Iron ore pellets as feed to Sponge Iron Plants

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Pelletisation of iron ore concentrate

Iron ore pelletising was firmly established in the late 40s, especially in USA, as a process of agglomerating the concentrate produced by beneficiating low grade magnetite/ martite ore which had to be ground to -200 mesh to liberate the gangue and upgrade it to +64% Fe by magnetic separation. Pellet plants had an added advantage that they could be stand-alone units established close to the mines and the pellets transported to the steel plants, whereas, sinter plants needed to be necessarily set up within steel plant premises as sinter could not be transported over long distances without deterioration in quality.

The first stage in the production of fired pellets is the formation of green balls in a disc / drum where fine grained iron ore with proper size distribution and mixed with a binder (usually Bentonite) and additives such as limestone/ dolomite is rolled with addition of water. Then the green balls are dried, preheated, and heat hardened (indurated) by predetermined heating rates under oxidizing atmosphere to facilitate bond formation. Then the pellets are cooled carefully to avoid crack/fissures formation.

Three technologies were developed for heat hardening of pellets, namely shaft furnace technology, grate - kiln process and travelling grate or straight grate process.

The shaft furnace technology was the first to be developed because of its simplicity in operation. The green balls, charged on top of a furnace move downward by gravity to various thermal zones while being exposed to friction and increasing pressure. It was not possible to control the thermal steps to achieve the required regimes. The shaft furnace was not very popular as it was suitable only for magnetite, the fuel consumption was very high, pellet quality was non-uniform and capacity was low.

Travelling grate process, originally designed for sintering, was modified to make it suitable for drying, pre heating, firing and cooling pellets in one single unit. However, the individual thermal zones are separate. These zones could be designed to suit the ore types by controlling flow rates and temperatures.

The grate-kiln process has three process units for

meeting radically different thermal conditions. Drying, pre heating and oxidation are carried out in a travelling grate while pellets are fired in a rotary kiln by radiation. Hot pellets are cooled in a rotary cooler. Hot air from the cooler and hot gases from the rotary kiln are used in the grate for drying and preheating. The hot air from the cooler is recirculated in the rotary kiln. Heat supply for various types of ore can be regulated very easily because of three units being separate.

The grate-kiln and the travelling grate processes are more widely employed for pelletising because of their flexibility to different ore types, uniform and high quality of pellets, high capacities, low operating costs and very high availability of the machines.

During 70s, the sharp rise in oil prices made it uneconomical to operate the stand alone pellet plants and many of them closed down. Natural gas could be used successfully to substitute oil, but its availability is limited and restricted to certain regions only. Use of gases from coal gasification has not been very successful commercially. Further, the economic scale of operation at 3 Mt/yr and above has been keeping the investment cost of pelletising plants very high and beyond the reach of small investors. Due to these factors, not many new pellet plants were being built.

Attempts have been made for a long time to replace oil with coal. Chinese have successfully developed the technology for 100% coal firing in the grate-kiln process. They have also succeeded in miniaturizing the capacities of pellet plants. There are some design institutions in China specialising in designing, manufacturing and offering mini pellet plants of capacity ranging from 0.3 Mt/yr to 1.2 Mt/yr with lower capital investment requirement. However, the basic requirement is that the coal should have ash below 12 %. This will compel Indian operators to depend on imported coal only for pelletising iron ore.

Iron ore is usually ground to 60 – 70% -325 mesh with the Blaine number ranging from 1900 – 2300 for pelletising. It is in this respect that the concentrate from low grade ores, which may need only a marginal grinding, becomes an ideal feed for producing pellets.

Many of the mine owners in India have been exporting iron ore directly without any value addition, for decades. Many of them have small to medium sized iron ore mines, producing anywhere between 0.3 to 2.0 Mt/yr iron ore fines. It has now become possible for these mine owners to set up mini pellet plants using non coking coal as fuel, especially at a time when Govt. of India has liberalized the policies for import of coal.

The studies have shown that such mini pelletising plants can be operated profitably in India with imported coal.

Present selling price of pellets (Ex-Works) is Rs. 3300/tonne, corresponding to US $ 75/t. However, based on a very conservative, long term sustainable selling price of Pellets could be around Rs. 3000/tonne.

A comparison of important economic indices for mini pelletising plants of three different sizes is indicated in the following table.

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

	0.3 Mt/yr	0.6 Mt/yr	1.2 Mt/yr
Iron Ore Fines (t/d)	1050	2100	4200
Non-Coking Coad (t/d)	60	120	240
Bentonite (t/d)	10	20	40
Power (Max. Load - MW)	6.1	11.5	21.5
Water (m3/h)	20	40	75

One may find that the return on investment and the pay back period is very attractive for a typical 0.3 Mt/yr, 0.6 Mt/yr and 1.20 Mt/yr mini pellet plants.

Item	Specific requirement in t/t	Price in Rs/t	Cost in Rs/t
Lump ore and indigenous coal			
Lump ore	1.8	2100	3780
Indigenous coal	1.4	2600	3640
Cost of raw materials			7420
Pellets and imported coal			
Pellets	1.45	3000	4350
Imported coal	0.8	3700	2960
Cost of raw materials			7310

The land required for setting up 0.3 Mt/yr, 0.6Mt/yr and 1.2 Mt/yr is approximately estimated as 6 ha, 8 ha and 11 ha respectively.

Typical specific consumption parameters for mini pellet plants are given below:

The recent upswing in the steel business is continuing to have very positive impact on iron ore mining industry. The capital investment required for stand-alone mini pellet plants are now within their affordable limits of many mine owners. Pellet is one of the few intermediate products in the chain for production of steel which has a ready market.

The internal cash accrual through pellet sales can be used for funding future projects such as DRI Units, Mini Steel Plants etc. The socio-economic outlook of the iron ore mining regions in particular and India in general will become pastoral with such investments.

Use of pellets to manufacture sponge iron

All most all the coal based sponge iron plants use iron ore lumps. The requirement is generally 1.8 t/ t of sponge iron. This high requirement is mainly due to the fines generated in handling the purchased ore from the source to the plant. Use of high ash indigenous coal not only raises the coal requirement to 1.4 t/t, but leads to kiln accretions. This reduces the kiln campaign length and increases ore fines lost.

Use of pellets with better physical and metallurgical properties for sponge iron production will reduce the accretion formation in the kiln and the pellets consumption will be about 1.45 t/t. Requirement of low ash imported coal will be about 0.8 t/t. Further, the production from the kiln is expected to increase by 25 % to 30 %.

The differential cost for the iron bearing material and the reductant is expected to be lower by Rs. 110/t for pellets when compared with that for ore, as brought out in the following table.

This coupled with increased production capacity strongly advocates for use of pellets for sponge iron manufacture. For a plant of 100 t/d capacity, increase in annual earnings will be more than Rs. 100 lakh, which comes with only management of raw materials and with no additional investment.

It is noteworthy that many iron ore mine owners are operating sponge iron plants too. For them, the profit margin will still be higher, while using pellets, if they have a captive pelletising plant. It is also worthwhile to consider a group of sponge iron manufacturers joining together to set up an iron ore beneficiation and pelletising plant to meet their requirement.

Conclusion

Thus, the analysis of the present and the expected scenario in the next ten to fifteen years indicates that it will be highly profitable for small and medium capacity mine owners to set up plants to beneficiate low grade iron ores and to convert the concentrate to marketable pellets. Early action to set up such plants and to acquire/ conserve even low grade iron ore deposits will be amply rewarded in the long run.