Development of Aluminum-Dross Based Materials for Engineering Applications: *Reduce land filling and energy usage to recover Al*

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Aluminum Dross is a by-product of Aluminum production. Today much energy is consumed to recover the Al from the dross; this is energy that could be saved if the dross could be diverted and utilized as an engineering material. There are two forms of dross – white dross and black dross. White dross is formed during the primary Al refining process, while black dross is formed during the secondary refining process, which uses relatively large amounts of Chloride salt fluxes. Subsequently, the dross is processed in rotary kilns to recover the Al, and the resultant salt cake is sent to landfills; although it is sealed to prevent from leaching, the potential for leaching exists and may harm the environment. There is much merit if the dross that is formed could be "recycled" as an engineering product for specific applications. Interestingly the main constituents of dross are Al and Al_2O_3 as well as MgO and $MgAl_2O_4$; this is ironic since there is much effort today to produce Al based composites containing second phase constituents (such as Al_2O_3).

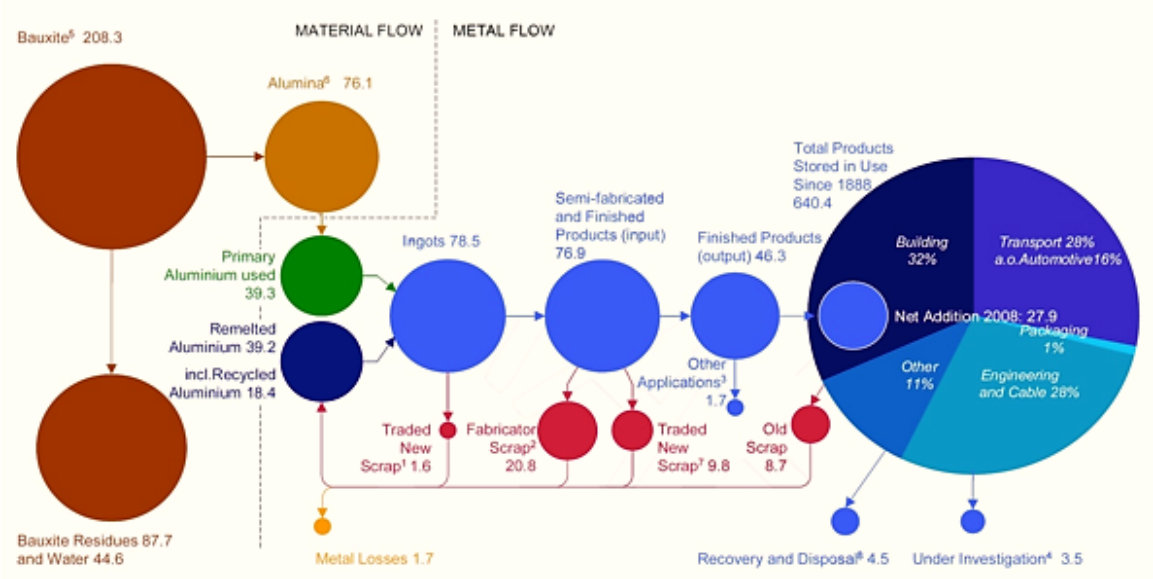

Figure 1: Mass flow in aluminum industry

As seen in Figure 1, the traded new scrap is 1.6 million tons. This represents the weight of metal in skimming, however, the dross weight would be approximately 2 times this amount, that is ~3.2 million tons. This is a considerable volume of metal and further emphasizes the need for channeling the dross towards useful life for appropriate engineering applications. The mass flow chart given gives a good overview of the material flow for Al production. The data is that for 2008. As Al production increases, the number for metal losses and dross will increase as well … further exacerbating the problem. The economic impact for "recycling" Al dross is huge as it mitigates metal losses, alleviates the use of salts, and eliminates the need to landfill salt cakes.

What do we do with such a large volume of dross that is produced on an annual basis? Some of the Al is recovered, however considerable effort and energy goes into doing so.

Some of it ends in landfills, and this is of great concern as leaching may occur since dross contains salts. The potential for pollution to the environment is a real one, and an issue that needs to be alleviated or mitigated.

The focus of the project was to find engineering applications for aluminum dross; the objective of this project was to channel the dross into other sectors of the market. Specifically, we considered viable industrial applications that can benefit from the constituents of dross - Al and Al_2O_3 as well as MgO and $MgAl_2O_4$. The project required "out of the box" thinking and to find pathways for recycling the dross, or upgrading of the dross, if you will.

We have investigated three avenues:

1. ***Use dross to make Al composites.*** We have found that dross powders are well dispersed in aluminum alloy matrix via friction stir processing; the product provides superior wear resistance with some sacrifice in strength. This certainly is a viable use of Al dross.

2. ***Use dross as a high temperature additive for de-sulphurizing steel slag.*** The dross could be used as an additive to the slag to modify the chemistry. However, for this application, only primary dross can be considered, because we need to alleviate fluorides in the dross. This also aligns with an ongoing project at K.U. Leuven in Belgium.

3. ***Use dross to make refractory materials*** such as brick, or used in concrete as filler. We have found that dross particles can be mixed well with cement. This improves stiffness, abrasion resistance, and controlling micro-cracking of the material. Work in this area became the main focus of the project.

Concrete material was investigated for the sake of channeling aluminum dross material towards certain applications. Two kinds of aluminum dross were tested as a replacement raw material in refractories. The results showed that dross can be applied either though a simple conditioning process or directly as a substitute for fine structural components in refractories. The process involved treating the dross in boiling water followed with a filtration step; the influence on the resultant product is remarkable. A series of experiments were carried out in order to investigate the properties of dross with different types, fractions, and sizes. Although pores and defects could be generated from gas releasing reactions, the properties are quite acceptable. Mechanical property evaluations revealed the possibility for dross waste to be utilized as an active aggregate in concrete, resulting in up to 40% higher flexural strength and 15% higher compressive strength compared to pure cement. Even though the fraction of Al dross waste that can be added to refractories is small (~10%), both the waste body and the potential market for reusing Al dross are huge.