An Overview on Steel Plant Waste Management in India

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Abstract: In India there are many steel industries which are meant for steel making and production, thus every day a large amount of steel slag is produced as waste material or by product through blast furnace and LD (Linz-Donawitz) furnace. LD slag is produced during oxygen converters process of steel making. The amount of steel slag produced from different steel industries is 150-200kg per tonnes of steel produced. The overall generation of steel slag in India is over 4 to 4.5MT per annum. Presently the huge amount of steel slag disposal becomes a big environmental concern. Thus, the better approach to recycling and utilization of this waste is based on their physico-chemical characterization, mineralogical characterization, etc. LD slag is having considerable amount of valuable minerals which can be re-used with suitable techniques. Presence of high phosphorous and sulfur content affects its recycling process, thus dephosphorisation and desulphurization may be a good technique to improve its utilization. This paper reviews the current state of utilization and recycling of LD slag produced from different Steel Plants in India.

Keywords: Characterization, Dephosphorisation, LD slag, Sintering, Utilization.

1. INTRODUCTION

During steel production integrated steel plants generate huge quantities of waste materials at different stage of processing and metallurgical operations. These considerable various types of wastes are generated like blast furnace slag, blast furnace flue dust, LD (Linz-Donawitz) slag, cokebridge, tar sludge, etc. The composition of these materials widely depending upon the source of generation, quality of raw material and metallurgical operations [1].The wastes produced in steel plants are generally disposed by dumping in a haphazard method which causes environmental problems. Nowadays, environmental legislations and economics force to steel industries to minimize the generation of wastes and maximize its recycling or utilization. Recycling or utilization of waste and has become necessary today as an eco-friendly cost saving technique because of shortage of space, depletion of natural resources, associated health hazards and economic advantages. Due to increasing awareness of environment, disposal, recycling, reuse of wastes without harming to environment has become a prime concern for industry [1, 5].

The steel plant slag mainly includes blast furnace slag and steel melting slag (LD process slag). LD slag is a by-product of steel making which comes from pig iron refining process using LD converters and one of the important waste materials in all integrated steel plant. In India the steel melting slag is over 4 million tonne per annum. The amount of steel slag from different steel industries is 150-180kg/t [2]. The total generation per annum is 1.28 million tonne in [3] Steel Authority of India (SAIL), about 0.98 million tonne in Tata Steel [4]. The slag contains variable substances like CaO, Fe and Mn. CaO is an important oxide present in the LD slag which can be used as flux material instead of lime. The blast furnace slag has a long term market in construction and fertilizer industries; Whereas LD slag is not suitable due to high phosphorus content. Till date only 40-50% of LD slag is possible to recycling in India. If removal of phosphorus is possible, LD slag can be recycled in steel making as a flux material. Use of this LD slag not only replace the lime but also avoid heat loss for calcination of limestone. Therefore, the removal of phosphorus from LD slag by reducing not only steel making cost but also the disposal cost [6].

2. PHYSICO-CHEMICAL AND MINERALOGICAL CHARACTERISTICS OF LD SLAG

Different studies have been carried out for physical, chemical and mineralogical characterization of LD slag. The physical properties of LD slag have been studied that high pH, and electrical conductivity indicating presence of high percentage of lime and ionic form of various salts. The specific gravity and bulk density was found to be high in comparison of fly ash and due to this characteristics LD bricks are heavier than fly ash [1]. Many authors have been studied the chemical and mineralogical characteristics of LD slag by inductively coupled plasma atomic emission spectroscopy (ICP-AES), X-ray diffraction (XRD), energy dispersive spectrometer (EDS), scanning electron microscopy (SEM) and electron probe microanalyses (EPMA). It was found that the slag contains desirable substances like CaO, SiO_2, Al_2O_3 FeO, MgO, MnO, P_2O_5. The chemical analysis of several phases analyses in Table 1.

Table 1 Chemical composition of LD slag (%) [1,7]

Components	FeO	SiO_2	Al_2O_3	CaO	MnO	MgO	P_2O_5	TiO_2	S
Average	24.05 ± 2.20	14.05± 1.2	4.34 ± 1.53	45.41 ± 2.24	8.17 ± 0.60	0.84 ± 0.60	1.53 ± 0.14	0.76± 0.06	0.24 ± 0.04
	26.30	12.16	1.22	47.88	0.28	0.82	3.33	-	0.28
	27.89	12.0	1.58	50.0	-	1.50	3.35	-	0.30

3. REUSE AND RECYCLING OF LD SLAG

Various studies have been done for reuse of LD slag in different fields such as for road making, floor preparation, cement/brick making, fertilizer/soil conditioner, recovery of metal values, for use in sinter plant etc. LD slag bolder is used in road making and floor preparation for its high hardness and cementing property. In Durgapur Steel Plant a major portion of the LD-slag is sold for road making. Similarly all the steel plants in India are selling more than 50% LD slag for road making and ground filling. It has been proved that Tata Steel LD- slag to be an excellent railway ballast material and is being used by Indian Railways. The lime and magnesia present in LD-slag absorb moisture and CO, from atmosphere to form hydroxides and carbonates respectively which lead to the volume expansion or swelling resulting in crack formation in road and building materials. This problem can be overcome by weathering the slag for six to nine months for hydration of free lime before the slag is used [8]. LD-slag has higher CaO content in comparison to BF-slag, which acts as an activator and gives better strength and presence of P_2O_5 results in corrosion of reinforced materials in concrete structure. If only 10% LD-slag is used in cement, due to low P_2O_5 in PSC react with alkali in slag contributing little strength of cement and P_2O_5 content around 0.3% which is not so harmful in Portland slag cement (PSC) [9]. Indian cement manufacturers are still unwilling to take advantage of LD slag as the low cost raw material for cement manufacture [10]. Experiments were conducted using pulverized LD slag for growing vegetables such as tomato, potato, onion, spinach, and crops like wheat, in the acidic soil [11]. The results show that by adding a concentration of slag of between 1.5 and 5.0 t/ha, according to soil type and its agricultural use, it is possible to achieve a proportional increase in the soil's pH as well as changes to the exchange complex. Production of fertilizers from steel manufacturing byproducts such as LD slag, semi-calcined dolomite and ammonium sulfate and their application in agricultural systems, viz. pasture farming, agro-forestry and forestry have been studied. The influence of these materials on the chemical composition of soil, grass and to the potential economic benefits of applying these new fertilizers to the soil were also evaluated [12]. LD slag may be used in refining of steel or iron making due to its high metal value and lime content. Recovery of metal values from LD slag was also carried out by different techniques. The recovery of valuable metals like vanadium and chromium from LD slag, smelting reduction technique was used in a Tamman furnace. The degree of metallization of slag was 98% at 1600^0C at 30 min of time [13]. In order to utilize more LD slag in sinter plant or in blast furnace it is desirable to remove the phosphorus content. Study results through electron probe microscope that phosphorous occurs predominantly in dicalcium phase. Other study has been reported that high gradient magnetic separation studies were able to separate 50% of phosphorus value from LD slag [14]. Several studies have been taken in the laboratory for removal of phosphorous from LD slag. The bacteria namely *Frateuria aurentia*is being used for removal of phosphorus from LD slag. The studies were undertaken at 10% (v/v) inculation. It was possible to remove around 72.17% P from the LD slag [15]. At Tata Steel the two staged crushing facility at the raw materials bedding yard has been found to be adequate to crush it to the desired size i.e. 90% to -3mm for sinter making. After crushing and grinding to suitable size LD slag is used as a Fluxing material in sinter plant. Tata Steel uses up to 50% of LD slag in their sinter plant and Steel Authority of India Ltd. (SAIL) uses up to 36.6%t of the same [8,16].

4. CONCLUSIONS

LD slag is one of the most important wastes generated in integrated steel plants. Due to its engineering qualities these are considered for construction and other fields such as fertilizer for agriculture, soil conditioner for acidity corrector of soil etc. For steel making route, LD slag can be a substitute for lime stone in blast furnace. However, the phosphorus content is quietly high which restricts its use in steel and iron making. It can be reduced by chemical, physical and biological means. Therefore, the reuse and recycling of LD slag on removal of phosphorus seems to be a better approach. The reuse and utilization must be put on a technically and scientific way so as to achieve the sustainable development and maximum benefit to society.

5. ACKNOWLEDGEMENTS

The authors wish to acknowledge to Prof. A.K. Pal, Head of the Environmental Science and Engineering Department and Prof. D.C. Panigrahi, Director, Indian School of Mines, Dhanbad, India.

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