Physical Cleaning of Lakhra Coal by Dense Medium Separation Method

SIKANDAR ALI CHANNA*, SAFIULLAH MEMON**, AND MUHAMMAD HASHIM RIND*

RECEIVED ON 13.11.2014 ACCEPTED ON 17.03.2014

ABSTRACT

This research is an attempt to upgrade Lakhra Lignite Coal using 'Dense Medium Separation' technique, to make it techno-environmentally acceptable product for different industries. The air-dried samples of ROM (Run of Mine) coal were crushed, screened, ground and subjected to initial analysis and specific gravity based sink-float tests. The initial analysis of air-dried samples shows the average values of moisture 19%, volatile matter 22.33%, ash 27.41%, fixed carbon 31.26% and sulphur 4.98%. The investigational results of sink-float analysis indicate that physical cleaning at particle size range from -5.6 to +0.3 mm and 75% clean coal recovery can potentially reduce the ash yield and sulphur content of Lakhra coal up to 41 and 42.4% respectively. This washed coal is techno-environmentally acceptable yield and simultaneously qualifies the quality parameters set by various industries of Pakistan.

Key Words: Physical Cleaning, Dense Medium, Lakhra Coal.

1. INTRODUCTION

Coal is an abundant, relatively cheap and widely distributed natural fossil fuel. It is known to be a polluter because coal utilization gives rise to major environmental problems due to presence of ash forming mineral material and sulfur constituents in the feed coal [1]. The relative abundance of coal in Pakistan compared to other fossil fuels makes it a natural choice as the primary source of fuel; be it for cement industry, steel making, power generation or for other consumptions. Pakistan has significant coal reserves 186 billion tons out of which the estimated reserves of Lakhra coal field are around 1.328 billion tons [2]. By reducing the impurities, a possibility of utilizing this lignite coal to its best, exists [3].

Among all the laboratory methods for separating the coal from its gangue minerals, dense medium separation technique is the simplest and cheapest one [4]. Coal washing is a common process in most of the countries where coal reserves are in sufficient quantities because of its cost effectiveness. The main criteria in coal washing are to obtain the maximum yield of clean coal of desired ash percentage from ROM coal at an economic price. Washability characteristics of coal can be best evaluated by dense media separation (Sink-Float tests). In this test the specific gravity is the only factor affecting the separation [5].

Halepota, et. al., [3] studied the washing characteristics of Lakhra coal. It was found that +20 mesh fraction of the representative coal sample can be separated at a clean coal recovery of 70% at an assumed 15% ash level, at a specific gravity of 1.52. In this investigation only one

*Assistant Professor, and ** Lecturer,
Department of Mining Engineering, Mehran University of Engineering & Technology, Jamshoro.

fraction of head sample of size (-6.68+0.833) mm was considered, which could not give good results.

Iqbal, et. al., [6] carried out studies to up-grade Dandot coal. ROM coal samples of different size were used for specific gravity based sink-float test. From the experimental results it was found that the size fraction of -50 to +2 mm at a specific gravity of 1.7 produced 68% cumulative yield with 14% ash. The product was suitable for substituting around 40% of imported coal in the local cement industry that could save 240 million USD per annum.

Das, et. al., [7] studied the washability characteristics of fine coal (-500 micron) samples by sink-float analysis in heavy liquids. The ash content was reduced from 35.5-17.0% in the clean coal with the first sample but the results obtained from the second sample were poor.

Nasir, et. al, [8] studied the wash-ability of coal samples of Azad Kashmir coal fields. The washability of 9.50x2.36 and 25.0x12.5mm size coal particleswas carried out by float and sink method. It was found from densimetric curves that the weight of sink was inversely proportional to specific gravity of liquid.

The objectives of this investigation are two-folds: First, the proximate analysis of as-received ROM coal for determining coal contents and second, optimal cleaning level of this coal, for its techno-economical use by different industries.

2. MATERIALS AND METHOD

Raw coal samples weighing 44.0 kg, collected from different mines of Lakhra coalfield operated by Indus Coal Mines (Pvt.) limited, Hyderabad, Sindh, were mixed together and then stored in polyethylene bags. This representative coal sample was designated as Head Sample which contained fines to coarser lumps. Sample was crushed using laboratory jaw crusher set at 30.0 mm. The product of jaw crusher was further processed in roll crusher. For the sufficient liberation of coal particles from associated gangue minerals, the sample was crushed up to particle size less than 6.0mm. This product was sieved by laboratory sieve shaker for 20 minutes.The sieve analysis results are given in Table 1 and the same are plotted in Fig. 1.

2.1 Proximate Analysis

The proximate analysis of Lakhra coal was carried out according to standard procedures ASTM D 3172 -07 for all the size fractions of raw coal sample. The average results obtained are shown in Table 2.

2.2 Sulphur Determination

The sulphur content was determined according to ASTM standards (D-3177) using Eschka method. The average value of sulphur content was found to be 4.98%.

2.3 Procedure for Conducting Sink-Float Tests

The solutions ofspecific gravities 1.35, 1.4, 1.45, 1.5, 1.55, 1.6,1.65 were prepared as liquids for dense medium

TABLE 1. SIEVE ANALYSIS OF ROLL CRUSHER PRODUCT

Mesh No.	Opening Size (mm)	Weight Retained (%)	Cumulative Weight Retained (%)	Cumulative Weight Passed (%)
3.5	5.60	1.75	1.75	98.25
6	3.35	18.33	20.08	79.92
14	1.40	46.93	67.01	32.99
25	0.71	15.77	82.78	17.22
35	0.50	5.09	87.87	12.13
50	0.30	5.076	92.95	7.05
60	0.25	1.56	94.50	5.5

separation, using CTC (Carbon-Tetra Chloride) and DCM (Dichloro Methane) in different concentrations. All these liquids were taken in graduated beakers and arranged in the order of increasing specific gravities. From the size fractions shown in Table 1, -0.5+0.3,-0.71+0.5, -1.4+ 0.71, -3.35+1.4 and -5.6+3.35 mm were considered for sink-float analysis. The selected size fractions of representative coal sample were used to immerse in the organic solutions of CTC and DCM at specific gravities varying from 1.35-1.65. Then the floats of each size fraction were separated and analyzed for moisture content, volatile matter, ash content, fixed carbon and sulphur content.

The sample fraction of size -0.5+0.3 mm weighing 100 grams was immersed in the solution of 1.35specific gravity. Both the sample and solution were agitated properly, then the sample was allowed to settle for 20-30 minutes to obtain two clear layers of sink and float. The fractions of float and sink were separated and filtered. Then, the sink fraction was put into solution of higher specific gravity. The sink fraction at specific gravity 1.65 and the float fractions obtained at specific gravities from 1.35-1.65were weighed after drying atroom temperature. After that, ash and sulphur analysis of these fractional floats was carried out. Finally, the cumulative weight percentage of floats, ash and sulphur contents were computed from their fractional values to obtain washability data. The same testing techniquewas used for other fractions of representative sample.

3. RESULTS AND DISCUSSION

The washability curves for the selected size fractions of representative sample were constructed by using the data and calculations of the sink-float test results as shown in Fig. 2(a-b).

It can be observed from the washability curves that -0.5+0.3 mm size fraction coal may be washed at specific gravity 1.65 which will give yield of 74% clean coal with an ash and sulphur content of 16 and 2.78% respectively. Both the ash and sulphur content gradually increase in the coal at higher specific gravities as shown in Fig. 3(a-b).

TABLE 2. PROXIMATE ANALYSIS (AVERAGE RESULTS) OF RAW COAL SAMPLE

Moisture content	19.0%
Volatile matter	22.33%
Ash content	27.41%
Fixed carbon	31.26%

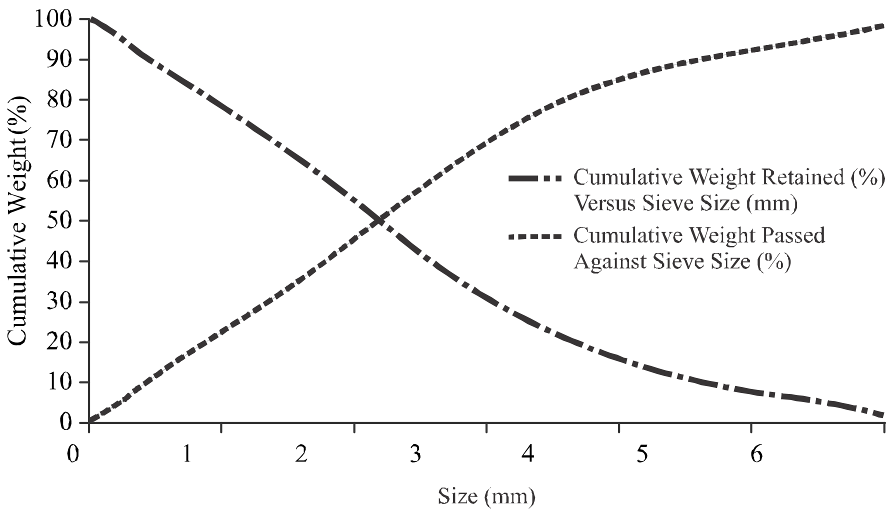

FIG. 1. SIEVE ANALYSIS OF CRUSHED PRODUCT

The washability curves show that -0.71+0.5 mm size fraction coal yields better quality of washed coal as compared to smaller size fraction at specific gravity 1.65. There is 75% yield of clean coal with 15% ash level which indicates more liberation and separation of ash forming mineralsas shown in Fig. 4(a-b).

It may be noted from washability curves that -1.4+0.71 mm size fraction coal yields 78.8% clean coal with 17.6% ash and 3.12% sulphur content at specific gravity 1.65. These results indicate less liberation and separation of impurities with higher yield of coal (float) as compared to smaller size fractionsas shown in Fig. 5(a-b).

The washability curves of -3.35+1.4 mm size fraction show 73.5% yield of clean coal with 16.3% ash and 2.61% sulphur content at specific gravity 1.65. The results indicate that lesser yield of coal float gives better quality of clean coal with considerable desulphurization rateas shown in Fig. 6(a-b).

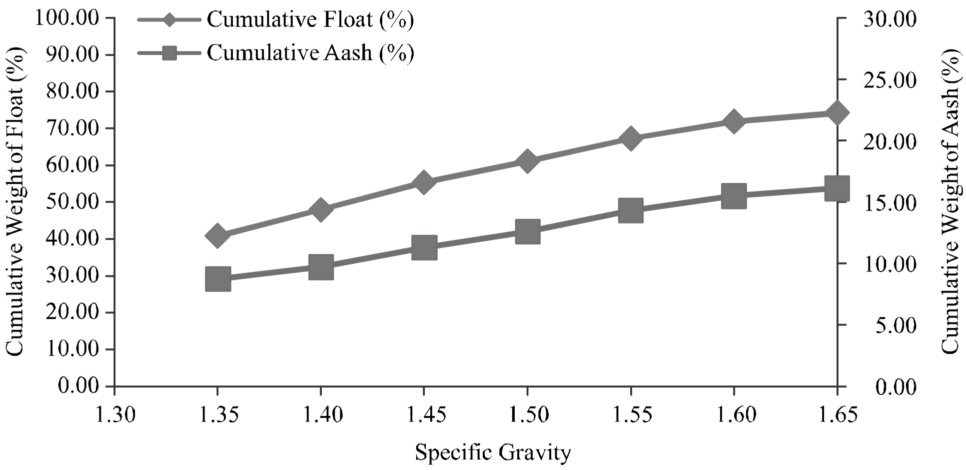

FIG. 2(a).WASHABILITY CURVES FOR SIZE FRACTION -0.5+0.3mm SHOWING CHANGE IN ASH CONTENT

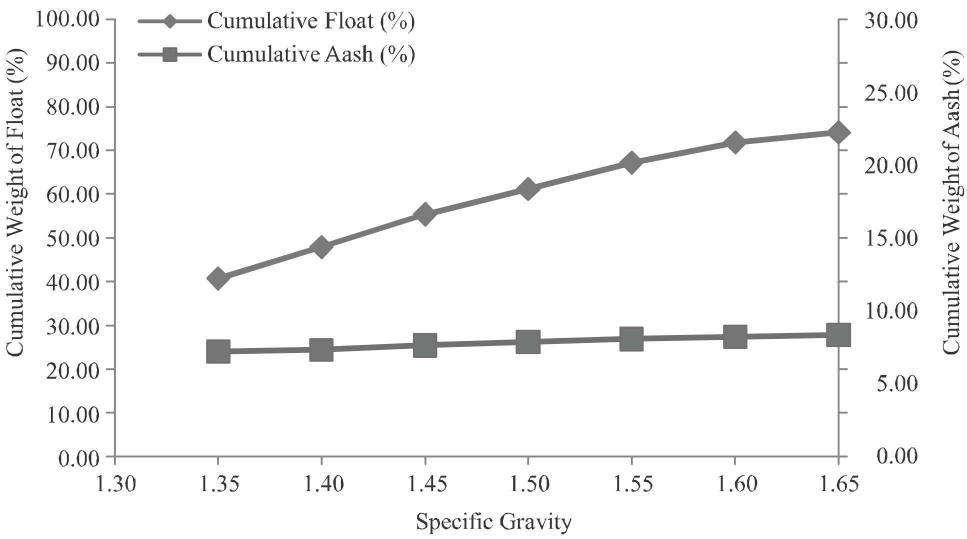

FIG. 2(b). WASHABILITY CURVES FOR SIZE FRACTION -0.5+0.3mm SHOWING CHANGE IN SULPHUR CONTENT

Study of washability curves of -5.6+3.35 mm size fraction coal reveals that there is a lesser yield of clean coal without further improvement in its quality as compared to other size fractionsat specific gravity 1.65.

Washability curves as depicted in Figs. 2-6show favorable liberation and separation of impurities from the coal particles of size ranging from -5.6to +0.3 mm with promising coal recoveryat specific gravity of 1.65. Both, the ash level and sulphur content gradually increase in the coal (floats) withincrease in specific gravity. However, the results werefound to be in the range of quality parameters established by various industries.

4. CONCLUSIONS

The physical cleaning of Lakhra Coal by dense medium sepration method was carried out and conclusion were mad:

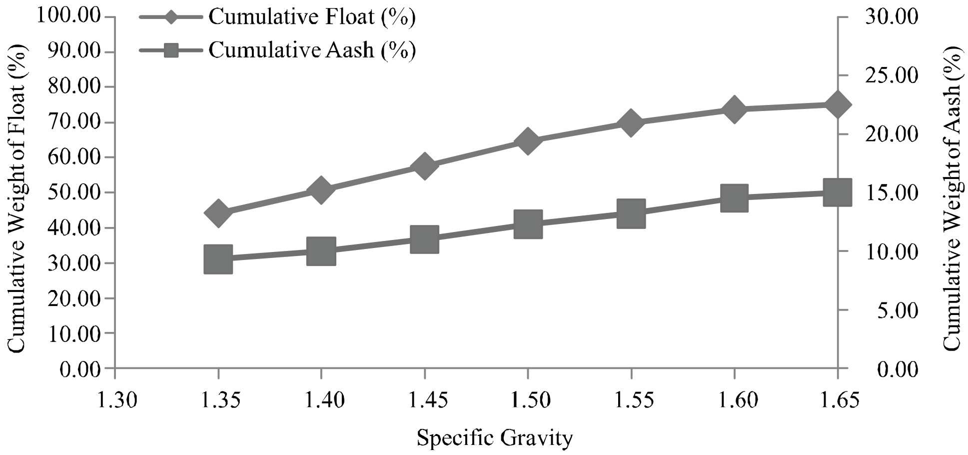

FIG. 3(a). WASHABILITY CURVES FOR SIZE FRACTION -0.71+0.5mm SHOWING CHANGE IN ASH CONTENT

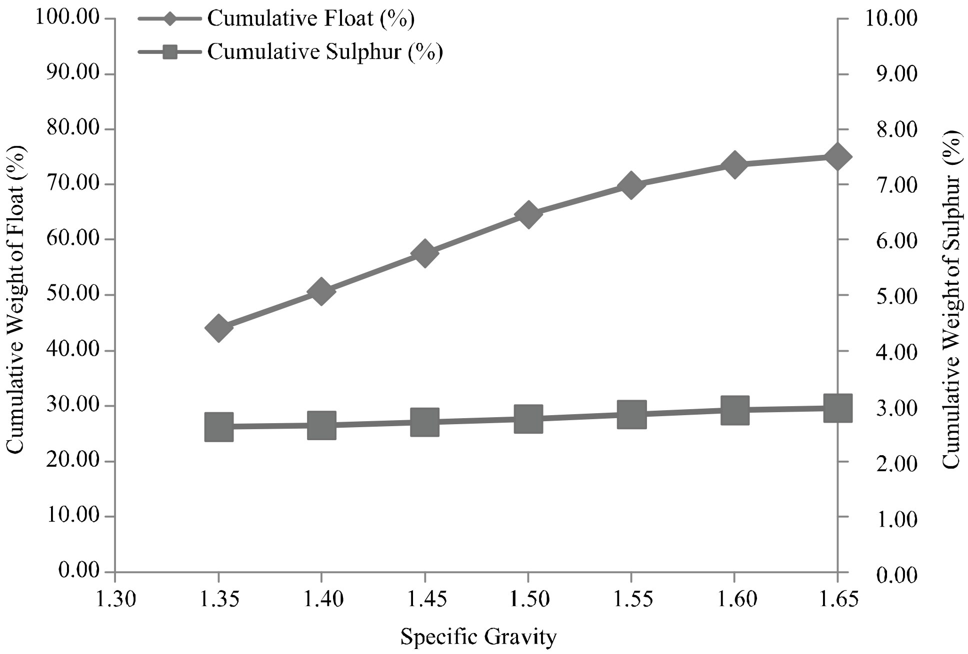

FIG. 3(b). WASHABILITY CURVES FOR SIZE FRACTION -0.71+0.5mm SHOWING CHANGE IN SULPHUR CONTENT

(i) The clean coal (Floats) recovery comes out to be 74.1, 75.0, 78.8, 73.5 and 70.3% respectively from coal sample fractions. The coal would be separated at sufficient yield level from its associated mineral metals, which are comparatively heavier than the pure coal, atspecific gravity 1.65.

(ii) Washability curves for selected sample fractions show that the physical cleaning at particle size range from -5.6 to +0.3 mm and 75% recovery of clean coal can potentially reduce the ash yield and sulphur content of raw coal up to 41 and 42.4%, respectively.

ACKNOWLEDGEMENT

Authors are extremely thankful to the authorities of Mehran University of Engineering & Technology, Jamshoro, Sindh, Pakistan, for providing facilities to carry out this research.

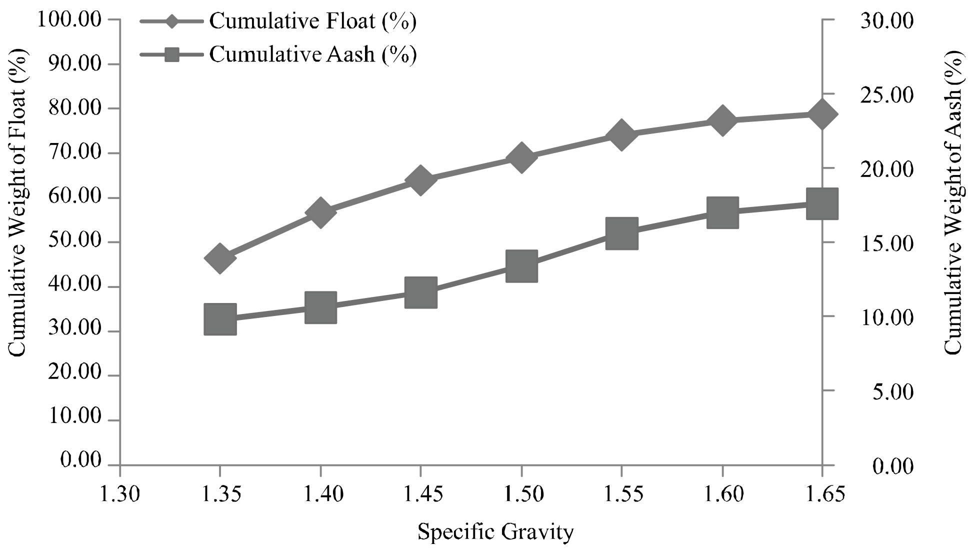

FIG. 4(a). WASHABILITY CURVES FOR SIZE FRACTION - 1.4+0.71mm SHOWING CHANGE IN ASH CONTENT

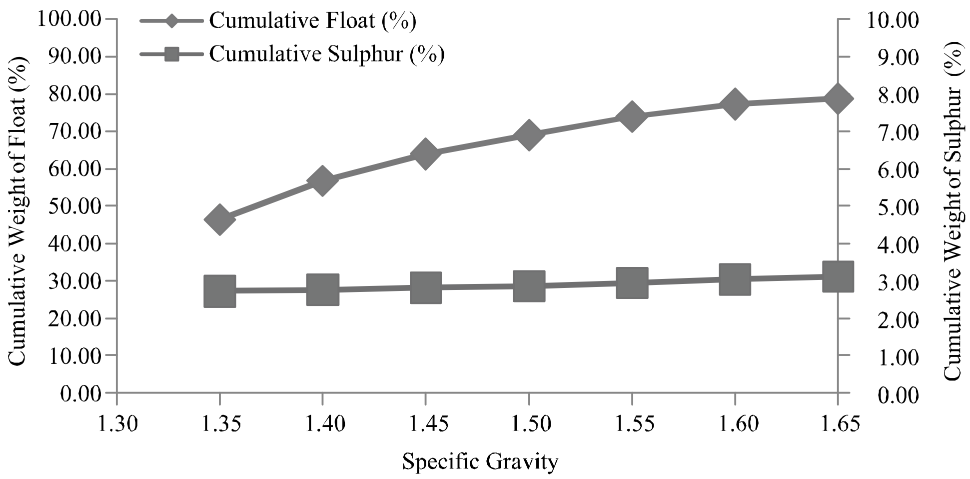

FIG. 4(b). WASHABILITY CURVES FOR SIZE FRACTION - 1.4+0.71mm SHOWING CHANGE IN SULPHUR CONTENT

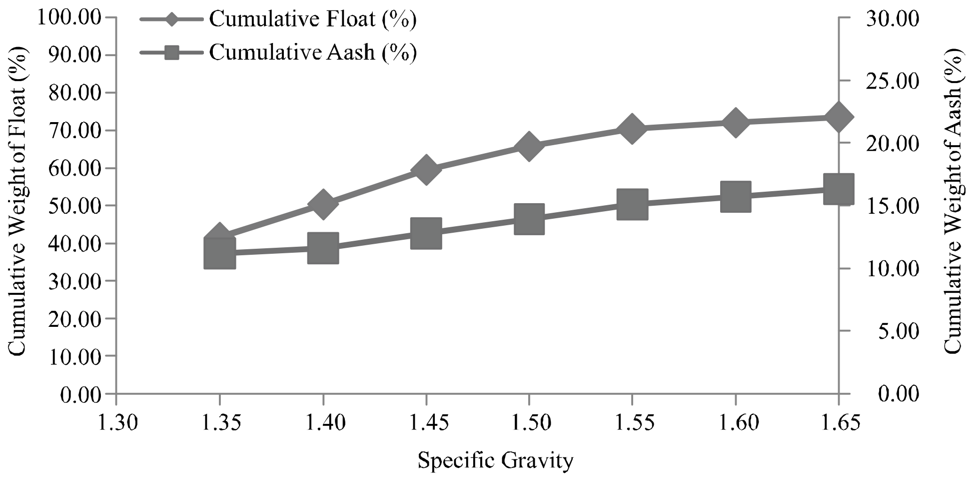

FIG. 5(a).WASHABILITY CURVES FOR SIZE FRACTION -3.35 + 1.4mm SHOWING CHANGE IN ASH CONTENT

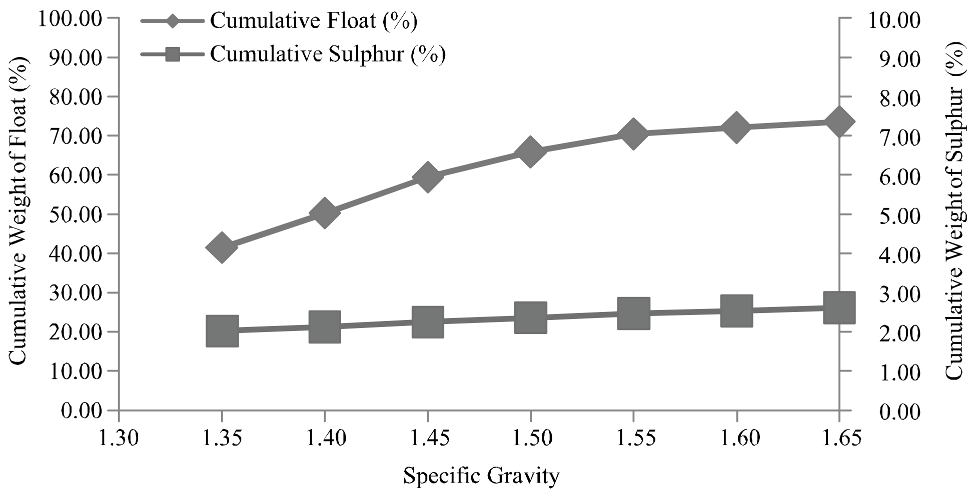

FIG. 5(b).WASHABILITY CURVES FOR SIZE FRACTION -3.35 + 1.4mm SHOWING CHANGE IN SULPHUR CONTENT

REFERENCES

[1] Yurum, Y., "Clean Utilization of Coal: Coal Structure and Reactivity, Cleaning and Environmental Aspects", NATO Science Series,Kluwer Academic Publishers, Dordrecht, Volume 370, pp. 153, 1992.

[2] Pakistan Energy Year Book, pp. 75, 2012.

[3] Halepota, G.R., Syed, A.H.R., and Channa, N.R., "Washability Study of Lakhra Coal", Mehran University Research Journal of Engineering& Technology, Volume 16, No. 1, pp. 28-32, Jamshoro, Pakistan, January, 1997.

[4] Wills, B.A., "Mineral Processing Technology", 7th Edition, Butterworth - Heinemann Publishers, pp. 246-265, UK,,2006.

[5] Jain, S.K., "Mineral Processing",Second Edition, CBHPublishing Co., pp. 166-184, New Delhi, India, 2001.

[6] Iqbal, A.,Ehsan, N., Khan, M.I., and Ashraf, I., "Analysis of Dense Medium Beneficiation of Dandot Coal for Use in Cement Industry in Pakistan", Journal of Quality and Technology Management, Volume VII, No.1, pp. 115-130, June, 2011.

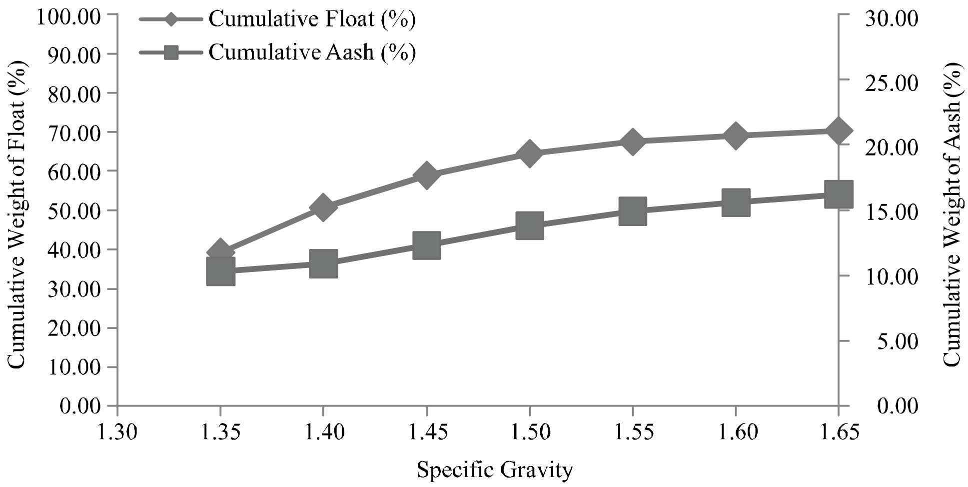

FIG. 6(a). WASHABILITY CURVES FOR SIZE FRACTION -5.6+3.35 mm SHOWING CHANGE IN ASH CONTENT

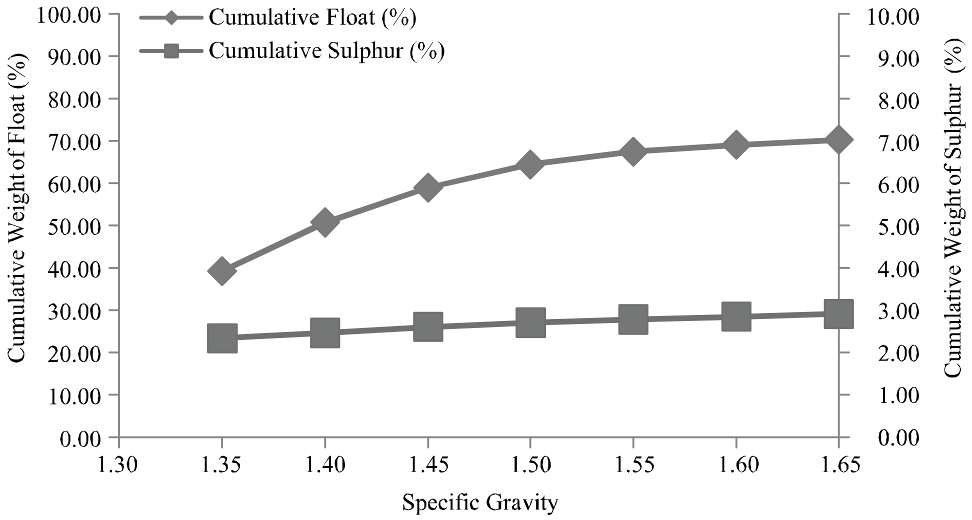

FIG. 6(b). WASHABILITY CURVES FOR SIZE FRACTION -5.6+3.35mm SHOWING CHANGE IN SULPHUR CONTENT

[7] Das, A., Singh, R., and Bhattacharyya, K.K., "Split Processing of High Ash Indian Coking Coal Fines using Jameson Flotation Cell", Mineral Processing and Extractive Metallurgy Review: An International Journal, pp. 2-6, 2010.

[8] Nasir, S., Kucerik, J., and Mahmood, Z., "A study on the Washability of the Azad Kashmir(Pakistan) Coal Field", Fuel Processing Technology, Elsevier Publication, pp. 75-81, 2012.

[9] Sarkar, S., "Fuels and Combustion", Universities Press (India) Pvt. Ltd., Third Edition, pp. 77-118, 2007.

[10] Chattopadhyay,U.S., Mukherjee, A.,Singh,K.M.P., Kabiraj,S.K., and Ghouricharan,T., "Cleaning Potentialities of Some Thermal Coals of Odisha on their Burning Behaviour", International Journal of Engineering Research and Science and Technology, Volume 2, No.2, May, 2013.

[11] Yakup, U.M.U.C.U., "Investigation of Separation Performance of Dense Medium Cyclone using Computer Simulation", Physicochemical Problems of Mineral Processing, Volume 51, No. 1, pp. 303 - 314,Turkey, March 24, 2014.

[12] Dehghan, R., and Aghaei, M., "Evaluation of the Performance of Tri-Flo Separators in Tapas (Parvadeh) Coal Washing Plant", Research Journal of Applied Sciences, Engineering and Technology, Volume 7, No. 3, pp. 510-514,Yazd, Iran, January 20, 2014.