

INDUSTRIAL APPLICATION OF VALUABLE MATERIALS GENERATED FROM PLK ROCK-A BAUXITE MINING WASTE

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Abstract.

PLK rock classified in to two products after a selective grinding to a particular size fraction. PLK rocks ground to below 45-micron size which is followed by a classifier i.e. hydrocyclone. The ground product classified in to different sizes of apex and vortex finder. The pressure gauge was attached for the measurement of the pressure. The production of fines is also increasing with increase in the vortex finder diameter. In order to increase in the feed capacity of the hydrocyclone, the vortex finder 11.1 mm diameter and the spigot diameter 8.0 mm has been considered as the best optimum condition for recovery of fines from PLK rock sample. The overflow sample contains 5.39% iron oxide (Fe_2O_3) with 0.97% of TiO_2 and underflow sample contains 1.87% Fe_2O_3 with 2.39% of TiO_2 . The cut point or separation size of overflow sample is 25 μm . The efficiency of separation, or the so-called imperfection I, is at 6 μm size. In this study, the iron oxide content in underflow sample is less than 2% which is suitable for making of refractory application. The overflow sample is very fine which can also be a raw material for ceramic industry as well as a cosmetic product.

Key words: Bauxite, PLK rock, Hydro cyclone, Overflow, Underflow, Cut point

1. INTRODUCTION

Bauxite mining belt covers the east coast region of Odisha and Andhra Pradesh. NALCO's Bauxite Mines at Panchpatmali, Koraput, Odisha. During bauxite mining of 63.4 lakh tonnes per annum, an equal amount of Partially Laterized Khondalite (PLK) rocks associated with kaolinised khondalite rocks are also being generated and dumped as waste material at mining area or sometimes used for back filling of abandoned mines. Fig.1 shows the mine site at NALCO, Damanjodi. This can be a valuable product after suitable beneficiations.

The hydro cyclone is a one of the classifier which separates the coarse and fine materials in liquid medium by using the fluid pressure to generate centrifugal force.

Prasad Rao et al. (Prasad Rao et al., 1995) studied on Shimoga kaolin clay. The beneficiation studies involving hydrocyclone and sluicing to improve the clay content from 25% to 95% which is suitable for industrial use. Qian et al. (2007) studied the effects of different inlet particle concentrations on the separation efficiency.

Gao et al. (Gao et al., 2008) studied on low-grade diasporic bauxite by using a hydrocyclone of small cone-angle. He studied about the separation indices with different process parameters like apex diameter, feed pressure and feed concentration. Recovery of Al_2O_3 increases in underflow with increase in apex diameter. The separation indexes were improved by increase in feed pressure, but were worst with increase in feed concentration.



Kuang et al. (2012) studied the effects of feed solid concentrations on the hydro cyclone separation performance. In their experiments, the solid concentration varied from 1% to 25% by volume, and the separation efficiency decreased as the feed solid concentration increased.

Liu et al. (2014) studied the circulation flow in a hydro cyclone, and they determined that higher separation efficiency results in a narrower circulation flow distribution area and a lower flow rate. If the feed flow rate is excessively large, the circulation flow will negatively affect the separation efficiency. Zhu and Liow (2014) found that the entrainment of small particles within the wake of a large particle is the major cause of the fishhook effect. As the particle size (DP) increased, the separation efficiency was higher because of a more dominant centrifugal effect.

Abdollahzadeh et al. (Abdollahzadeh et al., 2015) observed that the separation performance of the mini-hydro cyclones increased as the inlet flow rate increased, and the separation efficiency decreased when the feed flow rate continuously increased. The feed flow rate ($P < 0.001$) significantly affected the separation efficiency.

Ghodrat et. al. (Ghodrat et. al., 2014) studied on the multiphase flow and performance of hydrocyclone. Separation efficiency was much more significant with vortex finder than shape and diameter of hydrocyclone. It was also showed opposite trend at low and high feed solid concentration.

In this paper, the sample (PLK rocks) prepared and classified into two products. Here the both product characterisation are projected, based on which the material applies for industrial applications.

2. MATERIALS AND METHODS

PLK rocks crushed and ground to a particular size below 100 μm size. Sample was classified using hydrocyclone. Fig. 2 shows the ROM of PLK rocks which is to be crushed for a particular size.



Fig.1 Bauxite mining area
of NALCO, Damanjodi



Fig.2 PLK rock sample

The Mozley C 155 one-inch hydrocyclone was used for the classification study. The different sizes of apex and vortex finder were used for the classification of the sample. The pressure gauge was attached for the measurement of the pressure. The dimensions of different parts of the hydrocyclone were given below:

Cyclone size:	mm	50
Vortex finder diameter:	mm	14.3, 11.1, 8.1
Spigot diameter:	mm	8.0, 6.3, 4.7
Pressure:	psi	5

The particle size analysis of overflow and underflow were determined by using standard sieves and as well as by using particle size analyzer (Cilas 1064). The iron content of overflow and underflow samples was determined by wet chemical method. The tromp curve was plotted with respect to the average size vs. percentage of underflow responded to the feed. This was referred as d_{50} size. The efficiency of separation, or also called as imperfection I, has been given by:

$$I = (d_{75} - d_{25}) / 2 * d_{50} \quad (\text{Eq. 1})$$

At first instance an attempt has been made to recover superfine particles from the optimum mesh of PLK rock ground sample using hydrocyclone at different operating conditions. The main aim of the cyclone study is to only recovery of fines for leaching studies. Hence, the details of cyclone design and other theoretical aspects are not given as priority.

3. RESULT AND DISCUSSION

The results of these studies are given in Table 1; the data indicate that with increase in the spigot diameter for a constant vortex finder diameter, the production of the fines is increasing. This observation is same for other vortex finder diameters. The production of fines is also increasing with increase in the vortex finder diameter. In order to increase in the feed capacity of the hydrocyclone, the vortex finder 11.1 mm diameter and the spigot diameter 8.0 mm has been considered as the best optimum condition for recovery of fines from PLK rock sample. The physical and chemical analyses of hydrocyclone overflow and underflow samples are given in Table 2.

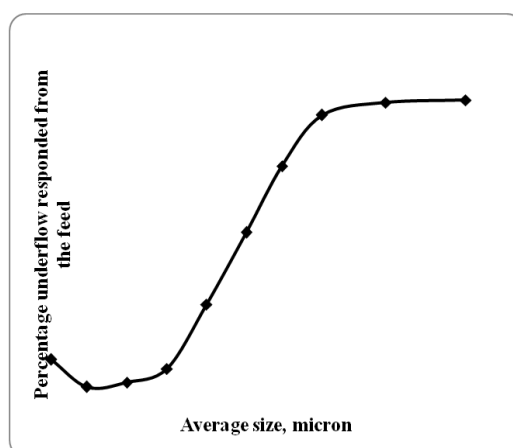


Fig. 3. Particle size analysis of hydrocyclone overflow sample

Table 1.Hydrocyclone studies on PLK sample at different conditions

Exp No.	Vortex finder, mm	Spigot dia., mm	Pressure, psi	Products	Wt., %	Fe ₂ O ₃ , %
1	14.3	8.0	5	Overflow	59.7	5.81
				Underflow	40.3	2.10
				Total	100	4.31
2	14.3	6.3	5	Overflow	58.6	5.30
				Underflow	41.4	2.91
				Total	100	4.31
3	14.3	4.7	5	Overflow	42.1	5.91
				Underflow	57.9	3.14
				Total	100	4.30
4	11.1	8.0	5	Overflow	69	5.39
				Underflow	31	1.91
				Total	100	4.31
5	11.1	6.3	5	Overflow	56.7	5.61
				Underflow	43.3	2.62

				Total	100	4.31
6	11.1	4.7	5	Overflow	40.8	6.31
				Underflow	59.2	2.93
				Total	100	4.30
7	8.0	8.0	5	Overflow	33.3	6.82
				Underflow	66.7	3.11
				Total	100	4.34
8	8.0	6.3	5	Overflow	31.3	6.91
				Underflow	68.7	3.23
				Total	100	4.38
9	8.0	4.7	5	Overflow	25	7.11
				Underflow	75	3.41
				Total	100	4.33

Table 2 Physical and chemical characteristics of the hydrocyclone overflow and underflow samples

Details	Particle size analysis			Chemical analysis				
	d ₁₀ , μm	d ₅₀ , μm	d ₉₀ , μm	Al ₂ O ₃ , %	SiO ₂ , %	Fe ₂ O ₃ , %	TiO ₂ , %	LOI, %
Overflow	0.86	4.11	13.09	37.09	40.92	5.39	0.97	15.6
Underflow	4.49	31.45	73.55	37.71	41.89	1.87	2.39	16.1

The data indicate that the overflow sample contains 5.39% Fe₂O₃ whereas underflow sample contains 1.87% Fe₂O₃. The overflow sample having 0.97% of TiO₂ whereas underflow sample contains 2.39% of TiO₂. The performance or partition curve for the hydrocyclone is shown in Fig. 3. This helps in measuring the efficiency of hydrocyclone.

This gives the relation to the weight fraction of each particle in feed which reports to apex or undersize particle. The is also found that the cut point or separation size of overflow sample is 25 μm. As per the definition of cut size, the size is determined at 50% of the particles passing through that particular sieve. The efficiency of separation, or the so-called imperfection I, is at 6 μm size.

$$I = (d_{75} - d_{25})/d_{50} \quad (\text{Eq. 2})$$

$$I = (31-19)/2 = 6$$

The complete chemical analysis of hydrocyclone overflow and treated as well as preconcentrated samples are given in Table 2. The data indicate that the overflow sample contains 5.39% Fe₂O₃ and underflow sample contain 1.87% of Fe₂O₃. Particle size analysis data of the sample are also given in Table 2. The data for the classified sample indicate that that d₁₀ passing size is 0.86 μm, d₅₀ is 4.11 μm and d₉₀ is 13.09 μm. The data for sample 2 indicate that that d₁₀ passing size is 1.12 μm, d₅₀ is 5.47 μm and d₉₀ is 20.33 μm.

The XRD of the hydrocyclone overflow sample is shown in Fig. 4. It is observed from this data that it contains major minerals such as kaolinite, gibbsite and goethite followed by minor minerals such as orthoclase, quartz, hematite and magnetite. The SEM of the overflow sample is also shown in Fig. 5. It is clearly found that the iron patches are present within the clay. The XRD of the hydrocyclone underflow sample is shown in Fig. 6. The major minerals are kaolinite and quartz whereas the minor minerals are orthoclase, hematite and goethite. The SEM of the underflow sample is also shown in Fig. 7. A small stone like feature found in this figure, which represents the presence of quartz with other impurities.

The characterisation data indicates that the underflow sample is one of sample can be utilised in refractory and ceramics as it contains less than 2% iron oxide. The fine samples i.e. overflow

sample contains high amount of iron oxide and it can be utilised as a high-grade filler material after a suitable beneficiation technique.

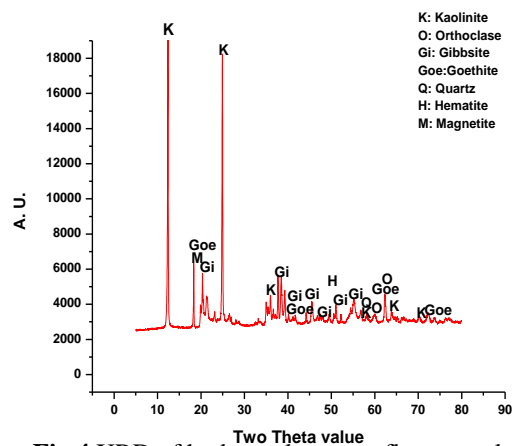


Fig.4 XRD of hydrocyclone overflow sample



Fig. 5 SEM of hydrocyclone overflow sample

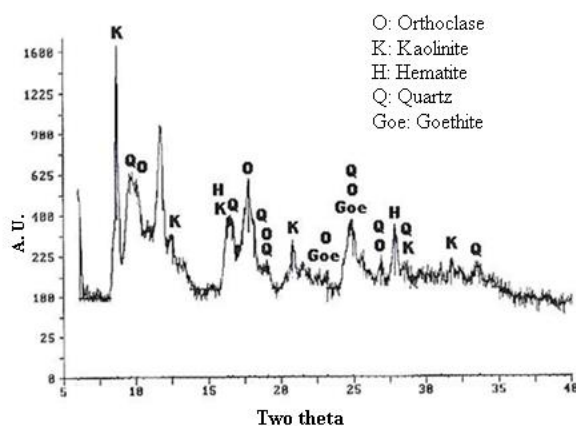


Fig. 6 XRD of hydrocyclone underflow sample

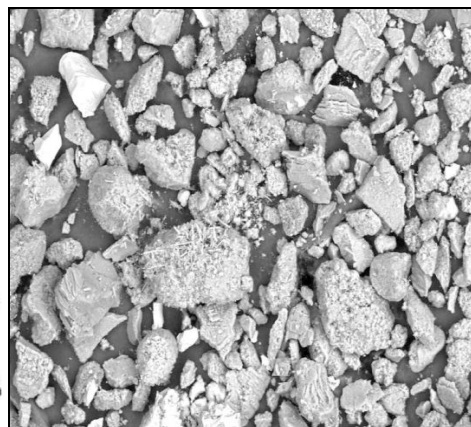


Fig.7 SEM of hydrocyclone underflow sample

4. CONCLUSIONS

This bauxite mining waste can be a potential mineral resource, which can fulfil the demand of refractory, ceramic, filler and other industries. The hydrocyclone overflow sample contains 5.39% iron oxide (Fe_2O_3) and underflow sample contains 1.87% Fe_2O_3 . Underflow sample is suitable for refractory brick preparation as it contains less iron content. Overflow sample also can be filler material after suitable beneficiation techniques.

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