The Techno-Commercial Aspect of Beneficiation & Pelletisation

- S. C. Khattoi
GM (Works)
S. K. Patnaik
Adl. GM (Proj. & Engg.)
Orissa Sponge Iron & Steel Ltd
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With the world witnessing unprecedented growth in steel driven primarily by China and India, the demand of the quality ore requirement is going up day by day and its deposit depleting at much faster rate, beneficiation and agglomeration has become the need of the hour. Different method of beneficiation followed by agglomeration, their techno commercial aspect, and the optimal way of converting Indian raw materials to feed material form the text of discussion.

Introduction

India is the biggest producer of Sponge iron in the world. Total gross capacity of the country is around 30million tons/annum with nearly 80% contributed by coal based plants. Additional 12.0 million tons capacity in the coal based route is waiting to come.[1]. To achieve this quantity of sponge iron production, the iron ore requirement is nearly 50million tons. Deposit of high grade hard and massive ore is ideal for sponge iron making but it's depleting every day. Manufacturers are forced to bank on low grade soft ore with 62-63% Fe, low tumbling index and low thermal degradation index. The specific consumption of has becomes high, campaign life has shortened and low usability has increased the production cost.

Lower Fe in the ore gives higher gangue which in turn gives lower yield in the melting furnace and higher energy consumption per ton of liquid steel.

Beneficiation

Ore beneficiation is the need of the hour for improving the available raw material to a suitable feed material. The process is always designed for every specific feed material, after conducting extensive laboratory tests. So the cost of the plant & equipment will vary depending on the requirement. One should choose cost effective plant which can take wide variation in quality of feed material with minimum rejection.

The standard techniques used for beneficiation are given below .

Mineral Phases	Size (mm)	Technique	Improvement
HEMATITE MAGNETITE ORE	+8- 40	HMS/JIG	UPGRADE Fe REDUCE Al_2O_3 & SiO_2
	0.5- 8/10	HMS/JIG	
	0- 6/3	LIMS/M IMS	
	0.1 -1.0 0.045- 1.5	SPIRAL	
	2.0 - 0.5 0.1 - 1.5	UPSTREAM CLASSIFIER	
	0 - 1.0	CYCLONE/WHIMS	
	0 - 0.150	FLOTATION	REDUCE SiO_2 P,S & Alkalies
	0-0.5 / 0.2		

Iron ore in general generates 35% of fines during blasting and sizing operation[2]. It produces 15% to 25% slimes in the washing plant[3,4]. The slime is accumulated in the tailing dams as waste material and is a threat to environment. The iron ore fines are usually lateritic in nature and minerologically dominated by hematite and goethite[2,5]. Iron ore fines and slimes contain about 58% Fe, high amount of alumina (over 8%)and silica (8%). The quality norm of feed ore for most of the plants are 64% Fe[6]. The increase of 1% Fe in the feed ore increases 2% hot metal productivity and requirement of coke is reduced by 1.8% in case of blast furanace[6]. A case study is given on the beneficiation process for over burden material in Joda,Keonjhar, Orissa .

Washing and Sizing

The size of raw ore is of 0-30mm and it contains a lot of sticky clay adhering to it. This over burden needs pre treatment to remove the clay(gangue mineral) adhering to its body. This is done by washing. It is difficult to achieve using plain water for which dispersion-cum-settling approach is adopted by using surface active agents. The equipments used for washing of ore are Classifier, Log washer, Barrel washer and screen washers. In the present case screen washer was chosen.

The feed material to the screen is 0-30mm & the over size +15mm is crushed by a cone crusher to produce all 0-15mm size. The 0 - 15mm ore is then fed to spiral classifier to classify 0- 0.21mm fines as overflow slims. The slimes are pumped in to high rate thickener for recovery of circulating water.

The classifier out put is then fed to a desliming screen to remove 1.5mm fines. The over flow 1.5 -15 mm from the screen is fed to air pulsating jig for up gradation of ore by gravity separation. The higher gravity sink product from jig is fed to a double deck dewatering screen having 5.0mm aperture to produce 2 fraction of concentrate ie 1.5- 5mm and 5- 15mm.

The 0.21-1.5mm goes to a pre clarification sump & the over flow of the sump is pumped to cluster of hydro cyclones. The cyclone over flow water is fed to the jig and under flow (thickened slurry) is fed to a high frequency slurry screen for fines and water recovery. Thisfines is again gravitate to the high rate thickener.

The under flow of pre clarified sump is fed to a slow speed spiral classifier(SSSC) for further de watering of fines.

The grade of 1.5-15mm ore improved from +55%Fe to +63% Fe with a total recovery of 43%. Recovery of 5-15mm is 33% and 1.5- 5.0mm is 10%.

Grinding and Magnetic Separation for Fines

The feed size of less than 5.0mm is neither used by sponge iron kiln nor by blast furnace. So the -5.0mm fines goes for primary grinding to reduce the size to -0.5mm.

This product -0.5mm is again fed to a Wet High Intensity Magnetic Separator(WHIMS) for subsequent processing to achieve +65% Fe in the fines.

This up graded product from WHIMS goes for final grinding to prepare pellet feed concentrate of desired granulometry. WHIMS is capable of separating feebly magnetic minerals like hematite and even the feed is very fine. The grinding is done by Ball mill or Rod mill Or by Roller Press.

The rejects are carried to separate thickner for disposal. Technology for Paste thickner is being explored to minimise the area required for slime disposal and maximize the recovery of re-circulating water.

The capital cost of a 5.0 Mt beneficiation plant will be approximately Rs 152 crores out of which the plant and machinery is Rs 90.0crores.

Pelletisation

Pelletisation is a kind of agglomeration process of making ball from finely powdered minerals mixed with some binder. It is a proven technology named as "pelletization" which produces hard pellets to be used in sponge iron making as well steel production through blast furnace route. This will result in gainful utilization of the iron ore fines and also yield a cost effective production route for domestic sponge iron plants.

The production of fired pellets begins with green ball formation in a disc or drum from fine grained iron ore with proper size distribution and with bentonite (suitable binder) and limestone (flux) is rolled with addition of controlled water. Then the green balls are dried, pre heated and heat hardened(indurate) by pre determined heating rates under oxidizing atmosphere to facilitate bond formation. Then the pellets are cooled carefully to avoid crack formation.

The bottle neck of this process is heat hardening to achieve a minimum strength of 30kg per pellet. The heat requirement is of the order of 120-130 k cal/kg[7]. The heat sources can be from Oil, Gas, Imported or indigenous low ash coal, Producers Gas. The indurate temperature is around 1300 deg c and the fuel has to be suitably chosen considering the cost economics.

There are three technology used for this heat hardening, namely shaft furnace technology, travelling grate or straight grate process and grate-kiln process. Shaft kiln is more suitable for magnetite pellets and fuel cost for heat hardening becomes high. It has a major disadvantage of controlling various thermal zones to achieve the required regimes. Travelling grate is a modified version of sintering machine and is suitable for drying , preheating, firing and cooling of pellets in one single unit. It has its individual separate thermal zones and the temperature control is varied to suit the type of ore. The most popular is the grate-kiln process. Drying, pre heating and oxidation are carried out in the grate car. Pellets are fired in the rotary kiln. Hot pellets are cooled in rotary cooler or circular cooler. The hot air from different

equipment is re-used for fuel economy. The heat controls of grate-kiln is easy due to heating units being separate.

Normally the pellet plants use blast furnace gas as the main fuel and the concentrate is transported to the plant in wet condition from the beneficiation plant. Presently the pellet plants are coming up as stand alone units close to the mines, so oil and low ash coal can be used as the fuel instead of blast furnace gas. China has successfully developed the technology of low ash coal(less than 12%) firing in the grate-kiln process. The standard Pellet plant designs are of higher capacities but the need of the day is for smaller ones. New design smaller modules available to-day are 0.3Mt/yr, 0.6Mt/yr, and 1.2Mt/year[8].

Parameters	0.3 Mt/yr	0.6 Mt/yr	1.2 Mt/yr
Investment Rs. Crore	50.0	80.0	110.0
Annual cost of			
Production Rs Crore	60.0	110.0	210.0
Annual turn over, Rs. Crore	80.0	160.0	320.0
EBIDTA, Rs. Crore	11.0	24.9	54.3
Return on investment (RoI)			
based on Gross Margin after tax	22%	28%	37%
Payback period in years	5.2	3.8	2.7
IRR in %	21	29	41
Land	6.0ha	8.0ha	11ha

Table -1 : The return on investment and the pay back period is attractive for the above mini pellet plants. The capital expenditure required for a 3.0Mt/yr plant is given below, which can be compared against mini pellet plants.

Capital Cost of the Project (PELLET)

Item	Rs. Crores
Land & Site Development	4.0
Testing & DPR	1.5
Plant & Equipment	250
Civil & Structural Works	25
Erection of Plant & Equipment	38
Preliminary & Pre Operative Expenses	5.0
Consultancy, Engineering & Supervision	5.0
Contingency @ 5%	16
Sub - Total	339
Margin Money for Working Capital	27.0
Interest During Construction (D:E:3:1) @11.0%	37
Total Capital cost	403

Table - 2 : The Economicsof Pellet vs Lumpy Ore Use in the Rotary Kiln is Given Below [8].

Item	Specific Requirement in t/t	Price Rs/t	Cost in Rs/t
Lump Ore & Indigenous Coal			
Lump ore	1.8	2100	3780
Indigenous Coal	1.4	2600	3640
Cost of Raw Materials			7420

Item	Specific Requirement in t/t	Price Rs/t	Cost in Rs/t
Pellet and Imported Coal			
Pellets and Imported	1.45	3000	4350
Imported Coal	0.8	3700	2960
Cost of Raw Materials			7310

Table - 3 : The requirement of lumpy ore is generally 1.8t /t of sponge iron where as the pellet requirement will be 1.45t/t of sponge iron. The requirement of low ash coal will be 0.8t against 1.4t of high ash coal per ton of sponge iron. As the ore price goes up the difference also increases and small pellet plant becomes more profitable.

Conclusion

India has only nine percent ore reserve of the world. We are exporting due to short sight branding ore fines as unusable. Time will not be far away when we shall be importing, if the export continues. Time has come to make the development of the steel industry sustainable in terms of ore availability, usability by adopting beneficiation and agglomeration.

It is highly recommended to go for beneficiation along with pelletization to conserve natural resources.

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Note :

HMS-Heavy media separation
MIMS-Medium Intensity Magnetic Separator
LIMS- Low Intensity Magnetic Separator
WHIMS- Wet High Intensity Magnetic Separator.