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Use of Karanja Oil for Recovery of Energy Values from Coal Washery Tailings

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ABSTRACT

The increment in generation of large quantity of fines while mining and beneficiation has led to the serious environmental issues. In this present study, non-edible oil such as Karanja oil was used as bridging liquid to recover coal fines from washery tailings sample, which were discarded while beneficiation process. The coal washery tailings sample was collected from Dhanbad, Jharkhand, with high ash content of 52.74%. The effects of pulp density, oil dosage, and agglomeration time were investigated. From the experimentation, it was found that ash rejection was in the range of 60.90% to 74.96% and organic matter recovery was in the range of 61.14% to 84.77%.

Keywords: *Karanja oil; Coal washer tailings; High ash content; Ash rejection; Organic matter recovery.*

1.0 Introduction

In India, coal is the major source of production of energy. With increase in energy requirement, mining of coal has also increasing significantly (Yadav et al 2017). The mining sector, in India, are employing modern mining techniques, heavy mechanized mining machineries to fulfil the requirement of coal by power sector as well as Iron and Steel sector. According to survey, 10-35% of total production contributes to the amount of fines and ultrafines generated. These fines, present in the slurry from coal beneficiation plant, when discarded without proper treatment pose significant threat to the environment. For beneficiation and recovery of these fines, there are several methods which can be employed such as froth flotation, selective flocculation, enhanced gravity separators, reflux classifier and oil agglomeration. Among these oil agglomeration has advantages in terms of higher yield, high ash rejection, suitable for coal containing high clay/slime (Yadav et al 2018a). Majority of literature are available on focusing lignite, sub-bituminous and bituminous coal but limited efforts have been made for the recovery of coal values from tailings (Yasar et al 2017, Temel et al 2000, Aktas and Unal, 2001) Oil agglomeration is a physicochemical process for the separation of organic (coal) from organic and inorganic mixture (coal + gangue minerals), by forming agglomerates of bigger size. In other words, shift particle size distribution towards coarser size. It exploits the surface property difference between coal and gangue mineral for the separation.

In the present study, coal waste slurry (washery tailings) from coal washery was used to recover coal fine values using karanja oil. The effect of pulp density, oil dosage and agglomeration time were analysed.

2.0 Sample Preparation and Experimental Procedure

The Coal sample was collected from Dhanbad, Jharkhand, India. The sample was prepared by series of riffling and coning-quartering to ensure uniformity in sample. The sample was subjected to dry grinding and sieved to obtain sample of coal fines below 75 micron. The size and size wise ash analysis are as mentioned in Table 1. The details of Proximate and Ultimate analysis are mentioned in Table 2. The size analyses of prepared sample used for experiments are as mentioned in Table 3.

An Agitair Flotation cell (Galigher, Model LA-500) without air addition was used for the experiments. Aqueous slurries of coal fines of -

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75µm, of desired pulp density (PD) were prepared. For each oil agglomeration test, freshly prepared slurry was taken in an agglomerating vessel of 1.5litres capacity. The experiments were carried out at fixed pulp density (3, 6 and 9% w/w of coal sample) and conditioning time of 3 min for better wettability of coal particles. Pre-determined oil dosages (OD) of non-edible oil karanja oil (KO), were added and mixing was done at agglomeration time (AT) of 5, 10, 15 min respectively. The agglomerates formed were separated by wet screening to recover agglomerates from water and mineral matter slurry. They were washed with water to remove mineral matter adhering on the surface of agglomerates and then with ethanol/acetone to ensure removal of oil and dried at 50°-60°C until constant weight was attained. The dried agglomerates were then weighed and stored in the airtight plastic bags for further analysis. The tailings was also subjected to size analysis to know the participation of particle size range, as it will be difficult to know the exact percentage of involved particle sizes (in agglomerates).

Table 1: Particle Size Distribution and Ash Analysis (Air Dried Basis)

Particle Size (mm)	Wt.%	% Ash
+0.500	2.54	51.93
-0.500 + 0.300	6.25	52.06
-0.300 + 0.212	10.77	52.49
-0.212 + 0.150	8.30	52.27
-0.150 + 0.106	11.79	52.36
-0.106 + 0.075	19.49	52.77
-0.075 + 0.053	20.43	53.52
-0.053	20.44	52.81
	100	**52.74**

Table 2: Proximate Analysis of Feed Coal Sample

Proximate Analysis	
% Moisture	3.37
% Volatile Matter	9.17
% Ash	52.74
% Fixed Carbon	34.72
Ultimate Analysis	
% Carbon	38.27
% Hydrogen	2.53
% Nitrogen	3.79
% Sulphur	0.93
% Oxygen + % Ash	54.48

Table 3: Size Analysis of Prepared Sample

Particle Size (mm)	Wt. %	% Ash
-0.075 + 0.053	18.25	52.56
-0.053 + 0.045	16.23	53.26
-0.045 + 0.038	16.75	53.24
-0.038 + 0.023	16.30	52.27
-0.023 + 0.015	17.38	52.75
-0.015 + 0.011	8.58	52.28
-0.011	6.50	52.55
	100	**52.74**

The efficiency of this process was based on responses% ash rejection (% AR) and % organic matter recovery (% OMR) which were calculated by the formulae as-

$$\% AR= 100 \times [(A_f-(A_p x W_p/W_f))/A_f] \quad ...(1)$$

$$\% OMR= 100 \times (W_p/W_f) \times [(100-A_p)/(100-A_f)] \quad ...(2)$$

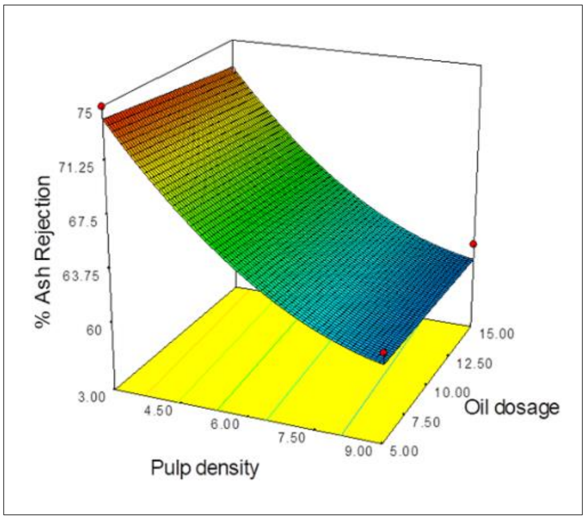
Where, W_p= weight of agglomerated coal, W_f = weight of sample coal, A_p = Ash of agglomerated coal and A_f = Ash of sample coal. The observed value obtained from experiment with varying process variables are presented in Table 2.

3.0 Result and Discussions

The process was evaluated on the basis of ash rejection and organic matter recovery. The 3D plots were used to evaluate the response of oil agglomeration for recovery of clean coal from coal-water slurry.

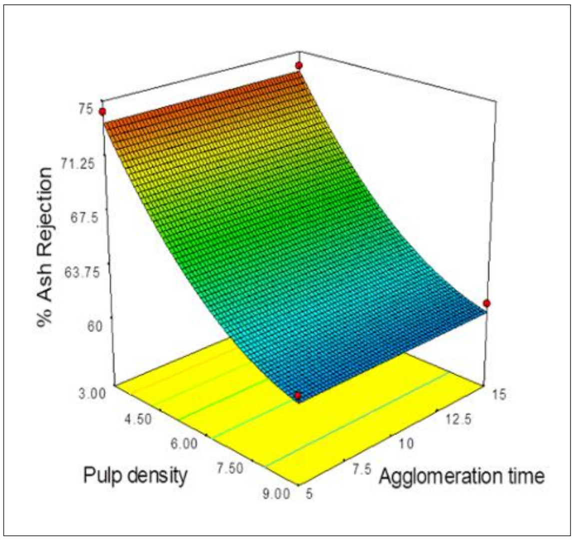
From Figure 1, it can be observed that with increase in pulp density at constant OD and AT, ash rejection found to be decreased, which can be attributed to the increase in number of particles present in the suspension for the same volume of slurry. Also, at high PD, the ratio of oil droplets to clean coal and gangue mineral will be low in comparison to that of low PD. As the sample contained significant amount of ashy or gangue mineral content, the increase in pulp density resulted in higher probability of entrapment of gangue mineral within agglomerates formed, which resulted in lower ash rejection at higher pulp density. Also, with increase in OD at constant PD, there is slight reduction in %AR, which can be due to the involvement of less hydrophobic or gangue mineral involvement at high OD. At high PD and OD, % AR found to be reduced, whereas, at high PD and OD, a slight increase in % AR can be observed (Yadav et al 2018a-b, Yasar et al 2017).

Figure 1: Effect of Pulp Density and Oil Dosage on % AR



From Fig. 2, it can be observed that with increase in PD at constant AT, %AR found to be decreased, which can be attributed to the increase in probability of collisions between particles, as the system was crowded with particles at high PD. As increase in PD means the increment in number of particles for the given volume of slurry. Also, it can be observed from Fig. 1-2, that at constant PD and OD, with increase in AT no significant change in %AR observed.

Figure 2: Effect of Pulp Density and Agglomeration Time on % AR



From Fig.3, it can be seen that, at constant PD and increase in OD (from 5% to 15%) significant increase in % OMR can be observed. Also, at constant OD and increase in PD, % OMR can be observed to be increased upto certain limit, then again there is a slight decrease can be observed. The variation in % OMR with change in OD can be seen significant at low PD in comparison to high PD, which can be attributed to the involvement of gangue minerals along with clean coal. Therefore, at higher PD, OMR decreased (Temel et al 2009, Unal and Aktas, 2001).

Figure 3: Effect of Pulp Density and Oil Dosage on % OMR

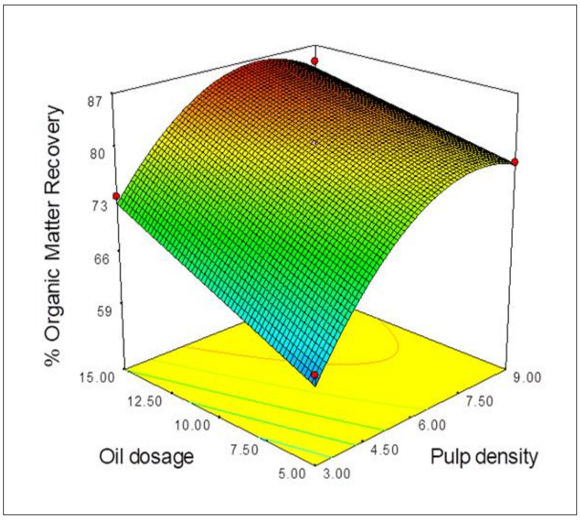
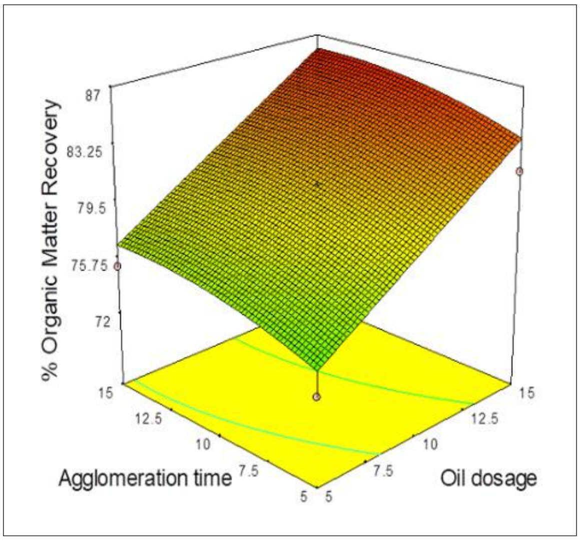
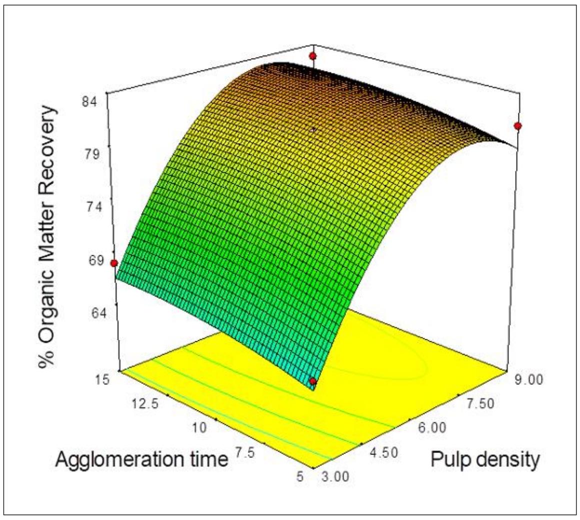


Figure 4: Effect of Oil Dosage and Agglomeration Time on % OMR



From Figure 4-5, it can be seen that with increase in AT, at constant OD, the change in % OMR is significant in comparison to change in PD.

Figure 5: Effect of Pulp Density and Agglomeration Time on %OMR



4.0 Conclusions

Coal washery tailings were treated by oil agglomeration using Karanja oil as bridging liquid. The pulp density, oil dosage and agglomeration were varied and their effect were analyzed. From the experiments, it was found that significant amount of coal values can be recovered with sufficient recovery from the tailings. The lowest ash content in recovered coal (29.03%) with yield of 50.63% was observed at PD 3%, OD 15% and AT 15 min. Usage of Non-edible oil can be better option for lowering down process economics.

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