

Indian Sponge Iron Industry

Status, Potential for use & Future Prospects

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Introduction

Sponge iron is a generic name of metallic product obtained through reduction of iron oxide (haematite) in solid state. The external shape of the ore is retained with 30% reduction in weight due to oxides removal resulting in change in true density from 4.4 gm/cc to 7.8 gm/cc in this product. This paves way for 54% reduction in volume which is manifested in pores formation through out the interior of reduced product and hence the name "Sponge Iron".

The evolution of sponge iron as metallic feed in electric steel making has been mainly due to reduced availability of high quality scrap and its increasing cost. It is a known fact that the continuous casting ratio which was a mere 4% in 1970 today stands at a staggering 88% of the crude steel output vividly explaining the decreasing availability of revert scrap (high quality scrap) in the world.

This material offer benefits like guaranteed uniform and predictable composition containing low amounts of sulphur, phosphorous & tramp elements along with environmental friendliness during usage. Its usage permits application of even low grade scrap as part of the charge in electric steel making without affecting the

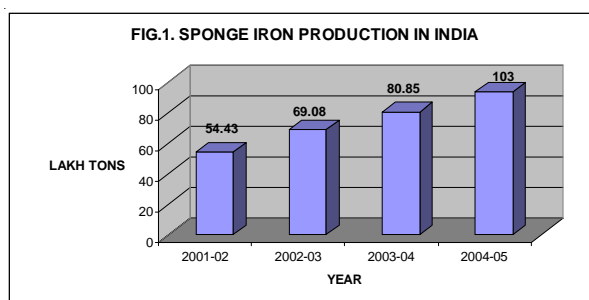
steel quality. Due to known chemical composition, it enables accurate prediction of end point analysis beginning with continuous feeding of sponge iron. Also, the productivity is increased due to uniformity of size. The iron present as oxide in this material reacts with bath carbon resulting in vigorous boiling action promoting better heat transfer and accelerated slag/metal interactions during electric steel making. Due to this, the bath homogeneity improves resulting in achievement of lower hydrogen and nitrogen contents in steel.

Sponge iron has also partially substituted scrap as coolant in Oxygen steel making. Even in Blast furnace iron making, it has been successfully used to the tune of 150 kg/ton of hot metal without affecting the bed permeability through improved productivity, lowered coke consumption and the technoeconomics are expected to work when the price of sponge iron is 1/3rd of the price of coke.

Production scenario

India has emerged as the largest producer of sponge iron in the world

and stands at a whopping 103 lakh tons in 2004-05. There are about 249+ coal based sponge iron units and about 3 gas based units in the country. The growth of sponge iron production in India has been phenomenal. The industry grew @ 29.74% per annum from 2001-02 till today. The coal based units showed a growth @ 46.26% per annum and the gas based units grew @ 13.07% per annum from 2001-02 till date. Last fiscal witnessed a growth of 27.40%. The production figures are illustrated in Fig.1.



The production is estimated to increase by 70 lakh tons in the coming 5 years through expansion of the existing units and green field projects started.

Production process

Sponge iron in India is produced primarily both by using non-coking coal

or natural gas and classified as Coal Based Process & Gas Based Process.

Coal based process

Here, rotary kiln is used as the reactor where iron ore lumps/pellets are treated with non-coking coal, the in situ gasification of coal in the latter generates CO

gas which reduces iron ore to sponge iron. There are various methods presently in use in India which include CODIR (Krupp), SL/RN (Lurgi), DRC(Davy), TDR (Tata Steel) & ACCAR (Allis Chalmer). Though all these processes started with different original concept, the ACCAR process is somewhat different in the sense that it uses the ported kiln concept against use of air tubes in other designs.

The major raw materials for sponge iron production through this route are the iron ore and non-coking coal. About 1.4 tons of calibrated lump ore (5 mm – 18 mm) is required for production of one ton of sponge iron wherein 2.5 tons of iron ore lumps are required to produce one ton of calibrated lump ore. Iron content in haematite ore has to be more than 65% and gangue content not exceeding 3%. Non-coking coal requirement is about 1.2 tons per ton of sponge iron produced.

However, whenever low grade coals (Grade D/E/F) depending upon the source are used, about 2.5 tons of these coals are required

which necessitates washing before use for one ton sponge iron production. The non-coking coal characteristics needed for sponge iron making are fixed carbon exceeding 40%, ash preferably below 25%, ash fusion temperature exceeding 1200°C, reactivity of 2 CC of CO/gm of C/sec, volatile matter of

28% to 32%, moisture of 6% max, and swelling index below 0.5. Coal needs to be crushed and screened to get about 0 mm to 15 mm.

The sponge iron produced has

C	S	P	SiO2	Al2O3	CaO+MgO	% Metallization
0.10	0.020	0.010	2.00	0.60	0.20	88.00
0.30	0.060	0.040	4.00	3.00	3.00	90.00

Table 1. Typical composition of coal based sponge iron

metallization to the tune of 88% - 90%, carbon about 0.15 – 0.25%, S & P about 0.03% and gangue content about 6% - 8%. The typical composition of coal based sponge iron is shown in Table 1.

Gas based process

A Shaft reactor is used where heat hardened iron ore pellets with or without closely sized lump iron ore are reduced by reformed natural gas. Here, two methods are available viz. MIDREX & HYL III in India. The difference in both these processes is the process of reforming and use of the spent gas. The MIDREX uses CO2 (+steam) based reforming of the natural gas while HYL uses mainly the H2O reforming process. The raw materials are iron oxide pellets/ore and natural gas. The specific consumption of various raw materials for production of one ton sponge iron (by MIDREX method)

C	S	P	SiO2	Al2O3	CaO+MgO	% Metallization
1.20	0.0.10	0.010	2.00	0.60	0.20	92.00
2.40	0.015	0.040	4.00	3.00	3.00	96.00

Table 2. Typical composition of gas based sponge iron

include iron oxide 1.49 tons, natural gas of 2.5 GCal, 100 kwh of electricity & 12 nm3 of oxygen. The haematite ore pellets/lumps should possess 67%+ iron, gangue content of 3% max, size of lump ore 6 X 35 mm with 85% min containing 10 X 35 mm & fines below 5 mm not exceeding 5%

and iron oxide pellets of size 6 X 16 mm & below 5 mm not exceeding 3%.

Sponge iron produced through this process possesses metallization to the tune of 92% - 95%, carbon of 1.0 – 2.5% and gangue content of 3% to 6%. The typical composition o gas based sponge iron is shown in Table 2.

Quality of sponge iron for steel making

• **Size**

The size of sponge iron is very important especially with regard to continuous feeding. A very fine sized material (1mm – 2 mm) would be quickly oxidized during falling to the slag or may be lost in fume extraction system. Extremely large size (exceeding 30 mm) poses problem during continuous feeding. The size fraction less than 2 mm need to be limited for continuous feeding through the roof.

• **Density**

Sponge iron after falling should have the ability to penetrate into the slag layer and reside at the slag/metal interface for effective heat transfer and chemical reaction. Sponge iron with

lower density tend to float on the slag while, high density material readily penetrates into

the metal. Hence, it is desirable to have the density of sponge iron in the range 4 – 6 gm/cc.

• **Unit weight**

The transition time of the sponge iron pellets through the slag is dependant on the momentum. If the

pellet stays in the slag layer for too long a time, the phenomenon of slag boiling occurs. Slag fluidity is highly important. However, a heavier sponge iron pellet does not require close control on slag fluidity.

• Crushing strength

Sponge iron should possess good crushing strength to prevent generation of large amounts of fines which are undesirable for use in EAF.

• Weather Resistance

Sponge iron is prone to oxidation and heat build up in contact with atmosphere. The storage of Sponge Iron (Direct Reduced Iron) for long periods of time affects its metallization partially due to surface re-oxidation caused by the porous structure of sponge iron pellets or lumps. It is expected to lose about 1% from its metallization after six months of storage in an open yard. Table 3 illustrates the relation between time and metallization.

The suitability of sponge iron to be stored depends on the density, specific surface area and as to whether any passivation agent has been applied. This problem does not however occur with HBI (Hot Briquetted Iron) due to the very slow re-oxidation rate caused by less porous structure.

• Gangue material content

The gangue content (SiO₂, Al₂O₃, CaO, MgO) has a direct impact on the

operation of EAF. The acid elements like SiO₂ need to be neutralized. The neutralization of acid gangue (Al₂O₃ + SiO₂) requires 20 Kg of lime and power to the tune of 11 Kwh/ton of liquid steel to achieve slag basicity of 2². This can help in good desulphurisation and protection of the basic refractory lining in EAF. Preferably, the gangue content should not exceed 5%. If more, the cost of extra lime to be charged along with power consumption goes up.

Also, elaborate slag handling facility becomes mandatory to take care of increased slag volume. It needs to be noted that high SiO₂ + Al₂O₃ content means iron loss as FeO with corresponding decrease in metallic yield.

• Carbon content

During continuous feeding, an active carbon –oxygen boil is necessary to shield the arcs. It has been observed that to achieve the aforesaid, sponge iron should possess a minimum of 0.60% carbon. The ideal oxygen content in sponge iron (as FeO) can be related with the rating of furnace capacity to power input for assuring proper boil during continuous feeding. Ideal %Oxygen would be about 0.475 Tons/MW at feed rate of 28 Kg/min./MW.

• Metallization

High metallization helps in lower power consumption but severely

reduces the bath activity and resulting in flat bath conditions. For low metallization levels, increased carburization is required to compensate for the extra oxygen in sponge iron. The reduction of 1% iron oxide requires approx. 2.3 Kg of carbon and 12 Kwh/ton of liquid steel. Preferably, metallization of 94% is ideally suitable.

Charging practice of sponge iron in EAF

• Batch Charging

The amount of use is limited up to 15% of the charge in a single charge. If higher amounts are used, DRI gets partially fused with lime and gangue creating agglomerates along the furnace banks making them difficult to melt due to low thermal conductivity of this material. It even leads to piling up at center of the discharged material in EAF resulting in poor electrode penetration thus, affecting the roof and walls due to radiation. Not the least, excess addition increasing the slag volume.

The amount of addition can be increased up to 30% by charging in small batches. But, this causes heat loss due to regular roof opening and affects the productivity of EAF. It even necessitates greater control of chemistry due to high slag volume.

• Continuous charging

This is the widely practiced method of charging. Here, charging starts after creation of partial molten pool in the bath and is continued through the charge bins provided along the roof. This charging system enables better distribution of charge with improved bath heat transfer and slag-metal mixing. It lowers heat losses and help in producing stable arc with improved productivity compared to the batch charging practice.

Storage Condition	Months	DRI Metallisation before storage	DRI Metallisation after storage
Not exposed to rain	03	94.36%	94.35%
	06	93.97%	91.76%
Exposed to rain	09	93.60%	87.00%
	12	94.33%	83.70%

Table 3 - Storage time and metallisation of sponge iron (DRI)

The optimum benefits are generally believed to be attained when the melting of DRI takes place at the slag/metal interface which necessitates appropriate feed rate. The feed rate further is dependent on the chemical composition of DRI and the bath temperature. Generally, feed rates of 27 to 35 Kg/min./MW of applied power are maintained. Up to 80% DRI in the charge can be successfully fed through this method.

There has been a new trend in continuous feeding of hot DRI with temperatures of 500°C - 600°C for the units which has accessibility to DRI furnace. Introducing hot DRI surge bin between the DRI furnace and EAF, up to 80% DRI in the charge is successfully fed.

Future Prospects

There is limited scope for new gas

based sponge iron units coming in India in near future mainly due to the unavailability of natural gas in other parts of the country except for the west coast belt. If the Godavari & Krishna basin natural gas materializes in the east coast belt, any new agreements between Bangladesh & India for pumping in natural gas from Bangladesh and the Iran gas pipe line project commences, then of course, gas based sponge iron units would rule over the scrap or even coke.

Coming on to the future of raw materials for sponge iron making, there won't be dearth of iron ore as the reserve base is large and many high grade ores are land locked. Through proper infrastructure development, large road containers can be used along with rail that can drastically reduce the transportation costs in the coming years. About 69%

of iron ore produced is fines in India, large capacity pelletisers may be installed in the mines for conversion of fines to pellets. This can reduce the consumption of iron lumps. As far as the non-coking coal is concerned, the ministry of coal has been steadily increasing the linkage to the sponge iron sector which last fiscal stood at nearly 11 million tons.

The future looks rosy for the Indian Sponge Iron Industry. To sustain growth, all the sponge iron units should compulsorily install and run pollution control equipment meeting the ecological norms.



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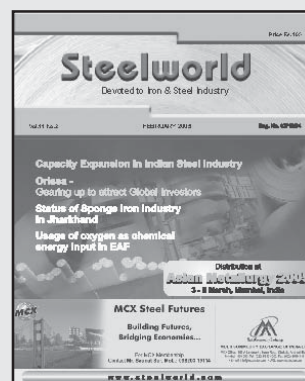
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