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Strategies for solid waste management in SAIL steel plants

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ABSTRACT

The paper discusses the various strategies adopted by Steel Authority of India Ltd. (SAIL) in their different steel plants for management of solid wastes generated. Future options available with SAIL have also been outlined.

INTRODUCTION

SAIL, as a responsible and premier Public Sector Organisation is fully committed to safeguard the environment around its various plants and mines. Towards this direction, SAIL has adopted environmental protection through appropriate natural resources management and pollution control as one of its important thrust area in its corporate policy. Steel Industry falls in the list of 29 highly polluting industries as categorised by the Ministry of Environment & Forest. An integrated Iron & Steel Plant is not a single entity, but involves a number of industrial operations, which are complex in nature : such as mining, raw material preparations, iron making, steel making and rolling etc., usually carried out through raw material handling plant, coal washery, coke ovens and by products, blast furnaces, sinter plants, steel making, rolling mills, captive power plants etc. All these processes contribute to various type of pollutants, in addition to generation of large quantity of solid wastes.

The major solid wastes generated in SAIL steel plants are, blast furnace slag (air cooled and granulated), steel making slag (both BOF and OH), fly ash from the captive power plants, blast furnace clarifier sludges, blast furnace flue dusts, steel making dust, mill scales, waste refractories, coke breeze etc. Generation of such products fully depends on the quality and quantity of raw materials used in the process. This paper will discuss type and quantity of the various solid wastes generated in SAIL steel plants, its present status of utilisation and the future plans and programmes in details.

Solid Waste Generation Pattern in SAIL Plants

Solid wastes in steel plants are essentially by products generated during various processing steps involved in the production of iron and steel. The quantities of such wastes are enormous and their nature quite varied and diverse. Some wastes like BF and SM Slags as well as fly ash, constitute a major fraction of the total generation, whereas mill scale and flue dust contribute comparatively smaller fraction. The solid waste generation in SAIL plants in kg/t of crude steel is given in Table-1.

Table-1 : Generation of total solid wastes in SAIL Integrated Steel Plants (1994-95) *Unit : ('000T)*

Solid by Product	BSP	DSP	RSP	BSL	IISCO
Air cooled BF Slag	1081	265	222	1479	332
Granulated BF slag	833	273	217	205	128
SMS slag-THF/OHF	438	133	74	-	33
SMS Slag-LD/BOF	254	74	193.3	754	-
BF GCP Sludge	61	76	3.9	NA	34
SMS GCP Sludge	18	8	-	NA	NA
Sinter Sludge	26	-	-	NA	-
Fly ash (Boiler ash)	200	102	332	556	104
Coke Breeze	360	341	88.5	5.39	106
Flue Dust		35	43.2	54.2	41.3
Lime/Dolo Dust	82/52	2	4.7	26/7	4.6
Waste Refractories	64	18	4		10.5
Mill Scale	65	37	41.8	135	14
Ore Fines	-	82	NA	-	166.6

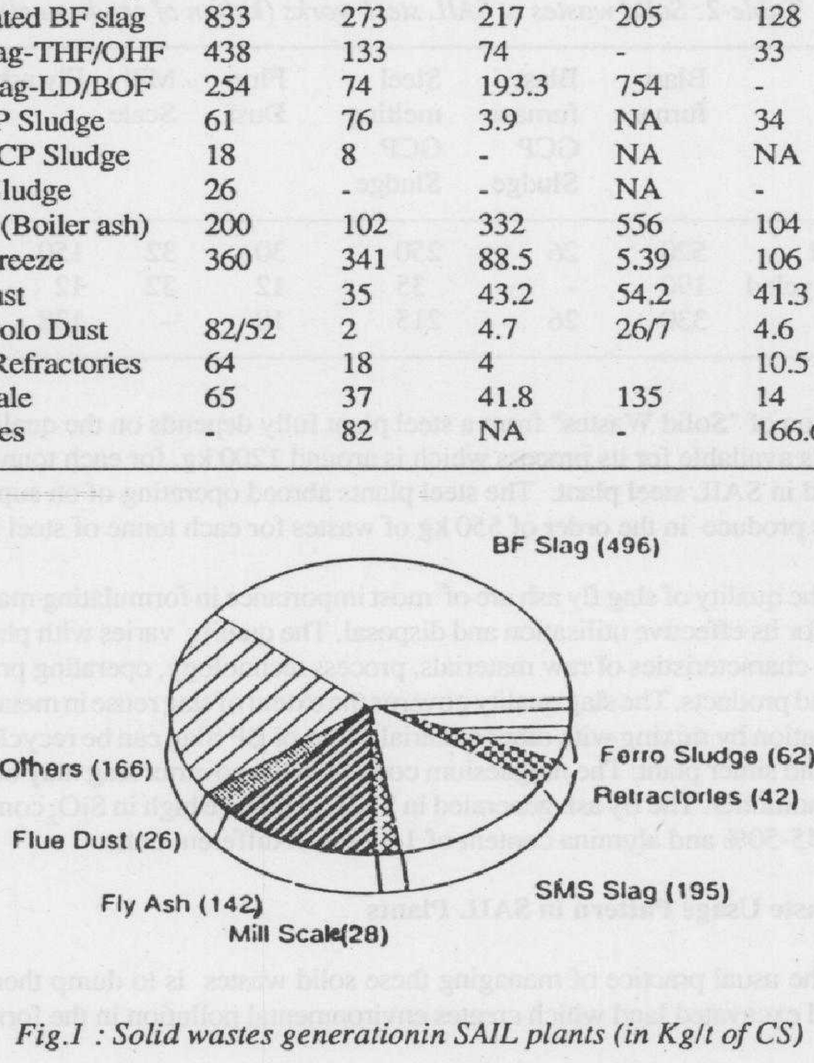

Fig.1 : Solid wastes generationin SAIL plants (in Kg/t of CS)

Substantial quantities of solid by product and wastes are generated from different processes of iron and steel making in an integrated steel plants which are termed as "Solid wastes". A recent estimate puts it around 1.2 tonnes of wastes for each tone of steel produced. Solid wastes generated from SAIL steel plants are mainly slag and fly ash (from the power plants). The other solid by-products are blast furnace flue dust, blast furnace clarifier sludge, steel melting dust, mill scales and refractories. From environmental point of view, it is necessary to dispose off or recycle the material efficiently and profitably. Table-2 below indicates typical solid wastes which arise at each stage in the steel making process. The listing is not necessarily complete but covers the majority of the problems of disposal and treatment of wastes.

Table-2: Solid wastes at SAIL steel works (kg/ton of crude steel)

	Blast furnace	Blast furnace GCP Sludge	Steel melting GCP Sludge	Flue Dust	Mill Scale	Fly ash	Refra-tory
Produced	520	26	250	30	32	150	17
Sold/Recycled	190	-	35	12	32	12	4
Dumped	330	26	215	18	-	138	13

Generation of "Solid Wastes" from a steel plant fully depends on the quality of raw materials available for its process which is around 1200 kg. for each tonne of steel produced in SAIL steel plant. The steel plants abroad operating of on superior raw materials produce in the order of 550 kg of wastes for each tonne of steel produced.

The quality of slag fly ash are of most importance in formulating management strategy for its effective utilisation and disposal. The quality varies with physical and chemical characteristics of raw materials, process technology, operating practice and type of end products. The slag quality governs the extent of slag reuse in metal recovery and utilisation by mixing with other materials. Part of BF Slag can be recycled to blast furnace and sinter plant. The magnesium content in the coverter slag may be useful as a slag conditioner. The fly ash generated in SAIL plants are high in SiO_2 content of the order of 45-50% and alumina content of 14-28% in different units.

Solid Waste Usage Pattern in SAIL Plants

The usual practice of managing these solid wastes is to dump them in open space and excavated land which creates environmental pollution in the form of dusts

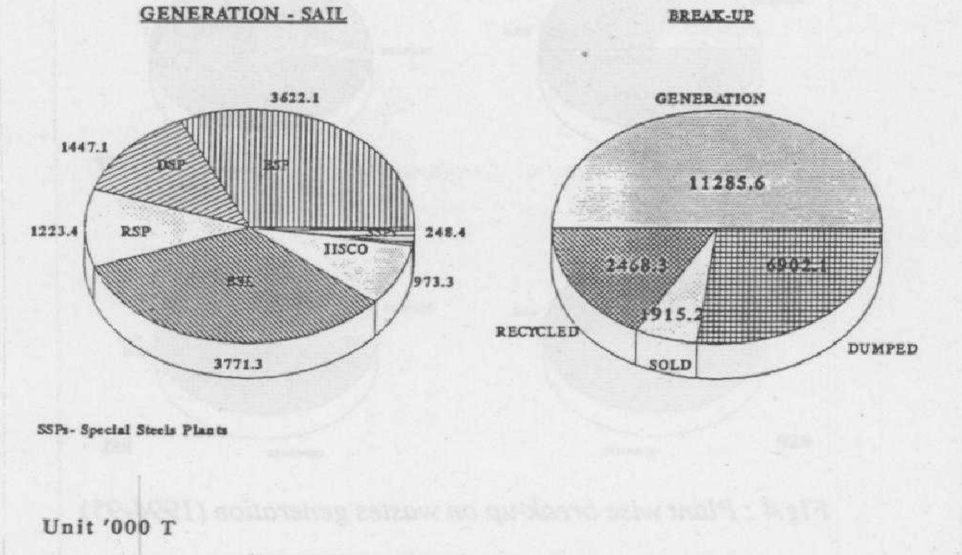

Fig.2 : Solid waste generation/utilisation (1994-95)

and leachates. Beside, these also need huge investment in dumping. As a age old practice, SAIL was also following the same method. The solid by products generated in SAIL steel plants can become profitable when disposed as saleable products. Out of total solid waste generated in our steel plants 16% are sold, 21% recycled and rest 63% are dumped.

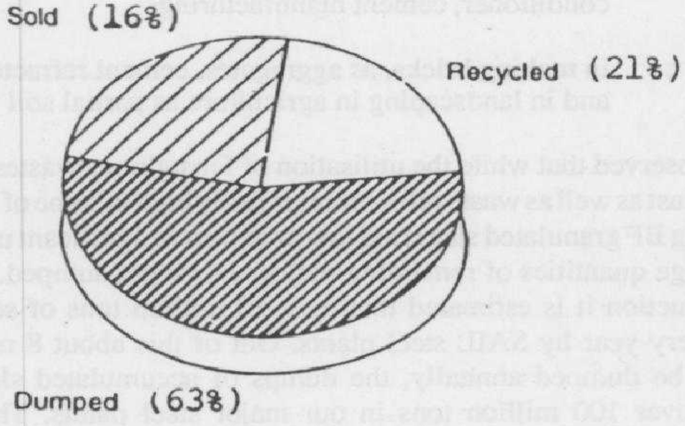

Fig.3 : Solid Waste Using Pattern in SAIL Plants

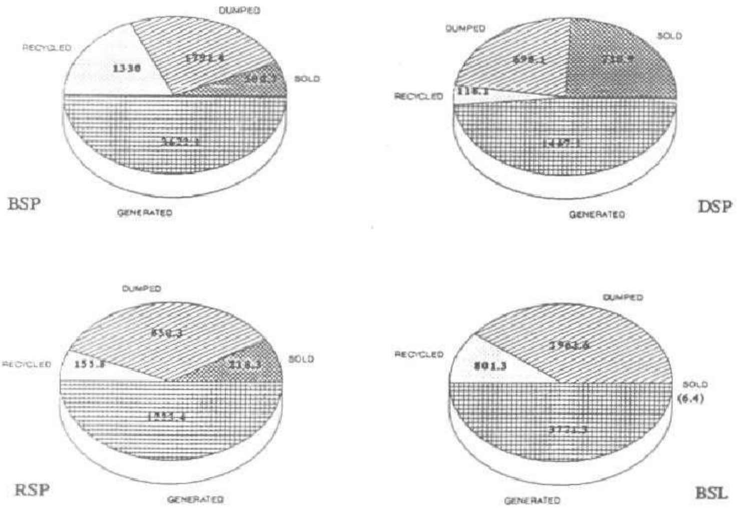

Fig.4 : Plant wise break-up on wastes generation (1994-95)

The utilisation of granulated BF Slag (GBFS) is 99.4% and that of coke breeze is 82%. Utilisation of rest of wastes such as air cooled BF slag, fly ash have been insignificant. This has resulted in the continuous increase of dumps and related environmental problems. A major thrust, therefore, needs to be focussed on increased utilisation of air cooled BF Slag, SM Slag and Fly ash, with progressive reduction in the existing dumps. The potential utilisation of these particular solid wastes are :

BF Slag	:	in road making, walls, embankment, land fill
SM Slag	:	in road making, as rail ballast, as aggregate and soil conditioner, cement manufacturing.
Fly ash	:	in making bricks, as aggregates, cement refractory products and in landscaping in agriculture as partial soil substitute.

It is observed that while the utilisation of ferruginous wastes like mill scale and BF Flue dust as well as waste refractories is fairly high in some of the steel plants, others (barring BF granulated slag) find low or almost insignificant utilisation. Thus extremely large quantities of remaining major wastes get dumped. At the present level of production it is estimated that over 10 million tons of solid wastes are generated every year by SAIL steel plants. Out of this about 8 million tons are estimated to be dumped annually, the dumps of accumulated slags alone may account for over 100 million tons in our major steel plants. The break up of generation and utilisation (1994-95) of some of the major wastes in SAIL plants are given in Table-3.

Table-3 : Generation and utilisation of solid wastes in SAIL plants (1994-95)

Solid waste Products	Quantity generated (MT)	Quantity utilised (MT)	% Utilisation
1. Granulated (BF Slag)	1.65	1.63	98.78
2. Coke Breeze	0.91	0.71	78.02
3. BF Slag (air cooled)	3.38	0.046	1.36
4. SM Slag	1.95	0.31	15.8
5. Fly ash	1.29	0.03	2.32

Technologies for utilisation of these and other wastes are available from national institutes and laboratories including RDCIS (SAIL). The technologies established/developed by SAIL are based on physico-chemical characteristics of the solid wastes generated in the steel plants. These technologies are in the areas of : (i) Utilisation of fly ash in brick making, pellet making and in agricultural field, (ii) Utilisation of ferruginous wastes through micro pelletisation-sinter making route, (iii) Utilisation of salvaged refractories in production of remming mass, mortar etc. and (iv) Recovery of acid from waste acid sludge.

Full scale adoption of these technologies will yield immediate financial/ environmental/social benefits to the steel plants. Solid waste dumps, apart from occupying precious land space, are liable to create serious pollution problems in the surrounding environment in the form of undesirable dust and leachates. The latter may contaminate the underground water. Further, the available space for dumping is continuously getting scarce due to pressures of population growth and also increase in materials requiring disposal.

Recently Indian Railways and BSL and RSP entered into an agreement that South Eastern Railways(SER) will procure LD/SMS slags for Rail ballast (size 20-40mm). A similar agreement between Bhilai Steel Plant and SER is likely soon.

In DSP, parties have been identified to manufacture bricks from Fly ash using CFRI technology. Land, water/raw materials and power will be supplied to entrepreneurs by DSP. The parties will have to identify the market for it. Each of them will be manufacturing 8000 bricks/day initially. Studies have also shown that there exists potential for reasonable use of LD Slag for cement making. Technologies have been perfected in China. For effective implementation of solid waste management plan, strengthening of the organisational set-up is necessary. This involves setting up of Committees at both Corporate and Plant levels.

Potential Technologies For Solid Waste Utilisation in SAIL Plants

Fly Ash : Fly ash generated in Captive Power Plant, is generally disposed of in slurry form along with ground cinder ash. They are dumped, in mixed form, in ash ponds especially dug for this purpose. Digging of ponds has become very expensive, furthermore, the present government policy is also likely to restrict further dumping of fly ash. Therefore, massive utilisation is the only solution. Fly ash can be converted into useful products such as bricks, Pozzolana Cement, base stabilization for road making, glazed tiles, light weight aggregate and refractory products etc. However, use depend on several factors like the physico-chemical characteristics, quality of fly ash, extraction and collection techniques and the market demand.

Brick Making : Central Building Research Institute, Roorkee; Central Power Research Institute, Bangalore; AEC Cement & Construction Ltd., Ahmedabad and Research & Development Centre for Iron & Steel, SAIL, Ranchi have developed clay-fly ash burnt brick block manufacturing technologies. The amount of fly ash used depends on the properties of fly ash and clay.

Lime Fly Ash Brick Making : Central Fuel Research Institute, Dhanbad, Central Building Research Institute, Roorkee and RDCIS, Ranchi have developed technologies for manufacturing lime fly ash bricks in which strength is imparted by auto claving. M/s AEC Cements & Construction Ltd. claim to have developed fly ash lime stabilised brick making technology which does not require heating, steaming or autoclaving.

Fly/Ash/Lime and Gypsum Brick Making : Fly ash, lime and gypsum are the constituents of brick/block which are produced in normal manner and cured for 28 days wherein water is sprayed twice or thrice a day. Depending on the quality of cement clinker and the fly ash, 10-25 percent fly ash can be blended in the cement to produce Portland Pozzolana cements. Fly ash can be added to the cement on site up to 20 per cent. This provides saving of 20 per cent cement. Dry fly ash is preferred in production of PPC as well as for mixing on site.

Aggregate Making: Aggregate Making Technology have been developed by Central Power Research Institute, Bangalore; Agrdelite Holding B.V. of Netherland and

SAIL (RDCIS), Ranchi. All the processes produce pellets and after sufficient strength development the pellets are broken and used as aggregate in concreting. CPRI, Bangalore, uses heat hardening techniques for imparting strength where as SAIL process requires autoclaving and Agredelite steam curing for 16 to 18 hrs. GBFS is used in cement production, depending on the quality of cement clinker and GBFS (Granulated Blast Furnace Slag). DSP and IISCO sell part of blast furnace slag to private cement manufacturers for granulation, the remaining being air cooled and dumped. The amount of GBFS added to cement is higher only if the glassy content of the slag is 90 to 96 per cent, which in turn is possible if temperature of the slag is above 1200°C. Cast house granulation in some of the blast furnaces at Bhilai and Rourkela has taken care of slag temperature. This needs to be extended to other Blast Furnaces and to the remaining steel plants. DSP's cast house slag granulation unit with BF-4 is expected to be commissioned shortly.

Road Making: 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. Necessary efforts are required to be made for its utilisation in road making in the steel townships and inside the plants. Utilisation of the crystalline air cooled blast furnace slag also requires persuasion and follow up with various road making authorities — Central, State, Local bodies — so that it is included in the schedule for economic transportation. CRRI has conducted laboratory studies on Rourkela Steel Plants slags for their use as substitute for stone aggregates in road making. Based on their report an experimental road patch is going to be constructed soon at Rourkela with the active participation of RSP, CRRI and state road authorities. The outcome of this trial is expected to help in popularising the slags for road making purposes. The SAIL plants are preparing for necessary supply of crushed and sized slag to the customer. The finer size of the BF Slag can be used as a substitute for sand in concrete/mortar making.

Grave Laitier- Tont Laitier Road Making: Developed countries like France, Australia and Holland are making and using Graved slag and all slag roads in which up to 100% of Steel Plant wastes like Blast Furnace and SMS slags, granulated BF Slag and Fly ash are utilised. RDCIS is conducting a study with samples from Bokaro jointly with Central Road Research Institute, New Delhi and is trying to develop a suitable combination for making high density — heavy duty roads with Steel Plants wastes. SAIL is exploring avenues to utilise blast furnace slag in the form of boulders for arresting erosion of the embankment of Hooghly and Digha shore lines.

Steel Making Slag : Steel making slag is generated at the rate of 165-200 kg per tonne of Steel produced. The present practice in almost all the SAIL steel plants, is to dump the material. This is occupying a huge chunk of useful land inside or near the plant.

SMS Slag can be used as rail ballast, as aggregate for road making, as soil condition and as filling material for land cavities.

Rail Ballast : SAIL's SMS slag has technically been found suitable for use in rail ballast. Negotiation have been made between SAIL and the Railway authorities. SAIL plants making necessary infrastructure for crushing and sizing facilities so that sized material can be supplied to the Railways.

Road Making : SMS Slag has already been successfully used as road making aggregate in BSP, BSL and RSP in place of stone chips. Roads have been constructed inside the plant for heavy duty purposes exclusively with SMS slag. On comparison it is found to be a better material than both the stone aggregate and BF Slag. Necessary efforts must be taken to gain approval by IRC and BIS for these products so that regular utilisation by Road Authorities take place.

Soil Conditioner : The basicity of the SMS slag makes it a good liming material for acidic soil. Phosphorous in the slag acts as nutrient to the soil. Therefore, SMS Slag can be used as soil conditioner. However, SMS slag is required to be ground to very fine size for this purpose. The conventional grinding techniques are energy intensive. It is therefore, necessary to develop a commercially viable crushing and grinding facilities for extensive use of this material as soil conditioner. Tea and coffee plantations are potential customers.

Filling Materials: The finer SM slag received after crushing and screening of bigger pieces can be used as filler material along with fly ash and fine size BF slag.

Cement Making : Some of the foreign countries like China, Japan and Germany already use SM slag in varying amounts in cement making. SAIL has initiated a joint study with the National Council for Cement and Building Materials where SMS slag is proposed to be used as (i) raw materials for production of ordinary Portland cement and (ii) an admixture in Portland slag cement. SAIL is also jointly working with R&D Group of ACC for making steel slag cement.

Ferruginous Wastes : The GCP sludges/fines generated in the sintering plant, Blast furnace, Steel making shop and Raw Material handling plant are disposed of in varying amounts in Bokaro and in other plants in their dry form. In Bhilai and Durgapur, GCP Sludge/dust of sintering plant and SMS, and in RSP, part of the sludge of sintering plant are recycled. This contained about 48 percent iron and about ten percent lime and magnesia on an average. The amount of dumped ferruginous waste is about 1500 tonnes/day in BSL, 500 tonnes/day in BSP, 250 tonnes/day in RSP and 250 tonnes/day in DSP. The yearly dumping of ferruginous wastes in SAIL plants is about one million tonnes. Accumulated deposit of about 5 million tonnes of ferruginous waste with an average iron content of about 48 per cent is available at Bokaro in two sludge ponds. The solids in the sludge settle and create air and water pollution.

RDCIS has developed technologies for utilisation of the ferruginous wastes of BSL, BSP and RSP through micro pelletisation-sintering route. In case of Bokaro, addition of about 100 kg. pellets/tonne of sinter increase the yield by 3-4 per cent, productively index by 8-10% and tumbler index by 2-3 per cent. This has also reduced flux and iron ore consumption by 13 kg/t and 87 kg/t respectively. Based on RDCIS technologies, CET has prepared feasibility report for BSL and BSP, MECON has prepared feasibility report for RSP. The CET proposal for BSL and BSP are under examination by various agencies.

Waste Refractories : Waste refractories are disposed of broadly in three manner (a) reusable portion of salvaged refractories are recycled, (b) broken pieces are recycled/sold to outside parties, (c) remaining debris are dumped as a waste. The source of salvaged basic refractories are QHF/THF,Lime/dolo plant and rotary kiln. They are reprocessed to produce various granular products in the mass powder shop in Bokaro and Bhilai Steel Plants where such facilities exist. Other plants get it recycled through external refractory processing units.

SAIL has developed technologies for reuse/recycling of the following waste refractories :(i) Salvaged MgO-C can be reused for production of carbonaceous mixes,.(ii) Fire clay/high alumina refractories can be used to produce different grades of castable and mortar, (iii) High alumina castable can be made out of the salvaged slide gate refractories like plate, nozzle etc., and (iv) The technology developed by SAIL for production of chemical bonded Magchrome bricks and ramming mass out of the salvaged basic refractories like magnesite, mag-chrome and Chrome-Mag is being used by IISCO.

Acid Sludges : Benzol refining schemes at BSL and BSP involves washing crude benzol with concentrated sulfuric acid (98%) to remove unsaturated hydro-carbons and sulphur products prior to distillation into saleable products - Benzene, Toluene, Xylene, etc. Acid washing of Benzol generates about 4000 t/yr of acid sludge at BSP and BSL. This is a waste production and pollution hazard, posing a serious problem of disposal. In addition, there is loss of sulfuric acid and benzene.

A process technology has been developed by SAIL after extensive laboratory, bench and pilot scale experimentation for re-generation of this sludge into usable acid. The amount of regenerated acid produced corresponds to an annual saving of 840 tonnes 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. The process enables recovery of sulfuric acid to a level of 85-90% of 20-21% strength from acid sludges and used up polymer as fuel.

CONCLUSION

Management of waste in an integral component of management of environment, as much as an important part of business opportunities. Metallurgical industries are energy intensive and mostly environment subvertive. Life cycle assessment of an typical product from any metallurgical industries reveals significant environmental impacts from "Cradle to Grave" operations. Though SAIL plants in some way or other, did practice waste management (mainly through recycling), an organised effort has been initiated recently. At present, one tonne of waste is produced for every tonne of steel output in SAIL Plants. Other integrated plants in India also have similar arisings. What is a needed is common strategy to be adopted by the main steel producers to find viable outlet for the bulk categories of the solid wastes. With the BOT schemes for road making under active consideration of Surface Transport Ministry, an MoU can be thought of between the road building agencies and the steel plants to use the BF and SMS slags and fly ash. World Bank/ UNIDO assistance can also be sought for this.