MERIT RESEARCH JOURNALS
www.meritresearchjournals.org

Merit Research Journal of Environmental Science and Toxicology (ISSN: 2350-2266) Vol. 1(9) pp. 166-169, November, 2013
Available online http://www.meritresearchjournals.org/est/index.htm

Full Length Research Paper

Comparative study of Pakistani coal using different methods

***Mahboob Ali Kalhoro, Gulzar Hussain Jhatail, Mateen Muhammad Khan, Santosh Kumar, Naseem Ahmed and Syed Najam Ul Islam**

Fuel Research Centre, PCSIR, Karachi.

***Corresponding Author's E-mail: kalhoro786pk@yahoo.com**
Mobile: 00923212201252

Abstract

This study was carried by standardizing national and international testing methods of coal. Methods for the determination of Moisture, Ash, Volatile matter, Fixed carbon, Total sulfur and Calorific Value in fourteen different samples of Pakistani coal. The result shown in three tables carried out with different analytical methods (American Platinum crucibles method, British single-crucible method and Franco-Belgian double crucible method).

Keywords: Pakistani Coal, Comparative study

INTRODUCTION

For many years the Illinois State Geological Survey has cooperated actively in the work of Committee D-5, Coal and Coke, of the American Society for testing Materials, whose goal is establishment of national standard methods for the analysis of coal and coke. The Methods have been found to differ considerably for the determinations of volatile matter and ash of coal and these methods have been used in various countries for the determination of volatile matter vary in specified temperature of heating from 875' to 1040°C and in time of heating from 7 minutes to 20 minutes. Methods for determining the ash specify temperatures from 700° to more than 850°C. At 815°C is under consideration as an international standard. This is higher than the American standard specification of 700-750°C. Furthermore, there is difference of opinion as to the proper rate of heating for the determination of ash in coal. Volatile matter in the coal and coke is defined by the American Society for Testing Materials (ASTM D 120-30, 1954) as "those products, exclusive of moisture, given off by a material as gas or vapor, determined by definite prescribed methods which may vary according to the nature of the material." It is one of the important determinations in the proximate analysis for use in certain classification systems and for evaluating coals as to combustion characteristics. Differences in temperature and in time or rate of heating are known to influence results beyond permissible tolerances. To meet the need for definite specifications of the American Society for Testing Materials in the United States sponsors two standard methods (ASTM D 271-48, 1954). The first, commonly referred to as the standard method, consists of heating the coal at a rapid rate in a vertical tube furnace maintained a t 950~~.*20T~he~ other method, commonly referred to as the modified method, consists of heating the coal in the same furnace at a considerably slower rate. Two methods are necessary because certain solid fuels (such as sub bituminous coal, lignite, peat, certain cokes, chars, anthracites, and semi anthracites) spark appreciably when heated at the rapid rate, causing high values through mechanical loss. By the slower rate of heating used in the modified method, sparking is reduced to a minimum. Unfortunately, the two ASTM standard methods may not give the same results. Calorific value is an important property, indicating the useful energy content of coal and its value as fuel. Heating value is a rank parameter, but is also dependant on the ma-ceral and mineral composition (Hower and Eble, 1996). A number of equations have been developed for the prediction of gross calorific value (GCV) based on proximate and / or ultimate analyses (Given et al., 1986; Parikh et al., 2005; Spooner, 1951; Mazumdar,1954; Channiwala and Parikh, 2002; Patel et al., 2007, Majumder et al., 2008). Neural network, as a new mathematical method, has been widely used in research areas of industrial processes (Zhenyu and Yongmo, 1996; Specht, 1991; Chen et al., 1991; Wasserman, 1993; Hansen and Meservy, 1996, Jorjani, E et al., 2007, Chehreh Chelgani, et al., 2008). Whereas artificial neural network (ANN) is an empirical modeling tool, which is analogous to the behavior of biological neural structures (Yao, 2005; Bagherieh, A.H.et al., 2008). Neural network is a powerful tool that has the abilities to identify underlying highly complex relationships from input–output data only (Haykin, 1999). The modified method frequently gives result as much as three percentage units lower than the rapid heating procedure. Because of this, it is not satisfactory to compare coal, some of which are analyzed by the standard method and some by the modified method.

Equipment

The equipment has been used in this comparison that specified by the American Society for Testing Materials for the American methods (ASTM D 271-48, 1954); by the British Standards Institution for the British method (BSI 1016-1942, 1942); and by the Association Francaise de Normalization for the Franco-Belgian method (AFN NF-M-03-004, 1950). Briefly, equipment used for the three methods is described as follows.

(1) For the American methods Platinum crucibles of 15 ml. capacity with tightly fitting capsule lids were used for both the standard and modified methods. Heating was done in a vertical tube or volatile-matter furnace, commonly known as the Fieldner furnace.

(2) For the British single-crucible method: Fused-silica cylindrical crucibles with capsule-type lids were obtained from England for this method. Heating was done in an electric muffle furnace. A refractory stand or “gas mantle” was used to hold the crucible in the furnace. Two discs of asbestos, each one mm thick was placed between the bottom of the crucible and the inside projections of the three legs of the stand. Mounting the crucible in this way removes it about 6 mm. from the floor of the furnace.

(3) For the Franco-Belgian double-crucible method: A double-crucible (one inside the other) arrangement is specified and was used for this method. The smaller crucible with lid was of glazed porcelain, and the larger crucible with cover was quartz. The two crucibles were separated by a layer of crushed wood charcoal. All crucibles and covers were obtained from France. Heating was done in an electric muffle furnace.

In all methods, temperature was measured by means of thermocouples and pyrometers.

Samples

Fourteen samples of Pakistani coals representing the high-volatile bituminous have been used in this comparison study.

METHODS

In all methods, I-gram of (minus 60-mesh) coal has been used, and all determinations were made in duplicate. In the American standard method, the sample, in a platinum crucible, was introduced directly into the hottest zone of the furnace (950°C) for exactly 7 minutes, thus obtaining a rapid rate of heating. In the American modified procedure, the sample, in a platinum crucible, was suspended in the Fieldner furnace (950°C) such that the top of the crucible lid was even with the top of the furnace. After 5 minutes, it was lowered one quarter inch for 2 minutes, then one half inch further for 2 minutes, after which it was lowered to the hottest zone of the furnace and heated 6 minutes. By this means, a slower rate of heating was obtained.

For the British single-crucible method, the sample was introduced into the hottest zone of the muffle furnace (950°C) and heated for exactly 7 minutes. A rather rapid rate of heating was obtained, but not as rapid as in the American standard procedure. Whereas the Franco-Belgian double crucible method, the smaller porcelain crucible, containing the coal sample, was placed inside the muffle furnace (960°C) and heated for exactly 20 minutes. By this procedure, a slow rate of heating was obtained.

RESULTS AND DISCUSSION

Moisture, Ash, Volatile matter, Fixed carbon, Total sulfur and Calorific Value in fourteen samples of Pakistani coal have been obtained by the three different methods are shown in Table 1-3.

Values obtained by the American standard method has lower than values obtained by the British method and Franco-Belgian methods, however the value of sulfur is obtained more or less same in three methods, where as the results of Moisture, Ash, Volatile matter, Fixed carbon, and Calorific Value are quite different . The lowest value of Moisture is (1.8-2.3), Volatile matter (12.0-16.39) in FATA sample, whereas the lowest value of Ash are in Sor-Range Deghari (2.7-14.3) and Duki (2.7-22.3) samples, the lowest value of fixed carbon in Duki (14.3-38.9) sample, the lowest value of total sulfur continents in Sor - Range Deghari (0.4-0.45), in Sonda

Table 1. Typical Analysis of Pakistani Coals by American Platinum crucibles methods

Name of Coal Field	Moisture (%)	Volatile Matter (%)	Ash (%)	Fixed Carbon (%)	Total Sulfur (%)	Calorific Value (K. cal/kg)
Mach	7.1	34.5	9.6	32.4	3.2	5,100
Sor-Range Deghari	5.1	31.0	2.7	36.0	0.4	4,830
Pir Ismail Ziarat	5.2	27.0	13.3	23.8	2.9	5,353
Khost-Sharigh Harnai	1.7	29.7	9.3	25.5	1.4	4,420
Duki	4.8	36.5	2.7	14.3	2.7	4,610
Meting Jhimpir	26.6	25.2	8.2	24.1	2.9	3,740
Lakhra	13.5	26.3	7.4	20.7	1.8	2,570
Sonda	9.0	20.0	5.0	15.0	0.4	3,600
Salt Range	3.2	21.5	12.3	25.7	2.6	3,760
Makerwal	2.8	31.5	6.4	34.9	2.8	5,200
Kurd-Sho	3.0	30.2	7.0	31.1	3.0	5,200
Thar	35	35.4	4.9	29.8	0.66	4,330
FATA	1.80	16.39	39.67	43.34	5.46	4,798

Table 2. Typical Analysis of Pakistani Coals by British single-crucible method

Name of Coal Field	Moisture (%)	Volatile Matter (%)	Ash (%)	Fixed Carbon (%)	Total Sulfur (%)	Calorific Value (K. cal/kg)
Mach	12.0	39.5	20.3	41.5	3.1	5,730
Sor-Range Deghari	21.2	43.1	14.3	43.0	0.4	6,060
Pir Ismail Ziarat	10.0	41.5	34.2	37.2	2.8	5939
Khost-Sharigh Harnai	11.4	45.7	38.0	45.2	1.4	7,000
Duki	9.2	53.0	22.3	38.9	2.8	6,380
Meting Jhimpir	36.6	34.2	16.8	32.2	2.9	4,260
Lakhra	39.4	42.5	25.0	39.2	1.9	4,200
Sonda	39.5	44.2	39.2	58.8	0.45	5,700
Salt Range	10.8	38.8	44.2	44.8	2.6	6,170
Makerwal	6.0	48.1	30.8	44.9	2.9	6,780
Kurd-Sho	5.8	45.2	9.0	40.2	3.1	6,100
Thar	50	48.3	26.7	33.3	0.64	5,855
FATA	2.0	12.00	34.65	30.95	5.45	4,120

Table 3. Typical Analysis of Pakistani Coals by Franco-Belgian double crucible method

Name of Coal Field	Moisture (%)	Volatile Matter (%)	Ash (%)	Fixed Carbon (%)	Total Sulfur (%)	Calorific Value (K. cal/kg)
Mach	9.2	36.5	16.2	37.1	3.1	5,300
Sor-Range Deghari	13.7	37.3	12.1	39.3	0.45	5,330
Pir Ismail Ziarat	8.1	37.0	23.4	33.7	3.0	5,599
Khost-Sharigh Harnai	7.4	39.5	19.8	35.2	1.45	5,950
Duki	6.9	43.5	12.2	24.8	2.75	5,600
Meting Jhimpir	32.3	29.4	10.6	29.3	2.85	4,070
Lakhra	23.3	34.2	17.2	27.9	1.8	3,500
Sonda	22.0	29.4	25.0	30.0	0.4	4,200
Salt Range	7.1	29.3	34.2	32.7	2.5	5,160
Makerwal	4.8	38.1	16.4	39.4	2.85	5,700
Kurd-Sho	4.5	38.5	8.1	34.1	3.0	5,600
Thar	43	44.3	14.6	30.3	0.65	5,300
FATA	2.3	15.09	37.60	40.30	5.4	4,700

(0.4-0.45) and in Thar (0.66-0.64) samples however the lowest Caloric value is 2570-4200 K.cal./kg in Lakhra and highest (4420-7000 K.cal./kg) in Khost-Sharigh Harnai samples. In the light of above data and the observation mentioned three tables we conclude that the Khost-Sharigh Harnai, Fata and Thar samples are the best in Pakistani samples, which are the best reservoir for the energy in Pakistan.

REFERENCES

Association Francaise de Normalization: Combustibles solldes, determination des matieres volatiles NF-M-03-004, June 1950

ASTM Standards on Coal and Coke: Sampling and analysis of coal and coke (D 271-48), p. 17, September 1954.

ASTM Standards on Coal and Coke: Standard definitions of terms relating to coal and coke (D 121-30), p. 108, September 1954.

Bagherieh AH, Hower JC, Bagherieh AR, Jorjani E (2008). Studies of the relationship between petrography and grindability for Kentucky coals using artificial neural network. Int. J. Coal Geol. 73, 130–138.

British Standards Institution (1942). British standard methods for the analysis and testing of coal and coke No. 1016-1942, March

Channiwala SA, Parikh PP (2002). A unified correlation for estimating HHV of solid, Liquid and gaseous fuels. Fuel, 81, 1051–1063.

Chehreh CS, Hower JC, Jorjani E, Mesroghli SH, Bagherieh AH (2008). Prediction of coal grindability based on petrography, proximate and ultimate analysis with multiple regression and artificial neural network models. Fuel Process. Technol., 89, 13–20.

Chen S, Cowan CFN, Grant PM (1991). Orthogonal least squares learning algorithm for radial basis function networks. IEEE Trans. Neural Networks, 2 (2), 302–309.

Given PH, Weldon D, Zoeller JH (1986). Calculation of calorific values of coals from ultimate analyses: theoretical basis and geochemical implications. Fuel, 65,849–854.

Hansen JV, Meservy RD (1996). Learning experiments with genetic optimization of a generalized regression neural network. Decis. Support Syst., 18 (3–4), 317–325.

Haykin S (1999). Neural Networks comprehensive foundation, 2nd ed. Prentice Hall, USA.

Hower JC, Eble CF (1996). Coal quality and coal utilization. Energy Miner. Div. Hourglass, 30 (7), 1–8.

Jorjani, E., Chehreh Chelgani, S., Mesroghli, Sh., Prediction of microbial desulfurization of coal using artificial neural networks. Miner. Eng. 2007, 20, 1285–1292.

Majumder AK, Jain R, Banerjee JP, Barnwal JP (2008). Development of a new Proximate analysis based correlation to predict calorific value of coal. Fuel, 87, 3077–3081.

Mazumdar BK (1954). Coal systematics: deductions from proximate analysis of coal part I. J. Sci. Ind. Res., 13B (12), 857–863.

Parikh J, Channiwala SA, Ghosal GK (2005). A correlation for calculating HHV from proximate analysis of solid fuels. Fuel, 84, 487–494.

Patel SU, Kumar BJ, Badhe YP, Sharma BK, Saha S, Subhasish B, Chaudhury A, Tambe SS, Kulkarni BD (2007). Estimation of gross calorific value of coals using artificial neural networks. Fuel, 86, 334–344.

Specht DF (1991). A generalized regression neural network. IEEE Trans. Neural Netw. 2(5), 568–576.

Spooner CE (1951). Swelling power of coal. Fuel, 30, 193–202. SPSS, 2004. Version 13, SPSS Inc., Help Files.

Technology Press, in Chinese.

Wasserman PD (1993). Advanced methods in neural computing. Van Nostrand Reinhold, New York, pp., 155–161. 35–55.

Yao HM (2005). Artificial neural network-based prediction of hydrogen content of coal in power station boilers. Fuel, 84, 1535–1542.

Zhenyu Z, Yongmo X (1996). Introduction to fuzzy theory, neural networks, and their applications. Beijing/Nanning: Tsinghua University Press/Guangxi Science and