PROCEEDINGS: NS-EWM 1996

Minimization of waste generation in steel sectors

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ABSTRACT

The operation in the integrated steel plant can be classified into three different groups. The first group involves iron making process comprising sintering and agglomeration, coke making and blast furnace operations. Steelmaking which includes all operations from primary steelmaking through secondary steelmaking to ingot/continuous casting constitutes the second group. Rolling and finishing processes including pickling, coating, shearing and other finishing operations constitute the third group. At all these stages enormous amounts of wastes are generated. These wastes have a wide ranging impact on the environment. Thus, minimization of waste through integrated waste management has gained special significance in the present scenario. This paper summarizes the scope to reduce waste generation of all kinds in the steel sector. It has been concluded that through the introduction of latest processing technologies, waste can be drastically reduced and whatever generated can be recycled in the process stream or converted into value added products.

INTRODUCTION

The production of steel in an integrated steel plant involves several operations starting from preparation of the natural occurring raw materials like iron ore, coal and flux stones in production of hot metal in blast furnaces, conversion of hot metal into steel and the subsequent rolling of steel into finished product in the rolling mills. Several other activities such as power generation, production of refractories etc.a re also performed in varying degrees inside the steel works. A large quantity of wastes are generated in view of the above activities. These wastes have a wide ranging impact on the environment. Thus, effective and efficient waste management is an important necessity for steel industry. The effective waste management is likely to achieve[1] :

- o Creation of pollution free work zone both inside and outside plant
- o High operational and techno-economics indices
- o Generation of additional wealth and profit for the company
- o Conformance to the government regulations and the social commitments for protection of environment
- o energy saving

It can, therefore, safely be argued that probably the greatest protection for minimization of waste generation and affecting cost savings lie in better management of waste.

WASTE MINIMIZATION

For effective and efficient waste minimization multipronged approach must be applied, which can be categorised as follows[2] : (i) By making improvement in operational techniques in existing plants, and (ii) By introduction of emerging technologies in iron and steel making and processing technologies in existing plants.

By making improvement in operational practice

Coal and Coke[2]

Partial briquette blending of coal (PBCC) first developed in Japan has now been adopted in South Korea, China, South Africa, Russia and recently been introduced in Bhilai Steel Plant. Bhilai blends (with 30% imported coal) had shown that the technology has the potential of improving the M_{10} value of the coke by nearly 2 points thereby minimizing generation of waste fines during handling, transportation and charging in blast furnaces. For indigenous coal, the potential is even higher by nearly 4 points. PBCC has been selected for introducing at Durgapur and Rourkela also. Recently, stamp charging technology has been installed at TISCO which besides other benefits will improve quality yield and minimize waste generation of fines. Groupwise crushing technology, which is expected to improve coke strength has been envisaged at Vizag. This is also expected to minimize waste generation of fines. Coke dry quenching is another new technology which minimizes the water consumption and thereby reduces the volume of waste water from the coke ovens. Dry quenching also improves the general ambient environment in the coke oven area. The technology has been introduced at Vizag Steel Plant.

Sintering[3]

Except IISCO Burnpur, all steel plants of the country use agglomerated ore fines in the form of superfluxed sinter. Ratio of sinter to iron bearing charge in the SAIL plants varies between 50 and 75%. Modernization programme envisages sinter charge to the extent of 70-80%. Increased charge of superfluxed sinter would minimize the coke rate, thus, reducing the eventual waste associated with coke making. However, a very large amount of fines are generated in the operation of sintering plant. New technologies are being introduced to minimize fine generation. Modification of sinter machine ignition hood, improvement in the chemistry and granulometry of the raw feed, improvement in the sinter machine suction are a few of the technologies being introduced currently which improve the strength and hence minimize the generation of sinter fines during handling, transportation and charging into the blast furnaces. High pressure sintering, developed recently for manganese ore fines by SAIL Research & Development, will have interesting implication for iron ore sintering also.

Iron making

Minimization of waste generation in the blast furnace is mostly associated with the reduction in slag volume. High ash content of the Indian coal is to a very large extent responsible for high slag volume in the operation of blast furnaces. Therefore, reduction of coke rate would minimize the waste generation. All technologies, therefore, which improve the energy efficiency, reduce the coke rate or improve productivity of the blast furnace would be classified as waste minimization technologies. Control of Alkali input through the burden, movable throat armour/bell less charging system, oxygen enrichment of blast, high blast temperature, natural gas injection to the tune of 50-80 Nm/thm etc. to reduce coke rate would minimize waste generation in the blast furnace operation.

Steel making

A number of new energy efficient technologies have been developed in the past two decades which have vastly improved the productivity of the steel making processes used in the integrated iron and steel works. Twin hearth furnace, KORF process, etc. are derived from the open hearth technology. A number of variations of oxygen blowing technology have also been developed. SAIL has developed SAIL combined blowing (SCB) process which has already been adopted in the converters A & B of Bokaro and converter X of RSP and currently under implementation in one converter at Bhilai and other converters at Bokaro and Rourekla. Facility of bottom injection of inert gases nitrogen, argon etc. through semi permeable refractory elements or tuyers has been provided in SCB. High metallic yield, lower use of ferro alloys, cleaner steel, better S&P partitions between metal and slag, higher recovery of manganese, higher lance life etc. are the advantages derived from these modifications. The benefits derived from this technology at RSP and Bokaro have been listed in Table-1 and 2[4]. The major benefit is improvement in the quality which ultimately minimizes the rejection rate of finished products and hence waste generation.

Table-1 : Benefits with SAIL combined blowing at RSP

Items	Percentage
Minimization of FeO in slag	2.5
Improvement in metallic yield	0.5
Minimization in ferro-manganese consumption	0.53 kg/ton
Minimization in ferro-silicon consumption	0.12 kg/ton

Table-2 : Benefits with SAIL combined Blowing (SCB) at BSL

Items	Percentage		
	SCB	L.D.	Difference
FeO% in slag	18.13	21.17	(-) 3.04
Metallic yield	88.82	88.37	(+) 0.45
S in steel at turndown	0.033	0.038	(-) 0.05
P in steel at turndown	0.022	0.025	(-) 0.003

Steel casting

A number of new technologies are available in the ingot casting area which directly or indirectly improve the yield and quality, thereby minimizing the scrap generation which is a waste product. Some of these are the usage of recessed bottom plates in ingot casting, optimization of hot tapping practice, improvement in deoxidation and teeming technologies for semi-killed and rimming steels, design material improvement in ingot moulds for better life of ingot moulds etc. However, continuous casting is probably the single most important technology in the area of steel casting which has made the greatest impact on the productivity, quality, yield and energy consumption. The growth in the adoption of this technology world wide is given in Table-3[4]. This technology, however, is being introduced in a big way during modernisation of SAIL plants.

Table-3 : Growth of continuously cast steel (%)[4]

Country	1976	1987	1989	1994
USA	10.5	59.8	64.6	70.0
Japan	35.0	93.3	93.5	97.0
EC	20.3	81.2	87.9	90.0
Russia	8.1	16.1	17.3	20.0
South Korea	21.9	83.5	94.1	95.0
Taiwan	0.0	89.4	96.3	96.5
Brazil	12.1	45.5	54.0	60.0
China	--	16.0	-	40.0
India	--	26.0	30.0	42.0
World	16.4	55.2	61.8	65.0

Rolling Mills

Many of the new technologies developed for the rolling of steels, aim at minimization of energy consumption and yield improvement. Introduction of these technologies would minimize waste generation indirectly. Some of these technologies are microprocessor control of heating and combustion regime in soaking pits and reheating furnaces for reduced energy consumption, yield optimization of primary mills including bite and back method of rolling for improved yield, hot charging of bloom and slabs respectively to section mill and hot strip mill and direct rolling of concast blooms and slab for energy conservation, rolling at lower temperature for energy saving, etc. All these result in reduced scale formation, improved yield and lower rejection rate.

EMERGING TECHNOLOGIES IN IRON AND STEEL

The iron and steel industry during the last four decades witnessed a continuous change in technology. Besides, modification and improvement in conventional practices, massive efforts were also continued to develop a radically different route for iron and steel making, bypassing the coke oven - BF route. A considerable headway has also been made in bringing about a major conceptual change attempting at partial or total elimination of the process of rolling through near net-shape casting[5].

These technologies are at different stages of development and are conveniently called emerging technologies. These technologies can be classified under the following categories : (i) The direct reduction (DR) technology, (ii) The new iron making technology, (iii) the new emerging technologies for steelmaking, and (iv) near net shape casting technology.

The Direct Reduction (DR) Technology

The DR technology can be classified in two groups : (a) Gas based, and (b) Coal based technology.

Globally, 9 out of 10 tonnes of sponge iron is produced using the gas based technology and the total production is about 15 million tonnes per year. Waste generation in terms of slag during iron making is very small and this technology is the significant step towards minimization of waste generation in the iron and steel industry.

New iron making technologies

The new iron making technologies in the horizon can be classified into two categories : (a) Smelting reduction processes, and (b) New technologies based on blast furnace concept.

These technologies have been classified according to their process characteristics and the type of energy used. This has been shown in Table-4[2]. Most of these technologies have already undergone pilot plant tests and are in the process of upgradation into demonstration and commercial/semi commercial units. All these technologies will significant minimize the waste generation.

Table-4 : Emerging smelting reduction process[2]

Energy/Sources	Single stage smelting	Two stage (melting/ reduction)	Three stage (melting/gasification/reduct.)	Elec.melting coal based reduction
Coal/oxygen combustion	BSC/ICI	Krupp COIN BSC/Hoogovens klocknev/CRA	Korf COREX Kawasaki sumitomo BSC,OXY/coal BF NKK O_2 BF	Elred inred
External Electricity (Separately or in combination with		Plasmasmelt Pirogas, Rotary kiln-SAF VRDR-SAF		

Steelmaking technologies[6]

Most of the emerging steelmaking technologies primarily aim at cleaner high quality products leading to minimized waste as rejects. As an example, Energy Optimizing Furnace (EOF) process conserves fuel consumption. In this process, oxygen is blown into the bath through submerged tuyers resulting in high productivity and minimization in waste generation. The charge in EOF can be 100% hot metal to scrap. A high degree of post combustion is practiced in EOF., which helps in attaining a low level of specific energy consumption and thus considerably reduced toxic gas and dust emissions, which are waste products.

Near net shape casting technology[7]

In the area of casting, a host of new technologies are on the horizon which aim at elimination of much of the rolling operation and the consequent waste generation normally associated with rolling in the form of scale, end discards and rejects. These technologies can be divided into three categories : (a) Thin slab casting, (b) Strip casting, and (c) Near-net-shape casting.

Thin slab casting

Continuous casting of thin slabs to 20-60 mm thickness is on the threshold of becoming a reality in the commercial scale. This technology would significantly minimize the rolling operation and associated waste generation.

Strip casting

This technology is still in its infancy. However, the technology has been demonstrated by various research/industrial organizations all over the world,. Strips having thickness around16 mm have been cast. Width of these strip ranges around 200 mm. This has the potential for drastic reduction in hot/cold rolling operations.

Near Net-shape casting

Attempts are being made to continuously cast a thin strip which can be used as a substitute to cold/hot rolled strips with equivalent properties. This process is eventually aimed at large reduction in the scrap generation which is inbuilt into the conventional ingot casting followed by hot and cold rolling operations.

CONCLUSION

i) Minimization and efficient waste is an essential step in effective and efficient waste management

ii) By making improvement in operational techniques, the waste can be minimized significantly.

iii) By adopting new technologies, minimization of waste can be achieved to a greater extent.

iv) The technology alone will not minimize the generation of waste material. It can be accomplished through increased awareness of people involved and a sustained change in the attitude.

v) The organization structure should be such that the responsibility for profit is pushed as far down in the organization as practicable. Shared values and commitment to goals are important factors for success.

vi) The organizational environment should be such that constant review of tactics and strategies are measurable in real time and success and problems are communicated to everyone involved. This would enable persuit of excellence with commitment.

vii) To foster technical and financial literacy, proper information system should be set up. This helps in creating deep involvement at all levels and provides impetus to enhanced productivity and increased profits through reduction in costs.

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