Experimental Studies on the Benification of Fine Solids by Forth Flotation

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Abstract

In this paper, the experiments were carried out in laboratory flotation cell treating solid fines. The effect of variables such as collector oil dosage, pine oil dosage and solid content of the feed slurry have been investigated on the flotation characteristics of low rank coal. Attempts have also been made to develop some empirical Eq. to predict the yield and ash content of concentrate with the operating variables, solids concentration, collector oil dosage, and pine oil dosage, to estimate the recovery at any operating conditions. The calculated results obtained from regression equation by correlating the variables with the yield and ash content of concentrate have been compared to study whether calculated values match closely with the experimental values by using F test at any level of significance.

*Keywords***:** Flotation, Solid fines treatment by flotation.

Introduction

It has been reported in the literature, Biswal et. al. (1), Lynch et. al. (2), Trahar (3), Vanagamudi and Rao (4), and Warren (5) that the particles reach the froth phase or concentrate either by true flotation or by entrainment. True flotation occurs when the floatable particles colloid with the bubbles, attach with them and the resultant mineralized bubbles rise towards the froth level and are then scraped off. Entrainment Biswal et al(1),Lynch et al (2), Trahar (3) Warren(5) when non-floatable particles enter in the water present in between the spaces of the bubbles and continue to move upwards. During the traverse, large particles drop back to the pulp phase becomes of higher mass, whereas, fine gangue continues to move and ultimately reports to the froth Vanagamudi and Rao (4). Hence, entrainment is non-selective and has determinal effect on flotation. Warren(5) found that in a batch flotation, the recovery of floatable mineral at a particular interval of time is linearly related to the weight of water recovered in a system in which experiments are carried out by varying the height of froth coloumn, rate and depth of froth removed**.**

Froth flotation is the oldest physical separation type and has the advantages of relatively low power consumption per unit mass of material processed and a proven capacity to handle higher tonnage rates of solids, than the newer oil agglomeration procedures. The obvious disadvantages of froth flotation are its tendency to entrain very fine materials and the production of a wet froth. Both effects can potentially be reduced by a cleaner float using a hydrocarbon entrainer, but first it is necessary to establish the best performance of the roughing float. Low rank coals have a high volatile content and a high H/C ratio. A demineralized low-rank coal would thus appear to be an excellent feed-stock for liquefactions, combustion, and of several possible uses would be as the solid component in a coal-oil mixture.

In this paper a mathematical approach based on correlations between variables affecting flotation process for the yield of concentrate (Y) and ash content of concentrate (A) respectively using multiple linear regression Kennedy&Neville (6),Francis(7), Klugh (8), & Mohrotra & Saxena (9).

Correlation between variables and yield of concentrate:

The process parameters can be correlated with the yield of concentrate by an equation of the form:

$$Y = k_0 (X_1)^{k_1} (X_2)^{k_2} (X_3)^{k_3} \qquad (1)$$

Correlation between variables and ash content of concentrate:

$$A = J_0 (X_1)^{J_1} (X_2)^{J_2} (X_3)^{J_3} \qquad (2)$$

Where (Y) represents yield% of concentrate, (A) represents ash% content of the concentrate, and X_1, X_2, and X_3 represent solids concentration, collector oil dosage (Kg/t) and pine oil dosage (Kg/t) respectively.

The constants k_0, k_1, k_2, k_3, J_0, J_1, J_2 & J_3, are evaluated from the principle of multiple linear least squares regression analysis, for which **STATISTICA** program package is used for any number of constants present in regression Eq. using the experimental data.

The prediction of concentrate yield%, and ash% can be made for any given value of solid concentrate, collector oil dosage and pine oil dosage respectively within the experimental limit.

Fisher's F-Test Kennedy & Neville (6), Francis (7) & Klugh (8) is used to see how the predicted Eq. of the concentrate yield, and ash are fitted to the experimental values. The statistic F is given by:

$$F = \frac{S_X^2}{S_Y^2} \qquad (3)$$

where

$$S_X^2 = \frac{1}{(n_1 - 1)} \sum_{i=1}^{n_1} (X_i - \overline{X})^2 \qquad (4)$$

$$\overline{X} = \frac{1}{n_1} (X_1 + \dots X_{n_1}) \qquad (5)$$

$$S_Y^2 = \frac{1}{(n_2 - 1)} \sum_{j=1}^{n_2} (Y_j - \overline{Y})^2 \qquad (6)$$

$$\overline{Y} = \frac{1}{n_2} (Y_1 + \dots Y_{n_1}) \qquad (7)$$

After F is found for yield of concentrate, and ash. The tabulated value of F for 5% level of significance and degrees of freedom d.f., f_1 and f_2 is F_p.

Where

f1 = number of observations (n_1-1)

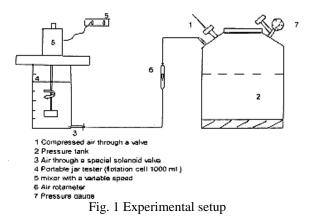f2 = number of observations (n_2-1)

F_p = tabulated value of F

Thus if $F < F_P$, then it shows a good agreement between the experimental and calculated values of yield of concentrate and calculated values of ash content of concentrate.

Experimental Work

Coal as a product of degradation of vegetable matter was prepared. The liberation size of ash in the coal was estimated at around below 100 microns and classified using standard test sieves. The size and ash distribution of sample used in these studies are given in Table 1.

Table 1 Size analysis of sample

Size, microns	Weight%	Ash%
-100+75	28.3	35.45
-75+45	22.8	40.58
-45	48.9	50.70
Total	100.0	42.24

The flotation tests were carried out in a batch laboratory flotation system as shown below:

1 Compressed air through a valve
2 Pressure tank
3 Air through a special solenoid valve
4 Portable jar tester (flotation cell 1000 ml)
5 mixer with a variable speed
6 Air rotameter
7 Pressure gauge

Fig. 1 Experimental setup

The flotation cell of 2.5 L capacity using the conditions: (1) mixing time for preparation of slurry =3min, (2) conditioning time =5 min, (3) impeller speed =1400 rpm, and (4) time of collection = 90 sec.

The pulp was conditioned with diesel oil (collector) for 5 min and after conditioning, pine oil (frother) was added at appropriate dose and solids concentration was maintained by adding required quantity of water. Then, aeration was started by operating the air valve at a pressure of 400 kPa and the froth floated concentrate was collected for 90s. The concentrate and tailings were then dewatered, dried, weighed, sub-sampled and ash content of each sample was determined. All the tests were carried out using the above procedure by varying operating conditions (Table 2).

Table 2 Operating conditions of the variables.

SL.no	Operating conditions of variables	Fixed operating conditions		
		Solids concentration %	Collector dosage kg/t	Pine oil dosage Kg/t
1	Solids concentration% (10,15,20,25)	–	2.0	1.0
2	Collector oil dosage kg/t (0.5,1.0,1.5,2.0)	25	–	1.0
3	Pine oil dosage kg/t (0.15,0.5,0.75,1.0)	25	2.0	–

Table 3 Comparison of experimental and predicted values of the test data.

SL. no	Operating variable		Experimental				Predicted	
			Cleans		Tails		Cleans	
			Yield %	Ash %	Yield %	Ash %	Yield %	Ash %
1.	Solid concentration %	10.00	35.55	20.55	70.55	45.00	35.56	20.13
		15.00	40.55	30.55	67.00	50.0	42	30.24
		20.00	45.00	28.00	55.55	50.55	45.36	28.67
	Collector oil dosage kg/t	25.00	38.00	25.00	65.5	48.50	38.06	25.02
2.		0.50	27.55	20.53	72.87	43.78	26.00	21.89
		1.00	30.83	26.55	70.15	49.10	35.15	26.00
	Pine oil dosage kg/t	1.50	42.15	24.57	59.86	50.01	37.05	27.10
		2.00	35.82	27.36	63.11	48.96	41.08	26.00
3.		0.15	29.84	20.97	70.13	48.00	31.05	24.00
		0.50	34.10	25.03	68.01	51.03	36.00	26.09
		0.75	41.08	27.10	58.99	50.00	38.01	23.98
		1.00	47.03	27.00	58.95	49.00	36.98	26.75

Results and Discussion

The regression equations using the experimental data given in Table 3 were applied for the correlations assumed above in Eq. 1 and 2 respectively to evaluate the constants for the concentrate yield% and ash content% of concentrate. Fisher's F-tests were used to see how Eq. 1 and 2 were fitted to the experimental values as follows:

The relation between concentrate yield and the variables reduces to:

$$Y = 23.002 \, (X_1)^{0.130}(X_2)^{0.330}(X_3)^{0.120} \tag{8}$$

A graphical representation for the experimental and predicted values of the test data for different solid concentration% collector oil dosage Kg/t are shown in Fig. 2 to 4.

The statistic F is calculated as 1.104 for yield of concentrate. The tabulated value of F for 5% level of significance and degree of freedom d.f. =11 and f_2 =11 is F_p =3. In this case also F< F_p results in a good agreement between the experimental and calculated values of yield of concentrate given in Table 3.
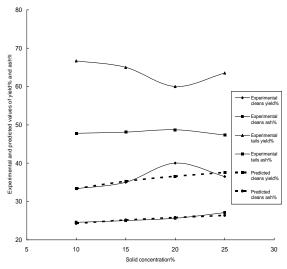

Fig. 2 Experimental and predicted values of the test data for different solid concentrations%
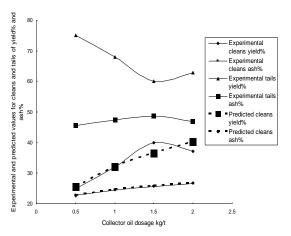
Fig. 3 Experimental and predicted values of the test data for different collector oil dosages kg/t
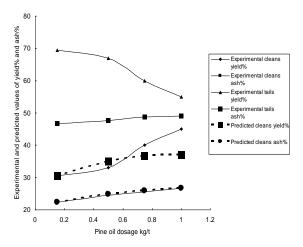

Fig. 4 Experimental and predicted values of the test data for different pine oil dosages kg/t

The relation between concentrate yield and the variables reduces to:

$$A = 18.983 \, (X_1)^{0.101} \, (X_2)^{0.120} \, (X_3)^{0.100} \qquad (9)$$

The standard deviation of the percent errors in the equation above is 0.054

The statistic F is calculated as 0.987 for ash content of concentrate. The tabulated value of F for 5% level of significance and degree of freedom d.f. =11 and f_2 =11 is F_p =3. In this case also F< F_p results in a good agreement between the experimental and calculated values of yield of concentrate given in Table 3.

The graphical representations of experimental and predicted values of the test data are shown in Fig. 2 to 4.

Conclusions

It may be concluded that when the experimental data were correlated with the operating variables through a regression equation then the estimated regression equation was found to fit within experimental limits and the same was tested and verified by using Fishers F- test at 5% level of significance.

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