KARNATAKA STATE COUNCIL FOR SCIENCE AND TECHNOLOGY

Indian Institute of Science campus, Bengaluru

46th SERIES OF STUDENT PROJECT PROGRAMME

Project Reference NO: 46S_MTech_007

SYNOPSIS

Performance Analysis of Magnetic Separator for Recovery of Iron Values from lean grade iron ores of Sandur Area.

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5) Keywords: Magnetic Separation, Iron ore, Low-grade ores, Beneficiation

6) Introduction:

Iron is the chemical element with the symbol Fe (From Latin ferrum) and atomic number 26.It is a metal in the first transition series. It is by mass the most common element on Earth, forming much of Earth's outer and inner core. It is the fourth most common element in the Earth's crust. Like other group 8 elements, iron exists in a wide range of oxidation states, -2 to +6, although +2 and +3 are common.
Iron ores are rocks and minerals from which metallic iron can be economically extracted. The ores are usually rich in iron oxides and vary in color from dark grey, bright yellow, and deep purple, to rusty red. India is bestowed with large and rich sources of iron ore in terms of quantity and quality with respect to the world scenario. India occupies the sixth position in iron ore resource base and ranks fourth with respect to world iron ore production. The existing reserves of hematite (averaging around 63 % Fe) are the only source of iron ore and as such, these reserves may not last beyond 25–30 years at the present rate of consumption. Hence to meet the future and projected requirements, additional domestic resources like slimes and fines dumped elsewhere in mines have to be utilized, which are in abundance. The ores and minerals are site-specific, non-renewable and finite. It is a challenging task for iron ore producers to meet the demand as envisaged in the draft national steel policy. In order to meet the demand, the iron ore producers have to face challenges like increasing the resource base, increasing production and productivity, utilization of low-grade iron ores, beneficiation of low-grade fines and slimes, overcoming the infrastructure bottlenecks like roads, railways, ports, power, capital and water, human resource, handling, storage and utilization of slimes/tails, encouragement for R&D activities, adopting environmental friendly measures and land acquisition for setting up new plants.

In this study, the inferior-grade iron ores of sandur (Bellary –Hospet Sectors) area are investigated for their response towards magnetic separation. Since the sandur area ores consisted major amount of silicates as gangue minerals and showed better recovery of iron values upon magnetic separation. The results of magnetic separation are assessed by using the MINITAB Statistical Software.

7) Objectives

The objective of the present work is as follows;

- Construction of the Transparent Canister for visualizing the ore slurry movement in between the magnetic poles
- Preparation of different magnetic media (Spherical Balls) of different dia for separation of Fe Values in Wet Magnetic Separators
- Grinding of 4 different graded ore samples to -100#, -150#, and -200# for magnetic separation studies
- To analyze the performance of magnetic separation for effective separation of Fe Values from low-grade ores.
- Discuss the results of the magnetic separation using statistical inferences

8) Methodology:

8.1 Materials:

Ore Sample: The low-grade iron ores of the sandur area were collected from SMIORE, BKG, and NADEEM mines. The collected ore samples show 45 to 55% Fe. The as-received sample contains -40mm lumps. The samples are pale yellow to dark grey in color. The sample were also contained a considerable amount of fines and strongly attracted to a magnet.

8.2 Equipment's:

Primary crusher; Primary Jaw Crusher 150 X 250 mm of MPE Mumbai was used for primary crushing purposes.

Secondary crusher: 200 X 150 mm lab rolls crusher MPE make used for secondary crushing.

Rod mill: 175 X 350 mm rod mill with 5 Kgs of rods with sizes ranging from 25 to 40 mm was used for grinding the ore. (Refer to Fig. 1)

Figure 1: ROD Mill

Figure 2: Spherical Ball Matrix

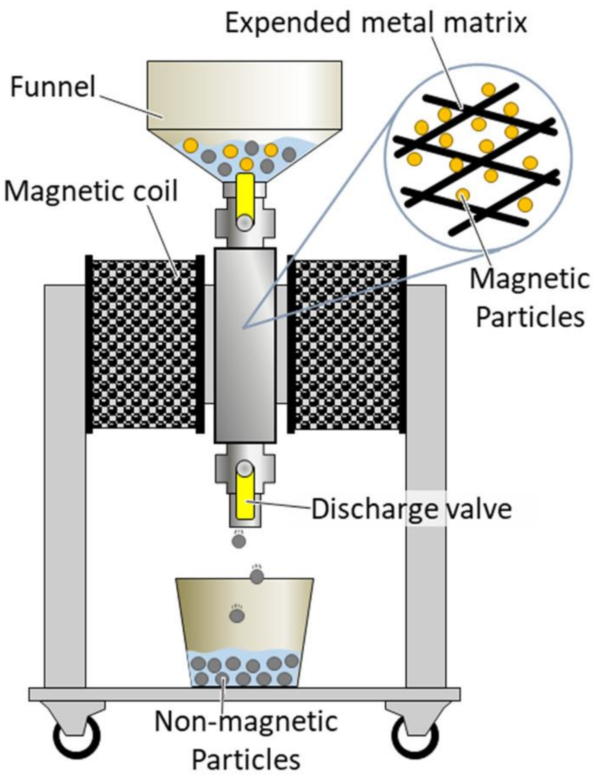

Figure 3: Wet High Intensity Magnetic Separator

8.3 Methods

Feed preparation and sampling; About 100 Kg of the low grade iron ore samples was collected from various mines for the present study. A representative sub-sample was taken from the bulk sample using coning and quartering. Sub sample was drawn for experiment and the material was crushed to -1mm size 100% passing by roll crusher and the sample were taken characterization studies which include particle size analysis (Dry & Wet), chemical analysis, rest of the sample was used for beneficiation studies.

Size analysis; The size analysis of different Samples was performed using the Standard laboratory Sieve Shaker and standard sieve. Representative sample was sized into different size fraction by size analysis in wet and dry state. The d80 passing size of the as received sample was determined.

Rod mill grinding: Known weight samples were ground for specified time interval in laboratory rod mill at predetermined load.

WET High Intensity Magnetic Separator studies: High intensity magnetic separation tests were done in lab model WHIMS with Electromagnetic Coil and a suspended separating cell between it as show in figure 3.

In the separation cell, spherical ball matrix (dia 3 mm to 9 mm) were placed to increase the number of high field gradient sites where magnetic particles could be collected. For each test, 50 g of sample was suspended in 600 mL of deionized (DI) water. a predetermined magnetic induction (0.2–1.0 T) was applied to the separation cell, and then the pulp was fed into the funnel placed on the top of WHIMS the was adjusted by controlling the discharge valve. When the slurry was entirely passed through the WHIMS, 1 L of DI water was introduced to wash the collected magnetic particles, which minimize the entrainment of non-magnetic particles in the magnetic concentrate.

Chemical Analysis: The analysis of Fe was done as per standard procedures enumerated in analytical chemistry hand books [IBM 2005].

8.3.1 Response Surface Methodology:

Response surface methodology (RSM) is a collection of statistical and mathematical methods that are useful for modeling and analyzing problems. In this technique, the main objective is to optimize the response surface that is influenced by various process parameters. The RSM also quantifies the relationship between the controllable input parameters and the response surfaces.

To determine the relationship between the independent variables and the dependent variables, the data collected were subjected to regression analysis using response surface regression procedure of

MINITAB 14.12. Regression analysis is used to model a response factor (Y_i) as a mathematical function of a few continuous factors. Each response (Y_i) was represented by a mathematical equation that correlates the response surfaces. The response was then expressed as second-order polynomial equation according to equation 1

$$Yi=f(X) = 0 + \Sigma k\ iXi + \Sigma k\ ii\ X2 + \Sigma -1\ \Sigma k\ ij\ XiXj + € (1)$$

i=1 i=1 i i=1 j=2

Where Y_i is the predicted response used to relate to the independent variable, *k* is the number of independent variables (factors) shown in Table 1. Xi (i = 1, 2, 3); while β is a constant coefficient and β_i, β_{ij} and β_{ii} the coefficient of linear, interaction and square terms respectively and ε is the random error term.

Table 1. Variables and levels for the three levels and three factor full factorial design.

Variables	**Symbols**	**Low(-1)**	**Intermediate (0)**	**High(1)**
MOG(in Mesh)	**A**	100	150	200
Magnetic Intensity	**B**	0.8 T	1.0 T	1.2T
Ball Matrix Size	**C**	3mm	6mm	9mm

9.0 RESULTS AND DISCUSSION

9.1 Grindability Studies:

A representative sub sample was taken from the bulk sample using coning and quartering. Sub sample was drawn for experiment and the material was crushed to -1mm size 100% passing by roll crusher and subjected to grinding using Laboratory rod mill with varying time from 25 to 35 minutes. Table 2 show the particle size distribution. The grindability data indicated that the sample is medium soft in nature.

Conditions ; 250 gms of -16# sample (concentrate) grounded in 175mm x 350mm rod mill with 5kg rod charge for time varying from 15 /25/35 minutes**.**

Table 2: Grindability Studies on ore sample

MESH NO	wt% passing		
	15'	25'	35'
+150#	100	100	100
-150+200#	80	84	100
-200+277#	40	58	100
-277+400#	38	50	63.9
-400+500#	0	0	43.7
-500#	0	0	0
D80 in microns	(-150#) 106	(-200#) 75	(-325#) 45

9.2 Results of WHIMS Studies:

A Statistically designed experimental run are carried out on a representative sample and for each experiments the weights of magnetic and nonmagnetic fractions were noted. Table 3 shows the experimental runs.

	Variables			Observed Responses		Predicted Responses	
Expt No	MOG	Magnetic Intensity	Matrix Size	%Fe Garde	%Fe Recovery	%Fe Garde	%Fe Recovery
1	150.0	10000.0	6.0				
2	200.0	12000.0	9.0				
3	234.1	10000.0	6.0				
4	150.0	10000.0	6.0				
5	100.0	12000.0	3.0				
6	150.0	10000.0	6.0				
7	65.9	10000.0	6.0				
8	100.0	12000.0	9.0				
9	150.0	10000.0	6.0				
10	200.0	8000.0	3.0				
11	150.0	6636.4	6.0				
12	200.0	12000.0	3.0				
13	150.0	10000.0	6.0				
14	100.0	8000.0	9.0				
15	150.0	10000.0	1.0				
16	200.0	8000.0	9.0				
17	150.0	13363.6	6.0				
18	150.0	10000.0	11.0				
19	150.0	10000.0	6.0				
20	100.0	8000.0	3.0				

The project is under collection of magnetic and nonmagnetic fractions using WHIMS and chemical analysis of the samples were yet to be done

After the complete chemical analysis of the products. The results were statistically analysed with response surface graphs