Proper Management of Metallurgical Wastes - A Paramount Necessity for Clean Environment

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ABSTRACT

Rapid industrialization has led to substantial decline in the quality of the environment. The long journey from mining of iron ores to the production of finished steel generates a variety of solid, gaseous and liquid wastes in considerable quantities. Some of the wastes have adverse effects that have long-term influence and demand remedies. Therefore, it is essential that proper management of harmful wastes be done on priority basis for maintaining clean environment.

This paper discusses in detail the various metallurgical wastes generated in steel plants and their effects on environment. The paper also deals with the necessity of recycling of metallurgical wastes and measures taken by Indian integrated steel plants to save and maintain clean environment in and around the factory premises. Some of the recent clean technologies adopted abroad have also been briefly presented.

Key Words : Metallurgical wastes, clean environment, emerging technologies, waste to wealth.

INTRODUCTION

Conversion of raw ore into finished steel in an integrated steel plant involves generation of many types of wastes at different stages of processing. These wastes have adverse effects on environment. The utilisation of wastes in an environment friendly and cost effective manner pose a major challenge. Raw materials constitute a major portion of the production cost. Most of the raw materials generally come from outside sources, where there is no price control. Recently, there has been steep rise in raw material costs. Therefore, to reduce production cost, minimization of generation and recycling of metallurgical wastes has become essential. It is no more an option but a compulsion. In view of present economic scenario, industrial policies of the Government of India, stringent pollution control regulations, survival and awareness generated among public, proper management of both the "Waste" and the "Environment" to minimize the adverse effects has become a paramount necessity. Experts agree that environmental protection is a global issue. It cannot be confined only to the utilization of waste or the application of a new filtration technique. It presents a technological challenge. It is necessary to make the production processes more environment friendly, to create closed material flow cycles and remedy weak points in the technological procedures. All environmental problems cannot be solved by technological measures, but it is vital that we try to do this every time when there is some potential for these measures.[1,2]

According to the deliberations of a recent seminar, waste can be converted into wealth, either by recycling in mother plant itself or be disposed off after value addition. The need for waste recycling arises due to following three reasons.[3,4]

- To handle the waste in an environment friendly manner, keeping in view the scarcity of land available for disposal of waste.
- To reduce the cost of production by lowering the specific raw materials consumption and elimination of cost of handling and disposal.
- Conservation of scarce natural resources.

The strategy adopted in overcoming this challenge and maintaining clean environment is four fold:

(1) To minimize the generation of dust through improved processing and material handling and adopting clean technologies.

(2) To maximize the recycling of wastes generated in different stages.

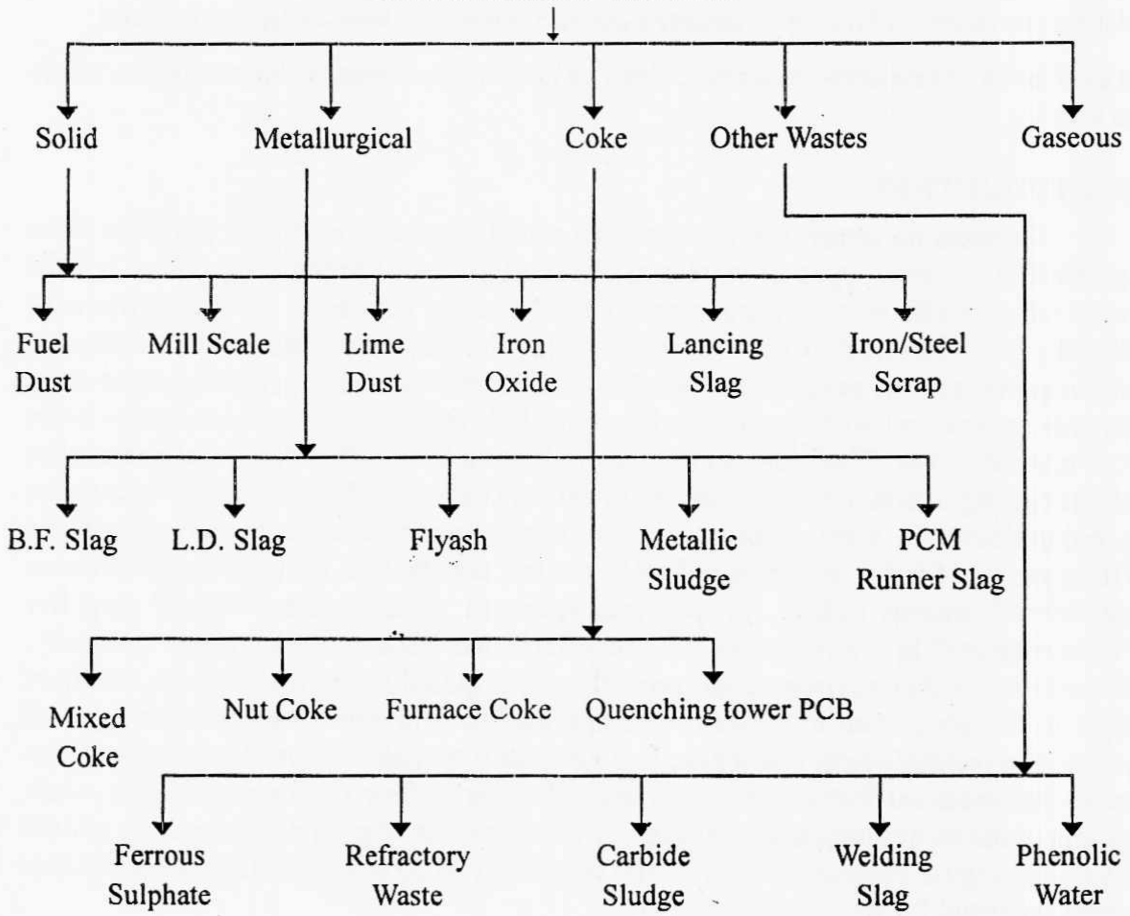
(3) To sell the waste as by-product after suitable treatment.

(4) To dump at suitably prepared site.

WASTES GENERATED AND THEIR UTILISATION IN STEEL PLANTS

In the long journey from mining of iron ores to the production of finished steel, a variety of wastes in considerable quantities are generated in an integrated steel plant. These are presented later.[5]

STEEL PLANT WASTES[5]



Not all of these are desirable or safe. Several of them are recoverable and reusable while others need to be disposed off with care. Some of the wastes have adverse effects that have long-term influence and demand remedies. The cost of environmental degradation is enormous and constitutes a significant fraction of National Domestic Product. The different type of wastes generated and their utilization in one of the steel plants of SAIL is presented in Table 1. Consumption of metallurgical wastes, iron ore fines and lime stone fines (kg/ton of sinter) from 1996-97 to 2000-2001 are given in Figs. 1 and 2.[6]

Table 1 : Generation and utilization of solid waste in Durgapur Steel Plant for the year 2000-2001

Serial No.	Materials	Generation (T)	Recycling (T)	Sold (T)	Utilisation (%)
1.	B.F. slag	724408	1517	694590	96.1
2.	B.F. flue dust	19085	2600	8106	56.1
3.	B.F. sludge	23400	Nil	3523	15.1
4.	L.D. slag	366052	145970	13143	43.5
5.	L.D. sludge	30309	3320	Nil	11.0
6.	Lime fines	18993	18993	Nil	100.0
7.	Mill scrap/ Ferro-scrap	48314	48314	Nil	100.0
8.	Cinder	50517	Nil	56480*	100.0
9.	Waste refractories	5956	745	5211	100.0
10.	Fly ash	148415	Nil	Nil	0.0

* Includes materials sold from previous stock also.

EFFORTS TO MAINTAIN CLEAN ENVIRONMENT

In recent times, large numbers of structural and operational changes are coming up in the steel industry. Therefore, steel industry will be affected by various changes. The prospective visions include low wastes waste free production of iron and steel, and appropriate recycling technologies for solid wastes. Ideally, recycling is the most economical and safer option; which all industries are striving for. The current recycling rate is reported to be around 90%.[7] The main difficulty does not lie in finding the processes aimed at utilization of solid wastes, but to find economic and flexible processes, which do not have adverse effects on the product output and the quality of the steel produced. This development should be stimulated by the following impulses:

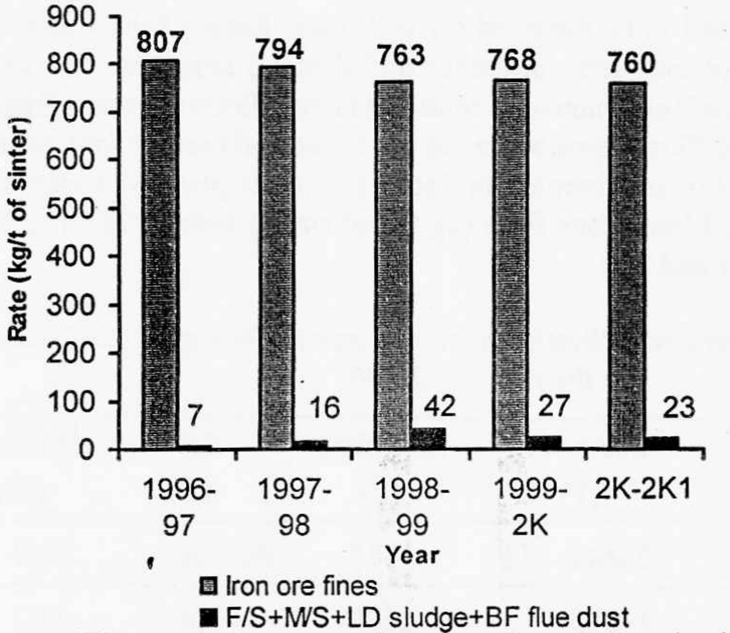


Figure 1. Iron ore fines and metallurgical wastes consumption in sinter plant

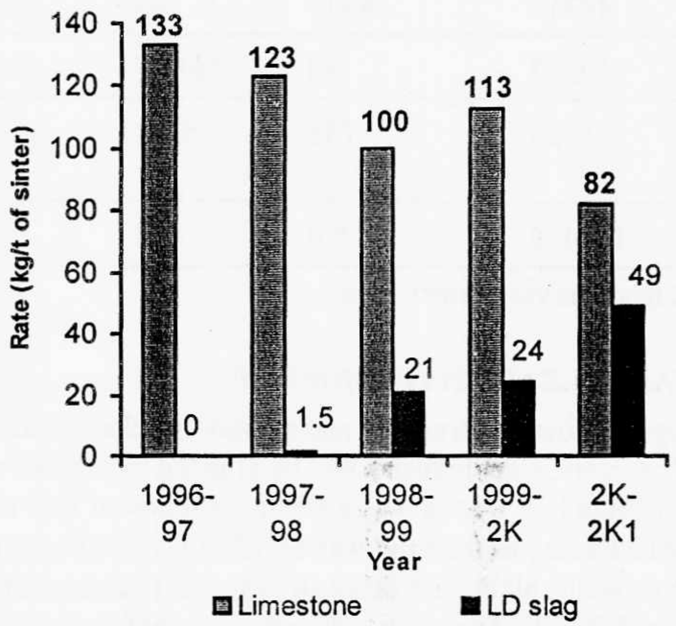


Figure 2. Limestone fines and LD slag consumption in sinter plant

- Environmental laws
- Public demand
- Economic tools, which would encourage

* The process of phasing out old, inefficient, expensive and polluting plants.

* Replacing these with new technologies/ clean technologies, which are environmentally sound.

The process of looking for an optimal solution to the problem of waste generation and environmental pollution clearly leads to the implementation of controlling systems ensuing from the ISO-9000 and ISO-14000 directives, or the EC Council Regulation No. 1836 on voluntary participation in the implementation of environmental management systems, the environmental impact of waste minimization, environmental policy and recycling technologies, management of power systems and water service management, or the issue of environmental protection with relation to new technologies.[8]

Another method, which is becoming more and more significant, is the Life Cycle Assessment (LCA) strategy, which focuses on assessing the total negative environmental impact of the product along its entire life cycle, i.e. the production, consumption and disposal. LCA principles and tools are covered by the ISO-14040 directive. Another tool whose application will be more and more required is eco-design, focused on optimizing the existing products with regard to their environmental impact.[8]

CLEAN TECHNOLOGIES IN IRON AND STEEL INDUSTRY

The iron and steel industry during the last four decades witnessed a tremendous change in technology. Besides modification and improvement in conventional practices, massive efforts are also continued to develop a radically different route for iron and steel making, by passing the Coke Oven-B.F. route to increase productivity, improve quality and to maintain clean environment so that the universe can be saved.

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. These technologies are at different stages of development and are conveniently called emerging technologies or clean technologies. These technologies can be classified under the following categories.[9]

- The agglomeration technologies.
- The direct reduction (DR) technology.
- The new ironmaking technology.
- The new emerging technology for steelmaking.
- Near-net shape casting technology.

Agglomeration Technologies

Depletion in reserves of high grade raw materials, production of fines due to mechanization of mining, stringent environmental regulations, raw materials conservation, stringent quality requirement for producing superior quality steels, etc., resulted in development of alternative technologies for mineral beneficiation and agglomeration for economic utilization of low-grade raw materials and fines for resource maximization and waste utilization resulting in clean environment. Agglomeration is a process of size enlargement, whereby small particles are gathered into larger, relatively permanent masses. Of the major commercially established agglomeration process technologies, briquetting, sintering and pelletisation processes are dominant. Agglomeration by cold bonding is very limited due to quality reasons. Sintering and pelletising technologies are by far predominantly used in iron ore agglomeration. The agglomeration process leads to :[10]

- Utilization of fines, which would otherwise be predominantly wasted.
- Reduced handling hazards.
- Sizing the materials for more convenient handling, storage and transportation.
- Produce useful structural forms.
- Create uniform blends of fine solid, which do not segregate.

In sinter plants, wastes are generated in the process of sintering i.e. during agglomeration of the furnace charge, cooling, crushing and returns. Non-process dust is generated in handling and treatments of the ingredient of the charge like grinding, screening, unloading, transportation etc. A large amount of gases evolve during the process of sintering. They contain harmful constituents like SO_2, CO and nitrogen oxides, which are exhausted into the atmosphere. To maintain the clean environment and to provide better working conditions, a large number of cleaning devices/ technologies are now a day used in sintering. Such technologies are cyclone separators, electrostatic precipitators, emission optimized sintering, desulphurisation of sintering waste gases, denitrification of sintering gases, etc.

Pelletisation of iron ores is also of great importance even with the vast high-grade iron ore deposits. In such areas, this unit operation is producing suitable blast furnace or DR feed from the rising mountains of high grade iron ore fines that are unavoidably created during crushing of lumps to specific sizes. Various emerging technologies/innovations are being made in the field of pelletisation of iron ore fines so that the clean environment can be maintained. To mention a few are Pelletising Grade Feed System, Pellet Car and Furnace Hood, Burner Control Modifications, Computerised Maintenance System, etc.

DR Technology

The DR technology can be classified in two groups:

- Gas based technology.
- Coal based technology.

As per the survey done by Midrex during the year 2000, the statistics of DR manufacturing facilities in the world is shown in Fig. 3. It can easily be said that globally, 9 out of 10 tones of sponge iron is produced using the gas based technology and the total production is about 43 million tones per year. The total DRI production at present in India is about 5.5 mtpa. Waste generation in terms of slag during ironmaking is very small and this technology is a significant step towards reduction of waste generation in the iron and steel industry. [11]

New Ironmaking Technologies

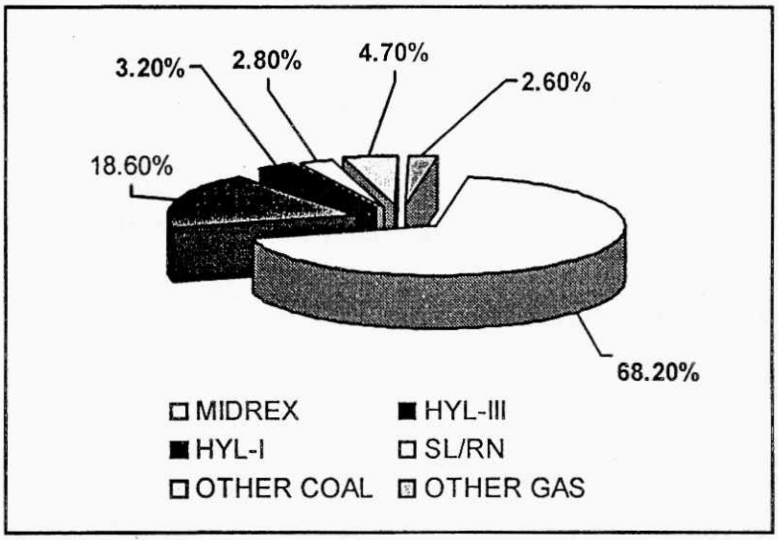


Fig. 3 : World DR production by processes in the year 2000

The new ironmaking technologies in the horizon can be classified into two categories:

- Smelting reduction processes.
- New technologies based on blast furnace concept.

These technologies have been classified according to their process characteristics and type of energy used in Table 2.

Table 2 : Emerging smelting reduction processes

Energy source smelting	Single stage smelting	Two stage (melting/reduction) coal based	Three stage (melting gasification/ based reduction	Electric melting coal
Coal/oxygen combustion	BSC/ICI, Romelt, Ausmelt	Krupp COIN BSC/Hoogvens Kobe Klockner/CRA HISMELT DIOS	Korf (COREX) Kawasaki Sumitomo SC BSC,Oxy/coal BF NKK O_2 BF Plasma smelt Pirogas Rotary kiln-SAF Process VRDR-SAF process AISI-DOE	ELRED INRED

Corex and ROMELT are the only smelting reduction technologies, which are under development for production of hot metal in India.[12,13] Most of above mentioned technologies have already undergone pilot plant test and are in the process of upgradation into demonstration and commercial/semi commercial units in the other parts of the world. All these technologies will significantly reduce the waste generation.

Steelmaking Technologies

Most of the emerging steelmaking technologies primarily aim at cleaner high quality products leading to reduced waste as rejects. Energy Optimizing Furnace (EOF) process conserves fuel consumption. In this process oxygen is blown into the bath through submerged tuyeres resulting in high productivity and reduction in waste generation. The charge in EOF can be from 100% hot metal to 100% scrap. A high degree of post combustion is practiced in EOF, which helps attaining a low level of specific energy consumption and thus considerably reduced toxic gas and dust emission. Some of the other examples are CONARC process, DCARC process, KORFARC process etc.[14]

Near-Net Shape Casting Technology

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[15]:

- Thin Slab Casting
- Strip Casting
- 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 reduce the rolling operation and associated waste generation.

Strip Casting

This is a new technology, which has been demonstrated by various research/ industrial organizations all over the world. Strips having thickness between 2-16 mm have been cast. Width of these strips ranged around 200 mm. This has potential for drastic reduction in hot/cold rolling operation.

Near Net Shape Casting

Now a days, a thin strip is continuously cast which can be used as 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.

ADOPTING WASTE TO WEALTH CONCEPT

Proper management of waste and its effective reutilization will convert waste into wealth. Therefore, waste treatment and its reuse be made as an essential process step in almost all integrated steel plants. A typical estimate of savings due to either reuse/recycling or selling outside is presented in Table 3.[5]

Table 3 : Saving through the utilization of solid wastes

Type of wastes	Utilisation			
	By selling		By reuse/Recycling	
	Quantity	Savings (Rs. lakh)	Quantity	Savings (Rs. lakh)
L.D. Dust (0-5mm)	2202 T	6.16	43,500 T	678
L.D. Ballast	-	-	3,350 M^3	3.35
L.D. Chips	-	-	6000 T	6.00
Acetylene sludge	2000 T	4.00	-	-
Regenerated oil	-	-	514 KL	190
BF granulated slag	5,91,171 T	2423.8	-	-
Lime fines	-	-	18,361 T	146.9
Dolo fines	-	-	9,033 T	72.26
Coke breeze	34,873 T	749.8	4,30,910 T	9264.6
RPM dust	-	-	22,936 T	91.744
BF flue dust	-	-	55,120 T	Cost N.A.
Mill scale	-	-	1,14,471 T	Cost N.A.
Refractory waste	2572 T	18.00	5,333 T	106.7

CONCLUSIONS

The clean technologies, through which waste generation itself can be significantly reduced, are being in almost all steel plants in the years to come. However, technologies alone will not reduce the generation of wastes or increase the utilization of the waste materials generated. It can be accomplished through increased awareness of people involved and a sustained change in the attitude of mind.

The organizational environment should be such that constant review of tactics and strategies are made in real time and success as well as problems are communicated to everyone involved. This would enable pursuit of excellence with commitment and impatience.

To foster clean environment and better working conditions in the plant so that efficiency of working and longevity of the workers can be increased, the directives of ISO-9000 and ISO-14000 be strictly adopted and implemented. Environmental audit should be made a regular routine. Recycling of wastes be adopted as an essential process step in steel plants. This will help us in minimizing the waste as well as maintaining the clean and safe environment in and around the integrated steel plant.

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