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MAXIMIZING LOW FE HYGROSCOPIC IRON ORE CONSUMPTION IN BLAST FURNACE THROUGH STRUCTURAL MODIFICATION, TECHNOLOGY INTRODUCTION & PROCESS OPTIMIZATION

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Abstract:-

Iron ore and coke together account for about 99% of cost of input materials in Indian Pig Iron manufacturing 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 Pig Iron plants. Accordingly the focus should be on maximizing the lower quality input materials and development & application of new technologies for efficient use of the same in the Blast furnace. It also requires a paradigm shift from adopting technology dependent primarily on high quality input materials to introducing and absorbing alternate technologies and innovation, which can efficiently utilise lower quality input materials.

It remains significant concern for the Pig Iron Plants in and around the Goa to use & maximize the Goan Iron Ore consumption in their Blast furnaces in order to be in the lowest quartile cost among the Global competitors. The main objective of this project is to maximize the available Low Grade Iron Ore @ economical price in Pig iron manufacturing process through better process optimization & thereby achieving lowest cost of production.

Keywords:- Low Grade Goan Iron Ore, Process Optimization, Cost of production.

Iron Ore

Iron ores are rocks and minerals from which metallic iron can be economically extracted. Iron ore is the raw material used to make pig iron, which is one of the main raw materials to make steel. 98% of the mined iron ore is used to make steel.



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INTRODUCTION

The economics of iron production along with the appropriate technology underwent several changes in the past. Although there are various iron making processes, the mini blast furnace route is the most preferred in the modern day scenario. Installation of big blast furnaces not only requires huge capital but the commissioning period is also too long. The ecological, economical and performance compulsions led to the development of the Mini Blast Furnaces (MBF) in India. The furnaces usually have a volume in the range of less than 100 m3 to a few hundred cubic meters. Nowadays Iron making capacity is enhanced in all routes in line with the steel demands in India.

Iron ore mining in Goa is completely in the private sector. Iron ore reserves in Goa are variously estimated to be around 1000 million tonnes. The Iron ore deposits in Goa are fines oriented. Around 80% of the deposits are fines and the rest lumps. Another peculiarity of Goan iron ore deposits is that the lumpy ore is of lower grade than the powdery ore. The iron ore deposits are distributed over the northern, southern and central blocks of Goa.

In the Pig Iron Manufacturing, Iron Ore contributes around 40-45% to the total Cost of Raw material & hence the cost of Iron Ore plays a crucial role in the success of pig iron business. By using the low grade iron ore available at economical price, the overall cost of production will come down by 15-20%. The underlying emphasis of efficient utilisation of lower quality input materials is to ensure cost effective utilisation of available natural resources, particularly iron ore 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, Sulphur 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. It calls for two-prolonged strategies – to ensure agglomeration of input materials for use in the existing technology and innovation, which can efficiently utilise lower quality input materials.

BLAST FURNACE OPERATION – AT A GLANCE...

The purpose of a blast furnace is to chemically reduce and physically convert iron oxides into liquid iron called "hot metal". The blast furnace is a huge, steel stack lined with refractory brick, where iron ore, coke and limestone are dumped into the top, and preheated air is blown into the bottom. The raw materials require 6 to 8 hours to descend to the bottom of the furnace where they become the final product of liquid slag and liquid iron. These liquid products are drained from the furnace at regular intervals. The hot air that was blown into the bottom of the furnace ascends to the top in 6 to 8 seconds after going through numerous chemical reactions. Once a blast furnace is started it will continuously run for four to ten years with only short stops to perform planned maintenance.



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BF PROCESS FLOW CHART (FIG.1)





THE FUTURE:-

On the surface, the future of iron production appears troubled. Reserves of high-quality ore have become considerably depleted in areas where it can be economically extracted. Many long-time steel mills have closed.

However, these appearances are deceiving. Many steel & Pig iron plants have closed in recent decades, but this is largely because fewer are needed. Many developments were done to the use of lower-grade ore much more attractive, and there is a vast supply of that ore especially around the Goa region. The efficiency of blast furnaces has improved remarkably & the low cost low grade iron ore and favourable logistics helps to sustain the cost of production in the lowest quartile.

STRUCTURAL MODIFICATION, TECHNOLOGY INTRODUCTION & PROCESS OPTIMIZATION:-

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 deg C), 100% prepared burden, PCI injection, use of nut coke, better burden distribution in the furnace and by these efforts, it is possible to cut down the consumption of metallurgical coke & improve productivity. 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



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and more sinter in place of lumps. It has also opened up opportunities to use new technologies, innovations & design modifications in sync with the present imperatives of lower quality input materials, particularly iron ore. The underlying emphasis of new technologies is to maximize the Low grade Iron ore in the Blast furnace eliminating the use of high grade Iron ore which are depleting faster. Several design related modifications & technologies were introduced in the Blast Furnace to ensure the optimum process parameters where it delivers the maximum productivity with lowest cost of production. Structural modification of BF 1&2 along with refractory modification resulting in increased ability to use low grade ore with higher slag rate & those are discussed in detail as follows.

A] Change in Blast Furnace Profile:-

Challenges:

Due to low bog depth, more turbulence was created in the tap hole region resulting in refractory wear out. The capacity of hearth volume plays a vital role in the productivity of the furnace and its consistency in the operation. If the hearth volume is not sufficient, the mushroom formed by the Tap hole mass is drowned by the turbulence caused by the hot metal and slag. As the level of the hot metal and slag in the hearth goes beyond the safe limit, this level creates a back pressure on the race way which leads to reduced depth of penetration of the blast. Simultaneously amount of blast going in to the furnace reduces. This leads further obstruction of the furnace movement. Also while operating the furnace with maximum low grade ore, Slag volume will shoot up & hearth volume gets occupied soon which leads to furnace hanging & other abnormalities. One of the tuyeres remains closed throughout the campaign and wind volume has been reduced frequently for smooth operation & hearth draining. Following were the frequent problems which are encountered during the BF operation.

- High Slag volume operation due to use of more low grade ores leads to frequent furnace hanging
- Improper working of the furnace due to frequent disturbance in gas flow pattern
- Furnace operation with one of the tuyeres in plugged condition most of the time which leads to improper gas flow & lower productivity

Solution:

Due to use of low grade local ore, slag load on the furnace has increased, innovations was required to handle the extra load of slag. Team has proposed to carry out the necessary hearth modification during the upcoming relining along with furnace shell changing. It was proposed to increase Bog depth from 576 mm to 693 mm by replacing Vertical brick arrangement to horizontal which lead to increase in bog depth by 117 mm and also the distance between Tuyere center to Tap hole Centre was increased from 1670 mm to 2300 mm keeping working volume of the furnace same. In other way, hearth volume is increased from 15.07 m3 to 20.75 m3 & Bog depth is increased from 6.12 m3 to 7.37 m3.

<u>Result:</u>

Hearth Volume to Working Volume ratio is increased from 0.099 to 0.12. Total 6.93 m3 increase in hearth volume done through this way, which was capable to handle 40 kg/thm additional slag volume. After these design modification, both the furnaces are managed to run with all tuyeres open and downtime was also reduced considerably thus increase in production by 8-10%.

B] Introduction of Cooling Plates & Carbon Hearth:-

Traditionally, Blast Furnace hearths were lined with high Al2O3 bricks. The latest refractory lining which we have introduced in the blast furnace is high thermal conductive Carbon Bricks. Along with the carbon Hearth we have also introduced copper cooling members at Bosh & Belly region in the blast furnace shell to provide better thermal conductivity and sustaining the partial brick load of the furnace. With the use of maximum low grade hygroscopic Iron ore, thermal fluctuations will be enormous & uniform gas distribution is uncertain. Since low grade ores are having high gangue material, furnace movement will be erratic & to maintain the burden movement, frequent snort checks to be given. In that case, the complete physical load will be on the refractory bricks which may leads to premature failure. After the introduction of Sinter, in the bell type charging system sinter gets rolled to the periphery & due to the thermal implication on the periphery the refractory wall erosion were observed & the same is resolved by introducing two more layer of cooling plates in the lower stack region.

We have seen the improvement in operational efficiency & increased in campaign life after introducing the same.

C] Other Technology advancement:-

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 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 utilized without agglomeration that India doesn't have much facilities. Furthermore, in spite of being rich in iron content, Indian hematite ores have adverse Al2O3 and SiO2 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.

Further in order to enhance the low grade iron ore consumption & to utilize the undersize & low quality input material which we cannot directly feed into the Blast furnace, we have introduced Sintering Plant [75 m2] along with the newly constructed Blast furnace [450 m3] of slightly bigger volume. With the use of low grade Iron ore, there will be loss in the productivity as well the fuel rate will increase & this loss was compensated by the Sinter usage in Blast Furnace.

"With every 10 % replacement of lumpy ore by Sinter, Productivity is increased by 2 % & coke rate is decreased by 1%".

In addition to the Sinter usage in BF, Bell Less top, Pulverized coal injection & Oxygen enrichment techniques were introduced in the newly constructed third blast furnace which further helps to maintain the better productivity with minimum fuel rate.

Efficient Process Control Mechanism:-

Sesa PID has a dedicated team of experienced metallurgists, who are playing a vital role in the process control of the pig iron manufacturing process, in order to meet the customer requirement. This is done by adjusting all the process so as to optimize all BF parameter which minimizing cost and maximizing throughput and efficiency, optimizing the feed & implementing better systems in place with cost control & safety approach towards the entire process. A full-fledged centralized process control team is continuously involved in the continuous process monitoring & optimization, Performance management, Procurement of suitable iron ore at economical price, strategic planning & execution in order to reduce the COP to maximize the EBITDA are the hallmark of this team. The Low Grade iron ore consumption is maximized using the following

- 4 Aligning BF Operating Parameters for smooth operation &
- **u** Better process monitoring & Control

Aligning BF Operating Parameters for smooth operation:

Since Goan iron ore are hygroscopic in nature, Tog gas temperature in the Blast furnace will be on lower side $\sim 70 - 80$ deg c where the TGT of ~ 150 deg c is obvious in normal BF operation. This becomes a challenging situation for the metallurgist to operate at such low TGT, where the indirect reduction in the furnace gets retarded & more direct reduction takes place. The complete thermal profile inside the BF gets changed & in order to maintain the smooth & safe operation, Fe/C will gets adjusted accordingly. Also, the differential pressure should be maintained in the optimum range of 0.8 to 1.0 Kg/cm2 to ensure the maximum indirect reduction in the furnace by increasing the resilience time. The hot blast temperature should be maintained constant in order to have control on thermal fluctuations which in turn have an impact on chemical composition of the hot metal. Furnace should be operated probably at the maximum wind volume & the same should be optimized in proportion to the utilization of CO in the blast furnace.

The most important checks to be ensured during charging such low grade ore is Fines entry into the blast furnace & the coke quality. The fines (-8mm) entry into the furnace should not more than 2% as there are already huge thermal fluctuations inside the furnace & hence efficient screening should be ensured before charging into the blast furnace. Coke quality plays a crucial role in the BF operation since it acts a source of heat. Coke VM should be less than 1.2%, Ash Content should be less than 11%, CSR should be more than 65 and CRI should be less than 24. Most important is moisture content of coke & there should not be more fluctuations in the same for smooth operation of BF with such low grade ore. Stack temperatures and Cross

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flow temperatures to be monitored continuously to know and understand the Gas distribution pattern & the bed permeability. The slag composition should be maintained as mentioned below (TABLE.1) which gives better result with low grade ore consumption. This Slag composition is concluded for a specific grades after various case studies & complete analysis where the successful result is evident.

Element	Basic Burden	Foundry Burden
Si	1.00-1.50	1.75-2.50
SiO2	32.00	36.00
Al2O3	19.00	19.00
CaO	37.00	34.00
MgO	9.00	9.00
FeO	0.58	0.56
MnO	0.61	0.59
Basicity	1.00-1.15	0.90-0.95

Better process monitoring & Control:

Apart from all the developments, Process control and optimization plays a crucial role in controlling the entire manufacturing process. With the usage of low grade iron ore where there is a huge thermal fluctuations, it is very important to have enhanced & stringent control over the entire process monitoring system. A Process Monitoring Model were developed in-house (FIG.2), where it gives the information on Raw Material Analysis which is used in the BF, Burden preparation & quick access to all without e-mail facilities, all process parameters of at your desktop for quick response & real time hot metal & Slag composition which helps to enhance the dispatch & sales further. This model directly or indirectly supports the entire manufacturing facility for efficient planning process which enhances the productivity further.



INSIGHT OF LOW GRADE GOAN IRON ORE IN THE PAST:-

On 19 th Feb 2014, PK Mukherjee, former head of Sesa Sterlite (iron ore to Wind up Redi
livision) added JSW Steel, Jindal Steel and Power and Bhushan Steel stayed
way from bidding due to low quality of ore and higher transportation cost.
Craditionally, iron ore from Goa with up to 55% Fe content is considered astrong designed as to be to prove all states of the st
rade, with Indian steel firms opting for ore from Jharkhand, Odisha,
Chhattisgarh or even Karnataka. However, the mining crisis and subsequent
baucity of ore in the last few years were expected to drive them and to antity better the bad by the product the product the bad by the product the product the bad by the product the product the bad by the product the
owards low quality ore. But none of the steel
ompanies have registered themselves, with DMG continuing their reluctance towards low quality ore.
Goan ore cannot be used more than 5-10% in the burden mix – MD Tata Metalliks (FIG.3) [Refer
(FIG. 3)

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LEARNING FROM THE FAILURES:-

In the last three years, 3 times the Blast furnace got chilled (FIG.4) because of the cold furnace. Several times, Small openings were made on F/c shell at belly, lower stack and Middle stack regions & continuous lancing was done to clear the jams throughout the length of the furnace as shown in the figure. With the blend of low grade ores with sinter, probably in monsoon furnace operations becomes challenging & based on the past learnings, many system operating procedures were reviewed and corrected according to the pros & cons of the low grade ore usage in the BF operation. Stringent administrative control has been put in place to avoid such failures in the future & have performance with maximum low grade ore



RESULTS & DISCUSSIONS:-

Characterization Studies

The chemical analysis of the iron ore sample is shown in Table 1. The sample contains 58% Fe, which is very low-grade in nature. The major impurities are SiO2 4.0%, Al2O3 3.1%, P 0.04% and loss on ignition (LOI) 8.00%. This sample cannot be used 100% in blast furnace without undergoing any break through process improvements. The high LOI content in the sample is due to hydroxyl bound minerals present in the sample. The 80% passing size of the material is around 10-40 mm. Goan Iron Ore are hygroscopic in nature, which are low Grade having Fe% variation in the range of 45-58%. These low grade ores are rich in Mn Content & this low grade Goan iron ore is generally discarded to use more than ~20% by the Indian Pig iron plants.

Parameters	Karnataka Iron Ore	Goan Iron Ore
UOM	%	%
Fe	65.10	59.13
Mn	0.10	0.71
SiO2	3.27	3.67
Al203	1.59	2.75
Р	0.03	0.04
Moisture	1.82	7.76
LOI	2.00	8.00

TABLE. 2

TABLE 2: Chemical analysis of the iron ore sample

Local Ore Consumption Trend [Fig.5]



In the above graph (FIG. 5), it is clearly visible that Local Ore Consumption has maximized over the last 5 years. In Oct'2012, The Supreme Court has banned mining operations in Goa on the basis of Justice MB Shah Commission report that claimed illegal mining there has caused a loss of Rs. 35,000 crore to the exchequer in the last 12 years. This has created a big impact on the mining industry as well as the main Goan Iron ore consuming centers & hence the Local Ore consumption is lower in 2012-13 & almost zero in 2013-14 as well. In 2014-15, there were limited availability of Goan Iron ore at the start of FY & stabilized within the period of six months and Goan Iron ore were pushed upto 92% in few months and the same has been streamlined in the FY 15-16 as well.

The entire manufacturing process is optimized which helps us to maximize the Goan Ore consumption from fewer upto 90% which helps us to maintain to be a low cost pig iron manufacturer among the competitors. This also helps us in survival of the business in the bad times.

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 & pig iron 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 innovation, technology adoption & stringent process control in place. Particularly, Sintering has a huge potential in India. The focus should be on producing sinter from cheaper iron bearing materials as Goa region is rich with fines content and incorporating technology/innovation in BF operation for lesser use of costly input materials.

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REFERENCES:-

- [1] http://articles.economictimes.indiatimes.com
- [2] https://www.google.co.in/
- [3] http://www.mineralresource.info/
- [4] http://www.goadmg.gov.in/IronInfo.aspx
- [5] https://en.wikipedia.org/wiki/Iron ore