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Reseach Paper

Effect of Drum Rotation Speed on Magnetic Separation Efficiency for Iron Grade Improvement of Galesong Beach Iron Sand Takalar Regency

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Abstract: Iron sand is a deposit along the coast formed from the weathering of rocks containing iron minerals, such as in Galesong Beach, Takalar, South Sulawesi. Its utilization is still minimal due to the lack of knowledge of its content and properties, so it is necessary to increase the content to obtain optimal recovery before being processed into useful products. This study aims to analyze the geochemistry of iron sand with XRF and XRD, determine the optimal recovery, and the best drum rotation speed on a magnetic separator for its processing. The method of increasing the content of iron sand uses magnetic concentration. The results of the XRD analysis show that the iron sand sample is composed of minerals such as Orthoclase ($KALSi_3O_8$), Magnetite (Fe_3O_4), Quartz (SiO_2), Iron ore (Fe_2O_3), Kaolinite ($Al_2O_9Si_2$). The results of the XRF analysis have Fe_2O_3 = 23.40%, SiO_2 = 38.38%, Al_2O_3 = 25.92%, CaO = 7.16 %, TiO_2 = 2.60 %, and K_2O, MnO, V_2O_5, Cr_2O_3, ZrO, SrO, ZnO, P_2O_5 each below 1%. The iron ore (Fe_2O_3) content of the concentrate product at each drum rotation speed is 45.11 %, 43.06 % and 64.16 % with recovery values of 75.19 %, 69.18 % and 97.16 %. The percentage of Fe_2O_3 content and the most optimal recovery rate are obtained at a rotation speed of 600 rpm.

Keywords: Iron Sand, Magnetic Separation, Content and Recovery, Rock, Minerals.

1. Introduction

Iron sand is a sand deposit containing iron particles found along coastlines, formed by the weathering process of surface water and waves on the original rock containing iron minerals [1], [2], [3]. Iron sand is typically dark gray and black in color [4], [5], [6], [7].

The iron content in iron sand is widely used in the iron and steel industry (such as iron/steel production, cast iron, wrought iron), the cement industry, and as a base material for dry ink in photocopiers and laser printers, the main component for cassette tapes, pigments, and mixtures (filters) for paint, as well as filters in electromagnetic filtration systems [8], [9], [10].

The availability of beach sand in Galesong, Takalar Regency, South Sulawesi Province, is quite promising in improving the standard of living of the surrounding community if managed properly, namely through mining and further processing, especially as a mixing material for the cement industry [8], [11] because there are Bosowa and Tonasa cement factories in Maros and Pangkep Regencies, located 1-1.5 km from Galesong.

The presence of iron sand on the beach located in the Galesong area of Takalar Regency, South Sulawesi, which has never been explored, serves as the backdrop for the author's research on iron sand in that region [4].

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Therefore, the author is interested in conducting research on "The Effect of Drum Rotation Speed on Magnetic Separation on Increasing Iron Content in Iron Sand in the Galesong Takalar area of Galesong subdistrict [11], [12], [13], [14]."

2. Research and Methodology

The research method began with sampling at the location, followed by sample processing and analysis in the laboratory, then calculation of levels and recovery of the data obtained. Determination of optimal recovery and conclusion drawing were the final parts of this research.

Iron sand samples were taken directly from Galesong Beach, which is administratively located in Galesong District, Takalar Regency, South Sulawesi Province. The data collection technique in this study was to conduct direct observations in the field by taking samples from several points using a small shovel and then digging to a depth of 60 cm to obtain high-quality iron sand [1], [4], [7]. The samples were placed in sample bags. The samples collected from the field were then prepared to obtain initial samples and feedstock for the concentration process using a magnetic separator.

The initial samples were analyzed using X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF). Iron sand concentration experiments were conducted using a magnetic separator with varying drum rotation speeds of 400 rpm, 500 rpm, and 600 rpm.

Magnetic separation in this study was carried out using a dry low-intensity drum magnetic separator. This device is equipped with permanent magnets installed inside a rotating drum to separate materials based on their magnetic properties. The separation process was carried out in three stages with different drum rotation speeds. Each rotation speed variation was observed and analyzed to determine its effect on the yield of the concentrate product.

Weighing was performed on product samples from the separation to determine the weight percentage of each. Next, XRF analysis was performed to determine the level of increase in iron content and recovery. The best recovery calculation was performed to determine the maximum recommended drum speed for the next experiment.

3. Results and Discussion

3.1 Characteristics of Iron Sand Samples

Based on the results of iron sand sample processing and laboratory analysis, XRD and XRF analysis data were obtained for the initial samples. The analysis was conducted after the separation experiment was carried out based on the differences in the magnetic properties of the minerals using a magnetic separator.

a. Analysis XRD (X-Ray Diffraction)

The mineral composition of a sample can be determined by conducting mineralogical analysis using the XRD (X-Ray Diffraction) method. XRD testing is performed on the initial iron ore sample before the magnetic separation process. The results obtained after XRD testing can be seen in picture1 below:

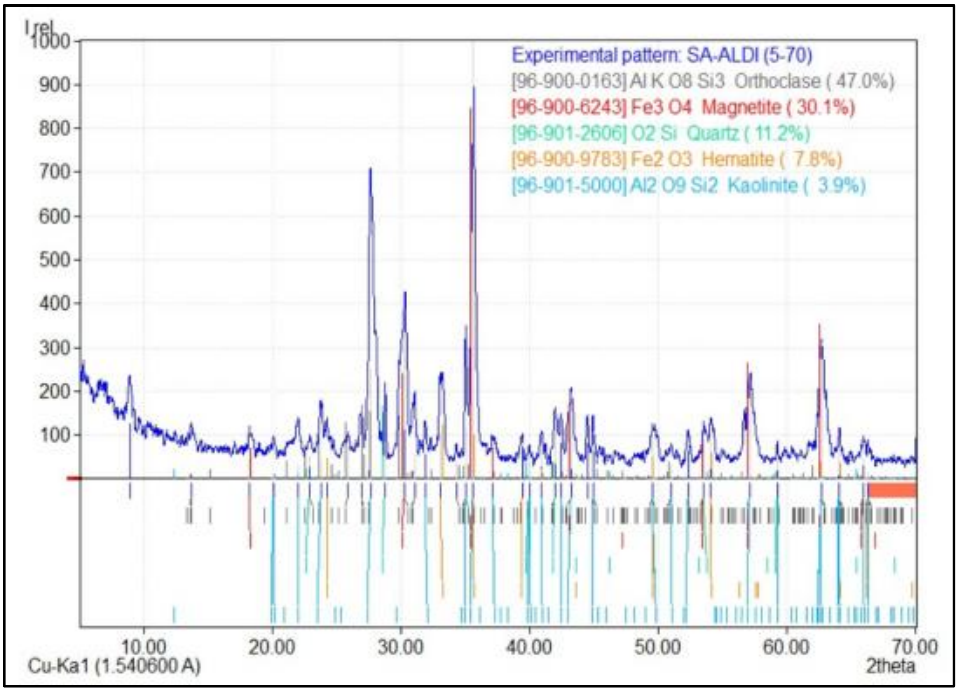

Figure 1. Difractogram of initial iron sand sample

Based on the results of mineralogical analysis using the X-Ray Diffraction method, iron sand from the Galesong Takalar area in Makassar City is composed of minerals such as orthoclase (KALSi3O8 = 47.0%), magnetite (Fe3O4 = 30.1%) cursite (O_2Si = 11.2%), iron oxide (Fe_2O_3 = 7.8%), and kaolinite ($Al_2O_3Si_2O_4$ = 3.9%).

b. Analysis XRF (X-Ray Fluorescence)

The results of this analysis show the percentage of elements in the form of oxide compounds. XRF (X-Ray Fluorescence) testing was carried out on the initial iron sand sample before the magnetic separation process, as well as on the products resulting from separation using a magnetic separator. The complete results of the XRF analysis are presented in Table 1 below.

Table 1. Chemical composition of initial samples

Primary Oxidation	Composition (%)
SiO_2	38.38
Fe_2O_3	23.40
Al_2O_3	25.92
CaO	7.16
TiO_2	2.61
K_2O	1.60
MnO	0.29
V_2O_5	0.15
Cr_2O_3	0.07
ZrO_2	0.04
SrO	0.06
ZnO	0.03
P_2O_5	0.27

Based on the results of chemical analysis using the XRF (X-Ray Fluorescence) method, the initial iron sand sample contained 23.40% Fe_2O_3, which originated from iron ore minerals such as magnetite. The SiO_2 content was recorded at 38.38%, Al_2O_3 at 25.92%, CaO at 7.16%, and TiO_2 at 2.60%. Additionally, there were minor compounds with percentages below 1%, including K_2O (1.60%), as well as MnO, V_2O_5, Cr_2O_3, ZrO_2, SrO, ZnO, and P_2O_5. The determination of the chemical composition was carried out using the XRF method, which has a detection limit of 0.001%. The results of this analysis are presented in the form of elemental percentages as oxide compounds.

3.2 Magnetic Separation

a. Analysis of Sample Separation Weight Magnetic Separator

Magnetic separation produces a concentrate (magnetic) and tailings (diamagnetic). During the separation process, there is also loss or weight loss caused by the transfer of material during the separation and weighing process or due to other factors. The results of magnetic separation can be seen in Table 2 below:

Table 2. Weight of magnetic separation results

Feed Weight (gram)	Speed of magnetic separator (rpm)	Concentrate weight (gram)	Tailings weight (gram)
1000	400	390.20	593.50
1000	500	376.10	616.20
1000	600	354.50	636.80

Based on Table 2 above, data on the amount of material separated magnetically at various drum rotation speeds was obtained. The results indicate that as the drum rotation speed decreases, the amount of magnetic concentrate produced tends to increase, and vice versa. The highest loss occurs at 400 rpm, amounting to 1.6%. This is due to material transfer from the feed container, material left behind in the magnetic separation equipment, weighing processes, airborne carryover, and weight loss of the sample during the separation process.

b. Analysis XRF (X-Ray Fluorescence) After Experiment

The product is a concentrate obtained from magnetic separation using a separator with three different drum rotation speeds. XRF analysis was then conducted to determine the percentage of magnetic and non-magnetic oxide minerals. The results of the XRF analysis are shown in Table 3 below.

Table 3. Chemical composition of concentrate and tailings

Element	Composition					
	Concentrate (%)			Tailing (%)		
	400 rpm	500 rpm	600 rpm	400 rpm	500 rpm	600 rpm
Fe_2O_3	45.11	43.06	64.16	11.84	13.34	11.26

Based on the data in Table 3, it can be seen that the magnetic separation process with varying drum speeds has a significant effect on the Fe_2O_3 content in the concentrate product. The initial Fe_2O_3 content in the iron sand sample was 23.40%, but after the separation process, this content increased significantly. The highest increase occurred at a speed of 600 rpm with an Fe_2O_3 content of 64.16%, followed by 400 rpm at 45.11%, and 500 rpm at 43.06%. This indicates that at 600 rpm, the centrifugal force and magnetic separation efficiency are more optimal in attracting magnetically charged particles such as Fe_2O_3 into the concentrate, resulting in the highest concentration.

Conversely, in the tailings containing non-magnetic (diamagnetic) particles, the Fe_2O_3 content tends to be low, with the highest value occurring at a speed of 500 rpm at 13.34%, indicating that some of the magnetic particles have not been completely attracted to the concentrate at that speed. The Fe_2O_3 content in the tailings decreases at 400 rpm (11.84%) and is lowest at 600 rpm (11.26%), indicating that at 600 rpm, most of the magnetic minerals are efficiently separated into the concentrate.

Thus, the increase in Fe_2O_3 content from 23.40% to 64.16% at a speed of 600 rpm confirms that a higher drum speed within certain limits can improve the effectiveness of separating magnetic minerals from impurities. However, excessively high speeds can lead to incomplete separation due to non-magnetic particles being carried into the concentrate or magnetic particles being ejected into the tailings, as observed in the Fe_2O_3 values at 500 rpm.

c. Recovery of Fe_2O_3 from Magnetic Separation

Mineral processing results generally show a contradictory relationship between quantity and quality, namely between the tonnage of product and the metal content obtained. The following table 4 presents data on Fe_2O_3 content obtained from the separation process.

Table 4. Magnetic recovery of Fe_2O_3

Speed (*rpm*)	Concentrate		Feed		Recovery (%)
	Fe_2O_3 (%)	Mass (gr)	Fe_2O_3 (%)	Mass (gr)	
400	45.11	390.20	23.41	1000	75.19
500	43.06	376.10	23.41	1000	69.18
600	64.16	354.50	23.41	1000	97.16

The highest Fe_2O_3 recovery rate in the table above is at 600 rpm with a value of 97.16%, while the lowest recovery rate is at 500 rpm with a value of 69.18%. The mass of the concentrate has a significant influence on the percentage recovery rate of iron sand obtained, and the Fe_2O_3 content in the beneficiation concentrate has a small range. At a rotation speed of 400 rpm, the Fe_2O_3 content is 45.11%, then decreases to 43.06% at 500 rpm, and increases to 64.16% at 600 rpm.

As the drum rotation speed increases, the Fe_2O_3 recovery obtained also increases. This is inconsistent with previous studies, which indicated that higher speeds do not necessarily result in significantly higher recovery rates. The relationship between drum rotation speed and content and recovery, as shown in Figure 2 below.

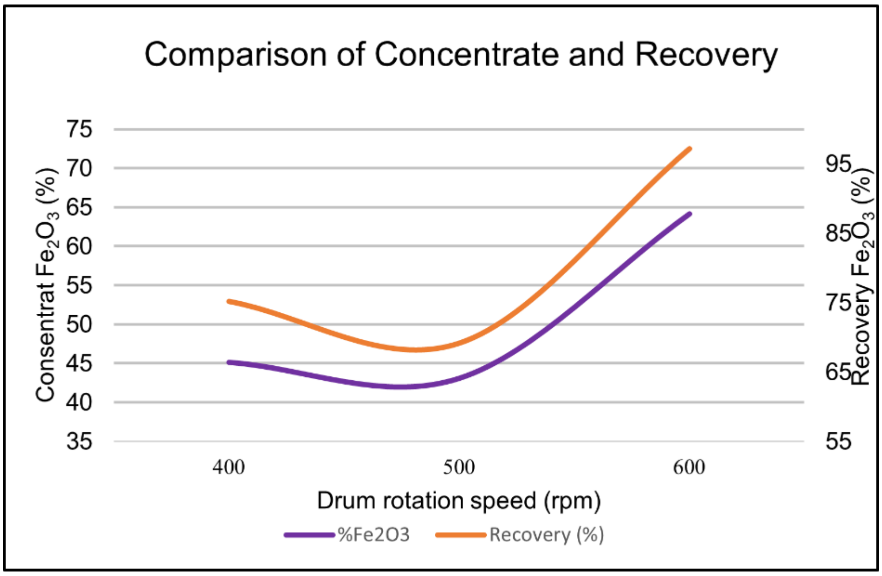

Figure 2. Comparison of Concentrate and Recovery

The recovery rate is directly proportional to the drum rotation speed, in line with previous research [15]. The results of the study are thought to be due to the iron sand samples used containing ferromagnetic minerals, so that the faster the drum rotates, the stronger and faster the magnetic minerals are attracted to the magnetic field. However, the higher the speed, the more electrical energy is required. Further research is needed using iron sand samples from different regions with varying RPMs. In this study, the optimal drum rotation speed was found to be 600 rpm, achieving a recovery rate of 97.16% with a 40.75% increase in Fe_2O_3.

4. Conclusion

Analysis results showed that the sample contained iron and other impurities, with an Fe_2O_3 content of 23.40 %. In this study, the optimum drum rotation speed was obtained at 600 rpm with a recovery of 97.16 % and an increase in Fe_2O_3 of 40.75 %.

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