAIN (g)	MASS PASSING (g)	CUMULATIVE MASS RETAINED (g)	CUMULATIVE MASS RETAINED (%)	CUMULATIVE MASS PASSING (%)
1000	1.45	96.80	1.45	1.48	98.52
-1000+710	1.86	94.94	3.31	3.37	96.63
-710 + 500	3.73	91.21	7.04	7.17	92.83
-500 +355	3.54	87.67	10.58	10.77	89.23
-355+ 250	14.61	73.06	25.19	25.64	74.36
-250 + 180	48.28	24.78	73.47	74.62	25.38
-180 + 125	0.15	24.63	73.62	74.93	25.07
-125 + 90	0.17	24.46	73.79	75.10	24.90
-90 +63	0.20	24.26	74.99	75.30	24.70
PAN(-63)	24.26	0.00	98.25	100.00	0.00
TOTAL	98.25				

Table 1 shows the summary of sieve tests carried out and, on the table, it was discovered that the mid-point is approximately 49% which is gotten from subtracting % cumulative mass passed from % cumulative mass retained at 250µm (74.36 - 25.64 = 48.72%), which is the economic liberation size.

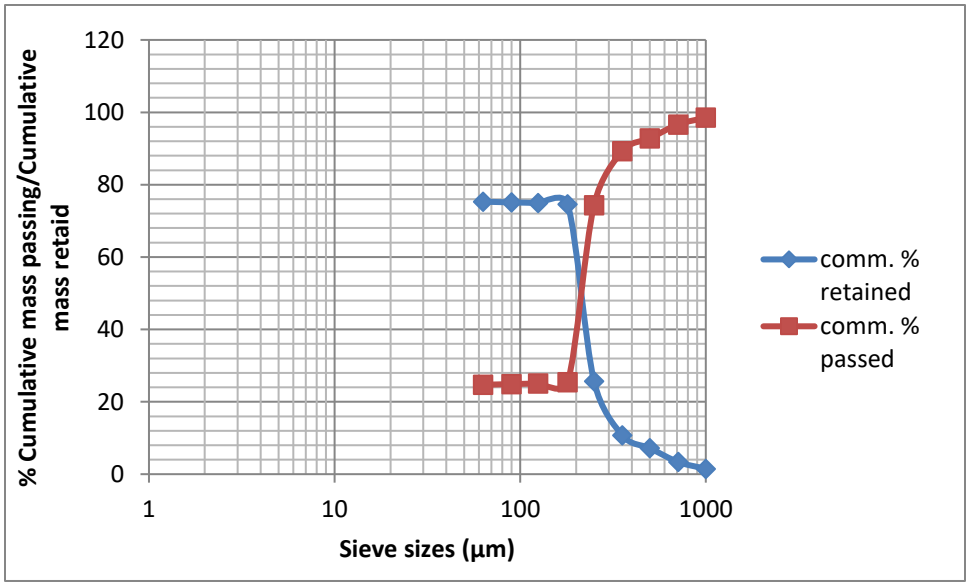

Figure 1: % Cumulative Mass Passed and % Cumulative Mass Retained against Sieve Size (µm).

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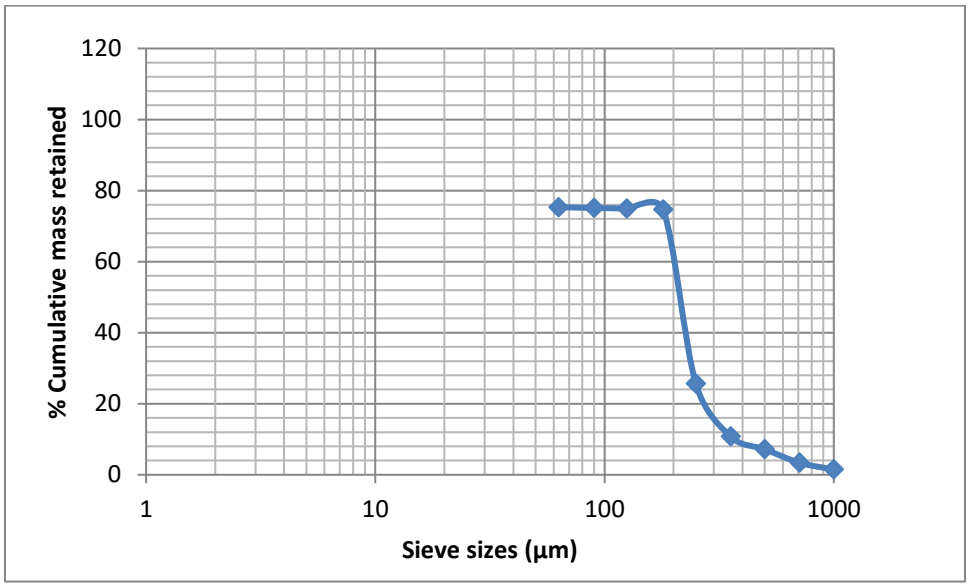

Figure 2: % Cumulative Mass Retained against Sieve Size (µm).

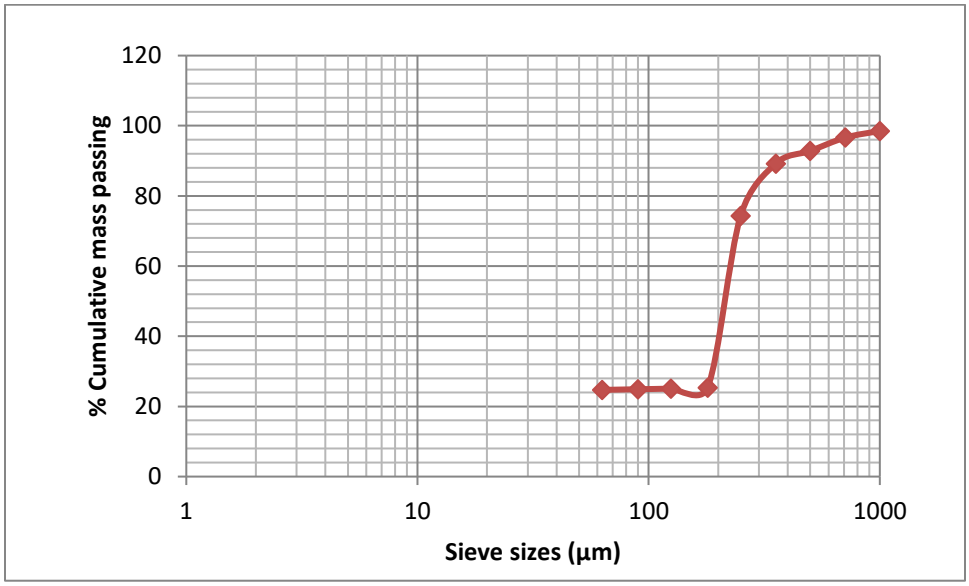

Figure 3: % Cumulative Mass Passing against Sieve Size (µm).

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Figures 1, 2 and 3 show the graphs of mass passed and mass retained against sieve size. This shows that at 50%, the cumulative mass retained and mass passed are at equilibrium but the actual liberation size is at 125μm, which is above the meeting point.

RESULT FOR PROXIMATE ANALYSIS

Table 2: Showing the summary of results for Proximate Analysis Tests for the head sample

SAMPLE	MOISTURE CONTENT (%)	VOLATILE MATTER (%)	ASH CONTENT (%)	CARBON CONTENT (%)
HEAD SAMPLE	3.17	47.79	8.44	40.65

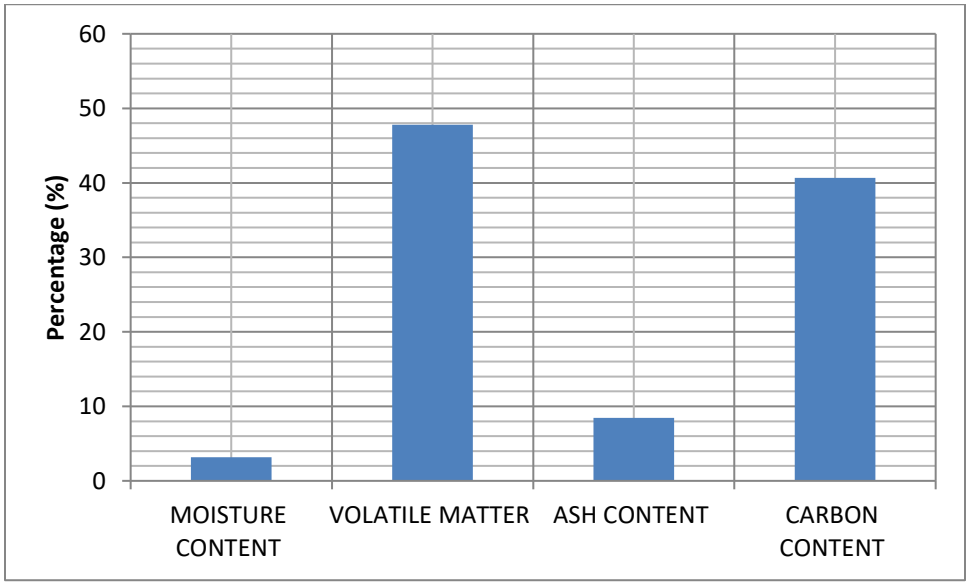

Figure 4: Showing the quality of the head sample of the coal, having a high volatile and carbon content, with a low moisture content and ash content.

Table 3: Showing the summary of results for Proximate Analysis Tests for various sieve sizes

SIEVE SIZE (μm)	MOISTURE CONTENT (%)	VOLATILE MATTER (%)	ASH CONTENT (%)	CARBON CONTENT (%)
1000	4.48	53.94	12.03	29.55
710	4.12	46.98	10.37	38.53
500	3.63	43.39	10.55	42.43
355	3.25	49.76	11.57	35.42
250	1.84	46.91	8.18	43.07

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180	2.07	58.48	8.53	30.92
125	9.60	15.42	11.58	63.40
90	18.72	42.25	38.53	0.56
63	14.12	43.64	41.62	0.62
PAN(-63)	3.51	52.82	33.76	9.91

Table 3 shows the proximate analysis of the coal sample, which indicates the moisture content, volatile matter, ash content and carbon content. These variables give a vivid description of the proximate parameters of the coal sample. It is discovered that at sieve 125µm is the actual liberation size and 250µm is the economic liberation size and this information will guide us into the next phase of this research work which is coal cleaning.

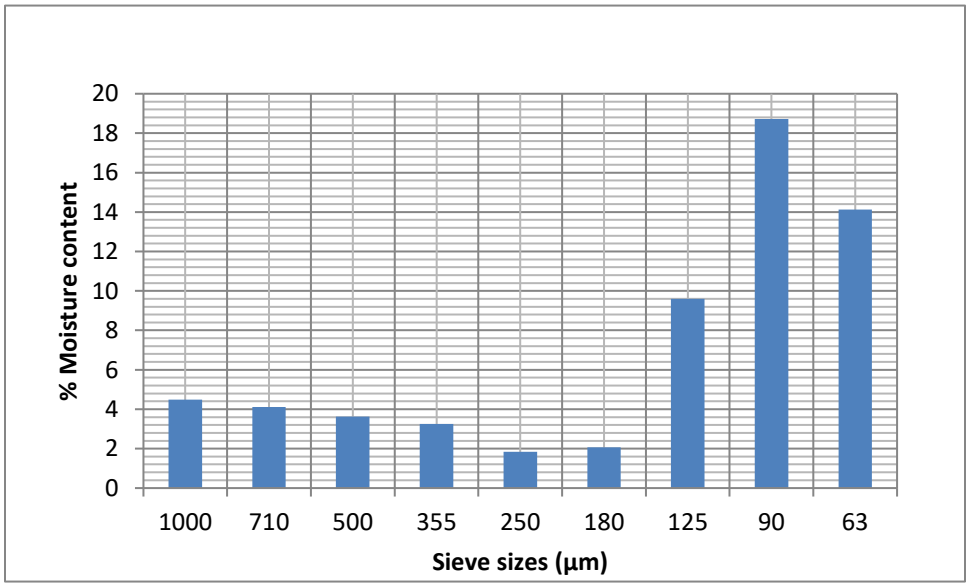

Figure 5: Moisture Content (%) against Sieve Size (µm).

Figure 5 shows the moisture content of all sieve sizes in their relative percentages. More moisture tends to be in the finer sieve sizes 125µm to -63µm. So finer particles absorb moisture than the coarse particles. Thus, when surface area is exposed, more moisture is being given off.

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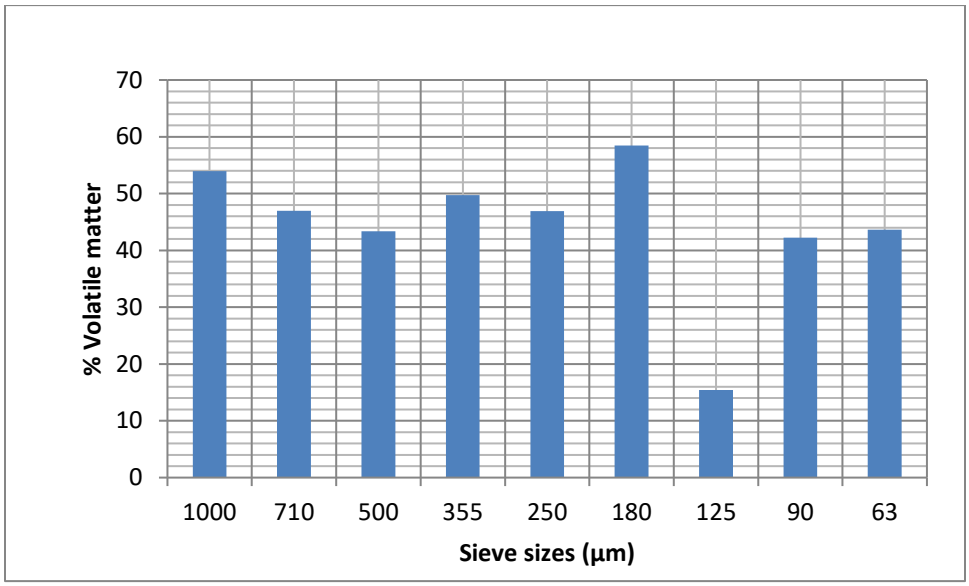

Figure 6: Volatile Matters (%) against Sieve Size (µm).

Figure 6 shows the volatile matter of all the sieve sizes in their relative percentages with more volatile matter in the 180µm and 1000µm sieve sizes; hence, so much volatile matter will be noticed during the coal washing process.

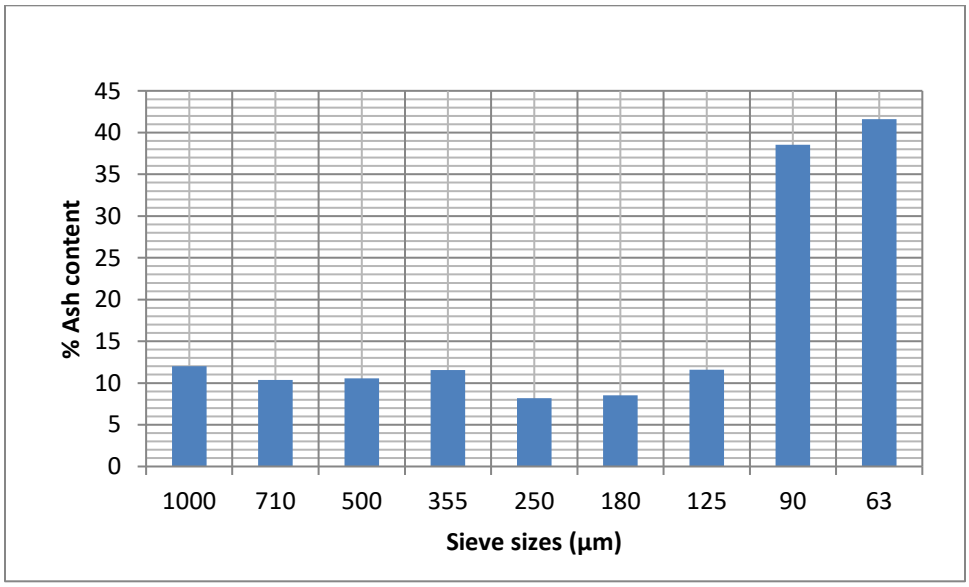

Figure 7: Ash Content (%) against Sieve Size (µm).

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Figure 7 shows the ash content of all the sieve sizes and their relative positions. The finer the particles, the higher ash it will generate. Most of the ashes are found in the sieve sizes of 90µm and below.

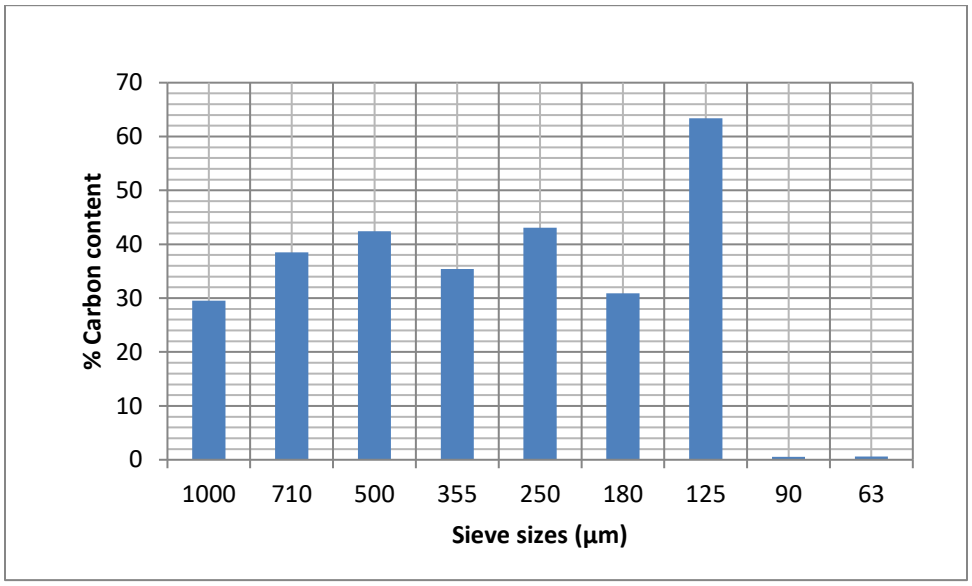

Figure 8: Carbon Content (%) against Sieve Size (µm).

Figure 8 shows that a good amount of carbon is still retained across various sieve sizes except for 90µm and 63µm which are relatively low. So this gives a basis for further reduction to 250µm before concentration can take place.

Result for Calorific Value

Table 4: Showing the summary of results Calorific Values for Head Sample.

TEST	CALORIFIC VALUE (MJ/Kg) DYNAMIC RESULT	CALORIFIC VALUE (MJ/Kg) FINAL RESULT	TEMPERATURE AT FINAL (°C)	RISE	FINAL TEMPERATURE (°C)
1	10.94	25.93	0.023		9.43
2	10.56	25.84	0.019		9.39
3	8.73	26.54	0.017		9.62
4	8.42	25.17	0.018		9.16
5	11.69	22.56	0.022		8.29

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Table 5: Showing the summary of results for Calorific Value.

SIEVE SIZES (μm)	CALORIFIC VALUE (MJ/Kg)
Head sample	25.41
250um	25.86
180um	18.57
125um	38.07

From Table 5, the data shows the calorific value of the coal to be 24.41Mg/kg. After classifying the coal into various sizes, sieve size 180μm is the economic liberation size and sieve size 125μm is the actual liberation size, with 180μm having carbon content of 30.93% and calorific value of 18.57Mg/kg, and 125μm having carbon content of 63.40% and caloric value of 38.07Mg/kg. This quality of coal in its natural state can only serve as a source of energy and as an additive to cement production.

Result from Ultimate Analysis

Table 6: Showing summary of result for Ultimate Analysis

Element	Compositions (%)
Nitrogen	1.15
Hydrogen	4.8
Sulphur	0.13
Oxygen	29.56

CONCLUSION

Characterization to assess the quality of this coal was carried out and the following was discovered: the coal is of low grade and sieve analysis showed that the economic liberation size is 180μm and actual liberation size is 125μm. From the results and data obtained, the coal deposit has a low carbon content of 40.65% and a low calorific value of 24.41Mg/kg. The economic liberation size has carbon content of 30.93% and calorific value of 18.57Mg/kg, and the actual liberation size has carbon content of 63.40% and caloric value of 38.07Mg/kg.

Finally, it can be concluded that the coal deposit is of low grade quality and can be upgraded to a fairly high grade quality product which can be used for domestic, metallurgical and industrial purposes.

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Article DOI: 10.52589/AJSTE-EWGVMPJK
DOI URL: https://doi.org/10.52589/AJSTE-EWGVMPJK

Rasheed M. A., SrinivasaRao P.L., Annapurna B., Syed Z.H. Arpit P., Vaidik .V.,Khamosh .P. (2015) "Geochemical Characterization of Coals Using Proximate and Ultimate Analysis of Tadkeshwar Coals, Gujarat in India, pp.115-116.

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DOI URL: https://doi.org/10.52589/AJSTE-EWGVMPJK