Investigation and Study of Recycling in Aluminium with Decrement of Ferrous Element

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***Abstract*—**Nowadays, aluminium is widely used in all sectors. It has the properties like ductility, corrosiveness, machinability and recyclability which cause tons of production in food, automobiles and aerospace sectors. The recycle of aluminium has the ferrous contents of 0.25 to 0.5% which cause major defects in core of the aluminium which cause low elastic modulus. So, papers were researched for reducing the ferrous content in aluminium by processes like chemical process, electrolysis process, ultra-sonic process, magnetic separation process, super gravity segregation process, filter process and heat treatments. As the ferrous content of the recycled aluminium increases pure Aluminium present in it reduces. This paper states that behaviour of Aluminium alloys with various elements like Cu of 0.1%, Mg of 0.2-0.6%, Si of 6.5 – 7.5%, Fe of 0.5%, Mn of 0.3%, Ni of 0.1%, Zn of 0.1%, Pb of 0.1%, Sn of 0.05%, Ti of 0.2 and remaining aluminium. The studies and researches of various ferrous reduction techniques in aluminium are discussed in this paper.

***Keywords*—**Casting; Chemical Analysis; Ferrous Element; Filtering; Melting.

***Abbreviations*—**Scanning Electron Microscopy (SEM).

I. INTRODUCTION

ALUMINIUM is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Far from being rare, Aluminium is in fact the third most common element in the Earth's crust, and it is the most common metallic element on Earth. In the pure form, Aluminium is silvery white and extremely lightweight. Because of its light weight and relatively strong structure it can be made into very thin wires which can then be re-enforced by steel and iron made into power lines [Gorelik et al., 1].

Because of the wide availability of Aluminium, it is not expensive and thus, is commonly used. One of the most common end uses of Aluminium is packaging, including drink cans, foil wrapping, bottle tops and foil containers. Hence, aluminium has got many uses which make it a very commonly used metal.

II. METHODOLOGY

Three assay series were performed. The first series corresponded to an experimental alloy (E series) and in the others the materials studied were based on 356 and 308 alloys made from aluminum-silicon and aluminum-copper-silicon system, respectively. The materials prepared are tabulated below and they are used for the experiments [Ji et al., 3].

Table 1: Alloy Composition

ALLOY	Si	Fe	Cu	Mn
E15F3M	0.25	1.45	1.00	0.30
E5F7M	0.25	1.45	1.00	0.75
E12S15F15M	12.0	1.50	1.00	1.00
E95S15F15M	9.50	1.50	2.50	1.50
E95S10F15M	9.50	1.00	3.00	1.50
308IF	9550	1.00	3.35	0.14
3082F3M	5.50	2.00	3.70	0.30
3081F7M	5.50	1.00	3.10	0.70
356IF	7.00	1.00	0.00	0.0095
356IF6M	7.00	1.00	0.00	0.60

2.1. Melting and Filtering

Alloy preparation was performed by melting the aluminum, then adding the alloy elements. Standard grade aluminum was used, while electrolytic copper and manganese, metallurgical grade silicon were used and low carbon steel was used as iron source. The total weight of the charge in all tests was 2.5 kg.

The melting of the metal was carried out at 850^0C. The system was held for a 2-hours interval following the stabilization of the temperature. The crucible was made of graphite with a diameter of 150 mm and 200 mm. the capacity of the crucible was 3 Kg [Podprocká et al., 4].

2.2. Preparation of the Filter

The filter used is a ceramic filter, and it is heated in another furnace at 750^0C. The amount of time is not clearly provided. The filter is then laid on the top of the graphite crucible. The filter prepared was kept at a fixed height for all experiments. The ceramic filter had a bore diameter of nearly 1mm on an average. 20 to 30 pores per inch is another specification that the filter has to possess.

2.3. Cooling and Casting

The material which is being melted in the bath had to be cooled so that it would match the temperature of the filter, cooling was also performed to improve the mechanical properties. The cooling rate provided was 4.4^0 C/min. At the filtering temperature, the bath was held for a period of 30 minutes. Subsequently, the molten metal was cast into the pre-heated filter. The bath temperatures were measured by a chromel-alumel thermocouple [Chen et al., 5].

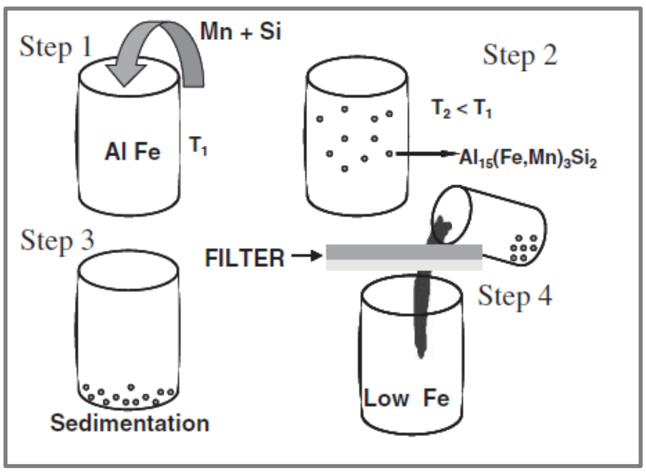

Figure 1: Filtration Process

2.4. Sample Preparation for Chemical Analysis

The contents of iron, manganese, and copper were analyzed before and after the filtering step by using atomic absorption spectrophotometry in all experiments. Before the filtering step, molten metal samples for analysis were collected with a stainless steel spoon. The metal was cast in a steel mold and each sample weighed 20 to 25 g.

2.5. Metallography

The materials were collected for analysis after the casting and filtering steps. The analysis was done by metallography. The observation was done under optical microscope in order to perform identification of present phases.

The various materials obtained include:

- Filtered material
- Filter material with retained material
- Sediments from the crucible

2.6. Scanning Electron Microscopy (SEM)

The aim of the step was to identify the intermediate phases that remained in the sediment at the bottom of the crucible and the phases presented in the filtered metal. Preparation of material samples was done by polishing and etching, so that the structure can be examined using optical metallurgical microscope [Sun et al., 6].

Figure 2: Optical Microscope

III. Results

The results obtained in the filtering process of aluminum alloys will be presented and discussed in this chapter. The procedure can be divided in two steps. In the first step, Eseries, additions of silicon, manganese, and copper were performed. The effects of the same parameters were studied for two commercial alloys from these results

Table 2: Fe Reduction Result [de Moraes et al., 2]

Alloy	Filter	Temp (°c)	Initial Fe	Final Fe	Removal of Fe
356IF	20	645	1.00	0.91	9
356IF6M	20	640	1.12	0.37	67
3082F	20	635	2.18	1.09	50
3081F	20	625	0.83	0.45	46
3081IF7M	20	618	1.00	0.21	79

The above table shows the values of how iron reduction has been achieved for different composition of materials. The microstructure of the material is also obtained by the XRD Tests [Samuel, 7].

All the experiments in which the content of iron was reduced by the filtering process coincided with dross forming at the bottom of the crucible. The amount of this dross is linearly proportional to the yield of the filtering process. Thus, part of the material precipitated from the liquid phase, at the filtering temperature, segregates to the lower regions of the crucible. Hence, the filtering process generated three samples: first, the filtered metal; second, the material retained in the filter and third, the material sedimented at the bottom of the crucible. The amount of low-iron aluminum recovered after the filtering process depends on the initial iron concentration. For an alloy with 1% initial iron, the amount of refined aluminum recovered is about 80–85%. Hence, 15 to 20% of the initial aluminum mass is lost in the sedimented dross and in the filter [Al Mehedi, 8].

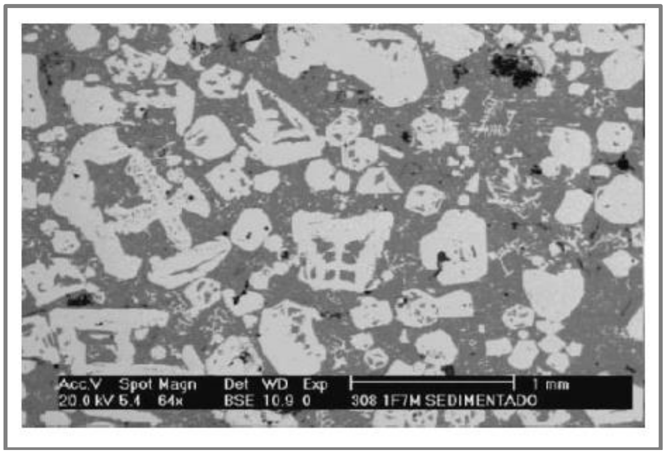

Figure 3: Material Sedimented at the Bottom of the Crucible [de Moraes et al., 2]

Microstructural aspect of the material sedimented and retained at the bottom of the crucible is shown in the figure above. This type of microstructure was observed in all samples. Thus, the crystallization of a primary faceted intermediate phase occurs in the liquid during the cooling, due to the addition of manganese.

IV. Filtered Material

The microstructure of the filtered material from the3081F7M alloy is indicated. The presence of primary aluminum dendrites and interdendritic eutectic constituent can be observed [Miller et al., 9].

4.1. Material Retained inside the Filter

The pores of the filter were effectively sealed by the particles of the intermediate phase, preventing the passage of aluminum. In regions unobstructed by intermediate phase particles, the filter is very clean. Below the borderline the material has a structure similar to the filtered material. Thus, the intermediate phases are effectively imprisoned with dimensions similar in size to the pores of the filter.

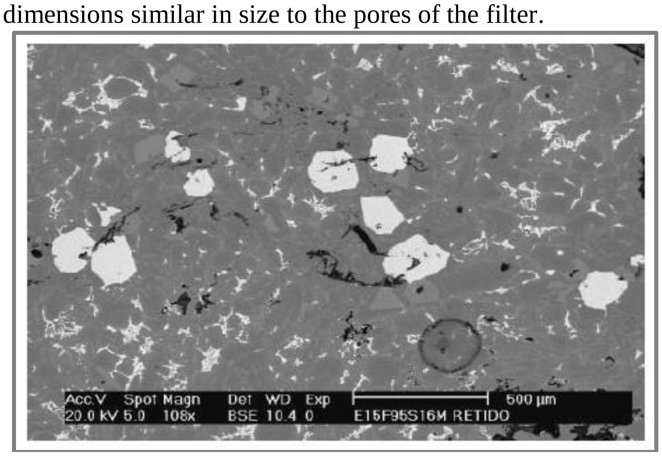

Figure 4: Material Retained inside the Filter [de Moraes et al., 2]

4.2. Identified Gaps in Papers

- The amount of manganese used to reduce the ferrous content in the aluminium alloy has not been mentioned by de moraes, et al., [de Moraes et al., 2]
- The side effects of this treatment used to reduce the ferrous content is also not mentioned.
- The type of furnace that is used in this process was not discussed in the paper [Mashhadi et al., 10].

V. Conclusion and Scope for Future Work

The recycling of aluminium scrap results the increase of ferrous and copper element which increases the ductile and corrosiveness in aluminium. The other elements like Si, Mg, Ni, Pb, Ti and Zn decreases. Hence, this result causes major defects and property changes in aluminium. The result of recycling of aluminium scrap with filtration method gives the decrement of ferrous element and increases the durability and other properties.

The process which has been performed for the Al-Si alloys can be done for the aluminium alloy LM-25 and similar tests can be conducted and the effects of the filtering of Iron can be studied in it.

de Moraes et al., [2] had found that the presence of manganese followed by the reduction of the temperature until the crystallization field of the primary phases containing iron could help to minimize the iron content .

It is evident that the occurs in two steps:

- A sedimentation
- Filtering step.

Studies could be made on the side effects that are caused due to this ferrous reduction process.

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