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RESEARCH ARTICLE

INVESTIGATIONS OF COAL QUALITY PARAMETERS AND ITS APPLICATION IN COAL UTILIZATIONS

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ABSTRACT

Coals are heterogeneous combustible sedimentary rocks made by the decay and deposition of organic and inorganic materials derived from plant parts in past geological processes. The major elemental constituents of coal consist of carbon, hydrogen, and oxygen, with lesser amounts of sulphur and nitrogen. Inorganic coal constituents like ash, are mostly derived from ash-forming compounds distributed throughout the coal. The Krishnshila coal mine selected for this study belongs to NCL (Northern Coalfields Limited).Five coal samples were collected and analyzed for their proximate, ultimate analysis, and gross calorific value estimation. According to laboratory analysis, the gross calorific values of these coals fall into the G-7, G8, G9, and G-6 grades, which determine the fuel's energy content, while the moisture content and carbon content define its heat value. Moisture content affects the burning power. Coals are bituminous in nature, medium to high in volatiles. After the beneficiation, coal KLS-4 and KLS-5 can be used in coke-based industries. This study will help in the better utilization of theses coal in various industries.

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INTRODUCTION

Introduction: India is one of the leading producer of coal in the world along with China, USA, Australia and South Africa. (Li, 2015). Coal quality specially the ultimate analysis and proximate analysis and gross calorific value (GCV) determine the end use of coal in the thermal and industrial utilization (Yi, 2017). The quality of a coal influenced by many factors like geological and mineralogical factors, these are associated with the peat formation during accumulation of source material, sedimentation, tectonic and environmental setting of the basin (Dreesen, 1995). Indian coals are mostly confined to the Gondawana and tertiary basins .The coal which are present in India are low bituminous and high in ash content. India is devoid of coking coal. But some coals have the potential for coke quality which are use in blast furnace in steel manufacturing (Mathur, 2003). In the present investigative study, five different types of coal were collected from the Singrauli coal mine have been studied for the proximate and ultimate study. The gross calorific value of coal samples were also calculated and discuss its use in various industries for the purpose of thermal power generation and coke making capabilities in steel manufacturing industries (Pareek, 1988).

Geological set up of Singrauli coal field: The Singrauli coalfield lies within the Permian basins that occur in central and eastern part of the India peninsula. These basins were started to form during the late Mesozoic period prior to the breakup of Gondwanaland. Through the breakup and extension of these basins, into low angle inclined blocks by one or more normal faults. In the Singrauli coalfield, the strata strike generally WNW-ESE and dip is about two to three degrees although near the faults the dips may observe more sometimes [6]. The entire region is traversed by the fault structures. The Barakar formation hosted the major seams in these basins, the upper seam known as Purewa Seam and lower seam known as Turra seam. The Turra seam is the bottom most workable coal horizon. The present mine is located in South-eastern part of the Moher coal basin of Singrauli Coalfield in Sonabhadra district of India. The seam occurs at a depth range from 106 (roof) to 249(floor) m. The stratigraphic thickness of seam from 13.90 to 23.61meters.

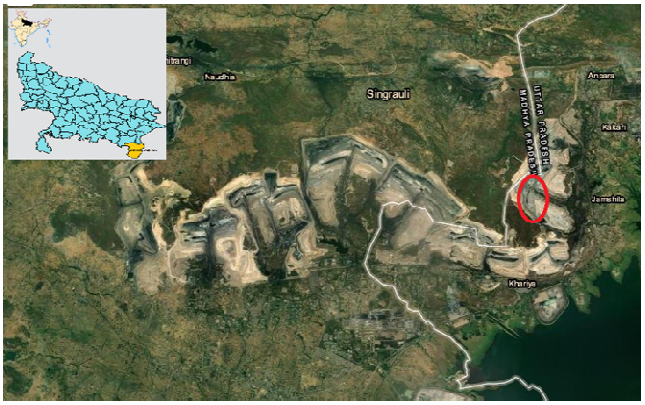

Fig. 1. Locations and satellite map of the present study Area and Krishnshila mine represented by red circle

Fig. 2. Vertical profile of coal seam showing the bottom Turra seam and collection of coal samples from the exposed seam section

MATERIALS AND METHODS

Collection and preparation of samples: Coal samples have been collected from the Singrauli coalfield located in the Singrauli district, India. These coalfields are located in the central part of India. The Krishnshila coal mine is an opencast mine situated in north eastern part of the coalfield .Coal samples were collected in the post monsoon period in the month of November so that moisture was inherent in nature. These samples were collected by the pillar sampling method. Samples were collected from the Krishnshila mine shown in red circle in fig.1 from the bottom seam known as Turra seam. Coal samples were collected from bottom to top and labelled as KSL-5, KSL-4, KSL-3, KSL-2, and KSL-1 respectively. The collected coal samples were put in plastic bags and sealed immediately to reduce oxidation and any other contamination. After the collection of samples they were crushed in a ball mill and sieved with a filter of -212 microns size for further analysis.

Determination of Proximate and Ultimate Analysis: The proximate analysis is taken into consideration for the estimation of coal quality which is helpful in thermal industries. It includes the determination of moisture; volatile matter (VM), fixed carbon and ash present in coal in weight percentage. This method is widely used for industrial purposes as well as for the grading of coals. After crushing the samples and pulverised to -212 microns. For the analysis of moisture content in coal a sample one gram of air dried coal (- 212 microns IS) sieved sample was taken in silica dish and heated up to a temperature at 108°±2°C in closed oven. The difference in the amount of weight before and after heating was taken as the moisture content in coal. The moisture is present in the form of inherent and surface moisture. The physically and chemically bonded moisture in the coal decomposes after heating at 108°±2°C .Ash is formed by the complete combustion of inorganic mineral matter present in the coal. For ash estimation in the coal one gram of air dried sieved coal (-212 microns size) sample was taken in a porcelain dish. In the porcelain dish coal should present in a very thin layer and heated in the muffle furnace. The temperature of muffle furnace was raised up to 500°C in thirty minutes and then again raised the temperature up to 815°±10°C for another 30 to 60 minutes. This temperature was maintained for another 60 minutes. After that the dish was taken out of muffle furnace. Then the loss in the weight was calculated and expressed as percentage of ash present in the coal. For the analysis of volatile matter in coal, 1 gram of air dried coal(ground to passed through -212 micron IS sieve) is taken into a crucible with a lid and placed it in the muffle furnace which have already at the temperature of 900°±10°C for a period of 7 minutes. Then the differences in the weight loss were calculated before and after heating. Data were expressed in form of weight percentage of the coal samples (ASTM D5142).The ultimate analysis is used for the determination of C (carbon), H (hydrogen) , S (sulphur), N (nitrogen) and O (oxygen) in elemental form present in coal by using Euro 3000 Elemental Analyzer. For estimation the GCV, we used an Oxygen bomb calorimeter Parr 6100 Series. A bomb calorimeter used to measure the heat of combustion of a particular material in a set conditions .A bomb is prepared with Ni-Cr fuse wire for GCV calculation, one gram coal sample was taken for the analysis (**ASTM** D5865).

RESULTS AND DISCUSSION

Table no. 1 revealed about the proximate analysis characteristics of different coal samples. The coal KSL-1 has high volatile matter 31.1wt% with 20.0 wt% of ash. It shows low fixed carbon 44.40 wt%, moisture content is moderate in this coal.

Table 1. Calculations of proximate analysis of coal

Sample no	Moisture	Volatile matter	ash	Fixed carbon	GCV
KSL-5	5.00	28.60	15.00	51.40	5630
KSL-4	6.00	30.00	15.00	49.00	5521
KSL-3	7.00	30.00	20.10	42.90	4830
KSL-2	6.10	28.00	23.00	42.90	4920
KSL-1	4.50	31.10	20.00	44.40	5280

Table 2. Calculations of ultimate analysis of coal

Sample no	Nitrogen	Carbon	Hydrogen	sulphur	oxygen	H/C	O/C
KSL-5	1.76	62.81	3.88	0.22	16.33	0.06	0.26
KSL-4	1.71	60.84	3.84	0.33	23.84	0.06	0.39
KSL-3	1.17	55.37	4.86	0.92	21.08	0.09	0.38
KSL-2	0.72	51.18	3.40	0.39	29.31	0.07	0.57
KSL-1	1.42	40.46	2.82	0.70	28.36	0.07	0.70

High ash in this coal is due to terrigenous mineral material derived by silica, alumina and other clay rich minerals during the deposition phase. Volatile content in coal contribute to its calorific value of coal and its energy efficiency, mineral matter in coal are generated by different ways these factors include detritus input, precipitation of minerals during and after peat formation (Navale, 1971). In KSL-2 total ash is 23.00 wt % ,moisture 6.10 wt %, VM 28.00 wt %,FC 42.90 wt% ,present in this coal , high ash is due to dominance of mineral phases (Khan, 2020). In KSL-3 proximate analysis revealed that it content 42.90 wt % of FC, ,7.00 wt% of moisture and VM of

30.0 wt%. The presence of aliphatic and aromatic compounds in coal derived from the lignin, cuticle and hard wood portion of plant parts during deposition enrich the carbon content. Burning of such coals substance release harmful gases to the environment .High moisture in this coal are found, they are of two types free moisture and inherent moisture. It is due free moisture that can be found in this coal when it comes in contact with water in seam or either through various sources cleats, fissures, cleavage and cracks developed in coal might increase the moisture content (Patra, 2018). KSL-4 proximate analyses have FC 49.00 wt%, moisture 6.00 wt %, VM 30.00 wt% and ash 15.00 wt%. Value of ash is low due to presence of carbon constituents, derived from the plant material present in this coal. In coal KSL- 5, FC 51.40 wt %, ash 15.00 wt %, volatile matter 28.60 wt % and moisture 5.00 wt %, low moisture and high carbon content give good energy efficiency in this coal (Mares, 2012). The ultimate analysis of collected coal samples are presented in Table 2.It can be seen that coal KSL-1 content carbon (40.46wt %), hydrogen (2.82wt %), nitrogen (1.42 wt %), sulphur (0.70 wt %), oxygen (28.36 wt%) in moderate composition. For KSL-1 high oxygen content (17.69 wt %) reveals the oxic condition during coal deposition in the fresh water environmental condition (Aggarwal, 2021; Bhowmick, 2017). The results of KSL-2 indicate the presence of carbon (51.18 wt%), hydrogen (3.40 wt%),nitrogen (0.72 wt %), sulphur (0.39 wt%),oxygen (29.31 wt%) (Acharyya, 2019). In KLS-3 carbon (55.37 wt %), hydrogen (4.86 wt%), oxygen (21.08 wt %) nitrogen (1.17 wt %).In coal KLS-4 Carbon (60.84 wt %), Hydrogen (3.84 wt %), oxygen (23.84 wt %) nitrogen (1.71 wt %). KLS-5 indicate the carbon (62.81 wt%), hydrogen (3.88 wt%), oxygen(16.33 wt%) nitrogen (1.76 wt%). Sulphur seen moderate in nearly all five coal samples in comparison to other high sulphur coal in India[9]H/C ratio of KLS-3 is high (0.09) as compared to rest of coal. H/C ratio is less as compare to other because carbon maturation is less in this coal, O/C ratio of KLS-1 high (0.70) as compared to other coal types; it represents the oxygenic condition during coal formation (Kopp, 1985). GCV of the coal define its grade for industrial utilization purpose, the KLS-1 have G-7 grade, KLS 2 G-8, KLS-3 G-9 , KLS-4 and KLS-5 have G-6 .These coals are of thermal grade quality can be utilized for power generation in thermal industries (Sarkar, 2019). Semi Coking Grade-II coals have moisture and ash content in between 19 percent to 24 percent. So coal KLS-4 and KLS-5 fall into this category and other coals are suitable for thermal power generation purposes. Low ash coal after the beneficiation can be used in the coke making process.

CONCLUSION

The detailed estimation of proximate ,ultimate and GCV of these coal samples from the Krishnshila coal mine make a good understanding of the mode of occurrence of mineral matter fixed carbon and its origin and end specific use of these coals .The coals present in this mine are bituminous in nature it reflects low level of sulphur so its origin is in fresh water environment .The lower ash content find in KLS-4 and 5 might find use in the metallurgical industries, the benefited coal can be mixed with coke in blast furnace and other coal are suitable for the generation of power in thermal industries.

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