EVALUATION OF HEMATITE ORE BY MAGNETIC ROASTING AND PELLETIZING

Divriği Hematit Cevherinin Manyetik Kavurma ve Peletleme ile Değerlendirilmesi

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ABSTRACT

High intensity magnetic separation of hematite ores is a well-known but an expensive method. In comparison with this traditional method, magnetic concentration of magnetite ore formed after magnetic roasting of hematite has been an alternative and reasonable process. Utilization of this process would be more economical than the traditional type and therefore, it has been preferred recently. In this process, the aim of the roasting is to increase the magnetic susceptibility of hematite and thus make it recoverable by a low intensity magnetic separator. Divriği Hematite ore having 47.06% Fe of grade was recovered with an efficiency of 91.23% and the grade was increased to a level of 62.26% Fe. Using the magnetic product obtained in this process, pellet production suitable for the industry was achieved

ÖZET

Hematit cevherlerinin yüksek alan şiddetli manyetik ayırıcılarda zenginleştirilmesi bilinen bir yöntem olmasına rağmen maliyeti yüksektir. Bu cevherlerin manyetik kavurma ile manyetit cevherlerine dönüştürülerek düşük alan şiddetli manyetik ayırıcılarda zenginleştiril-

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mesi daha uygun bir yöntem olarak görülmektedir. Bu yöntem bilinen diğer yöntemlere göre daha ekonomik ve son zamanlarda tercih edilen bir yöntem olmuştur. Divriği hematit cevheri manyetik kavurma sonucu, düşük alan şiddetli manyetik ayırıcılarda zenginleştirilerek, optimum çalışma parametreleri tespit edilmiştir. %47.06 Fe tenörüne sahip tüvenan cevherinden, %62.26 Fe tenörlü konsantre %91.23 verimle elde edilmiştir. Elde edilen bu manyetik üründen endüstrinin istediği özellikte pelet üretimi gerçekleştirilmiştir.

1. INTRODUCTION

It is well known that iron has been used since early centuries of the human being. Iron is required for the development of a country economically and socially. In the nature, there are a lot of materials containing iron. However, only a few of them have a significant economical value.

Global untreated-steel production has increased by 6.2% in 1997 and reached at 794.1 million ton, which is the peak level achieved so far. The greatest iron-steel producers are in Japan, USA, CIS, Germany, England, Italy, Greece, Israel, Chine, Algeria, Turkey etc.

World-wide steel consumption in 1997, has increased 6.5% in contrast to decrease in 1996. Steel consumption is significant especially in OECD, Latin America, Middle East and Asia countries. In 1998, a 2.0% decrease in both production an consumption of steel is predicted due mainly to the global financial crisis (Oktem, 1998).

2. IRON ORES AND CONCENTRATION METHODS

Iron ores are partly separated to seven groups according to their properties and chemical compositions. These are magnetite ores, hematite ores, magnetite + hematite ores, siderite ores, limonite ores, titanomagnetite ores, and silicatic ores. Until recently, titanomagnetite and silicatic ores could not be utilized. The grade of limonite and siderite ores can be increased by calcination methods. Hematite and magnetite ores are most commonly consumed (Ekkehart, 1994).

Concentration methods of iron ores are given as; sorting, properties of structural (mechanical) concentration, gravity concentration, magnetic separation, flotation, magnetic roasting + magnetic separation (Cilingir, 1990).

2.1. Magnetic Roasting

In magnetic roasting, paramagnetic iron minerals (especially hematite) are magnetized to perform low intensity magnetic separation. In this process, hematite ore is mixed with reducing coal and heated in a revolving furnace. Sometimes fuel-oil can be used in heating.

However lignite is preferred to the others since it is cheaper and practical. Lignite is heated to 575 ^{o}C and CO is obtained to use in extracting magnetite from hematite (Ekkehart,1994).

When the natural alfa hematite is heated in a revolving furnace, gamma hematite, maghemite and magnetite are produced in an order with gradually increasing heat (400-575 °C). In order to accelerate magnetite formation, the heat is increased to above 575 °C. However; at this temperature, magnetite is converted to wüstite which has undesired diamagnetic property. So the heat of magnetic roasting furnace should be kept below 575 °C. Here, the crucial point is spontaneous oxidation of magnetite with oxygen during cooling of magnetized material, which results in reducing to previous mineral forms and even hematite. Cooling should be realised in a media with less oxygen and 5-20 % coal should be used to react the furnace.

Four requirements in roasting process are; sufficient surface, oxygen, temperature and adequate mixing (Akdag, 1984; Cilingir, 1990).

2.2. Magnetic Separation

There are two types magnetic separations: Dry (+5 mm) and wet (-200 μm)

- Low Intensity (500-1500 Gauss) used especially to magnetite.
- High Intensity,(10 000-25 000 Gauss) used especially for hematite (Weiss, 1985).

Magnetic separation is commonly used in mineral processing and drum type magnetic separator is preferred to the others for iron concentration.

Main parameters of magnetic separation in drum magnetic separators are; particle size – rate, rpm of drum, spliter adjustments, belt thickness, configuration of drum, number of stage (Sundberg, 1998).

3. EXPERIMENTAL STUDIES

3.1. Material and Method

The samples used in the tests were taken from the ore deposit and undergone to the sample preparation tests. Then they were separated into several the groups by weighing the feed. -100 mm of samples were crushed and sieved to -20 mm by jaw crusher and standard screens. The particle size analysis and the grades of the samples are given in Table 1.

In magnetic roasting tests, the samples were roasted with CO at different temperatures and times. The roasted magnetic product was separated in laboratory type low intensity carpco dry magnetic separator. The experimental conditions are given in Table 2.

The magnetic concentrate was rich in grade and had different mineralogical contents. During the tests, the optimal conditions were determined. After this, pelletizing tests were performed. The principle flowsheet of the experimental procedure is shown in Figure 1.

The main parameters have been investigated during the roasting tests; Optimum particle size, roasting temperature and roasting time. These parameters were investigated mainly in a stationary revolving furnace of laboratory type. After the roasting tests, the roasted product was concentrated by magnetic separator. The concentrate was grounded down to-45 μm (80% W). The ground material was added

0.5%, 0.7%, 0.9% and 1.1% of bentonite and optimum binder quantity was determined at a moisture rate of 10%. After pelletizing, pellets were dried at 300 °C (preheating) and heated at 1100 °C. Pellets were cooled in atmospheric conditions and impact strength was determined (Meyer, 1980; Kemal, 1990).

Table 1. Chemical Composition of the Samples

Particle Size (mm)	Feed (%)	Grade (% Fe)
+11,2	23	45,49
-11,2 +4,75	45	49,02
-4,75 +0,85	20	44,45
-0,85 +0,106	9	42,96
-0,106	3	41,55
TOPLAM	100	46,52

Table 2. Experimental Conditions

Roasting Conditions	
Roasting Temp. Roasting Time Coal Weight Percent Size	550-600 °C 1-3 hours 20% 0.85-4.75,4.75-11.2,11.2mm
Magnetic Separation Conditions	
Revolution Rate Magnetic Intensity	10-30-50 rpm 700 gauss

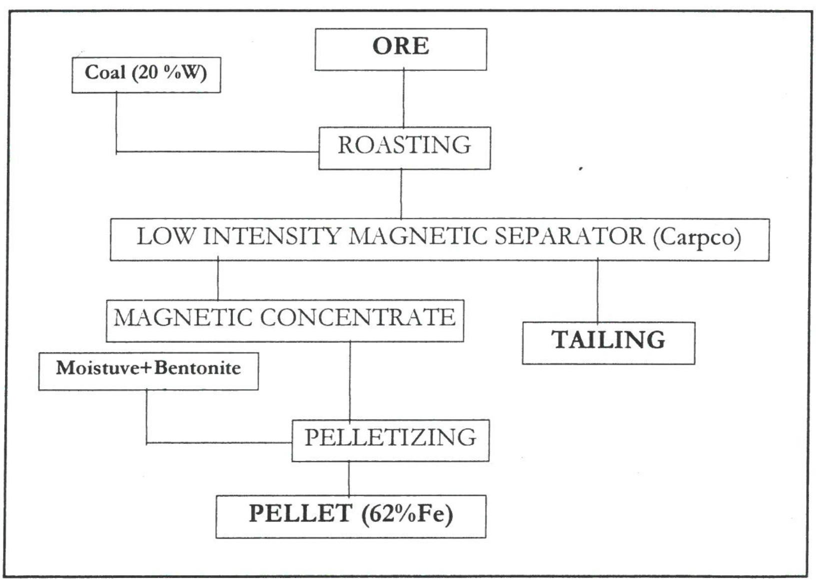

Figure 1. Principle flowsheet of experimental procedure

3.2. Experimental

The effect of particle size for test specifications:

Roasting temperature	:	575 °C
Roasting time	:	1 hour
Magnetic intensity	:	700 gauss
Revolution rate of drum	:	30 rpm

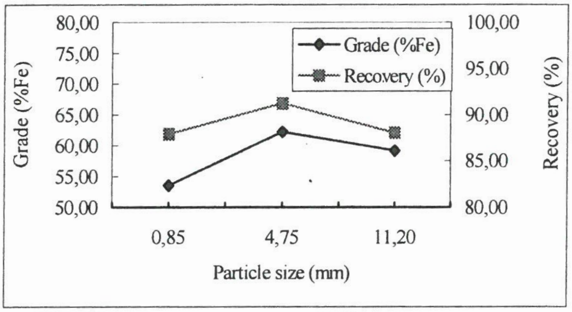

Figure 2. Effect of particle size on roasting-magnetic separation

During our observation, –11.2+4.75 mm particle size fraction has been found to be the optimum level, for which the grade was 62.26% Fe and iron concentrate recovery was 91.23%.

The effect of roasting time for test specifications:

Roasting Temperature	:	575 °C
Particle Size	:	-11.2+4.75 mm.
Magnetic Intensity	:	700 gauss
Revolution Rate of Drum	:	30 rpm

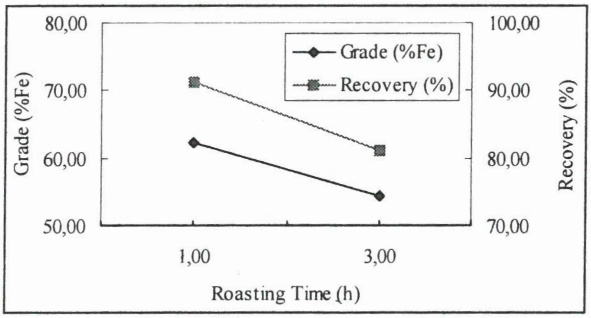

Figure 3. Effect of roasting time on roasting-magnetic separation

According to Figure 3, it is seen that 1 hour is the optimum roasting time.

The effect of roasting temperature for test specifications:

Roasting Time : 1 hour
Magnetic Intensity : 700 gauss
Revolution Rate of Drum : 30 rpm

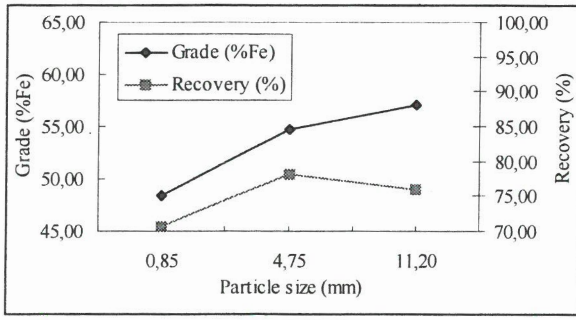

Figure 4a. Particle size on magnetic separation (at 550 °C)

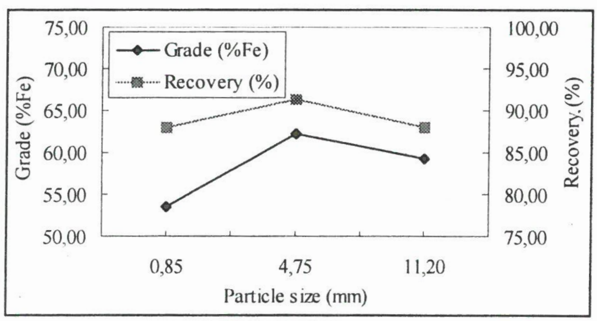

Figure 4b. Particle size on magnetic separation (at 575 °C)

As it is observed in figures 4a and 4b, the optimum grades and recoveries are obtained at 575 °C and -11.2+4.75 mm.

The effect of revolution rate for test specifications:

Roasting Temperature : 575 °C
Roasting Time : 1 hour
Particle Size : -11.2+4.75 mm
Magnetic Intensity : 700 gauss

According to Figure 5, it is seen that the optimum revolution rate of drum is 30 rpm.

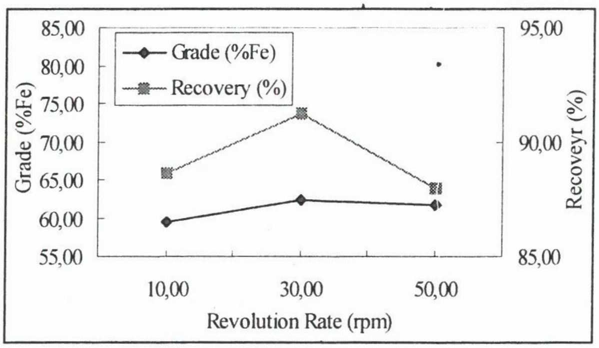

Figure 5. Effect of revolution rate on magnetic separation

The effect of bentonite quantity for test specifications:

Roasting Temperature	:	575 °C
Roasting Time	:	1 hour
Particle Size	:	-11.2+4.75 mm
Magnetic Intensity :	700 gauss	
Revolution Rate of Drum:	30 rpm	

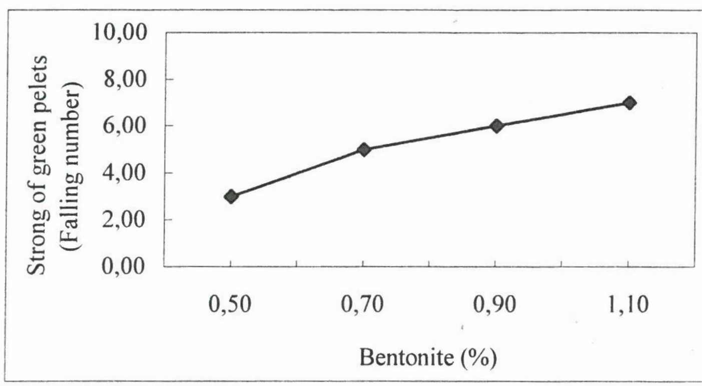

Figure 6. Effect of Bentonite Quantity on Pelletizing

According to the results obtained from Figure 6, 1.1% of binder is found to be the optimum. However binder addition should be kept 0.7% as a standard to reach at pellets having 200 kg/cm^2 of impact strength.

4. CONCLUSIONS

Processing properties of Divrigi hematite have been examined, and fallowing conclutions were drawn;

- The magnetic product grade increased from 47.06 % to 62.26 % Fe at a recovery of 91.3 % by low intencity magnetic seperation

- Pellet production of the concentre,which exhibits standart characteristics and suitability for industrial use has been achieved. But, if it is necesary it may be evaluated with added some amount of concentre at Divriği Concentration Plant.

REFERENCES

Akdağ, M., (1984): (In Turkish) **Ekstraktif Metalurji,** 9 Eylül University Press, Mining Engineering Dept., İzmir, sf 95-101

Çilingir, Y., (1990): (In Turkish) **Metalik cevherler ve zenginleştirme Yöntemleri,** 9 Eylül University Press, Mining Engineering Dept., İzmir, V1, Bl 2.

Ekkehart, M., (1994): **Increasing the recovery of valuable mineral in Hematite/Magnetite ore benefication process, Progress in Mineral Processing Technology,** ed.by. Proceedings of the 4th International Mineral Processing Symposium, Cappadocia,.

Kemal, M., (1990): (In Turkish) **Aglomerasyon,** 9 Eylül University Press, Mining Engineering Dept., İzmir, ..

Meyer, K., (1980): **Pelletizing of Iron Ore,** Spiringer-Verlag Berlin Heidelberg New-York Verlag Stahleisen m.b.H., Düsseldorf

Öktem, M.M., (1998): (In Turkish) **1997-98-99 Yıllarında çelik pazarının temel özellikleri üzerine notlar,** Metal Maden Türkiye İhraçatçılar Birl. Derg.,C-7, 45.

Sundberg, R.T., (1998): **Wet low intensity magnetic seperation of iron ore, İnnovation in Mineral and Coal Processing,** Atak Önal Çelik (ed.), Proceedings of the 7th International Mineral Processing Symposium, Istanbul

Weiss, L.N., (1985): **SME Mineral Prosessing Handbook 2,** American Institute of Mining-Metallurgical and Petroleum Engineers, New York.