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Recovery of Aluminum from Its Oxide Using Low Cost Fluxes

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--***ABSTRACT***--
In this research recovery of aluminum from its oxide (slag) was carried out. Fluxing agents Kcl and Nacl with little Zncl2 were added to lower the melting point of the slag and to speed up the reaction. Clean aluminum was weighed in a digital weighing balance and melted in a crucible furnace (gas fired). After sieving the aluminum slag, coarse aluminum slag with low surface energy was weighed and added to the furnace at intervals. Fluxing agents were then weighed and added into the furnace until the whole mixture is melted. The analysis shows that fluxes work on the surface chemistry by reducing the surface tension and thereby enhancing liberation of the aluminum from the slag. In the first, second, and third experiments 8g, 11g and 9g of aluminum were recovered respectively. The result shows that aluminum can be reused in products after its initial production which is far less expensive and low energy than creating new aluminum Oxide (Al_2O_3) which must first be mined from bauxites and then refined.

KEYWORDS: *Chloride Fluxes, Slag, Clean Aluminum and Recovery.*

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I. INTRODUCTION

Aluminum is an important material in the packaging, and transportation industries. The aluminum industry produces approximately two million tons of waste by-products from domestic aluminum smelting annually. The most significant by-products are called salt cake and dross, and are generated in the melting process.

Hwaug et al (2006) opined that most aluminum bearing scrap is recycled through smelting process. Although the details of the smelting process differ between various installations, most involve melting the scrap in the presence of chloride-based salts, generally using either a reverberatory or rotary furnace. This slag is typically a eutectic or near-eutectic mixture of sodium and potassium chloride containing low level fluorides (cryolite) or other additives. It serves two primary functions. First, since the material is molten and fairly fluid at typically aluminum smelting temperature, the slag coats the metallic aluminum being melted and minimizing oxidation losses during processing. Second, the presence of the fluorides and other additives assists in breaking down prior surface oxide layers on the aluminum charge and promotes improved separation between the aluminum and the residual nonmetallic in the charge.

The aluminum-bearing scrap for recycle may be either reclaimed metallic aluminum products (e.g. castings or used beverage containers) or metal-bearing aluminum oxide drosses skimmed from primary aluminum melting furnaces. Drosses obtained from primary melting operations so called white drosses consist primarily of aluminum oxide (with some oxide of other alloying elements such as magnesium and silicon) and may contain 15 to 70% recoverable metallic aluminum. Drosses from secondary smelting operations so-called "black drosses") typically contain a mixture of aluminum /alloy oxides and slag, and frequently show recoverable aluminum contents ranging from 12 to 18%. The non metallic byproduct residue, which results from such dross smelting operations is frequents from such dross smelting operations is frequently termed "salt cake" and contains 3 to 5% residual metallic aluminum. It is normally disposed of as landfill (Hwang et al, 2006).

Recycled aluminum would be processed utilizing automatic sorting, shedding and separation technology to facilitate its reuse in new products. Secondary aluminum is also known as recycling aluminum. Recycling of aluminum is extremely important due to several economic and environmental reasons. Compared with production of primary aluminum, recycling of aluminum products needs as little as 5% of the energy and emits only 5% of the greenhouse gas (Tsakiridis, 2012).

In 1990 total aluminum production was around 28 million tones (with over 8 million tones recycled from scrap) and in 2010 the total was close to 56 million tones (with close to 18 million tones recycled from scrap). By 2020 metal demand is projected to have increase to around 97 million tones (with around 31 million tones recycled from scrap).

Finally, parallel to the existing situation with beverage cans, there would be a number of high-value applications into which the recycled metal would flow, meeting the required specification limits and performance requirements for these applications (subodh K, 2006).

II. METHODOLOGY

The dross was sieved to separate the coarse dross from the fine dross. The tray was weighed and its weight was recorded in grams. The actual weight of the fine and coarse dross were weighed and recorded respectively. A known weight of clean aluminum was poured in a crucible furnace, until it melted. The coarse dross was poured on the molten aluminum and, Known weights of fluxes mixed in proper ratio, were poured into the furnace at intervals. After some times the waste floats on the liquid melt and was skimmed off and aluminum was recovered. Coarse dross was used in this research for economic reasons because it consumers less energy. Fluxes lower surface tension, lower the melting point of the slag and reduce cost. This experiment was repeated two more times to get more results.

Table 1.1 Table of Results

MATERIALS	WEIGHTS(G)		
	1st Exp.	2ndExp	3rd Exp
Tray	133	133	133
Tray + coarse dross	361	334	307
(tray + coarse dross) – tray	228	201	174
Coarse dross	228	201	174
Tray + clean aluminum	401	406	413
Tray + clean aluminum) – Tray	268	273	280
Clean Aluminum	268	273	280
The calculate the amount of flux, we assume 10% of clean aluminum	10/100x268 = 27 27	10/100x273 = 27.3	10/100x280 = 28
Melting temperature			
Kcl – 776^0C			
Nacl – 801^0C			
Since Nacl has the highest melting temperature compared to Kcl, therefore less Nacl flux is required			
Kcl = 60% of flux	60/100x27=16.2 16.2+133= 149.2	60/100x27.3 = 16.4	60/100x28=16.8 16.8+133 = 149.8
Nacl = 40% of fux	40/100x27/1 = 10.8 10.8+133 = 143.8	40/100x27.3 = 10.9	40/100x28 = 11.2 11.2+133=144.2
Total flux used	27	27.3	28
Actual fluxes used =)original flux remaining fluxes)			
Remaining fluxes + Tray	148	148.3	161
Actual fluxes used = 27 – 15=12	12	12	12
Therefore fluxes used	12	12	12
Percentage of fluxes x 100/1 Clean aluminum	12/268x100/1 = 4.5	12/273x100/ 1 = 4.4%	12/280x100/1 = 4.3%
	4.5%	4.4%	4.3%
To obtain the actual aluminum recovered we find the difference .			
Recovered aluminum Tray	409	417	422
(recovered aluminum + Tray)	276	284	289
Recovered aluminum	276	284	289
Actual aluminum recorded from dross = (total weight of aluminum recorded – weight of clean aluminum)	276-268 8	284-273 11	289-280 = 9g 9
Aluminum recorded	8	11	9

III. RESULTS AND DISCUSIONS

It is observed that aluminum recovery from scraps involves crusing, sizing and melting the metal from the scrap in furnace under a salt flux protection. The salt fluxes absorb the oxides and contaminates from the scrap and protect the aluminum melt from oxidation. It consist mainly NaCl, and KCl , and some additional $ZnCl_2$. After melting, aluminum metal and salt slag are tapped from the furnace. Depending on the scrap type, large amount of salt slag are generated, which contain mainly oxides, nitrides, chlorides and some residual aluminum metal or alloys. Due to the high consumption of the salt flux and thus high generation of salt slag, it has to cleaned and recycled. The salt slags are treated in a series of steps: separation of the entrapped aluminum metal; leaching and filtering to separate the soluble salts and the residual; crystallizing to regenerate the salt fluxes;

The results in table 1.1, it can be deduced from this research that the amount of aluminum oxide increases with the quantity of aluminum recovered. It was also observed that the amount of clean aluminum increase with aluminum recovered. It can be established that fluxes work on the surface chemistry and reduces surface tension thereby enhancing the liberation of aluminum.

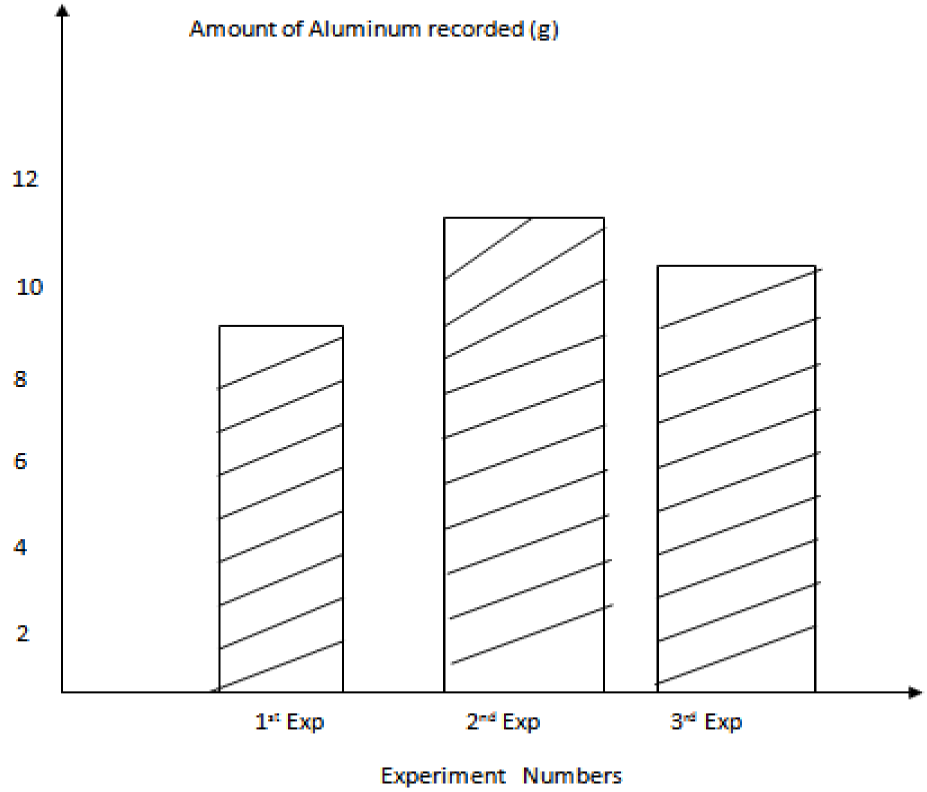

Fig1.1 Amount of Al recovered against numbers of experiments

IV. CONCLUSION

The recovery of aluminum from the dross has been intensively discussed in this paper. Observations showed that smelting of aluminum scrap with chloride fluxes increases aluminum metal recovery. Therefore, the result recommends recycling of aluminum metal because smelting requires about 5% of the energy compared with using bauxides ore process. Adoption of this process will help to save our environment litered aluminum scraps.

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