

Processing of Fine Grained Iron Ore and Coal Samples Using Multi-Gravity Separator

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Abstract

One of the major problems of gravity based methods has been their limitation in treating particles in relatively fine size range. However, application of centrifugal forces in some of the recent gravity separators (e.g. Kelsey Jig, Knelson Concentrator, Falcon Concentrator, Multi-gravity Separator etc.) have been developed that can treat particles of much lower sizes. Development of Multi-Gravity Separator (MGS) by M/s Richard Mozley Limited, U.K. is considered to be one of the potential equipment for the treatment of fines and ultra-fines in the range of 500-1 micron. This paper deals with the results of studies carried out on recovery of mineral values from typical Indian iron ore slimes and coal fine samples using this equipment. In case of iron ore slimes, assaying 7.49% Al₂O₃ with 68% particles passing below 44 micron, it was possible to reduce alumina ~2% with a yield of 42%. Similarly, the clean coal products of coking and non-coking coal fines samples resulted in ash contents of 16.43% and 31.55% with yields of 47.3 % and 83.5% respectively.

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1. Introduction

Gravity separation of minerals has traditionally been recognized as a low cost and environmental friendly process for the separation of minerals [1]. However, in most cases, the traditional gravity concentrators (i.e. jigs, spirals and dense media cyclones) loose efficiency in fine particle size range. Further in fine size range fluid and viscous forces become dominant relative to the gravity and this in turn affects the separation efficiency. However, in recent past efforts have been made to develop gravity separators to treat the fine particles efficiently. The enhanced gravity separators such as Kelsey Jig, Knelson Concentrators, Falcon concentrator and Multi-gravity Separator have been developed that can treat much lower size particles [2]. These enhanced gravity separators are gravity concentrators that employ centrifugal forces to enhance the relative settling rate of particles by rotating the separating vessel itself. At NML studies were undertaken on processing of fine grained mineral particles using different enhanced gravity separators. Development of Multi-Gravity separator (MGS) by M/s Richard Mozley Limited, U.K. is considered to be one of the potential equipment for the treatment of fines and ultra-fines in the size range of 500-1 μ m. This paper presents the salient results of the studies carried out on recovery of mineral values from typical Indian iron ore slimes and coal fines (both coking and non-coking) using this equipment.

2. Materials and Methods

Basically three samples viz. iron ore slimes, coking coal and non coking coal fines were used for the present study. The iron ore slime contains significant quantity of iron values assaying 55.51% total Fe. The granulometry is such that around 67.8% material is below 44 microns. Mineralogical studies had indicated that the slime primarily consists of goethite, hematite, and clay with minor quartz and gibbsite. The coking coal and non coking coal contain ash around 33.25% and 38.62% respectively in feed.

The chemical composition and particle size distribution of the three samples are given in Tables 1, 2 and 3.

Table 1 Chemical analyses of iron ore slime

Constituents	Assay, %
Fe(T)	55.51
Al ₂ O ₃	7.49
SiO ₂	4.24

Table 2 Particle size distribution of iron ore slime

Particle size, micron	Weight %
- 147 + 105	7.9
- 105 + 74	8.8
- 74 + 63	3.8
- 63 + 44	11.7
- 44	67.8

Table 3 Size and size-wise ash analyses of coal samples (both coking and non-coking coal)

Particle size, mesh	Coking coal		Non-coking coal	
	Weight %	Assay, % ash	Weight %	Assay, % ash
+28	6.5	22.90	12.6	28.77
- 28 + 35	14.7	22.51	34.2	42.84
- 35 + 48	16.0	21.83	5.4	33.10
- 48 + 65	18.8	24.34	5.4	30.17
- 65 + 100	14.5	29.10	3.8	31.45
-100 + 150	12.4	38.45	6.4	34.09
- 150 + 200	4.2	49.22	5.4	37.45
- 200	12.9	77.29	26.8	43.03
Head	100.0	33.25	100.0	38.62

Multi –Gravity Separator

Multi-gravity separator (MGS) is considered to be a potential equipment for the separation of particles in fine size range. The equipment is based on a concept developed by M/s Richard Mozley Limited, U.K. [3]. The principle of MGS may be visualised by rolling the horizontal surface of a conventional shaking table into a drum and rotating the same along the horizontal axis. Combined effect of centrifugal acceleration and forces in the conventional tables is responsible for desired separation. This causes application of an enhanced gravitational force, many folds higher than the normal one, on the mineral particle flowing across the surface. This leads to improvement in the treatment of fine particles in comparison to conventional separators like shaking table.

The schematic diagram of MGS is shown in Fig. 1. This basically consists of slightly tapered open ended 0.6 m long horizontal drum with a diameter of 0.5 m. The drum rotates in clockwise direction with a variable speed between 140 and 300 rpm leading to generation of a gravitational pull between 6 to 24 'g' on the drum surface. A sinusoidal shake with amplitude varying between 12 mm to 25 mm is superimposed upon the motion of the drum in an axial direction. The shaking frequency ranges between 2 and 6 cps. The drum is provided with a scraper assembly which also rotates in the clockwise direction but at a slightly faster speed. The important variables affecting the separation of minerals using MGS are the rotational speed of the drum, the shake intensity, the wash water flow rate, the angle of tilt and the flow rate and pulp density of the feed. Feed in the form of slurry is introduced midway into the drum via an accelerator ring launder. Due to the high centrifugal force and the shearing effect of the shake, heavy particles migrate through the slurry film and are deposited against the wall of the drum. These heavy particles in turn are conveyed by the scraper towards the open end of the drum to discharge into the concentrate launder. The wash water added through another ring accelerator cleans the heavies and carries away the lighter particles to the rear of the drum to discharge into the tailings launder.

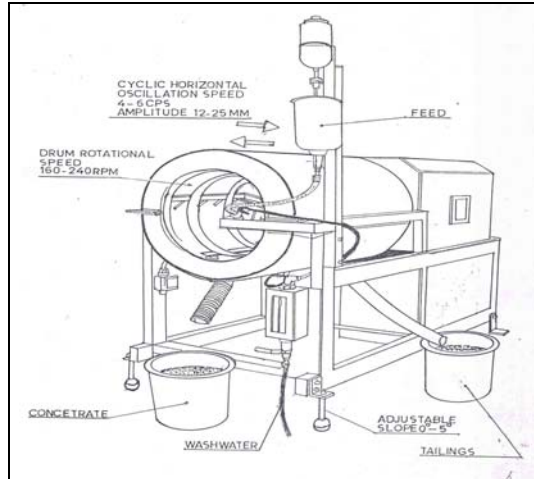


Fig 1 Schematic diagram of multi-gravity separator

3. Results and Discussion

The results on the beneficiation of iron ore slime and coal fine samples are discussed below:

Processing of Iron Ore Slimes

The iron ore slime sample containing 55.5% Fe with 7.49% Al_2O_3 and 4.24% SiO_2 consists of 67.8% particles passing below 44 microns (Table 1, 2). The typical results of the effect of drum rotational speed, pulp density and wash water on recovery of mineral values are shown in Figs. 2 to 4. As it can be seen from Fig. 2 an increase in drum speed from 160 to 240 rpm, there is an increase in yield of iron ore concentrate from 17.5 to 52.5% with a corresponding increase in alumina content of the products from 1.63 to 3.70%. With an increase in pulp density there is an increase in yield of iron ore concentrate but with an adverse effect on alumina content of the product (Fig. 3). A pulp density of 25% was maintained for further studies to accommodate higher percentage of solids without much deterioration in the grade [3]. The results depicted in Fig.4 clearly show that wash water plays an important role in the reduction of alumina content in the sample. An increase in wash water from 3 to 7 lpm helped in reducing alumina and silica contents but with a lowering in yield. The results show that a yield of 42% could be achieved with alumina of 2.05%. Even it was possible to get concentrate with 1.61% Al_2O_3 but yield was relatively low.

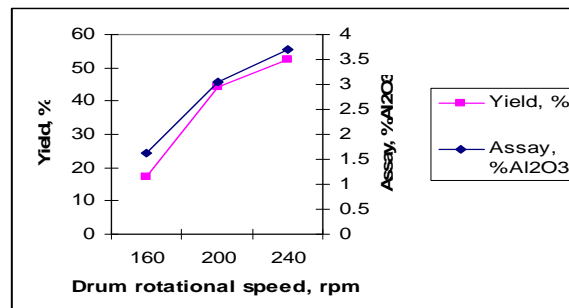


Fig 2 Effect of drum rotational speed on concentration of iron ore slimes

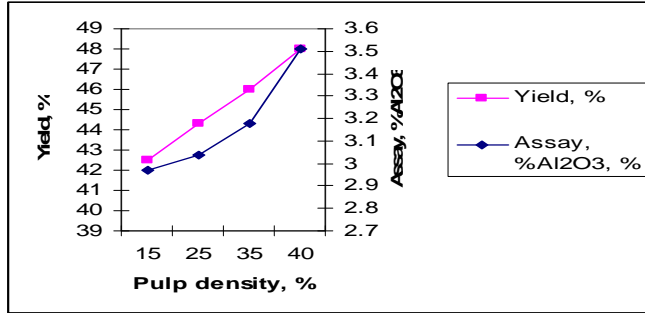


Fig 3 Effect of feed pulp density on beneficiation of iron ore slimes

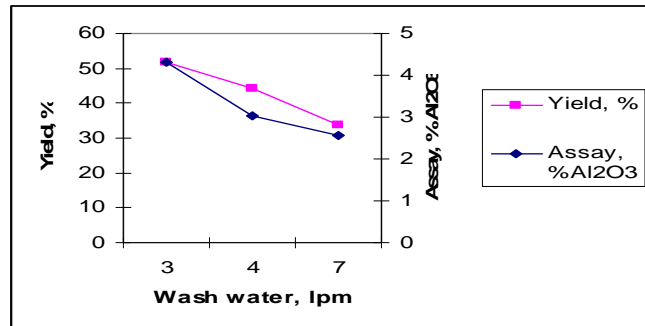


Fig 4 Effect of wash water on concentration of iron ore slimes

De-ashing of Coal Fines

Studies were undertaken to process high ash coking and non-coking coal fines using MGS. Typical results showing the effects of drum rotational speed on processing of coking coal fines are shown in Fig.5. As it can be seen with an increase in drum speed from 240 to 280 rpm at 25% pulp density, a better clean coal can be produced. At 280 rpm a clean coal having 16.43% ash with 47.3% recovery can be achieved from a feed of 33.25 % ash. Few experiments were conducted under varying pulp density. There was marginal effect on ash content of clean coal with a change in pulp density for 25 to 30%.

The results on non-coking coal sample are shown in Table 4. As it is evident that with increasing drum rotational speed there is lowering in ash content from 32.33% to 31.55% with a decrease in yield of clean coal from 87% to 83.5%. The product is considered to be suitable for generation of thermal power. At 260 rpm, clean coal with ash content 31.55% could be achieved from a feed of 38.62% ash with a yield of 83.5%.

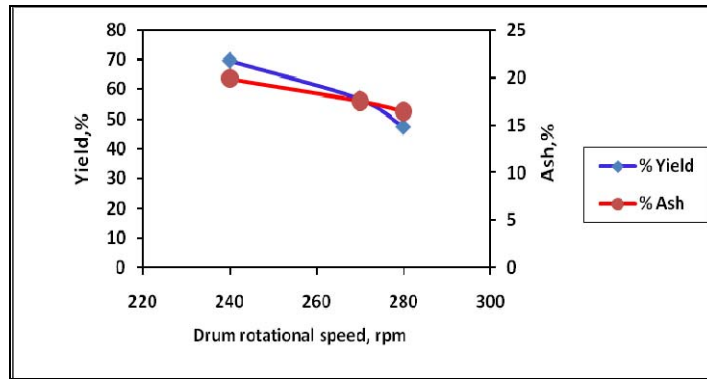


Fig 5 Effect of rpm on assay and recovery of coking coal

Table 4 MGS result with pulp density-25 in non coking coal

Product	RPM	Wt%	Assay%
Conc	240	87.0	32.33
	250	84.2	32.23
	260	83.5	31.55

4. Conclusions

Studies were carried out on beneficiation of iron ore slimes and coal fines using MGS. Iron ore slimes having 68% particle below 44 micron containing around 7.5 % Al_2O_3 can be reduced to ~2% Al_2O_3 . Similarly clean coal products can be obtained with good recovery in case of both coking and non-coking coal fines. The ash contents of the clean coal products of coking and non-coking coal fines samples revealed 16.43% and 31.55% with yields of 47.3 % and 83.5% respectively. Due to the application of enhanced gravitational force MGS resulted in improved separation of mineral values in case of particles in finer size range.

5. References

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