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Management of Solid Waste for Sustainability of Steel Industry

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Abstract

Iron & Steel industry has been notified under one of 17 highly polluting industries in India by Ministry of Environment & Forest. In an integrated steel plant, 1-1.2 tons of solid wastes are generated for every ton of steel produced. Though conventionally being dumped, sustainability of Indian Steel Industry critically depends on management of these wastes. This paper enumerates the waste management practice, starting with emphasizing on continual reduction of waste generation, recycling and reuse, and thereby ultimately minimizing adverse impact of steel plant solid waste on mother earth.

Keywords

Steel Plant Solid Waste, Types of solid waste, Management of solid waste, R&D in solid waste, Reuse & Recycle solid waste

Introduction

In terms of crude steel production, India presently holds the 4th position in world, producing 87.67 MT in 2013-14[(1)]. Broadly there are two types of producers in India viz. integrated producers and secondary producers. Integrated steel plants (ISP) consume raw materials e.g. iron ore, coal in typical Blast Furnace (BF) /Basic Oxygen Furnace (BOF) route and produce finished products e.g. Plates, Coil, Structural etc. Secondary producers (SSP) use steel scrap or sponge iron/direct reduced iron (DRI) or hot briquetted iron (HBI) in Electric Arc Furnace (EAF) and Induction Furnace (IF) units. In addition, there are 120 sponge iron producers; 650 mini blast furnaces, and 1,200 re-rollers in India.

Raw materials for steel making necessarily exist in nature in compound form, hence metallurgically the process of steel making is basically purification of iron. Impurities (gangue) are separated as slag (single largest solid waste generated in a steel plant).

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Additional solid waste include dust and sludge, spent consumables etc. (**Table 1**)

Pelletisation • **Primary dust** • **Secondary dust/handling** • **Sludge**	**Sintering** • **Primary dust** • **Secondary dust/handling** • **Sludge**
Blast Furnace • **Top gas cleaning Dust & Sludge** • **Air cooled slag** • **Granulated slag** • **Other Dust & Sludge**	Pretreatment slag • De-Phosphorization slag • De-Siliconization slag • De-Sulphurization slag
BOF • **Dust & Sludge** • **Steelmaking slag**	EAF/IF • Steel making slag • Dust & Sludge
Continuous Casting (CC) • **Scale (coarse & fine)** • **Sludge**	Secondary steel making • Sludge from BOF • Slag from EAF
Hot Rolling Mill (HRM) • **Mill scale (coarse & fine)** • **Mill sludge** • **Dust & Sludge**	Cold Rolling Mill (CRM) • Sludge • Iron oxide • Dust & Sludge
Captive Power plants • **Fly ash** • **Bottom ash** • **Coal mill rejects**	All shops • Spent refractories

Table 1: Types of various solid wastes in different processes [(2)]

Solid Waste generation in Indian vis-à-vis International Steel Plants

As estimated in Steel Industry By-Products Project group report 2007-2009 by WorldSteel[(2)], the average production of 1 ton of steel results in 200 kg (EAF) to 800 kg (BF/BOF) of solid wastes globally. However, there exists considerable variation. (**Table 2**) Indian steel plants have performed poorly as compared to international counterparts. Conventionally solid wastes have been conceived as 'waste', awareness about them have been limited upto the statutory requirements only. No R&D resources spent on waste, no domestic technology practically available for value creation. Limited waste utilisation systems are being imported, but only at high capital. The topic of solid waste has been endemically neglected by steel plant management, no audit, no supply chain diagram, no integrated policy have been drawn. This vicious cycle has resulted dumping and landfilling to be the predominant Indian practice of solid waste management.

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BF Dry slag	**290-320 kg/thm**
BOF Slag	81-100 kg/tcs
EAF slag	111-140 kg/t
Sinter Dust	6.3 kg/t
Sinter Sludge	3-54 kg/t
BF Dust & Sludge	8-48 kg/t
BOF Dust & Sludge	19-39 kg/t
EAF Dust & Sludge	1.40-25 kg/t
HRM Mill scale	2- 54 kg/tcs
HRM Sludge	2-6 kg/tcs
CRM Sludge	17 kg/t
CRM iron oxide	6 kg/t

Table 2

Solid Waste Management: Increasing Awareness in India

Post Kyoto Summit, environmental concerns have been taking the centre stage in every sector, steel industry definitely feels the heat. Ministry of Steel, Govt. of India set target of 100% utilisation of solid waste (National Steel Policy 2011). Under Charter on Corporate Responsibility for Environment Protection (CREP), steel plants are required to set mutually agreed targets with the purpose to go beyond the compliance of regulatory norms for waste utilisation. Probably the most fundamental changes are those of public attitude, awareness and acceptability with respect to waste. These changes are increasingly applying pressure to minimise waste, encourage waste recycling and demanding waste disposal as landfill to be the last option.

Integrated solid waste management in Steel Plants

Significantly opposing the common belief, integrated waste management doesn't consider waste as 'waste', rather view as potential raw materials to be conserved or reused rather than wasted, both for environmental sustainability, social license to operate and bottom line cost saving. Utilizing solid wastes can fetch considerable revenue. Considering the case of ArcelorMittal Brasil units, beneficiation of waste arising from long steel and flat steel segments fetched $ 100 million in 2010 alone[3,4] ArcelorMittal Monlevade and ArcelorMittal Juiz de Fora generated $ 20 million, mainly with the sale of blast furnace slag to domestic cement industry[3,4]. The material has been used as replacement to clinker, which provides significant reduction in CO2 emissions in the manufacture of cement. Waste recycling can reduce fresh raw material consumption rate from 3.0 - 3.4 t/tcs to the good ratio of 2.9 t/tcs, thus saving on raw material input cost.

The general rules on waste management are:

- Avoid, and if not possible, minimize waste production in every activity
- Assure reclamation or recycling whenever possible
- Neutralize all waste that may not be reclaimed

- Waste should be reclaimed or neutralized at the place of its generation
- Waste management policy should be planned, coordinated and controlled on various levels (corporate, local, area)
- All waste movement has to be properly recorded and reported

Waste audit is a new tool with multifaceted advantages e.g.:

- It defines sources, quantities and types of wastes generated
- Identifies where, when, how and why these wastes are produced
- Identifies areas of wastage and root causes
- Establishes targets and priorities for waste reduction

Reduce the generation of solid waste: It requires careful planning, changing in attitude, sometimes capital investment, and most important a real commitment. More often than not, investment on waste minimisation and recovery pays off tangibly within a short time. Waste reduction at source is most economic. A specific example worth-mentioning in this context is removal of fly ash through coal beneficiation process at the mine head in view of high ash content. It is evident that the larger the volume of waste and the longer the distance of transportation of coal, the bigger will be the economic benefit in favour of coal beneficiation instead of carrying the filthy fly ash.

Recycle the wastes: In view of the technological limitations of direct recycling of various solid wastes in steel plant process technologies developed for value added utilization of wastes e.g.:

- Sumimoto Kawasaki Ageing Proces (SKAP) for steel making slag
- Hamborn shaft furnace for reuse of Zn, Pb, alkali bearing dusts & sludge from Blast Furnace
- Cold briquetting of sludge, coal & lime fines
- Dry slag granulation by molten slag atomization
- Velco injection technique for BF dust at BF
- FASTMET process for EAF dust and any other ferruginous waste
- Hybrid Pellet Sintering for utilizing micro fines in sinter making (JFE Japan)

Reuse the solid wastes in other applications:

- GBFS (Granulated Blast Furnace Slag) is used in cement production. Finer size of the BF Slag can be used as a substitute for sand in concrete/mortar making [4, 5]. The Indian Road Congress (IRC) and the Bureau of Indian Standards (BIS) accept air cooled blast furnace slag as a substitute of store aggregate /chips for road making purposes. Developed countries like France, Australia and Holland are using roads in which up to 100% of Steel Plant wastes like Blast Furnace and SMS slags, granulated BF Slag and Fly ash are utilised. Innovative technology for ceramic floor and wall tiles has been developed consuming fly ash, BF slag and iron ore tailings from mines.
- SMS slag has technically been found suitable for use in rail ballast [4, 5]. The basicity of the SMS slag makes it a good liming material for acidic soil. Phosphorous in the slag acts additionally as nutrient to the soil. Therefore, SMS Slag can be used as soil conditioner.

- SAIL R&D has developed technologies for utilisation of the ferruginous wastes (dust) through micro pelletisation-sintering route. Consuming of about 100 kg micro-pellets for producing 1 ton of sinter increase the yield by 3-4 %, productivity by 8-10% and strength by 2-3 %, in addition it saves fresh resources (flux & ore) consumption by 13 kg/t and 87 kg/t respectively [4, 5] .
- Benzol refining plant consumes 98% sulfuric acid to wash crude benzol. A process technology has been developed by SAIL for re-generation of this sludge into usable acid. The amount of regenerated acid produced corresponds to an annual saving of 840 ton of sulphur, which would have to be otherwise imported. Thus there is an annual savings of Rs. 25 lakhs in foreign exchange in each plant. [5]

Research & Development

Generating wealth from wastes needs knowledge and R&D. Following new technology initiatives have been taken up at different SAIL plants, under R&D Master Plan (High Impact Project – 3) of SAIL[1], for enhanced utilization of solid wastes:

- Development of Technology for Dry Granulation of LD slag and Heat Recovery
- Almond briquetting of sludge and its use in BOF Converter
- Micro-pelletisation of Sludge for use in Sinter Plant

Conclusion

As in nature where nothing goes waste, steel makers also use some process units like Sinter Plant as scavenging units where wastes and by products from other process can be combined to produce high quality input material as a replacement for virgin iron ore thereby saving precious natural resource. Bio-mimicry model practiced in SAIL operations since long; is best example of taking opportunity in waste utilization. Near future as being predicted, competitive sustainability shall be dependent on waste utilization efficiency and environmental footprint. Similar to the Kimberley Process Certification Scheme (KPCS), clean chit for waste management may be demanded from customers before opting for any steel product. Utilising solid waste is an option today, but it’s likely to be a necessity very soon.

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