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Research Paper

Iron Recovery from the Tailings of the Balestan Iron Ore Plant

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Abstract: The reprocessing tailings of iron ore processing plants is important from economic (as a secondary source of iron) and environmental points of view. The aim of the present study is to determine the appropriate method for recovery iron from the tailings of Balestan iron ore processing plant (located in the northwest of Iran). For this purpose, after taking samples from the tail piles of this plant, a representative sample was selected, and chemical, mineralogical, size distribution, and bond's work index analyses were performed on it. The total iron grade in the tailings was measured to be about 10%, of which 8.5% was identified as magnetite mineral (with a degree of liberation less than 40%). The d_{80} value of the sample was 7 mm, and the bond index was measured as 11.84 (kWh/ton). To determine the appropriate method for iron recovery, pre-processing with magnetic drum, grinding, and Davis tube tests were performed. With the magnetic pre-processing of tailings with a particle size of 0-10 mm, under a field of 2000 G and in a dry method, about 80% of the load entering the drum with a total iron grade of 5% was transferred to the tailings. 20% of the input load with an iron grade of approximately 24% was recovered to the concentrate. In order to remove the gangue minerals and enrich the pre-processed concentrate, stepwise grinding and separation had the best results. Comminution was done in two stages to produce products with smaller dimensions of 250 and 45 microns, respectively. Magnetic separation was also done in three stages with 3000 G, and two stages of separation with 1000 G, which finally resulted in a concentrate with a total iron grade of more than 66% and iron recovery of 44.88%.

Keywords: Iron tailings, Pre-treatment, Stepwise concentration, Grinding, Energy consumption.

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INTRODUCTION

In recent years, with the increase in global demand and the rapid development of the iron and steel industries, the amount of tail produced from the mining and processing of this metal has increased. These accumulated tails not only cause serious environmental damage, but they also are a potential risk about the consumption and waste of mineral resources [1,2]. The reprocessing of the tails of iron processing plants will bring significant benefits along with solving the environmental challenges. In addition to the possibility of recovering iron, tailings piles of iron ore processing plants, depending on the type of primary ore, have the potential to extract other minerals and metals such as copper, cobalt, gallium, rare earth elements, gold, etc. [3]. On the other hand, the tailings of iron processing plants have been successfully used in the production of construction materials, including concrete and ceramics, with unique characteristics. Therefore, the reprocessing of tails of iron processing plants is important from the economic and environmental points of view.

The use of conventional processing methods will not have a favorable result for the processing of iron tail piles; because the tailing piles of iron ore processing plants are the remnants of the processing processes, which, according to the primary mineralization type, contain a variety of valuable minerals and gangue with more complex mineralization than the plant's initial feed. In general, with optimal grinding of granulated iron ore tailings (in order to achieve the appropriate degree of liberation), magnetic separation methods can be used to recover iron from the tailings. However, due to the low degree of liberation of valuable minerals in iron ore tailings (thus the necessity of comminuting them to very small dimensions), the magnetic separation method will face many problems; including the misreported of tailings particles to iron concentrate. On the other hand, the presence of other minerals with low magnetic properties causes the reduction of the magnetic concentration grade and, as a result, the reduction of its separation efficiency. The aim of this research is to identify the mineralogical characteristics and chemical composition of the tailings of the iron ore processing plant and to provide a suitable solution for iron recovery from them.

METHODS

In order to achieve the maximum recovery of iron from the tailings of Balestan iron ore processing plant, pre-processing tests have been carried out on the tailings of this plant. In this regard, magnetic separation tests with a magnetic field intensity of 2000 G have been performed for different size fraction of particles 0-10, 0-6.35, 0-4.75, and 0-2 mm.

To determine the optimal conditions for recovering iron from the tailings of the processing plant by the magnetic separation method, grinding and Davis tube tests have been performed on the tailings (at field strengths of 1000, 2000, 3000, and 4000 G). In Figure 1, the general outline of the tests is shown.

FINDINGS AND ARGUMENT

The results of the pre-processing tests using the dry magnetic separation drum at a field strength of 2000 G for the storage of the studied tailings are shown in Table 1. The change in the size of the feed did not have a significant effect on the iron content. The changes in the weight of the magnetic product also did not have a noticeable and clear trend with the change in the dimensions of the feed. In general, by performing the magnetic pre-processing stage, about 20% of the weight of the input load with a total iron grade of approximately 24% was recovered to the magnetic product. The amount of iron recovery in the pre-processing stage was more than 50%. By performing magnetic pre-processing, the SiO_2 content has been reduced to less than 30%, while its amount in the feed was more than 43%. Reducing the amount of this compound is important from the point of view of reducing the comminution energy in the next comminution stages, as well as reducing the amount of fine production and its adverse effect on magnetic separation. Therefore, it can be said that the dry magnetic pre-processing is recommended for tailing piles without any comminution or classification (0-10 mm) in the field strength of 2000 to 3000 G.

The iron grade in the pre-processed product is approximately 24%. Considering the grade of iron and also the need to grinding it to very small dimensions, step by step removing gangue minerals to produce a high-grade product is the most optimal solution. By removing mineral fines including silica in larger dimensions, and then grinding the remaining product, a higher grade of Fe can be achieved in the final product. For this purpose, step-by-step crushing and separation tests have been performed for the pre-processed product. In the first stage, the pre-processed product was grinded to a size of

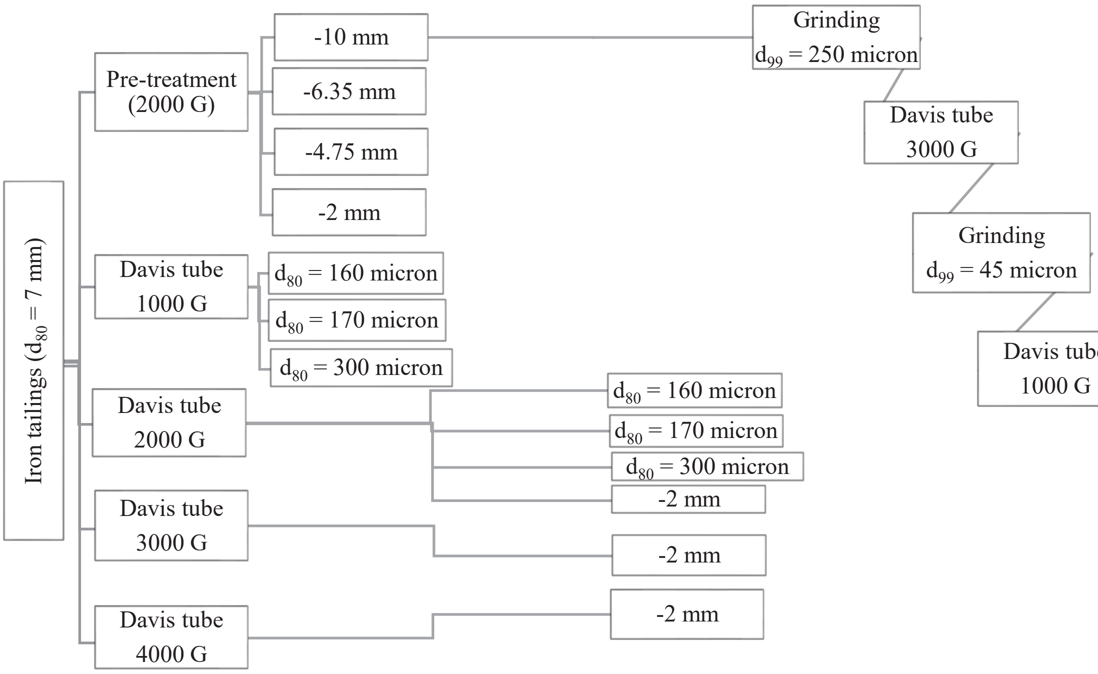

Figure 1. Schematic of grinding and magnetic separation tests of iron ore processing plant tailings

Table 1. The results of magnetic pre-processing tests (2000 G - dry)

Particle size (mm)	Products	Weight (%)	SiO_2 (%)	Fe (T) (%)	Recovery (%)
	Feed	100.00	43.35	9.77	
0-10	Concentrate	20.23	28.07	24.77	51.29
	Tail	79.77	44.89	5.40	
0-6.35	Concentrate	19.04	29.98	24.19	47.14
	Tail	80.96	45.44	5.43	
0-4.75	Concentrate	22.14	29.63	23.90	54.14
	Tail	77.86	46.30	5.13	
0-2	Concentrate	20.75	30.07	24.21	51.41
	Tail	79.25	46.34	5.24	

fewer than 250 microns (by a rod mill with a 10 to 1 ratio of grinding media to the feed into the mill). Then, the Davis tube test with 3000 G intensity was performed on it. During this test, 45.85% of the input load (weight recovery) with a total iron grade of more than 42% was recovered to the concentrate. The amount of silica in the concentrate also reached less than 20%.

The 3000 G concentrate was grinded again in a rod mill, and a product with dimensions less than 45 microns was produced (grinding time is approximately 25 minutes). A magnetic separation test was performed on the grinded product (with the same operating conditions as before) with a field strength of 1000 G. By performing the grade enrichment in the first cleaning step, a concentrate with a grade of more than 65% Fe was obtained with a recovery of 76% for iron.

CONCLUSIONS

Based on the results of this research, with the magnetic pre-processing of iron processing plant tailings (with an iron grade of 10%) without grinding, under the field strength of 2000 G and by the dry method, about 80% of the input load to the drum of 2000 G, with iron grade about 5% (which are mainly non-magnetic minerals) is transferred to tail. Due to the lack of comminution at this stage, energy consumption will be saved. The pre-processed product is 20% by weight of the load entering the drum, which its iron grade is about 24% and is mainly due to the magnetite mineral. Due to the interlocking of magnetite with gangue minerals, the right degree of liberation for magnetite (90%) is obtained in dimensions less than 45 microns. On the other hand, considering the grade of silica more than 30% in the pre-processed product, in order to prevent the production of fine particles and grinding all the particles to the desired dimensions, comminution and stepwise separation are suggested as the best solution. If all the pre-processed product is comminuted in one step, a significant number of fine particles will be produced. In this case, in addition to the high consumption of comminution energy, fine particles will reduce the efficiency of magnetic separation by creating a cover on magnetite particles and also agglomeration. However, with step-by-step comminution and magnetic separation, a concentrate with an iron grade of more than 66% will be produced.

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