NODULIZING FINE MANGANESE ORES IN
A PILOT PLANT ROTARI KILN

Dr. M. Servet Buyuran[*], Garip Yildirim and Batu Bütün

ABSTRATC

The nodulization behavior of the fine manganese
ores mined from the Çatalca District of Easten Trachia,
has been investigated. Following the laboratory tests,
pilot plant testings were carried in a rotary kiln
with 8 m length and 70 cm I.D. It was inclined at 2°
and rotated at 1.07 R.P.M. and diesel oil was used as
fuel. About 9,4 MT of fine manganese ore of-30 mm
size with 22,9% moisture and 32,76% Mn content (dry
basis) were charged in at the rate of 319-389 kg per
hour and nodulized at about 1250^oC. About 88% of the
nodules were of 10 mm size with 39,87% Mn content. The
retention time was determined as about 60 minutes and the
unit energy consumption as 1232-1011 kcal/kg of product.
Based on the results of the pilot plant testing, basic
data necessary for the construction of an industrial
plant with an annual capacity of 30 000 MT of ore have
been developed. A rotary kiln with 20 m length and
1,75 m.I.D. would be required and the unit energy
consumption would be about 860 kcal/kg of product.

* Dr. M. S. Buyuran is Senior Researcher and Leader of
  the Extractive Metallurgy and Casting Group, Dr. G.
  Yildirim and B. Bütün are researchers at the Materials
  Research Dept. of the Marmara Scientific and industrial
  Research Institute. Gebze, Turkey.

INTRODUCTION

The manganese ores mined from the sedimentary deposits of Çatalca in Eastern Trachia consist of mostly pyrolusite with some manganite and other manganese minerals. They usually have a nodular or spongy structure. Clay as the major gangue material either fills the cavities or is finely disseminated in the nodular layers. Other minerals such as calcite and gypsum are also found in minor amounts. As mined, they are crushed in two corrugated roll crushers and sized.

The coarse ore of over 10 mm size with 36% Mn content is exported or used domestically for iron production. Since the off-size grades are normally rejected by the industry, large stockpiles of fine ores have been accumulated over the years. The object of this work was to investigate the nodulization behavior of fine ores in rotary kiln. In comparison with other agglomeration processes such as briquetting, sintering and pelletizing (1-4), this process was preferred because of its simplicity. The upgrading of ore prior to the nodulization has not been investigated as it was not requested by Egemetal Mining Co., who sponsored this project.

LABORATORY AND PILOT PLANT NODULIZATION TESTS

Preliminary tests were carried out in a laboratoty type rotary kiln with 90 cm length and 20 cm I.D, it was lined with firebricks and rotated at a speed of 0,4 R.P.M. with an inclination of 1°.

After preheating it with LPG to a temperature of about 1150° C, it was charged periodically with fine manganese ore of-10 mm size, containing 31,3% Mn (on dry basis) and 24% moisture. The nodules of up to 40 mm size with

37,1% content were readily produced and discharged into a waterjacketed cooling box.

As the results were encouraging, further tests were carried ou in the pilot plant rotary kiln with 8 m length and 70 cm ID. It was originally designed by the authors for firing iron ore pellets and was manufactured at the Institute's Workshops. The inside of the kiln was lined with 125 mm thick firebricks and insulated with a 25 mm thick layer of asbestos sheets. Its inclination could be readily varied between 0-2° and the rotational speed between 0,25 - 1,1 R. P. M. Its firing was effected by means of a diesel oil burner mounted at the discharging end. The inside temperature of the kiln was measured by means of five thermocouples situated along the kiln length. For these tests the kiln was set at an inclination of 2° and rotated at a speed of 1.07 R. P. M.

After preheating it to the required temperature, fine manganese ores of -30 mm size with 32,76% Mn content were charged in through an inclined feeding pipe. The hot manganese nodules with average 39,87% Mn content were formed and discharged into a receiver box, from which they were transferred into the bins.

The quantity of the material charged and the nodules produced were recorded against time and samples were taken periodically for chemical analysis, the results of wich are given in Table 1.

Table 1
Chemical Analysis of the Fine Manganese ore and Nodules

| | % Weight, on dry basis | | | | | | |
	Mn	Fe	CaO	Al_2O_3	SiO_2	P	S
Fine Ore	32,76	3,6	6,3	3,6	14,5	0,16	0,39
Nodule	39,87	5,1	6,8	4,2	17,3	0,20	0,28

The pilot plant nodulization tests lasted nearly 36 hours, during which 9,37 MT of crude ore was charged at the rate of 319-389 kg/hour and 5,94 MT of nodules were produced at the rate of 185-230 kg/hour. The crude ore was rather sticky as its contained about 22,9% moisture. On standing it bridged in the bin, causing some difficulty in feeding. The nodulization took place without much trouble at about 1200-1250°C. The scales usually accumulated at the not zone of the kiln lining could easily be removed by reducing the feeding rate and raising the temperature. The temperature distribution inside the kiln is shown in Fig. 1. The flue gases normally left the kiln at about 240°C, but during the descaling periods it rose to 620°C. About 88% of the nodules as shown in Fig. 2a of + 10 mm size. The higher temperatures and lower feeding rate increased the tendency to produce large nodules of upto 250 mm size as illustrated in Fig. 2b. The red hot lumps discharged from the kiln still had some plasticity so that on standing they tended to stick to each other. Upon cooling they became rather brittle breaking with flat faces.

The loss of weight upon nodulization was found to be 17,8% on dry basis and 36,6% on wet basis. The bulk densities of the crude ore and the nodules were measured as 1,0 and 1 5 kg/dm^3, respectively. The useful kiln volume at the charging end in determined as 10, 4-12, 6% and that at the discharging end interms of the product volume as 4-5%. The corresponding bed heights were of 11, 2-13, 0 cm at the charging end and 5, 8-6, 9 cm at the discharging end. The retention time of the material inside the kiln was estimated as 60 ± 20 minutes, it is also given by the following relationship;

$$\Theta = \frac{kL}{mND}$$

where,

Θ = Retention time, minutes,
k = Kiln coefficient,
L = Length of kiln, m
D = Diameter of kiln, m
m = Inclination, ratio
N = Rotational speed, R.P.M.

From the above relationship the kiln coefficient can be determined as k = 0,1966 assuming that the retention time, Θ = 60 minutes. The unit energy consumption in the pilot plant nodulization tests was estimated at 1232-1011 kcal/kg of product.

ESTIMATION FOR AN INDUSTRIAL PLANT

Based upon the results of the pilot plant testing, the dimension of an industrial kiln with an annual capacity of 30 000 MT of ore or 19 000 MT of nodules were determined as about 20 m length and 1,75 m I.D. It would operative continuously for 300 days per year at a rotational speed of 1.0.R.P.M. and inclination of 2°. From the material and heat balances it was estimated that for nodulizing 4167 kg of ore per hour, approximately 238 kg of No 6 fuel oil and 2959 Nm^3 of combustion air (assuming 20% excess air) would be required and 4999 Nm^3 of flue gases with a composition of 7,6% Co_2, 43,6% H_2O, 2,0% O_2 and 46,8% N by volume would be produced.

The unit energy consumption for the process would be about 860 kcal/kg of product which is less that observed in the pilot plant testing, as would be

expected. About 45,9% of this energy would be used for
the evaporation of the moisture in the charge, and the
rest would be distributed between the exhaust gases, the
hot product and the heat loss from the kiln surfaces to
the atmosphere.

CONCLUSION

It has been demonstrated that the fine manganese
ores from the Çatalca District of Turkey could
successfully be nodulized in the pilot plant rotary
kiln, which could be scaled up for an industrial
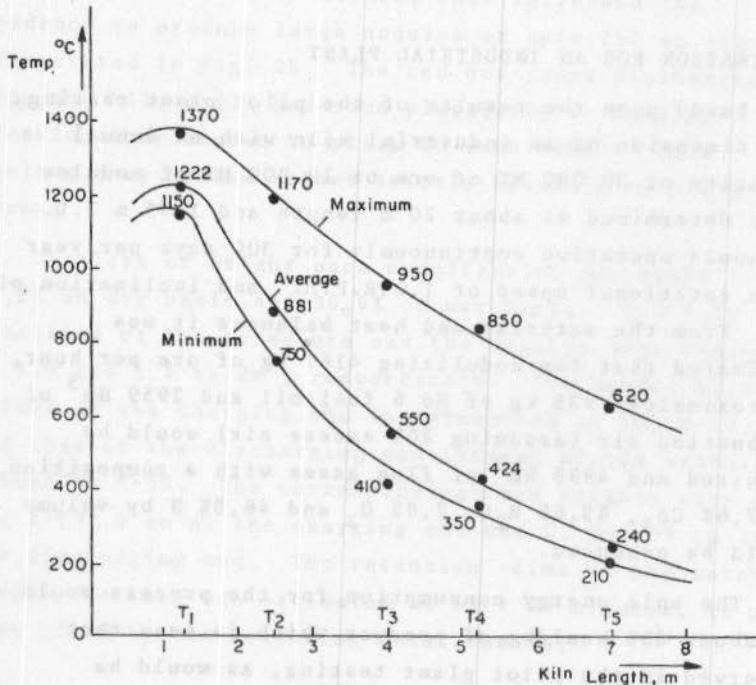application providing it is economically feasible.

Fig.1- THE TEMPERATURE DISTRIBUTION IN THE ROTARY KILN

REFERENCES

1. Metallurgy of the Non Ferrous Metals,
   by W. H. Dennis,
   Sir Isac Pitman and Sons Ltd, London 1961.

2. Handbook of Mineral Dressing
   by A. F. Taggart
   Willey Handbook Series
   John Wiley and Sons Inc., New York, 1945

3. Mineral Facts and Problems
   Bureau of Mines Bulletin 650
   U. S. Dept. of Interior, 1970

4. Chemical Engineers Handbook
   by J. H. Perry
   Third Edition
   Mc Graw-Hill Book Company. Inc., New York,
   1950