Enrichment Chromite Sand Grade Using Magnetic Separator

S Subandrio1*, W Dahani1, M Alghifar1, and T T Purwiyono1
1Department of Mining Engineering, Trisakti University, Jakarta, Indonesia

*Corresponding author : Subandrio@trisakti.ac.id

Abstract. To fulfill requirements of metallurgical grade 48% Cr2O3 with Cr:Fe ratio 3:1 need the right beneficiation, one of them is using magnetic separator. Chromite sand sample obtained from Konowe-Southeast Sulawesi have low grade, so it needs process to enrichment Cr:Fe Ratio. Cr:Fe ratio feed was 0.55, after the process for size variation, roll speed, feeder speed and electric current decline Cr:Fe Ratio around 50.5%. When size -65+100 mesh Cr:Fe ratio was 0.282. At roll speed 20 RPM, feeder speed 50 Kg/Hr and electric current 1.5 A have Cr:Fe ratio 0.3525. Therefore, it needs more beneficiation before using magnetic separator for chromite sand from Konowe-Southeast Sulawesi.

1. Introduction
Chromite ore is the only commercial source of chromium in the metallurgical industries [1]. It occurs as a chromium spinel, a complex mineral containing chromium, iron, aluminium and magnesium in changeable proportions depending upon the deposit [2]. Chromite deposits can be estimated using geostatistics and geotechnical methods [3,4].

Chromite can be classified on the Cr/Fe ratio. The highest-grade chromites are those having Cr/Fe ratio of more than 2 and containing a minimum of 46 to 48% Cr2O3 [5]. Chemical-grade (high-iron) chromite contain large amounts of iron, which often results in Cr/Fe ratios from 1.5 to 2.1, although the total amount of chromium ranges from 40-46% Cr2O3. Refractory-grade chromite contains relatively large quantities of Al2O3 (> 20%) and have (Cr2O3+Al2O3) levels of more than 60% [6].

One of the chromite potentials in Indonesia is located in Sulawesi. Metallurgical quality concentrate, refractories or chemicals can be increased by beneficiation through gravitational, magnetic and flotation processes on chromite ores [7,8]. Chromite sand from Konowe-Southeast Sulawesi has a low Cr/Fe ratio of 0.9 so it is melted with an arc furnace to increase the Cr/Fe ratio [9] and eliminate the surfactant templates used in the materials [10,11,12]. Increasing Cr/Fe ratio to 2.31 (Cr2O3 grade 48.9%) using the wet shaking table and can reprocess it to 3.35 with Cr2O3 levels of 52.3% using High Intensity magnetic separator (IRMS) [13].

In this study, the sample of chromite sand from Konowe-Southeast Sulawesi was only processed using magnetic separator. Cr, Fe and others are transition metal elements that have paramagnetic or ferromagnetic properties. If the material is only processed using a magnetic separator, it will simplify and accelerate the beneficiation process [14].

2. Experimental
Sample taken from Konowe-Southeast Sulawesi contain chemical composition as shown in the table 1. Sample weighed 200 gr and be examined into 4 variable. There are size variation, roll speed, feeder speed and electric current. For size variation tested is -35+48, -48+65, -65+100 and -100 mesh. While for roll speed variation that is 15,20,25,30 RPM. In feeder speed were tested 45, 50, 55 and 60 Kg/Hr.
also for electric current 1.25, 1.5, 1.75 and 2 Ampere complete as shown in the table 2. Therefore, postition of feeder and splitter kept constant during testing.

### TABLE 1. Chemical composition of chromite sand from Wosu-Morowali

| Fe Cr₂O₄ | Ca Fe Si₂O₆ | Fe₂MgO₄ | SiO₂ | Ca TiO₃ | Mg Al₂O₄ | Unidentified |
|----------|-------------|---------|------|---------|---------|-------------|
| 26       | 21.6        | 19.3    | 17.2 | 10.3    | 5.4     | 3.4         |

### TABLE 2. Research design

| No. | Roll Speed (RPM) | Feeder Speed (Kg/Hr) | Electric Current (A) | Size Feed (Mesh) |
|-----|------------------|----------------------|---------------------|-----------------|
| 1.  | 20               | 50                   | 1.5                 | -35+48          |
| 2.  | 20               | 50                   | 1.5                 | -48 +65         |
| 3.  | 20               | 50                   | 1.5                 | 65 +100         |
| 4.  | 20               | 50                   | 1.5                 | -100            |
| 5.  | 15               | 50                   | 1.5                 | -65 +100        |
| 6.  | 20               | 50                   | 1.5                 | -65 +100        |
| 7.  | 25               | 50                   | 1.5                 | -65 +100        |
| 8.  | 30               | 50                   | 1.25                | -65 +100        |
| 9.  | 20               | 50                   | 1.50                | -65 +100        |
| 10. | 20               | 50                   | 1.75                | -65 +100        |
| 11. | 20               | 50                   | 2.00                | -65 +100        |
| 12. | 20               | 45                   | 1.5                 | -65 +100        |
| 13. | 20               | 50                   | 1.5                 | -65 +100        |
| 14. | 20               | 55                   | 1.5                 | -65 +100        |
| 15. | 20               | 60                   | 1.5                 | -65 +100        |
| 16. | 20               | 60                   | 1.5                 | -65 +100        |

**FIGURE 1.** Result difaktogram XRD of chromite sand

**FIGURE 2.** Dry magnetic separator
### TABLE 3. Feed grade of chromite sand from Wosu-Morowali

| Size   | Feed Grade | Cr | Fe | Cr:Fe Ratio |
|--------|------------|----|----|-------------|
| -35+48# | 12         | 44.2 | 0.271 |
| -48+65# | 22.9       | 40  | 0.573 |
| -65+100# | 24.3      | 44.2 | 0.550 |
| -100#   | 12.2       | 42.6 | 0.286 |

3. Result and Discussion

As shown table 3, on each size have best Cr:Fe ratio amount 0.573 at size -48+65 mesh. However, in testing variation of roll speed, feeder speed and electric current use size -65+100 mesh because it have the best grade of Cr 24.3% nevertheless doesn’t have best ratio as -48+65 mesh 0.55. In this test hope the highest grade of Cr at -65+100 mesh it can reduce silica (SiO₂) and iron (Fe) grade.

In this research to test influence of size variation against recovery and Cr:Fe ratio. Can be seen in figure 3, at -65+100 mesh position is the best condition of Cr grade 18.2% and the greater of sample size will make Fe grade tends to go down. Therefore, the best of Cr:Fe ratio also in the -65+100 mesh 0.282 however Cr:Fe best variation on the -35+48 mesh is 4.4%
On roll speed it can be seen that the faster roll speed will make Cr grade decrease, however it will make lowest point of Fe grade and after that it will increase again. The best roll speed of Cr:Fe ratio is 0.35, however an increase roll speed will make Cr:Fe ratio decrease because Fe grade will increase but Cr grade decrease. The best of recovery Cr roll speed is 3.48%.

![FIGURE 7. Concentrate Cr and Fe grade](image)

![FIGURE 8. Cr:Fe ratio and Recover Cr with Fe](image)

On feeder speed (Kg/Hr), Cr grade formed will be better if feeder speed faster although on roll speed 55 Kg/Hr have decrease. As well Fe grade will decline on roll speed 50 Kg/Hr and little increase feeder speed will increase the Fe grade. So that, Cr grade on roll speed 55 Kg/Hr have significant decline and the best Cr:Fe ratio on roll speed 50 Kg/Hr is 0.3525. the best of recovery Cr roll speed 60 Kg/Hr is 3.88%.

![FIGURE 9. Concentrate Cr and Fe grade](image)

![FIGURE 10. Cr:Fe ratio and Recover Cr with Fe](image)

On electric current, an increase electric current will increase Cr grade. However on electric current 1.5 A will make lowest grade of Fe and slowly increase with additional electric current. Then, the best Cr:Fe ratio on electric current 1.5A is 0.352. an additional electric current will make recovery Cr increase and the best recovery Cr when 2A is 3.72.

4. Conclusion

If observed further, Cr:Fe ratio on feed more better than after process. Cr:Fe ratio on feed is 0.55 but after process obtained Cr:Fe ratio for size variation 0.282 and roll speed, feeder speed, electric current is 0.352. A decrease in Cr:Fe ratio because Cr grade wasted with silica (SiO₂). Beneficiation is needed to use shaking table before magnetic separator for chromite sand from Konowe-Southeast Sulawesi.
Acknowledgments
The author would like to thank the laboratory of mineral processing Bandung Institute of Technology (ITB), Dr. Ir. Edy Sanwani, M.T. who has provided support, encouragement and opportunity to do this research. For XRD and XRF analysis was supported by Institut Teknologi Sepuluh Nopember (ITS).

References

[1] Gupta A, and Yan D S 2006 An Introduction Mineral Processing Design And Operation, Amsterdam: Elsevier.
[2] Gu F and Wills B A 1988 Chromite-Mineral and Processing Minerals Engineering 1 235-240.
[3] Marwanza I, Badaruddin S P and Azizi M A 2018 Copper Resource Estimation in PT X Batu Hijau, Regency of West Sumbawa, West Nusa Tenggara Province using Geostatistical Method IOP Conference Series: Earth Environmental Science 212.
[4] Azizi M A, Marwanza I, Amala S A and Hartanti N A 2018 Three Dimensional Slope Stability Analysis of Open Pit Limestone Mine in Rembang District, Central Java IOP Conference Series: Earth Environmental Science 212.
[5] Sen R 2010 Physical and Chemical Characterisation of Briquettes Made From Indian and South African Chromite Concentrates and Their Smelting Behaviours, PhD thesis, Jadavpur University.
[6] Bhandary A K, Gupta P, Mukherjee S, Chaudhuri M G, and Dey R 2016 Benefication of Low Grade Chromite Ore and Its Characterization for the Formation of Magnesia-Chromite Refractory by Economically Viable Process International Journal of Chemical and Molecular Engineering 10 1096-1104.
[7] Subandrio, Dahani W, and Purwiyono T T 2017 Optimizationof Gravity Chromite Processing with Shaking Table Journal Petro 6 2.
[8] Seifelnasr A, Tammam T, and Abouzeid A 2012 Gravity Concentration of Sudanese Chromite Ore using Laboratory Shaking Table Physicochemical Problem of Mineral Processing 48(1) 271-280.
[9] Nurjaman F, Subandrio S, Ferdian D, and Subarno B 2018 Effect of Basicity on Beneficiated Chromite Sand smelting process using submerged arc furnace AIP Conference Proceedings 1964.
[10] Zi S C, Chandren S, Yuan L S, Razali R, Ho C S, Hartanto D, Mahlia T M I, and Nur H 2016 New Method to synthesize mesoporous titania by photodegradation of surfactant template Solid State Sciences 83-91
[11] Kurniawati R, Iryani A and Hartanto D 2018 The effect of 2-propanol on the shifting band gap of ZSM-5/TiO$_2$ Composite Prepared Via Sol-Gel Method AIP Proceeding 2049 020089
[12] Pambudi A, Kurniawati R, Iryani A and Hartanto D 2018 Effect of calcination temperature in the synthesis of carbon doped TiO$_2$ without external carbon source. AIP Conference Proceedings.
[13] Tripathy S K, Singh V and Ramamurthy Y 2012 Improvement in Cr:Fe Ratio of Indian Chromite Ore for Ferrochrome Production International Journal of Mining Engineering and Mineral Processing 1 101-106.
[14] Rao R B, Dasand B, and Sastri S R S 1997 Improving Grade of Indian Chromite Ores by High–Gradient Magnetic Separation Magnetic and Electrical Separation 8 175-183.