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Investigation of different coal types effect on the overall plant recovery

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ABSTRACT

Coal washing plants are usually fed from various sources. Coals include different combinations which should be considered for increasing the plant proficiency. Thus different methods have been used to enrich various coal types. In this study, Alborz-Sharghi coal washing plant was investigated which is fed from five coalmines. The optimum recovery was achieved for all coal types individually through experimental design. The controllable operation parameters in the experiments were collector dosage, frother dosage, solid percent content and particle size. The other parameters such as impeller speed, pH, conditioning time and flotation time were kept constant for all experiments. The optimum combination of coals was also specified. The results show that the optimum recovery for coal blends is 91.2% which shows much improvement relative to the plant conditions.

1. Introduction

Coal is considered as an important source of energy. Coal preparation to be used as coke in steel industries, needs special mineral processing methods such as flotation practice by with considering appropriate controlled condition. Coal with less than 12% ash content and coke number of more than 7 is usually appropriate for conversion to suitable coke used in steel industries [1]. Coal flotation is a complex process involving several phases (particles, oil droplets and air bubbles). These phases simultaneously interact with each other and with other species such as the molecules of a promoting reagent and dissolved ions in water. The physical and chemical interactions determine the outcome of the flotation process [2]. More recently, the statistical techniques have been widely used to study the flotation of minerals. Design of experiments (DOE) provides a statistical means for analyzing how numerous variables interact. The tool is a planned approach for determining cause and effect relationships [3]. The statistical design experiments have several advantages over the classical method of treating one variable at a time [4,5]. Taguchi designs are a type of factorial design. Design options are available with differing numbers of factors and levels. The analysis of Taguchi designs is done using standard analysis of variance techniques [6–8]. As the case study, Alborz-Sharghi coal washing plant in Iran was selected. Fig. 1 shows the location of the plant and the mines feeding it. Owing to numerous mines feeding the plant, different types of coals must be processed in the plant. The difference is mainly due to the macerals composition of the coals.

2. Experimental and modeling procedure

2.1. Material and methods

About 150 kg samples were taken from mines which supply the feed of the Alborz-Sharghi coal washing plant. The material crushed and passed from 850, 500, and 75 μm screens. The material was classified to samples between 75 and 500 μm and samples between 500 and 850 μm as class I and class II, respectively. The percentage of solids in the feed pulp was considered for samples class I, 10% and for samples class II, 20%. To perform the tests, kerosene was used as collector and MIBC (Methyl isobutyl carbonyl) as frother.

2.2. Experimental design

Firstly at these tests the slurry was mixed and conditioned in the cell for five minute by the impeller (impeller speed was monitored by the tachometer and kept constant as 1000 r/min in all of the flotation experiments). The specified dosage of collector and frother for each of experiments was then added and conditioned for 120 s. Then flotation was carried out by adding the air and the froth collected for 180 s. To obtain the recovery and ash content, the flotation concentrate and tailing were filtered and then dried separately for each of the tests.

The main parameters are shown in Table 1. The tests were done just for the first stage of flotation (rougher), thus the recovery was

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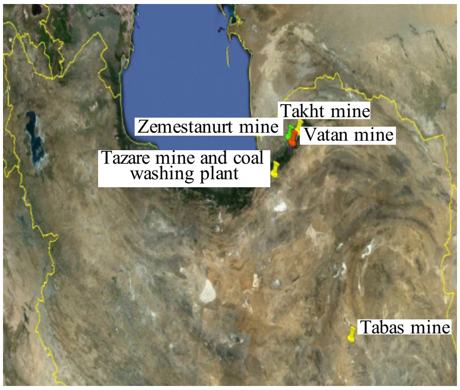

Fig. 1. Location of the feed suppliers of the Alborz-sharghi coal washing plant.

Table 1
Selected parameters and their actual.

Factor	Symbol
Collector dosage (g/t)	*A*
Frother dosage (g/t)	*B*
Solid content (%)	*C*
Particle size (μm)	*D*

selected as the response. Experiment conditions and their responses are shown in Table 2.

3. Results and discussion

Firstly, the results for all coal types were investigated individually. To optimize the process and verify creditability the experiments results, a software based design (DX8) was used. Analysis of parameters and interactions were conducted with analysis of variance (ANOVA) for all response values. ANOVA makes it possible to check that the postulated model fits well the experimental points. The model terms retained in the equations, are after elimination as insignificant variable and their interactions. Table 3 shows the analysis of variance for the coal recovery data. The results in Table 3 demonstrate that main factors, collector dosage, frother dosage and solid content were effective within 95% confidence interval.

Effects of each factor on the recovery are shows in Fig. 2.

The empirical models which relate recovery to collector dosage (*A*), frother dosage (*B*), and solid content (*C*) are presented in Eqs. (1)–(5).

$$\text{Recovery (Zemestanurt)} = 94.88 + 0.54A - 1.08B - 3.18C \quad (1)$$

$$\text{Recovery (Tazareh)} = 89.50 - 1.5A + 1.44B - 1.32C \quad (2)$$

$$\text{Recovery (Tabas)} = 82.59 - 5.10A + 0.20B - 8.66C \quad (3)$$

Table 3
ANOVA results for flotation recovery of five mines.

Mine	Source	Sum of squares	df	Mean square
Zemestanurt	Model	46.41	3	15.47
	A	1.18	1	1.18
	B	4.68	1	4.64
	C	40.54	1	40.54
Tazarehh	Model	25.52	3	8.51
	A	10.16	1	10.16
	B	8.34	1	8.34
	C	7.02	1	7.02
Tabas	Model	403.84	3	134.61
	A	104.05	1	104.05
	B	0.15	1	0.15
	C	299.64	1	299.64
Takht	Model	19.12	3	6.37
	A	5.04	1	5.04
	B	12.23	1	12.23
	C	1.85	1	1.85
Vatan	Model	2541.00	3	847.00
	A	137.06	1	137.06
	B	78.54	1	78.54
	C	2325.40	1	2325.40

$$\text{Recovery (Takht)} = 91.48 - 1.12A - 1.75B - 0.68C \quad (4)$$

$$\text{Recovery (Vatan)} = 33.37 + 5.85A + 4.43B - 24.11C \quad (5)$$

The results show that the characteristics of the coals are so different. The effect of solid content on the recovery is also illustrated in Fig. 2. It is observed that the recovery of Zemestanurt coal, Tazareh coal, Tabas coal, Vatan coalmines increased with increasing collector dosage and only the recovery of Takht coal mine decreased with increasing collector dosage, it is also observed that recovery for Zemestanurt coal, and Takht coal mines decreased with increasing in frother dosage, for the Tazareh coal mine, Tabas coal mines increased with increasing frother dosage and for Vatan coal mine slightly increased with increasing frother dosage. Thus blending these coals without a concise program is not profitable.

4. Optimum conditions

Numerical optimization technique of the Design Experts software was used for simultaneous optimization of multiple responses. Figs. 3–5 illustrate the results of optimization. In Fig. 3 optimum conditions for control parameters are as follows: collector, 2000 g/ton; frother, 150 g/ton; and solid content 10%. Optimum recovery for coal Zemestanurt, 98.5997%; coal Tazareh, 90.974%; coal Tabas, 96.1512%; coal Takht, 95.0086%; coal Vatan, 47.1958%. The optimum recovery for the best combination of coals is obtained which is 91.2%.

Figs. 4 and 5 show that the desirability of Vatan coal is the minimum of all. Thus by not taking it into account, in flotation part, the compound desirability would be increased.

Table 2
Design of experiment and responses.

Run	*A*	*B*	*C*	*D*	Recovery(%)				
					Zemestanurt	Tazareh	Tabas	Takht	Vatan
1	2500	200	10	(+75–500)	97.52	90.67	86.34	89.27	67.76
2	2000	150	10	(+75–500)	98.60	90.97	96.15	95.01	47.19
3	2000	200	20	(+500–850)	90.07	91.21	79.23	90.15	7.83
4	2500	150	20	(+500–850)	93.32	85.14	68.64	91.40	10.68