

COMPARISON OF PRE-CONCENTRATION AND DIRECT CONCENTRATION IN THE TREATMENT OF LOW-GRADE IRON ORES

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ABSTRACT

Hasaңcelebi iron ore deposit is located at 94 km northern west of Malatya, close to the Hasaңcelebi town and is one of the most important iron ore deposits known in Turkey with a geological reserve of 3.2 billion tons. Since 1975, several investigation projects including intensive feasibility studies were realised on Hasaңcelebi iron ore deposit, however, no one had been found feasible, therefore, ore deposit has not been operated up to now. After 14 years, the new project entitled "*Re-evaluation of the Malatya-Hekimhan, Hasaңcelebi Iron Ore*" subjected to this paper was awarded to Mineral and Coal Processing Section. Concentration results as a part of whole project are discussed in this paper.

Pre-concentration and direct concentration studies were realised on laboratory and pilot scale in order to develop process flow sheet including material balance. The tests were conducted on the representative ore sample containing 25.9% magnetite. Pre-concentration tests were carried out on this sample with the particle sizes of minus 4 mm. Pre-concentrate obtained at minus 4 mm; was ground for final concentration at wet magnetic separator. As a result of experiments, a concentrate with 23.4% by weight of the original ore, assaying 69.15% Fe with a recovery of 74.8% was achieved. On the other hand, in the case of direct concentration with run-off mine ore on minus 0.074 mm, a concentrate with 24.2% by weight, assaying 69.10% Fe, with a recovery of 74.7% was obtained. Although the results seem very compatible for both cases, 44.4 % tailings containing 6.60% Fe can be rejected with 13.5% metal losses from coarse size treatment, therefore, valuable energy saving can be obtained for fine size grinding from pre-concentration application.

INTRODUCTION

When the iron ore demand of Turkey taken into consideration, the "Hasaңcelebi iron ore deposit" is one of the most important raw material resources. Since 1975, several investigation projects including extensive exploration, intensive metallurgical tests and feasibility

studies were realised on Hasaңcelebi iron ore deposit, however, no one had been found feasible, therefore, ore deposit has not been operated up to now.

The new project entitled "*Re-evaluation of the Malatya-Hekimhan, Hasaңcelebi Iron Ore*" subjected to this paper was awarded to Istanbul Technical University-Mining Faculty, Mineral and Coal Processing Section in 1998. This project consists of following main chapters: reserve calculation, mine project and equipment selection, mineral processing, pelletising, recovery of by-products from tailings and pre-feasibility study.

According to the investigation project results, completed in 1999, total investment cost of mining operation, processing and pellet production plants is almost 145 million US dollars including operational capital cost. The plant is established for 7.5 million tons run-off mine ore and 1.5 million tons pellet production per year based on 17 years mine life. It is also calculated that operational cost for run-off mine ore and internal profitability ratio of project is to be 5.85 US\$/t and 12 % respectively.

In the previous studies, whole ore deposit was taken into the consideration and the replacement of the route of railway, road and Uludere River existed on the mining area was subjected for the feasibility studies. Furthermore, all of the concentration studies were carried out with the samples ground into minus 0.044 mm in size.

In recently completed project, following targets had been chosen for the evaluation of ore deposit:

- * Localisation of mining operation at a certain area instead of considering the whole ore deposit.
- * Rejecting a considerable amount of tailings by pre-concentration at coarse sizes before final concentration step.

This paper includes evaluation of western part of the ore body with an exploitable reserve of 94.8 million tons and with an average Fe assay of 21.66%. For this purpose magnetic and gravity separation techniques

were applied at various size fractions. In this paper the comparison of the results of pre-concentration and direct concentration tests by using magnetic separators are discussed.

MATERIAL AND METHODS

There are five abandoned galleries in the mining area and next to each gallery ore stocks of 300 to 3000 tons are present. During the investigations, it was noticed that all the galleries are damaged and filled with water. Under the existing conditions, it was decided to take representative samples from the stocks next to the galleries. During the sampling; channels were opened in each stock adjacent to the galleries and the piled samples systematically taken from these channels were reduced. About 4 tons of representative ore samples taken from five galleries were shipped to the laboratories. For the tests, blended samples taken from Gallery-I and Gallery-II were prepared to be used in investigation.

Pre-concentration and direct concentration studies on laboratory and pilot scale were realised in order to develop process flow sheet including material balance. Laboratory type dry magnetic separator (REMS-Rare Earth Magnetic Separator) and drum type wet magnetic separator were used. Results are interpreted based on Fe and Fe_3O_4 content. Typical chemical analysis of blended sample introduced all tests are given in Table I.

Table I. Chemical Analyses Results of Blended Samples.

Element	-%-	Element	ppm
Fe	21.68	P	0,07
Fe_3O_4	25.9	Cu	30
TiO_2	0.97	Co	38
SiO_2	27.98	Ni	142
Al_2O_3	12.31	V	339
K_2O	2.47	Cr	158
Na_2O	2.31	Mn	397
S	0.19	La	32

EXPERIMENTS

Within the framework of technological research project entitled "*Re-evaluation of the Malatya-Hekimhan, Hasançelebi Iron Ore*", laboratory and pilot-scale experimental studies were conducted: Concentration experiments aimed at producing concentrates suitable for pelletising were conducted in the following steps;

- Performing separate pre-concentration experiments on each gallery sample,
- Conducting laboratory scale direct and pre-concentration experiments on the blended samples prepared on the basis of feasible ore grade, which was determined in the light of statistical computer evaluation work using ore reserve and average grade,
- Carrying out pilot-scale concentration experiments with the blended samples in order to develop the flow-sheet,
- Developing the process flow sheet, with solid, water and metal content balance are made in the light of data obtained from the concentration experiments.

In this paper, comparison of direct and pre-concentration tests results are discussed as a part of investigation project.

Direct Concentration Tests

Samples, all in different sizes between 0.210 mm and 0.038 mm, were separately used in the direct magnetic separation tests in order to produce final magnetite concentrate. Laboratory type high intensity wet drum separator was utilised in these tests. Samples in different sizes were fed to the wet magnetic separator and rougher concentrates were subjected to two stages cleaning. Tailings of cleaning stages were mixed and named as middlings. All experimental results are given in Table II.

According to the experiment results obtained from direct concentration, it is obviously seen that the best magnetite content of concentrate and metal recovery can be achieved with the sample ground into minus 0.074 mm. In this case; final Fe recovery can be calculated as 79% when middlings is taken into consideration.

Table II. Results of Wet Magnetic Separation Tests Conducted with Samples Ground to Different Sizes.

Particle Size mm	Product	Amount - % -	Fe	
			Content - % -	Recovery -% -
-0.210	Concentrate	30.3	55.54	77.9
	Middlings	6.3	11.27	4.4
	Tailings	63.4	5.68	17.7
	Feed	100.0	21.14	100.0
-0.106	Concentrate	23.8	61.60	66.4
	Middlings	6.1	35.74	9.3
	Tailings	70.1	7.24	24.3
	Feed	100.0	21.92	100.0
-0.074	Concentrate	24.2	69.10	74.9
	Middlings	7.7	17.49	6.0
	Tailings	68.1	6.27	19.1
	Feed	100.0	22.34	100.0
-0.053	Concentrate	24.0	69.05	74.9
	Middlings	5.2	18.10	4.2
	Tailings	70.8	6.54	20.9
	Feed	100.0	22.14	100.0
-0.038	Concentrate	23.1	69.00	73.4
	Middlings	6.2	22.24	6.3
	Tailings	70.7	6.24	20.3
	Feed	100.0	21.73	100.0

Pre-concentration Tests

Results of laboratory-scale concentration tests on blended sample for pre-concentration concept of iron ore were evaluated and in the light of these results a pilot scale process study was preformed. Pilot scale work was conducted in Istanbul Technical University by using the pilot plant with a capacity of 200 kg/h.

The objective of this series of tests are to discard tailings with minimum amounts of magnetite loss. However, tests conducted at sizes of 30 mm, 20 mm, 10 mm and 4 mm. The best result was obtained at minus 4 mm in size. Therefore, the pilot scale test was carried out on minus 4 mm blended sample.

During the experiments; the particle size of the sample was reduced to minus 4 mm followed by two stages drum type low intensity wet magnetic separation.

Magnetic separation was applied for discharge of some amount of tailings in the coarse size. Pre-concentrate with 55.6% by weight and 30.34% Fe was obtained while 44.4% of fed material was discharged with a Fe content of 6.60%.

The pre-concentrate was then ground to 0.074 mm and subjected to the final concentration step by using wet magnetic separator. The concentrate was cleaned twice and the results are shown in Table III and Figure 1 in terms of both Fe and magnetite content and process flow sheet of magnetite beneficiation, respectively.

At the end of experiments, it is seen that the pilot and laboratory scale test results are in agreement with each other. Therefore, these results have been accepted as process parameters in the plant design stage.

Table III. Process Test Results Obtained on - 4 mm Particle Size.

Product	Amount by wt.	Fe		Fe ₃ O ₄	
	%	%	% Recovery	%	% Recovery
Concentrate	23.4	69.15	74.7	96.0	86.6
Tailings-I	44.4	6.60	13.5	1.9	3.3
Tailings-II	32.2	7.91	11.8	8.2	10.1
Total	100.0	21.66	100.0	25.9	100.0

(Tailings-I: -4+0.074 mm; Tailings-II: -0.074 mm)

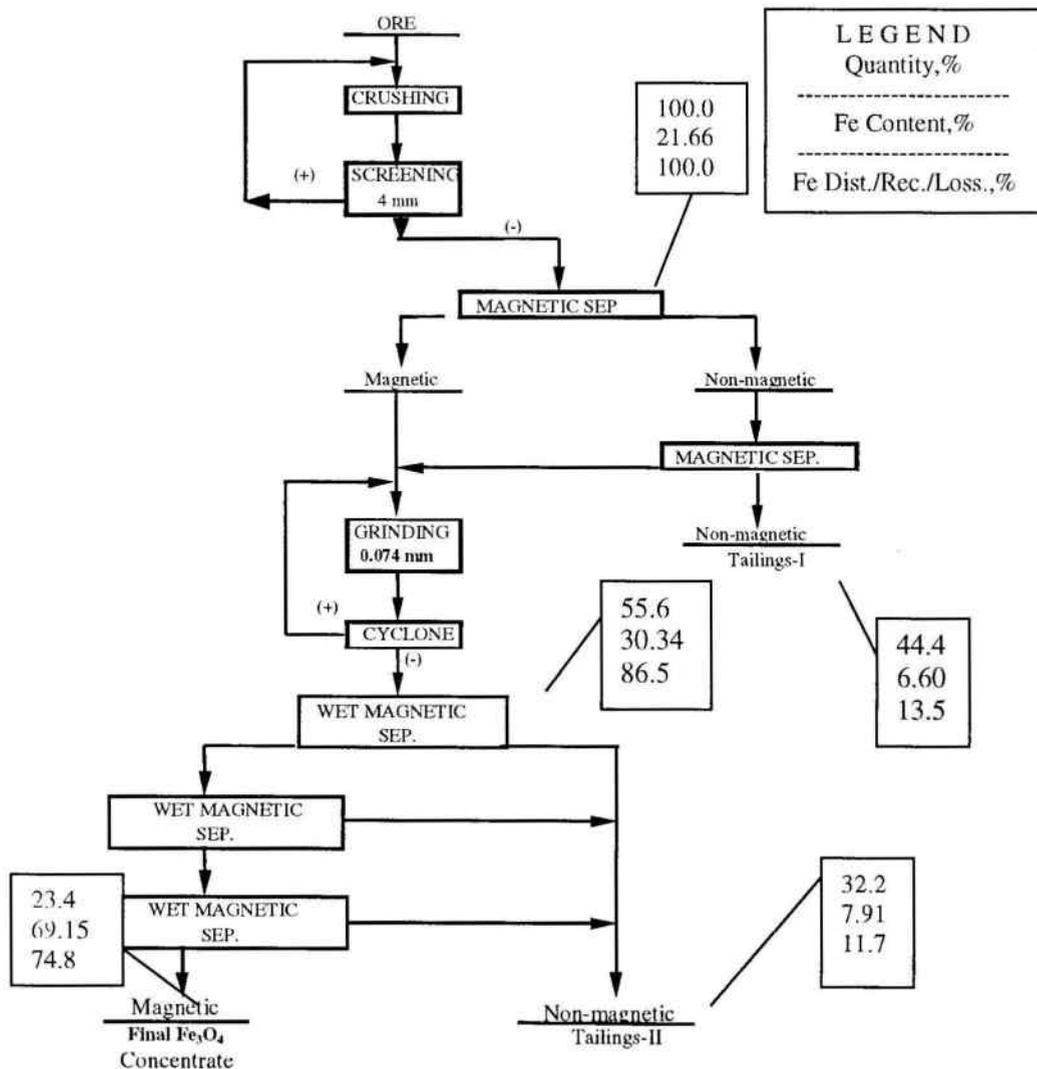


Figure 1. Process Flow sheet For Magnetite Concentrates Beneficiation Conducted on-4 mm.

CONCLUSION

* According to the feasibility study, 94.8 million tons of exploitable ore with an average grade of 21.66% Fe at 0.27 overburden ratio and a total overburden of 25.4 million tons were ascertained.

* As a result of pre-concentration tests, a magnetite concentrates with 23.4% by weight and 69.15% by Fe content with a recovery of 74.7% was obtained. In this case, 44.4% of the fed material was discharged as

tailings in the coarse size (- 4 mm) with an iron assay of 6.60%.

* Direct concentration tests were carried out with the sample ground to minus 0.074 mm in size and it can be deduced that, 24.2% of the fed material was obtained as the magnetite concentrates with an iron content of 69.10% and the recovery of 74.9%.

* Although the evaluation of pre-concentration and direct concentration tests has given compatible results in terms of metal content and recovery values, pre-concentration route has performed an advantageous occasion with the discharge of the 44.4% of fed material in coarse size. Therefore the removal of that fraction of material without applying any grinding operation will make the process profitable in terms of a considerable amount of energy saving.

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