Review on Extraction of Aluminium from Dross

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ABSTRACT

Primary Extraction of aluminium from its ore bauxite leaves unrecovered aluminium in the form of dross. Dross contains 15% - 20% aluminium oxide, 30-35% of Chloride salts of sodium and Potassium 5-7 % of Metallic aluminium and remaining impurities of carbides, nitrates and nitrides. Normally this is regarded as waste and disposed as toxic compounds. Instead dumping as waste metallic aluminium can be recovered from the dross. Aluminium being non-magnetic recovering it from the dross has different processes which includes chemical, Physical and Electrical methods. These methods includes screening, leaching, Electrolysis, Separation techniques like eddy current separation and few advanced techniques like DROSRITE technique. By analyzing these processes and techniques the best effective method is identified for large scale reclamation of the metal.

Key words: Aluminium , Reclamation , Dross, Recovery

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INTRODUCTION

The next industrial revolution is gaining momentum in transformation of linear production to circular production or economy where the used and waste materials will be recycled and reused to produce new products. Aluminium the abundant and cheap metal available in earth is consumed around 50k metric tonnes in a year contribute around 1 percent of global GDP and this consumption is increasing around 0.5% - 1% every year.During production of aluminium from ore around 40% of pure aluminium is carried away in the dross. This dross contains additional elements such as magnesium, Zinc, Tin etc. in it. Pure aluminium can be reclaimed from dross through many processes that involve Chemical, Physical and Electric

methods which are more economical than producing aluminium from its ore bauxite by Bayer process or Hall-Heroult process. Recovering this metal from dross can used to meet the increase in the demand for the metal. By reclaiming aluminium from the dross industries can improve the production of aluminium with the dross they have, so that cost incurred in purchasing virgin metal to meet up the production quantity will be decreased.

Aluminium dross falls into two major categories they are Black dross and white dross. White dross is formed during primary smelting of aluminium ore which contains about 20%-70% of recoverable Aluminium. Black dross is formed during secondary recycling process which contains about 12% - 18% of recoverable aluminium.

METAL RECOVERY FROM DROSS

Dross is recovered from hot melt by skimming, from which dross of different grade such as Liquid aluminium [100%], Flat cake and crumbs [90%-70%], Concentrate [70-50%], Coarse residue [50-20%], Fine Residue [20-5%] is separated by various process which include Mechanical agitation [Pressing, Shaking, Stirring, Centrifuging], crushing ,Sorting, Sieving etc.

Extraction by Screening

The dross is crushed into finer particles for the screening process. The water dissolved with sodium and potassium chloride helps to liberate the metallic aluminium. The salt cakes which are not in finer shapes are again crushed. Then they are passed into a tube mill where the metallic aluminium is screened, the other substituents present are crushed into finer particles as they are being brittle than the aluminium. Then the resultant product is fed into the Dutch State Mines [DSM], where it is wet screened and then the aluminium is dried.

Extraction by Floatation

The metallic aluminium will get activated and they float readily when copper sulphate is added to the xanthate type collectors. It is well suited for the recovery of the aluminium particles size range from 100-275 µm [05].

Extraction By Electostatic Separation

The aluminium recovery from dross is very effective by this process. The dross is first crushed to a size of 840 µm. The processes involved in the electrostatic separation are well explained by Mah et al [1986]. This method achieves the 70% recovery of the aluminium from the dross. [05]

Recycling by smelting process

By smelting process aluminium is recycled in the presence of chloride based salt slag in a reverberatory furnace. This chloride slag serves two functions: 1) prevents formation of oxides of aluminium. 2) It breaks down the prior formed layers of aluminium oxide thus promoting easy separation of aluminium from the residues. [09]

The dross formed in primary and secondary aluminium smelting process is initially pulverized into coarse powder and it's screened with 10-20 mesh screens, which filters about 60% - 70% of aluminium and the remaining coarse material is landfilled or it's used for other purposes like back filling mine grout, Light weight masonry and as foamed concrete.

Inspite of landfilling these residues which are screened by above step they can be pulverized again into small powders and screened to filter some aluminium and the remaining aluminium can be separated by eddy current method as aluminium has separability ratio of 13.0 which increases the recovery of aluminium about 10%.

Recovering Alumina from Dross by fusion process

Alumina can be recovered form aluminium dross by fusing it with NaOH solution. This is carried out by Leaching process. Sultana et al has conducted an experiment which shows 72% of Al_2O_3 [11]. This is fused with 1:2-4 Ratio [Weight basis] of aluminium dross to NaOH solution at room temperature and the temperature is raised to 500-750 ˚C where it is maintained for 60 minutes [5, 6, 12]. The amount of alumina precipitated is determined by EDTA method. He found that maximum precipitation occurs at a weight ratio of 1:3.5 of Aluminium dross to NaOH solution which is shown in figure 1. The optimum temperature for the fusion is determined by maintaining the temperature of 750◦C and conducting the experiment for 1 hour.
From the alumina formed aluminium can be recovered by energy efficient process which uses electrolytic method where alumina is heated using carbon electrodes. During this process anode is consumed as it reacts with the alumina to form Co_2 which is shown below

$$4Al(OH)_3 + 3C \longrightarrow 4Al + 3Co_2(\uparrow) + 6H_20(\uparrow)$$

The aluminium produced is in liquid form which can be directly used to cast extrusion ingots, sheet ingots or any other ingots based on the further application.

Eddy Current Separation method

In case study done by Dr.EvaggeliaPetavratzi [13] aluminium is recovered from eddy current separation process with 100% purity. The process has series of steps. First step is to Mill down the dross to smaller sizes, then screen the ground of required sizes. Screening is done by Air Separation method. Dross of size less than 1.2mm and 50% by weight is used for eddy current separation technique. Then the separated dross is screened to get pure aluminium.
J.Y. Hwang et al has carried out eddy current separation method in two circuits from which one has 3/8" Screen and other has ½" screen to filter the crushed dross. In 1/2" Screen white dross with a feed composition of 41.05% Aluminium, was recovered about 74.07% as an average with range of 66.70% to 78.73%. Black dross with a feed composition of 42.44% Aluminium is recovered about an average of 48.61% with a range of40.81% to 58.60%. In 3/8" Screen white dross with a feed composition of 60.27% Aluminium, was recovered about 70.28% with mesh size of 14-20. Black dross with a feed composition of 15.44% Aluminium is recovered about an average of 30.21%. From he concluded that circuit with 3/8" was more efficient than screen size of ½".

Recycling by DROSRITE process

Drosrite is a process where aluminium is recovered from hot aluminium dross. It's a salt free process which does not produce CO_2 and NO_x gases, thus causing no environmental harm. This extraction process from drosrite is carried out in different methods. In conventional method adopted by Jesse brough metals group [JBM International] uses a process which recovers 100% of aluminium from dross.

DROSRITE^{TM} Plus treatment of aluminium dross:

DROSRITE^{TM} is a technique that requires neither flux salts nor external energy input as the energy is extracted from solid residue and used for next batch. Michel.G et al [02] has explained the drosrite process which is carried in five steps

Step 1: Charging of the Furnace with aluminium dross.
Step 2: Processing the charge in argon atmosphere for roughly 15-30 minutes.
Step 3: Tap hole is opened and the metal is poured out.
Step 4: Controlled amount of oxygen is supplied to heat the furnace such that residues burn to melt aluminium at temperature around 800-900˚C.

Step 5: Finally the remaining residue is discharged and new charge is fed into the furnace.
Further he had an economic analysis of this process and found that it saves the money about $170/ ton.

P.Carabin et al [1] replaced conventional ball-mill-sieving process by drosrite technique which includes charging of hot dross into a rotary furnace immediately after skimmed from the melt. The furnace is sealed and maintained in argon atmosphere. The only heat source for the furnace is controlled reaction of oxygen with unrecoverable metal residue in the dross that is melting those residues in the furnace. By this method a temperature of 1000˚C is produced in the first batch which is used as in put energy for burning residue in the next batch and also it eliminates the requisition of salts for recovering metal. On comparing this Drosrite process with conventional RSF the oxygen required to burn the residues is reduced to greater extent about 1622456 m^3 for RSF to 350,000 m^3 for Drosrite and also aluminium extraction is increased about 45.06% in RSF to 50.08% in Drosrite technique. Thus the process becomes economic and effective.

Recycling by Leaching with H_2SO_4

B.R.Das et al [3, 4] have used leaching method for production of alumina from Aluminium dross. They took dross of size <850µm and dissolved it in H_2SO_4 solution and maintained at 90˚C for three hours followed by analysis of leached liquor by EDTA-$ZnSO_4$ and the leach solution is added with 10% of aqueous ammonium hydroxide to remove iron by precipitating Aluminium hydroxide. This product is treated at temperatures ranging from 200-1100˚C to extract alumina. Since the process of leaching itself an exothermic process the amount of heat required is less. It is found to be 30% of acid will leach out 88% of Al_2O_3 and 15% of acid shows around 71% recovery.

Extraction of aluminium from Al_2O_3 using AlF_3-$BaCl_2$-NaF salt

Mikito Ueda et al [7] in his paper conducted experiments on extracting aluminium from Al_2O_3 using AlF_3-$BaCl_2$-NaF salt. A molten salt of 51 mol% NaF, 33 mol% of AlF_3 and16 mol% of $BaCl_2$ was used in electrolysis of alumina. 250g of salt melted at 1073K in a high purity ceramic tube of 42mm diameter and 4g of Al_2O_3 from alloy A356.0 was added to it. This mixture is then subjected to electrolysis. It is found that the stirring the molten mixture for 300s. After 900s for stagnation of 99.2% of aluminium alloy is floated from 120g. By electrolysis at 1.5A for 12h, 4.8g of metallic aluminium was produced from 20.8g of oxide particles in the dross.

CONCLUSIONS

By combining the above mentioned process aluminium can be extracted to an optimum quantity by using a sieve of 3/8” to screen followed by fusion with 1:2-4 ratio of NaOH solution and treating this mixture at a temperature of 750˚C for 1 hour.

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