Environmental and Waste Management (ISSN : 0971-9407)
Eds. - A. Bandopadhyay, N.G. Goswami and P.R. Rao
© NML, Jamshedpur - 831 007, 1998, pp. 3-10

Environmental and waste management in non-ferrous metallurgical industries – Critical issues*

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ABSTRACT

The paper summarizes the various environmental issues being faced by the non-ferrous metallurgical industries in regard to pollution control and waste management and highlights specific examples from the aluminium sector.

Keywords: Environmental and waste management, Non-ferrous metallurgical industries, Waste disposal.

INTRODUCTION

In early sixties the *Club of Rome* proclaimed that *Mother Earth* would soon be depleted of major mineral resources as well as fossil fuel. The green house effect and the acid rain will change the world environment. *Doom's Day* for the mankind was within sight.

Twentieth century has witnessed two World Wars in the first half followed by major scientific achievements in space research and information technology. Material need has been a part of the techno-engineering achievements which has led to over exploitation of the natural resources. Mankind, the supreme creature of the nature, has in itself been the major cause for destruction of nature. *Good news* is that both the developed and developing countries are one in voicing their concern for protection of the environment for the continuity of our civilisation through sustainable economic growth.

Under controlled economy over the last five decades, India's economic growth on absolute measure though substantial, in relative term, was meagre. With liberal economic policy of our successive governments, it is expected that the economy

* Excerpts from the key-note address delivered during the National Seminar, EWM-98.

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will grow faster and the metal production will grow many folds in the 21st century. At the same time, it will have the danger of affecting the ecology of our planet. The higher metal production will demand higher power generation. With limited hydel and nuclear options, over 95% power generation will be through the coal route. We are, therefore, standing at the cross road to witness major spurt in metal related activity, with its toll on the environment unless environment and waste management becomes a part of our economic activity. Fig. 1 indicates major mineral reserves of our country and Table 1 *illustrates production* level of some of our major metals and their expected growth by 2010 AD. Fig. 2 indicates the relative energy consumption per kg production of a few selected major metals.

This clearly illustrates that our power generating capacity at around 85000 MW has to be doubled in the next 20 years if we wish to improve the quality of life through economic prosperity of our people. In our future industrial endeavour we shall not only address domestic consumption but also export market. As indicated, this growth will not occur without any damage to the environment unless appropriate precautionary measures are taken throughout the life cycle of these metals. We need to be pro-active and not reactive. Non-ferrous metal group includes besides Aluminium, Copper, Lead and Zinc, many other uncommon, rare, scarce and nuclear

	KNOWN RESERVE (Mn TONNES)	LIFE AT CURRENT CONSUMPTION (YEARS)
IRON ORE	13000	250
BAUXITE	3000	590
COPPER ORE	600	100
ZINC & LEAD ORE	400	1000
MANGANESE ORE	154	120
CHROMIUM ORE	155	200
COAL	86044	744

POWER GENERATING CAPACITY - 85000MW

- THERMAL 62,600 MW
- HYDEL 20,400 MW
- NUCLEAR 2,000 MW

85,000 MW

Fig. 1 : Mineral base in India.

Table 1 : Production of major metals in India

	Current (million tonnes/year)	Projections for 2010 AD (million tonnes/year)
Iron & Steel	20.0	50.0
Aluminium	0.6	1.5
Copper	0.05	0.35
Zinc	0.15	0.3
Lead	0.07	0.15
Power production (MW)	85000	~150000

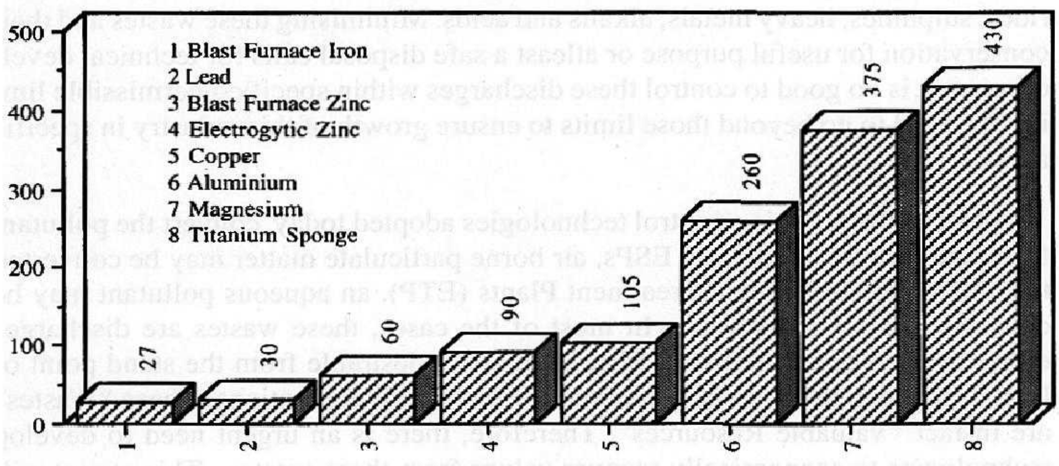

Fig. 2 : Energy consumption in metal production (MJ/kg metal).

metals such as Magnesium, Titanium, Cobalt, Molybdenum, Cadmium, Vanadium, Gallium, Tungsten, Uranium, Thorium, Niobium, and many others. Many of these strategic metals are associated with other minerals and metals and are recovered from the tailings and the effluents of the other metallurgical processes. Metal industry starts from mining through mineral processing, mineral upgradation (mostly wet process), smelting, refining, casting, alloying and downstream fabrication to the end products. At every stage, we interact with environment. Metal industry by and large has earned the reputation of being a polluting and eco-unfriendly industry. This reputation must be corrected. It is known by now that many Indian metal producers have resorted to eco-friendly mining with respect to sound and dust pollution as well as restoration of mined area to its original form. Adoption of environment management system like ISO:14001 helps in resource conservation and pollution prevention through pro-active measures. It is necessary that all non-ferrous industries specially the mines and the smelting units adopt these systems. Beauty of this management tool is that it ultimately offers economic benefit while ensuring environment protection.

Non-ferrous metals besides gold, silver and platinum are somewhat toxic to living organisms. It is, therefore, important that we not only take care of the process of manufacture but also their safe consumption.

We are mostly concerned with the release of pollutants during extraction process of these metals. The extraction process is either based on pyro metallurgy or hydro metallurgy involving use of chemicals that give rise to toxic gases, liquids and solid wastes. These waste materials depending on their source, contain fluorides, sulphides, heavy metals, alkalis and acids. Minimising these wastes and their conservation for useful purpose or atleast a safe disposal calls for technical development. It is no good to control these discharges within specified permissible limits. We need to go beyond those limits to ensure growth of this industry in specific areas.

Most of the pollution control technologies adopted today, convert the pollutant from one form to another. In ESPs, air borne particulate matter may be converted to solid waste. In Effluent Treatment Plants (ETP), an aqueous pollutant may be converted into a solid waste. In most of the cases, these wastes are discharges either in open or secured land-fills. Both are undesirable from the stand point of land use, which needs to be preserved for our future generations. These "Wastes" are in-fact "Valuable Resources". Therefore, there is an urgent need to develop technologies to economically recover values from these wastes. This aspect will be more beneficial to Copper, Lead, Zinc and Aluminium Industry, since, they also have wide areas of application. Besides, their escape to environment are more detrimental. Today, recovery of Sulfur as Sulfuric acid is one of the major concerns in Copper Smelting. Otherwise, more than the Government Controls, community will discourage the industrial growth.

Lead can cause toxic injury to man at levels of exposure that only a decade ago were thought to be safe. Lead – Acid Battery consumes half of world's Lead production. 14% of the world production is from recycled materials like battery plates, lead pipes, etc. While the modern primary lead industry in mining, smelting and refining are equipped with pollution control facilities, the small scale secondary refineries are causing localised pollution due to lack of knowledge, absence of cost effective technologies and cash crunch. In Lead – Acid Battery industry, out of typical uncontrolled emission of 8 kg Lead/1000 Batteries, 80% emission can be checked by simple control measures.

In nuclear metal industry and its usage, the sources of radio active wastes are diverse and include among others, Uranium ore mining, nuclear fuel manufacture, operation of reactors, spent fuel reprocessing, decommissioning of nuclear facilities, separation of radio active isotopes and their use in medicine, etc. A three tier system of regulatory control and compliance is employed for radiological surveillance of effluents to ensure that the radio active doses to the public are kept well below the specified value. In addition to the nuclear fuel a number of other rare and reactive metals like Zirconium, Niobium, Tantalum, Hafnium, Beryllium and rare earths are required for nuclear power programme. Production of these metals from their natural sources is a multi step operation involving ore breakdown, preparation of pure compounds, reduction of compounds and refining of metals. Each of the processing steps results in generation of variety of waste streams. Environmental protection and pollution control is an important aspect in the design and operation of such chemical plants.

Universal awareness of radio active waste makes the scientific community highly conscious of developing totally safe and environment friendly process of operation. Titanium, which is one of our strategic metals, creates 63000 tonnes of waste materials for production of 12000 tonnes of titanium sponge. Material and energy balance are critical for the economy of such production processes. As a pollution control measure, no chlorine slip is permitted at the chlorinator. Magnesium and Chlorine used in the process are fully recycled. Titanium plant can thus be made a totally environment friendly operation. Looking at the Aluminium industry in particular, some of the specific actions taken by Indian Aluminium Company Limited (INDAL) in waste management are discussed below.

MAJOR WASTE DISPOSAL PROBLEMS IN ALUMINIUM INDUSTRY

Red Mud Disposal

Red mud is an alkaline waste containing *oxides* of Iron, Silicon, Titanium and water soluble soda. It is generated at the rate of around 2000 tonnes per day. It is stored in specially constructed leach proof ponds. Prior to 1985, most of the world alumina refineries used to store Red Mud in slurry form. Indal was the first Indian alumina refinery to adopt dry mud stacking. The mud is stacked in cake form to create mountains. With this, the life of pond has been increased from 5 to 25 years. In addition to this, water and caustic are also recovered and recycled into the process. Indal is now working out ways and means of recovering residual soda from the red mud and then use it in cement manufacturing or non-ferrous metal extraction.

Alumina Fines from ESP's

Prior to 1990, the dust emission from alumina calciners was controlled by installation of poly-clones and multi-clones. This was not meeting the emission standards set by the law. Therefore, electrostatic precipitators were installed in all the alumina calciners. Dust collected at the ESP's is under calcined and fine in particles size, and hence not acceptable to Aluminium smelters. World over, the ESP dust is disposed off as waste. At Indal, the aluminium hydrate granulometry was modified and the ESP dust was recycled as kiln feed. Thus, complete recovery of dust was ensured. This activity has paid back the cost of ESP within three years.

Spent Potlining/Black Mud

Indal is the first smelter in India to recycle entire SPL waste. The cathode lining of electrolytic cells gets degenerated after a life of around 2000 days, due to absorption of fluoride bearing materials. World over, as also in India, this material is secured land filled, as it is highly toxic. At Indal, cryolite is recovered from this waste material and recycled back to electrolytic cells. Black mud waste generated during cryolite recovery is sold to cement plants as a fuel-cum-mineraliser. But, since the generation of black mud is more than what cement plants can consume, this waste will now be consumed in the captive power plant as a substitute for low grade coal.

Wet Scrubber Sludge

Aluminium electrolytic cells emit fluoride fumes. These are collected in a wet scrubber and then neutralised with lime to produce a solid waste called "Scrubber Sludge". This waste is also secured land filled, as it contains toxic fluoride chemicals. Technology was developed to convert these hazardous wastes into a product which can act as a flux in alloy steel refining. However, this project has not yet taken off, due to the absence of a suitable and cost effective calciner.

Fly Ash from Power Plants

The Hirakud Power Plant operating on CFBC Technology is one of the few Power Plants in India, which collects ash in dry condition. This ash is found to be a good soil conditioner and also agro-friendly. At present, around 3000 tonnes per month of ash is being used by cement plants to produce PPC grade cement. Efforts are now on, to either reuse the entire ash in cement plants or install a dedicated cement plant close to the power plant.

Recycling of Water from Power Plants

The power plant generates around 1800 cum day of waste water from cooling tower blow down, boiler blow down and raw water treatment plant. This water was being discharged to the surrounding environment. Arrangements are now being made to reuse the entire waste water in the wet scrubber, thereby, making this power plant, the first "zero" discharge power plant in India.

Oil Emulsion from Rolling Mills

A technology has been developed to convert hazardous oil emulsion from rolling mills into waste water conforming to discharge limits of the Central Pollution Control Board. The technology is based on vermiculture biotechnology and does not give rise to any down stream pollution. The first plant will be installed at Belur in West Bengal during the next year.

Heavy Metal Sludge

In the printed circuit board (PCB) plant at Mysore, copper clad laminates are used to manufacture mother board. Besides, various chemicals are used, that involve acids and alkalis including hazardous chemicals that contain Lead, Tin, Copper and Fluorides. Systems and technologies were developed to recover and recycle many of the chemicals and heavy metals from the waste materials. This plant is now positioned among the greenest PCB plants in the world that demonstrates recovery and recycle of hazardous spent chemicals, with virtually no pollution.

ENERGY MANAGEMENT

Another important area in environment protection is the "Energy Management". It is needless to mention that the extraction of primary metals needs much more energy than recycling of scrap. Primary aluminium requires ten times more energy than secondary metal. The story is similar in other metals too. This gives rise to two environmental approaches. In the first place, energy consumed in primary extraction in Indian industry is much higher than the world average. This not only results in loss of competitiveness but also in over exploitation of non-renewable energy resources. Therefore, all out efforts are required to minimise the energy consumption. Secondly, in India today, the secondary metal production is mainly in the hands of small scale sector. The scrap collection, processing and recycling is not only energy inefficient but also environmentally unsafe. In Japan, Europe and North America, secondary metal production is gaining momentum and becoming a serious competitor to primary metal. This is a right step as it not only helps in extending the life of mineral reserves, but also conserves the energy and reduces the extent of pollution. In India today, this activity needs to be nurtured and promoted.

OTHER ISSUES

Next, let us take a look at the use of water. In India, its wastage is maximum because either it is priced low or not priced at all. Water conservation is required not from the point of view of cost competitiveness, but, from the stand point of availability of potable water. Today 70% of Indian water is polluted, only 5% waste water is collected and out of this only 25% is treated. All out rivers are polluted. Water from many lakes and ponds is unfit for treatment and reuse, primarily due to discharge of both municipal and industrial effluents. Environmentalists claim that, if this rousing problem is not tackled on war footing, there could be civil wars between regions of a state or between states themselves. Clearly, industries are required to take urgent actions and non-ferrous industry is no exception. Many industries in India are already working on "Zero Discharge" concept.

New materials, composites and laminates are posing a different kind of problem on the environment as they are neither environment-friendly nor are they recyclable. Bio-leaching technology needs to be pursued with greater vigour. We need a new class of product designers who would design keeping *recyclability* in view. Lastly, the non-ferrous industry needs to take initiative and lead role in development of forest cover and community welfare. In India, the forest cover is just about 19% of the available land as against 33% minimum. India has almost 30% of waste land. In an industrial country, like Japan, it is 65%. Many industries have taken up development of waste land into social-forest using treated industrial effluents. We need to take similar initiatives. The forest cover will not only act as "Carbon Sink", but also serve in regenerating the bio-diversity and provide renewable source of energy. As we all know, our country largely lives in villages which are deprived of basic amenities. Over and above this, if industrial complexes start discharging wastes in all forms, the villages will be the major recipients. They will revolt, unless their needs are fulfilled. This fact is increasingly influencing the industrial activities, thanks to the intervention of Green NGOs. However, one needs to take a guarded approach.

CONCLUSIONS

1. *Resource conservation,* waste minimisation and pollution prevention should be the guiding principles for sustainable industrial growth.
2. *Proactive and preventive approaches* will only make the industry environment-friendly.
3. *Recycling of metals* should have the top priority since it is cost effective, conserves minerals & energy and is also less polluting.
4. *Zero discharge* concept should be encouraged by the industry.
5. *Industry should work towards obtaining ISO : 14001* which helps in addressing the environmental issues in a comprehensive and economic way.