Recycling Of Aluminum from Aluminum Cans

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Summary: High purity salt flux composition and additive composition, which is used in the melting of scrap aluminum such as found in used beverage containers, have been optimized in this investigation.

Results indicated that the use of temperatures from 450 to 950C and flux amount of at least 5 wt.% lead to good recovery of aluminum after the recycling of cans. Utilization of chlorides and fluorides in excess result in formation of craters and dendrites in the recovered metal, which denote that the magnesium and aluminum oxides in the form of drosses, a heterogeneous system, accumulate in these craters. A visual examination of the images shows visible holes which provide continuous channels to the internal surfaces of the metal to the atmosphere. It is observed that the oxidation of the internal surfaces and channels result into huge amount of drosses. The molten chlorides and fluorides in excess corrode this structure and break the oxide links, subsequently liberating the pure aluminum.

Key Words: Aluminum cans, Salt flux, Temperature, Dendrites, Drosses, Powder aluminum.

Introduction

Recycling of aluminum is extremely important due to several economic and environmental reasons. Aluminum is a vital material in the construction, packaging, and transportation industries. Structural components made from aluminum and its alloys are vital to the aerospace industry. The most significant byproducts of aluminum industry are called dross and salt cake and are generated in the smelting process. Typically 15 – 25 kg of dross is produced per metric ton of molten aluminum [1].

Drosses acquired from primary smelting operations (white drosses) consist predominantly of aluminum oxide and may contain upto 70 % of recoverable metallic aluminum. Drosses from secondary smelting operations (black drosses) may contain aluminum and alloy oxides and slag. The black drosses most often show recoverable aluminum ranging from 12 to 18 %. The nonmetallic residue which results from such dross smelting operations is termed salt cake and is disposed of in a landfill [2].

The production of one metric ton of aluminum from bauxite requires about 17000KWh of electricity while the same amount of recycled aluminum consumes approximately 750 KWh which substitutes primary aluminum with a gain of 95 % energy [3]. Aluminum powder is used exclusively as a fuel in the reusable solid rocket motors.

The mass of a single aluminum can is nearly 14 g, but a huge number of such cans are produced each year, using a large amount of the metal. Since large amounts of electrical energy are required to produce virgin aluminum, recycling the metal or converting it into other useful materials is desirable, both environmentally and economically.

Many investigators have addressed several aspects of the recycling process of aluminum cans and drosses [4-6]. Some of the authors have studied the explosion and ignition characteristics of aluminum powder [7-9]. A variety of methods are available for production of aluminum powders and metallic aluminum from the melt but the most significant volumes of fine powders and metallic are prepared by using the high purity salt flux composition during the aluminum recovery process to improve coalescence of the molten aluminum. The present process is a concise attempt which is relevant to the subject area. This investigation explains a simple route to recycle aluminum from aluminum cans. The aim of the assessment is to provide a composition and the method of using that composition in the recycling process. Various instrumental techniques have been employed to support the experimental findings.

Results and Discussion

Metallic aluminum recovered from different cans is given in Table–1and 2. With the use of NaF flux appreciable aluminum is recovered at low temperature. The SEM images (Fig. 1–3) of the recovered metallic aluminum from pepsi cola cans are smooth and do not show any traces of dendrites or drosses. The internal dispersion of aluminum particles in these images shows that the recovered aluminum is ignitable on composite solid propellants. Similarly, the photo images (Fig. 6 and 7) for pepsi cola and coca cola cans do not show any noticeable indentation.

Table-1: Flux composition in wt. % for recycling of aluminum scraps.

Aluminum Cans	Scraps (g)	Purity of Aluminum Cans			Flux Composition						
		% Al	% Mg^{2+}	%Other Impurities	% KCl	% NaCl	% Na_2CO_3	% Na_3AlF_6	% NaF	Temp C^0	% Al (Recov.)
Pepsi cola	20	95	4	1	30	70	20	20	-	800	96. 37%
Coca cola	28. 07	95	4	1	70	30	5	5	5	450	98.72

Table-2: Flux composition in wt. % and formation of craters.

Aluminum Cans	Scraps (g)	Purity of Aluminum Cans			Flux Composition				Temp. C^0	% Al (Recov.)
		% Al	% Mg^{2+}	% Other Impurities	% AlF_3	% CaF_2	% $Bacl_2$	% Na_3AlF_6		
Orange merinda	25.27	95	4	1	42. 34	38. 38	24. 45	9. 89	950	81. 22

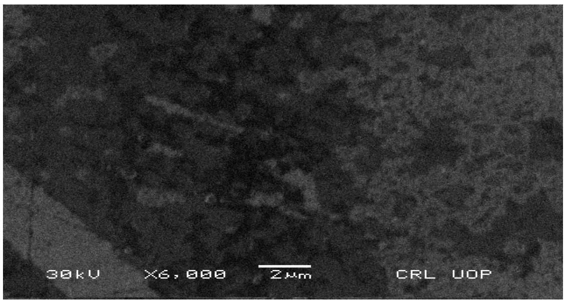

Fig. 1: SEM image for metallic aluminum recovered from pepsi cola can. The internal dispersion of aluminum particles showing ignitable on composite solid propellants.

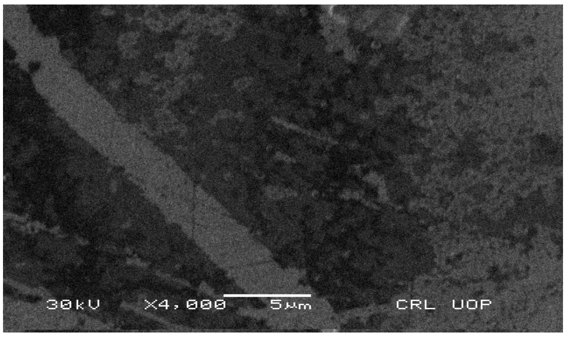

Fig. 2: SEM image for metallic aluminum recovered from pepsi cola can. Dispersed aluminum particles, ignitable.

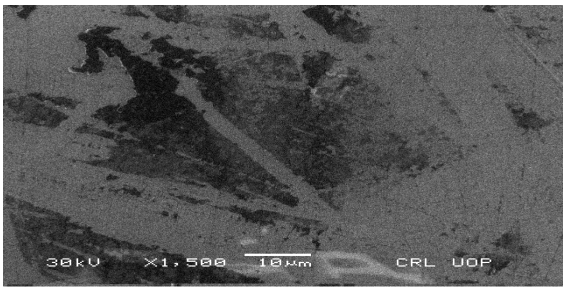

Fig. 3: SEM image for metallic aluminum recovered from pepsi cola can.

For the processing of orange merinda can fluorides and chlorides were employed in excess which resulted in the formation of visible dendrites on the top surface of the recovered aluminum as shown in the photo images (Fig. 4 and 5), although fluxes were melted at high temperature. The flux composition in wt. % is given in Table – 2.

Fig. 4: Photo image of recovered aluminum from orange merinda can showing visible craters

Fig. 5: Photo image of recovered aluminum from orange merinda can denoting visible holes and dendrites.

Results indicated that the use of temperatures from 450 to 950C and flux amount of at least 5 wt.% lead to good recovery of aluminum after the recycling of cans. Utilization of chlorides and fluorides in excess result in formation of craters and dendrites which denote that the magnesium and aluminum oxides in the form of drosses, a heterogeneous system, accumulate in these craters. It is observed from SEM images (Fig. 1 and 2) that metallic aluminum is ignitable. A visual look of the photo images (Fig. 4 and 5) show visible holes which provide continuous channels to the internal surfaces of the metal to the atmosphere. It is the oxidation of the internal surfaces and channels that result into huge amount of drosses. The molten chlorides and fluorides in excess corrode this structure and break the oxide links, subsequently liberating the pure aluminum.

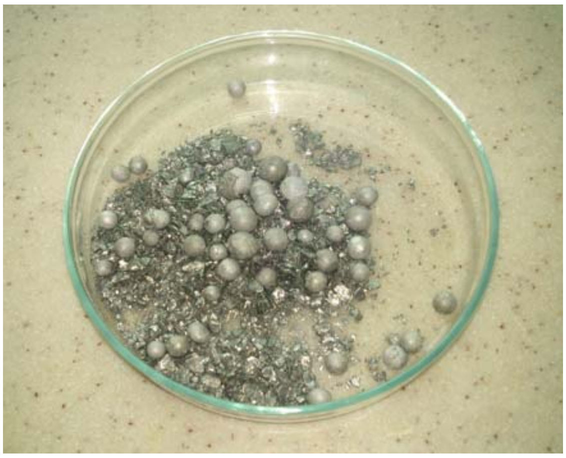

Fig. 6: Photo image of recovered aluminum from pepsi cola can showing smooth surfaces.

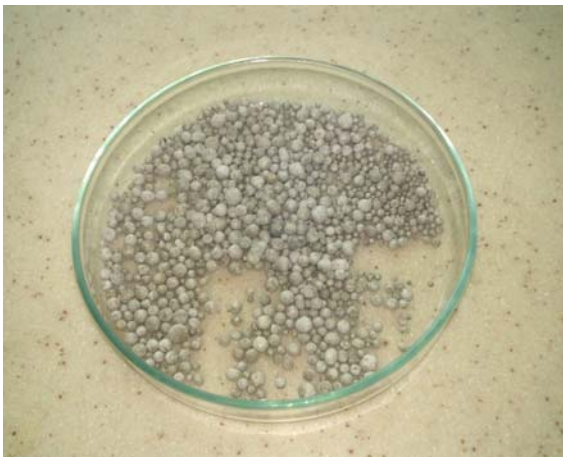

Fig. 7: Photo image of recovered aluminum from coca cola can showing smooth surfaces.

Experimental

Melting Process

Paint from the can was removed by sulphuric acid. The difference in the weight before and after the paint was minimal.

In this process high purity salt flux composition and additive composition have been optimized which are used in the melting of scrap aluminum such as found in used beverage containers. An attempt has been made to prevent an oxide film tends to form on the surface of the molten aluminum droplets during the melting process, The oxide film, if formed, impedes fusion of the molten aluminum, causing smaller particles to be lost in the process thereby reducing the amount of aluminum recovered. The unrecoverable aluminum droplets having the oxide film are referred to as dross.

One type of salt flux is predominantly composed of a mixture of high purity sodium chloride and potassium chloride. The high purity salts used in such processes are solution mined. The main objective of this work is to provide a process for improved aluminum recovery in a recycle process which includes scrap aluminum and salt flux.

For the recycling of pepsi cola can in addition to high purity salts (NaCl and KCl), Na_2CO_3 and cryolite (Na_3 AlF_6) were also added which are effective for improving fusion and reducing aluminum loss in the recovery of aluminum from molten scrap aluminum.

The flux composition was optimized in a way that for instance for each 14 g scraps 280 g flux composition as a whole was required while percentage of each flux was calculated as percent of the whole flux composition. Thus for 20 g scraps of pepsi cola can the flux composition comprises of 30 % NaCl (120 g), 70 % KCl (280 g) 5 % Na_2CO_3 (20 g) and 5 % Na_3 AlF_6 (20 g). Different flux compositions for different cans were melted at the required temperatures. The flux composition was optimized in a large amount so that the shredded aluminum remains dipped in the molten flux. The flux composition was taken in a graphite crucible and was allowed to melt at a requisite temperature. Natural gas was used as a source of heat. The scrap and shredded aluminum were added to the molten mass and was kept at constant temperature for one hour. The crucible then was cooled to room temperature. Water soluble material was removed by dissolving in water. The purity of aluminum can was determined from which the percent recovery of pure metallic aluminum was calculated.

Conclusion

Results indicated that at elevated temperature and even a nominal composition of flux amount lead to good recovery of aluminum after the recycling of cans. The molten chlorides and fluorides in excess place emphasize on the structure of dendrites in metallic aluminum where drosses (Al_2O_3 and MgO) are embedded. The molten salts corrode this structure and break the oxide links, subsequently liberating the pure aluminum.

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