Utilisation of ore fines by agglomeration with special reference to sintering of manganese ore fines

D. N. Gupta*
G. P. Khandelwal**

ABSTRACT

Agglomeration is required to coagulate the ore fines to the desired size to make them suitable for metallurgical operations. The well known methods of agglomeration are briquetting, pelletisation and Sintering. About 20-30 % of fines are generated during mining operation, handling and screening of ores before they are sized for the smelting furnace.

This paper deals with the various process parameters which are determined for the manufacture of Manganese Ore Sinter on a continuous sinter plant of 20 Tons per day capacity.

Introduction

In the process of mining of ores, a lot of fines is generated. Similarly in operations such as crushing, screening, transporting & stacking, a large quantity of fines is generated For smelting operation in furnace, raw materials in a particular size fraction are required, since fines in the ore reduce the porosity of the charge adversely affecting the smelting operation The fines, therefore have to be screened out before using the ore in the furnace for metallurgical processing It is estimated that on an average 20-30% fines is discarded of the total ores utilised Thus huge quantity of fines is getting accumulated both at mines site and at the plant lying unused for the last so many years The fines unless agglomerated to required size cannot be used for metallurgical applications. Hence a suitable method of agglomeration has to be used. Agglomeration can be achieved by briquetting, pelletising and sintering.

*Works Manager, **Senior Metallurgist,
Khandelwal Ferro Alloys Ltd , Nagpur.

Sintering of ore fines appears to be a most suitable method of agglomeration under present condition. In the present case sintering characteristic of Mn Ore fines from MOIL, Nagpur has been studied in a continuous strand type sintering pilot plant of 20 MT/day capacity. The sinters so produced were charged in electric smelting furnace for production of Ferro Manganese as a part of the charge Furnace behaviour with different percentages of sinter of the total charge was studied This paper mainly deals with the production of sinter in a 20 MT/day capactiy pilot plant and its subsequent use in electric smelting furnace.

Physical specifications and chemical analysis of raw materials

Lumpy manganese ore containing fines was screened on vibrating screen at 3mm size. The fines were taken for sintering trials while lumpy ore was charged to the smelting furnace for Fe - Mn production Table 1 and 2 shows the sieve and chemical analysis of ore fines respectively.

TABLE — 1

Sieve analysis of ore fines

	(1)	(2)
+ 8 mesh	30.28	28.53
− 8 + 16 mesh	28.44	28.53
− 16 + 30 mesh	14.67	14.02
− 30 + 60 mesh	11.01	12.04
− 60 mesh	15.60	16.88

TABLE — 2

Chemical analysis of manganese ore fines used for sintering

Batch	(1)	(2)
Mn	36.50	37.17
Fe	8.40	9.20
SiO_2	12.82	12.07
Al_2O_3	5.60	6.76
P	0.130	0.126

Reductant

The coke used as reductant in the smelting should preferably be in the size range of 5 to 25 mm. The fines below 5 mm was therefore rejected after screening. Similarly for sintering of manganese ore fines above 3 mm were rejected by screening. The chemical and sieve analysis of coke fines is shown in Table-3.

TABLE — 3

Chemical analysis of coke fines

Fixed Carbon	70%
Ash	28-30%
V. M.	3-4%
P	0.15%

Screen analysis

Size	Percentage :
+ 3 mm	Nil
− 3 mm + 20 mesh	30.1%
− 20 mesh + 65 mesh	43.6%
− 65 mesh	26.3%

Flux

Lime is used as flux only when it is found necessary.

Sintering

Manganese ore fines is mixed with 6% coke fines of - 3 mm size and 30% return fines. The mixture after thoroughly drying is charged into a pelletizer where 6% water is added. The pelletizer revolves at a speed of 10-15 R. P. M. The pellets are transported by belt conveyor and bucket elevator to the hopper above the sintering strand. On the grate hearth of sintering conveyor a 25 mm layer of pellets is made followed by a bed of 150 mm depth of charge, which is then ignited by oil fired burner at temps. between 1100°C to 1150°C. The movement of the sintering strand is maintained at 2000 mm per minute and the vacuum is also maintained at 150 mm (of water guage) by a suction fan. The charge gets sintered layer by layer as the grate moves and the sintered material falls at the other end of the sintering conveyor into a grizzly of 6 mm opening -6 mm fines are taken as return fines alongwith the charge.

The lumpy sinter from the screen + 6 mm is broken into the size range of 10 to 50 mm for charging into the smelting furnace.

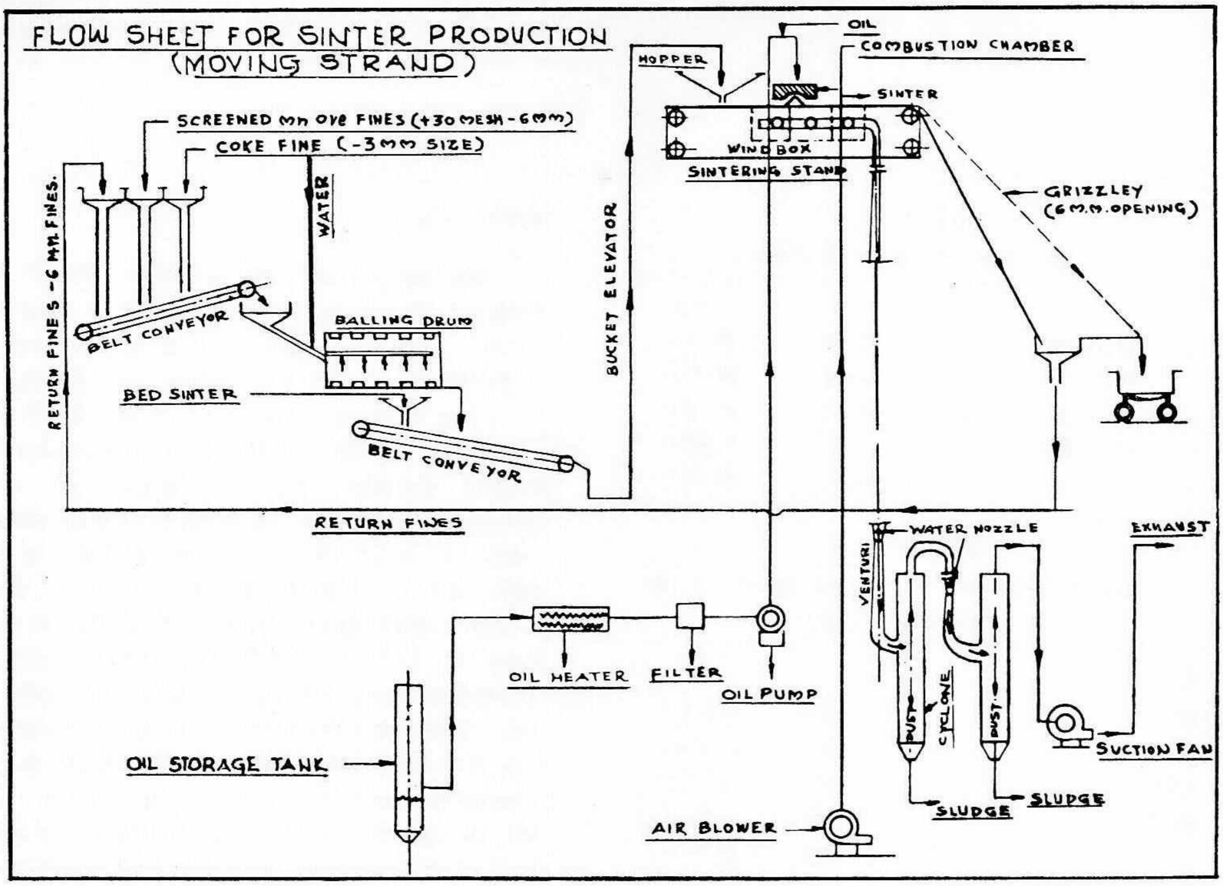
The operating parameters for sintering are summarized in Table - 4.

TABLE — 4

Coke	— 6%
Return fines (below 6 mm)	— 25%
Manganese	— 60%
Moisture	— 7%
Bed depth	— 150 mm (6")
Hearth Layer	— 25 mm (1")
Vacuum	— 150 mm of water guage.
Machine speed	— 200 mm / minute

Observations

Based on the above parameters a sintering trial in the range of — 3 mm + 30 mesh size fines was undertaken. It was noted that with the ore fines in the range of — 3 mm, porosity



of bed was low and the bottom layer was not getting sintered properly. Hence sintering was done after screening and using only — 3 mm + 30 mesh fraction. By screening, it was noted that the % Mn of fines increased from 36.6 % to 39 % Mn and silica reduced from 12.7 % to 10.23 %.

The average analysis of sinter produced was :

Mn	—	45.10%
Fe	—	6.55%
SiO_2	—	12.50%
P	—	0.169%

Results of screening test conducted at I. B. M. are shown in Annexure - I.

From this test it is seen that screening efficiency drops sharply above 2.25 % moisture in feed. Therefore the moisture content was restricted to below 2.25 %.

For determining the strength of sinter & its suitability for smelting furnace, shatter index test was carried out. (25 Kgs. of sinter of size + 10 mm — 100 mm was dropped from a height of 2 meter on a steel plate four times. The fines produced during each drop being admixed with the total quantity of sinter taken for the test for each successive drop The product thus obtained was screened on 10 mm screen. + 10 mm fraction was reported as shatter index.)

Shatter index of the sinter was 87.8 % which was quite suitable for furnace use.

By screening manganese ore fines on 30 mesh screen and by utilising + 30 mesh fines only, 20 to 40 % of fines of — 30 mesh size get rejected. Hence in another trial only unscreened manganese ore fines were used and lime was added to the extent of 0.5 to 1 %. Lime acted as binder for fines and balls were formed in balling drum. So porosity of charge did not suffer because of excess fines below 30 mesh in the mixture. The results were quite satisfactory. Chemical analysis of sinter was as follows :-

Mn	—	41.0%
Fe	—	9.2%
SiO_2	—	16.45%
P	—	0.152%

Use of sintered ore fines in Electic Smelting Furnace

There are many advantages and also some disadvantages in making use of sintered charge in electric smelting furnace.

Advantages

By charging sinters as part of electric furnace blend, porosity of charge increases, which leads to better distribution of reduction gas through the charge. Due to better heat transfer from gas to charge, flue gas temperature is lowered, so also the flue dust losses.

Due to less fines & moisture in the charge, chances of explosion are reduced & furnace condition is better stabilised.

By using sinter the chemical analysis of charge remains more uniform & because of less variation in charge and low moisture, frequent changes in burden can be reduced.

Because of good porosity of charge & thus improved furnace operation electrode consumption may reduce.

Disadvantages

The high axide of manganese viz. MnO_2 is already reduced to Mn_2O_3 & Mn_3O_4 in sintering process. Since this reduction is exothermic, therefore, by using sinter the exothermic reaction which would have taken place in electric smelting furnace, does not take place. Hence power consumption increases.

The silica and alumina content of coke ash joins the sinter. Hence, silica content of charge increase thus increasing the slag volume & power consumption per tonne of FeMn.

Manganese content in Ore Increases due to reduction of oxides, but SiO_2 / Al_2O_3 ratio does not increase, that is the slag volume per tonne of FeMn increases.

In sinter SiO_2 & Al_2O_3 are present as manganese silicates. The melting point of these silicate is lowered to 1200°C. Hence there is difficulty in the reduction of MnO to Mn which takes place at 1220°C. Thus high power & time is required for the burden with sinters and it may increase % MnO in Slag while decreasing the yield of FeMn.

Smelting trial with sintered charge

Smelting trlal with sintered charge was undertaken in electric smelting furnace of 9 MVA capacity.

Chemical & physical quality of sinter was as follows :-

1) Chemical Analysis :		
Mn	—	45.3%
Fe	—	8.7%
SiO_2	—	12.3%
P	—	0.149%
2) Screen Test :		
+ 70 mm —	—	25.0%
— 70 + 50 mm	—	30.0%
— 50 + 25 mm	—	30.0%
— 25 + 10 mm	—	10.0%
— 10 mm	—	5.0%

Conclusions

1) This trial indicated that a good quality (physical strength) sinter could be produced with the fines generated at MOIL beneficiated and unbeneficiated from Manganese Ore.

2) By use of beneficiated fines, increase in % Mn in sinter is about 6 % while in case of unbeneficiated fines is about 4% the silica content is around 12 % to 16 %.

3) Use of sinter upto 23% of blend in furnace did not show any adverse effect on furnace condition.

Discussion

F. Neterwala, Universal Ferro & Allied Chemical Ltd., Bombay

What effect has sintering of Mn fines had in the reduction of power consumption during FeMn production in your plant ? What would be the approximate pay back period for the capital inputs ?

Answer

The reduction in specific power consumption is to the tune of 50 to 65 KWH/MT of Fe-Mn produced at 15% utilisation of sintered ore. The effect upto 25% utilisation was not adverse in any way but the exact quantification was not possible. The pay back period would mainly depend upon whether the sinter plant is mechanised or manually operated but it would vary from 1½ to 2 years only, as the total investment is not huge.

V. N. Babu, Nava Bharat Ferro Alloys Ltd., Palonch

Has the author made any study regarding the cost benefit analysis regarding the usage of Mn ore by agglomeration ?

Answer

The average cost of the lumpy manganese ore equivalent of sinter comes to around Rs. 350/- per M. T. Whereas the fines being there almost free and the sintering cost around Rs. 200/- per M. T., the net economic advantage will be Rs. 150/- per M. T. of sinter utilised. Besides, the utilisation of fines itself which otherwise a waste material, helps in no small measure in conservation of mineral resources. The good furnace operating characteristic is another advantage.

N. N. Patra, Universal Ferro & Allied Chemicals Ltd, Tumsar

Do you suggest ore fines should be beneficiated before sintering ?

Answer

Beneficiation gives an effect of 6% increase in manganese content, which in turn should increase the ferro-manganese produced per day.

K. N. Singh, Regional Engineering College, Rourkela

Was the production of basic sinter tried ? If so, with what results ?

Answer

Yes. By basic sinter I mean fluxed sinter. Fluxed sinters were made at our plant with almost the same chemical characteristics as unfluxed sinter. The production of sinter with flux was useful in case where Mn ore is of finer fraction with increased content of gangue material. However, the shelf life of the fluxed sinter was comparatively less and also involved fine crushing of dolomite/limestone incurring more cost. The same therefore ultimately was not economical and advantageous.

S. Y. Ghorpade, Sandur Manganese & Iron Ores Ltd, Hospet

What are the pollution problems associated with sintering in your experience ?

Answer

In the 20 M. T. pilot sinter plant not much of pollution level was observed. Since the problem did not appear to assume any serious nature, the regular investigation in this regard was not made. However, if a bigger capacity plant is envisaged then some measure may have to be thought of. In our pilot plant the hot suction air containing dust passes successively through two numbers wet ventury scrubbers.

A. S. Ray, Alloy Steel Plant, Durgapur

Is it not possible to utilize the rich Mn-ore fines to produce Mn-metal/Fe-Mn by aluminothermic process ?

Answer

Yes, it may be possible to produce low carbon ferro-manganese by aluminothermic process, but cost wise it is too prohibitive. Manganese dioxide reduction by aluminium is highly exothermic and very vigorous. A primary reduction roast of Mn ore is necessary before the aluminothermic process is applied.

G. Rangarajan, Maharashtra Elektrosmelt Ltd., Chandrapur

Did you try using FeMn fines as feed to sinter plant ?

Answer

No

P. Dakshina Murty, Indian Standards Institution, New Delhi

Do you test the Mn sinters produced for the production of Fe-Mn to any national or foreign Standard ? If no such standard is available, do you have your own well laid down company standard to assess their suitability ?

Answer

Till to date we do not test the Mn sinters for the production of Fe-Mn to any national and/or foreign standard. Perhaps there is no I.S.I. Standard for this product. We are testing the shatter index and chemical composition for inplant process control. However, if porosity and reducibility tests are also carried out and colrelated with the various sinters produced, suitable standards can be evolved which would be advantageous for the process control. This would be of very great advantage if instead of captive sinter units, a separate sintering plant is established to liquidate the Mn-ore fines available and lying waste at present, at various mine heads.

ANNEXURE — I

SCREENING TEST AS CONDUCTED BY I. B. M. NAGPUR

DRY SCREENING					WET SCREENING				
% of Moisture in Feed	Wt. %		% of Moisture		% of − 30 present in + 30	Size of material	Moisture content	After sun drying	
	+ 30	− 30	+ 30	− 30				5 hrs.	24 hrs.
1.28	58.96	41.04	1.03	1.48	10.98	Feed	1.6 %	–	–
2.25	55.11	44.89	1.32	2.85	17.37	+ 30	16.0 %	9.95 %	NILL
3.46	95.51	4.49	3.33	3.48	45.89	− 30	–	3.16 %	1.67 %

1) Flow of water was 9.5 Lit/Min.
2) Feed to screen was 2 Kg./Min.
3) % of solid present in Feed — 17.39 %
4) 20 % — 30 is present in + 30 material.
5) + 30 is 60 %.
6) − 30 is 40 %.

Wt. %	
+ 30	− 30
60 %	40 %