Efficient Use Of Lower Quality Input Materials - An Urgent Need In Indian Steel Plants

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Abstract: Iron ore and coal together account for about 72% of cost of input materials in Indian steel plants. Moreover, sourcing iron ore and coal for steel plants is posing multitude of challenges including availability, quality and logistics. At present it is found that high quality input materials are hard to reach and easy to reach ones are of lower quality. Hence efficient utilisation of lower quality input materials has assumed greater significance for the sustainability of the steel plants. Accordingly the focus should be on beneficiation and agglomeration of lower quality input materials and development & application of new technologies for efficient use of the same in the steel plants. It also requires a paradigm shift from adopting technology dependent primarily on high quality input materials to introducing and absorbing alternate and mixed routes of production, which can efficiently utilise lower quality input materials.

Key Words: Steel Plant, Input Materials, Beneficiation, Agglomeration

1 Introduction

In India, steel is produced through two major processes: Blast Furnace (BF) – Basic Oxygen Furnace (BOF / LD) route in integrated steel plants and Scrap / DRI / Sponge Iron route in mini steel plants. With 76.7 million tonnes steel production in 2012-13, India is the 4th largest steel producer in the world. The domestic steel production as envisaged in the National Steel Policy-2005 was upwardly revised in 2008. As per this revised estimate, the projected steel production in 2019-20 is 180 million tonnes in which about 60% (around 108 million tonnes) would be through BF-BOF route, 33% (60 million tonnes) through Sponge Iron & Electric Arc Furnace (EAF) / Induction Furnace (IF) route and the rest 7% (12 million tonnes) through other routes[1]. In light of this projection, it is evident that iron making capacity is to be enhanced in all the routes in India. The primary input materials for steel plants are iron ore, coal, limestone, dolomite, manganese ore and scrap. The input materials account for 60-70% of cost of steel[2]. Out of this, iron ore and coal together constitute around 72% of cost of input materials. Hence these two are the most important input materials for steel plants and need focused attention. It is obvious that iron ore is the principal input material as it supplies the fundamental element iron, which is the major constituent of steel. Superior quality iron input has good impact on blast furnace productivity e.g. 1% increase in iron content improves the blast furnace productivity by 2% and reduces coke consumption by 1%[3]. Hence higher iron content (over 60%) in the feed to blast furnace is preferred in the existing steel plants. The other important raw material is coal. Coal is carbonized to coke, which is used in blast furnaces to reduce iron ore to hot metal / pig iron.

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The underlying emphasis of efficient utilisation of lower quality input materials in steel plants is to ensure cost effective utilisation of available natural resources, particularly iron ore and coal, which India has large stock. It is directly linked to technology choice and investment decisions in the industry. It is pertinent to mention that sourcing iron ore from new mines raises a number of issues in terms of ore quality (iron content, gangue materials, phosphorus, sulfur etc. and granulometry) and of logistics such as access to the mines and to shipping. A rule of thumb suggests that new resources of high quality ore are hard to reach and that easy to reach ones are of lower quality[4]. It calls for two-pronged strategies – to ensure more beneficiation and agglomeration of input materials for use in the existing technology and to introduce & absorb technology, which can efficiently utilise lower quality input materials.

2 Iron Ore Beneficiation & Agglomeration

Hematite and Magnetite are two most prominent types of iron ores in India. Hematite ores having higher iron (Fe) content and being lumpy are extensively used (98% of total domestic consumption) in the Indian steel sector. The ore deposits with around 40% Fe and poor grade lumps have not yet been exploited for domestic use. The silver lining is that it can be used after beneficiation at a finer size followed by pelletisation. The mining from the majority of the iron ore deposits in India started after the independence when major integrated steel plants in India were set up. In tandem with the technology of iron making available at that time, mining of iron ore was restricted only to high grade lumps with 60-63% Fe. As a result, zones of lower grade ores were not mined with exceptions of those zones where lower grade ores coexisted with high grade[5]. As per the United Nations Framework Classification (UNFC) of mineral resources, the total iron ore reserves in India as on 01.04.2010 were estimated to be 28.5 billion tonnes. Out of this, hematite and iron ores with less Fe accounted for 62.7% and 37.3% respectively. However, hematite, which was estimated to be around 17.88 billion tonnes, had 8.09 billion tonnes under 'reserves' category (which are not permitted to be mined) and 9.79 billion tonnes under 'remaining resources' category. In case of ores with less Fe, which was estimated at 10.64 billion tonnes, had a meagre quantity of 0.02 billion tonnes only in 'reserves' category and a huge 10.62 billion tonnes in 'remaining resources' category[6]. Thus the existing hematite reserves (averaging around 63% Fe) may not last beyond 15-20 years with the projected steel production. Though the threshold value of iron ore mining has been reduced to 45%, a cut-off grade of +60% of hematite reserves only have been taken up for exploration. At present domestic iron ore production takes place in the form of lumps and fines in the ratio of around 2:3. Of these, domestic consumption in the steel plants is around 45% only in the form of lumps and sinter and the remaining is exported. The bulk (around 90%) of iron ore fines are exported as it can't be utilised without agglomeration that India doesn't have much facilities. Furthermore, in spite of being rich in iron content, Indian hematite ores have adverse Al_2O_3 and SiO_2 ratio of 1.5-3.0 for lumps and 3-4 for fines. This adverse ratio is detrimental to both blast furnace and sinter plant productivity and should be less than 1.5 and preferably below 1. Consequently, beneficiation / processing of iron ores are necessary to reduce alumina in the feed[7]. The alumina in iron ores primarily comes from clay (kaolinite), gibbsite, lateritic materials and also solid solutions in hydrated iron oxides. Major steel plants in India consume medium to high grade iron ores with +62% Fe by resorting to selective mining keeping the cut-off to 58-60% Fe only to meet the physical standards. Thus there is a fast depletion of high grade iron ore reserves in the country. The ores are passed through multi-stage crushing, washing and sizing to produce lumps (-30/+10 mm) and sinter feed size (-10/+0.15 mm) materials. In this process, a large amount of unused fines (-10/-6 mm) and slimes (-100 mesh/0.15 mm) are generated at the mine sites. These fines, slimes and low grade resources are the potential source for producing usable grade iron after agglomeration[8]. The two primary methods of agglomeration are sintering and pelletisation. Sintering process uses iron ore fines in the size range of -10/+0.15 mm to produce agglomerated sinter for use in blast furnaces and major steel plants have sintering facilities. In pelletisation, iron ore fines below 325 mesh are used for agglomeration. While sinters are porous and brittle, pellets are hard and compact. Hence pellets can be transported over a long distance. Nevertheless pellets have not yet got wide applications in Indian steel plants except in some gas based DRI units. Moreover, against the installed pelletisation capacity of 28.8 million tonnes, the production is only 11.5 million tonnes in India[9]. However, of late many integrated steel plants have proposed to use some portion of pellets in the blast furnace burden replacing lumps for its superior chemistry, strength and quality. Interestingly, the market price of high grade lumps and production cost of quality pellets from rejects and slimes after beneficiation are comparable[10]. Thus the iron ore beneficiation followed by agglomeration is having several benefits including utilisation of valuable rejects, which are as such dumped and pose environmental hazards. Along with sinter, if the integrated steel plants use a minimum of 15% pellets in the blast furnace burden then around 25 million tonnes of pellets would be required for them. Moreover, if DRI units use 50% pellets, the requirement of pellets on this account would be around 25 million tonnes. It is tantamount to additional 50 million tonnes pellets per annum[12]. Hence pelletisation has a huge potential in India.

3 Coal: The Challenges Ahead

Coal is also an important input material for steel plants. As on 01.04.2011, India had total coking coal resources of 33.474 billion tonnes, out of which 17.67 billion tonnes was of 'proved' category. Even in the 'proved' category, the prime coking coal was only 4.61 billion tonnes. Majority of coking coal reserves in the country have high ash content, which is not suitable for the steel industry unless washed & blended with low ash coking coal. As on 01.04.2011, India had total non-coking coal resources of 252.39 billion tonnes, out of which 96.33 billion tonnes are of 'proved' category[13]. The essence is that India has relatively higher reserves of non-coking coal and less reserves of coking coal. Even the coking coal available in India has high ash content and is not suitable for direct use in Indian steel plants. Poor domestic availability as well as quality problems of Indian coking coal has forced the steel industry to import coking coal (more than 75% imported coking coal in the coal blend) subjecting them to the vagaries of the fluctuating international coking coal prices. Import of coal was 100 million tonnes in 2011-12 and at the present rate it is expected to reach a level of 2 billion tonnes by 2031. The total washed coking coal production in the country during 2010-11 was 6.373 million tonnes declining from the level of 7.181 million tonnes during 2008-09. The Indian coals with high ash content require high precision washeries with stricter technological controls. However, Tata Steel has shown the way by producing coal with 13-14% ash content with good yield by adopting superior beneficiation technology and is also pioneering towards production of 8% ash coking coal in India[14]. Reduction of ash content in coking coal substantially (at least to a level of 13-14%) through washeries will have huge impact on the Indian steel plants. In parallel, there is also a need to augment resources of prime coking coal available beyond 300m depth by special exploration efforts. The coking coal in other coal fields is also required to be explored in detail to make them available for exploitation. Though these efforts may not eliminate import totally but will definitely improve availability within the country.

4 New Technologies: New Opportunities

The challenges are opportunities in disguise. In the existing iron making technology through blast furnace route, efforts are being made to reduce coke consumption by higher blast temperature (1000^0C), 100% prepared burden, coal dust injection, use of nut coke, better burden distribution in the furnace among others. By these efforts, it is possible to cut down the consumption of metallurgical coke to less than 300 Kg per tonne of hot metal. At the same time, as the availability of lumpy iron ore with higher %Fe is itself becoming scarce, it is necessitating the use of more and more sinter and pellets in place of lumps. It has also opened up opportunities to use new technologies in sync with the present imperatives of lower quality input materials, particularly iron ore and coal. The underlying emphasis of new technologies is to provide alternatives to traditional iron making and to do away with metallurgical coke as the prime reducing agent and heat source. Some of them are mentioned below[15]:

4.1 Direct Reduced Iron (DRI) or Sponge Iron

The basic principle of DRI is to get solid metallic iron by reduction of high grade iron ore either by using non-coking coal or natural gas. The coal based DRI process with indigenous technologies has become popular in India mainly due to locational flexibility. In gas based DRI process, MIDREX and HYL-III (now called Energiron) are in vogue. While Essar has used the gas based DRI technology, JSW Steel is setting up one DRI plant using Corex gas in place of natural gas on the concept adopted in Saldhana, South Africa. As India has sufficient reserves of non-coking coal, an alternate technology may be attempted for gasification of non-coking coal by the coal gasification process of Lurgi and also use of synthesis gas (syn-gas) as a reducing agent to produce gas based DRI. JSPL is setting up two gas based modules at Angul, Orissa using syn-gas produced from coal gasification.

4.2 COREX Iron Making

This process has been developed by Siemens VAI for producing hot metal from iron ore (lumps or pellets) and coal by blowing oxygen without going through the process of coke making. JSW Steel has successfully implemented COREX process (C-2000) in Karnataka. Essar Steel is also installing two similar modules at its Hazira plant. Though a substantial amount of coal is directly used, the COREX process has certain inherent drawbacks, which include limited modular size, requirement of lumps / pellets, partial requirement of coke and coking coal for optimum operation and high oxygen consumption.

4.3 FINEX Iron Making

This process has been developed by POSCO at South Korea for making iron by using iron ore fines and by blowing oxygen. The Finex process could overcome the major limitation of the COREX process as it can directly use iron ore fines. Nonetheless it has certain limitations like requirement of inputs in melter gasifier in lumpy form, need for lumpy coal / coal briquettes etc. However, the process ensures significant reduction of SOx, NOx and dust emissions. SAIL has signed an MOU with POSCO to set up a plant at Bokaro Steel Plant with this technology.

4.4 HIsmelt Iron Making

HIsmelt stands for High Intensity Smelting Reduction. Instead of using oxygen, this process uses oxygen enriched hot air blast for making iron. This process is particularly relevant for Indian iron ores with high alumina and phosphorous. It is different from Corex and Finex in the aspect that it directly uses ore and coal fines in a single step reactor. The first plant with this technology was set up at Kwianana, Western Australia in 2005. However, the plant was subsequently shut down. JSPL has signed an MOU with RIO TINTO to get the technology for its further development at its site.

4.5 FASTMELT / FASTMET

This process aims at reduction of ore-coal composite pellets in rotary hearth furnace. Various carbon sources like coal, coke breeze and carbon bearing wastes can be used as reducing agent in this process. MIDREX Corporation, USA in collaboration with Kobe Steel, Japan set up a plant with this technology at Kobe Steel's Kakogawa Works. MIDREX Corporation is marketing FASTMET process for mill waste oxides.

4.6 ITmk3 Iron Making

ITmk3 stands for Iron Making Technology Mark 3 and it uses low grade iron ore and non-coking coal for production of high purity iron nuggets. The process, developed by Kobe Steel, Japan uses rotary hearth furnace to convert dry pellets made from low grade iron ore fines and pulverized coal into solid iron nuggets (97% Fe) for use in EAF, BOF and Foundry. SAIL has signed an MOU with Kobe Steel to set up a plant with this technology at Alloy Steels Plant, Durgapur.

5 Conclusions

The developed countries followed the strategy to procure the best quality raw materials from all across the globe and directed their R&D on improving the technology of the main production processes of the steel plants. India adopted these technologies from the developed countries. However, with the rising scarcity of high quality input materials, the pressing need today is to develop our own solutions to this challenge. It calls for more and more beneficiation and agglomeration of input materials. Particularly, pelletisation has a huge potential in India. The focus should be on producing sinter / pellets from cheaper iron bearing materials and making good quality coke from cheaper coal blend and incorporating innovation for lesser use of costly input materials. The need is also to introduce and adopt technologies, which provide alternatives to traditional iron making and replace metallurgical coke as the prime reducing agent and heat source. The processes like DRI, COREX, FINEX, FASTMELT / FASTMET, HIsmelt, ITmk3 etc. can utilise lower quality input materials and hold excellent promises for the future.

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