APPLICATION OF FRACTIONAL CRYSTLLIZATION FOR REFINING OF MOLTEN ALUMINIUM SCRAP

Takayuki Sotome and Mitsuhiro Ohtaki

The Furukawa electric co.,ltd, Metal Research Center,
500 Kiyotaki. Nikko-city, Tochigi, Japan

ABSTRACT

To promote aluminum scrap recycling, possibility of application of fractional crystallization for possibility of refining metallic impurities as silicon and iron from molten aluminum alloy and scrap such as sash, radiator and cars was investigated. Refining characteristics was evaluated both by yield rate and impurity removal efficiency. In the 8kg/charge experiment, the influence of basic experimental factors as pressure and alloy composition on the refining characteristics was investigated. Increase of pressure gives high silicon removal ratio on Al-Si binary alloy. On practical scrap, removal of silicon, copper, and iron was possible. Refining efficiency of sash and radiator scrap was better than that of car scrap. The removal efficiency is lowered by intermetallic compounds crystallizing in the solid-liquid co-existing zone.

Keywords: *aluminum scrap, fractional crystallization, Si-removal, refining, recycling*

1.INTRODUCTION

Recycling is a very effective means in reducing the burden on the global environment and improving the efficient use of energy.

The emphasis should be placed on the establishment of efficient aluminum recycling technology which enables the removal of metal impurities from useless aluminum compounds to produce high quality recycled materials.

In this study, fractional crystallization process using compression and separation is applied for the removal of metallic impurities from molten aluminum scrap by fractional crystallization process. A research target is focused on the removal of silicon and iron, major impurities in aluminum scrap, from molten aluminum alloys.

2.PREVIOUS STUDY

Refining by fractional solidification is based on the phase diagram. When $k<1$, in the solidification process, primary solid crystals having low impurities and liquid having high impurities is co-existing. Refined alloy is produced by separating and collected only the primary crystals. That technique is also commercially applied to produce high purity aluminum alloy. Lux and Flemings [1] have reviewed various separating methods by gravity sedimentation, centrifugal sedimentation, filtration, and filtration with compression. ALI, STUBINA and TOGURI[2] also describe an isothermal compression technique of reheated semi-solid samples with a filter. These methods are small scale reheated process and it takes a lot of times to make uniform temperature distribution in sample.

3.EXPERIMENTAL PROCEDURE

3.1 SAMPLE

Table 1 lists the chemical composition(mass.%) of experimental material.

Table1 The chemical composition(mass.%) of experimental material

	Si	Mn	Fe	Cu	Zn	Mg	Al
Al-Si binary alloy	3.0	–	–	–	–	–	bal.
Radiator scrap	1.0	1.0	0.6	0.2	0.8	–	bal.
Car scrap	7.8	0.4	0.9	3.1	0.6	0.4	bal.
Dirty sash scrap	0.7	–	0.8	0.4	0.8	0.2	bal.

3.2 APPARARTUS

A schematic illustration of the apparatus to separate the primary crystals from the semi-solid alloy is shown in Fig1. It consists of two major parts:

(1)vessel to hold and cooled down the material to the liquid-solid co-existing temperature;

(2)plunger to compress and separate the primary crystals from semi-solid materials;

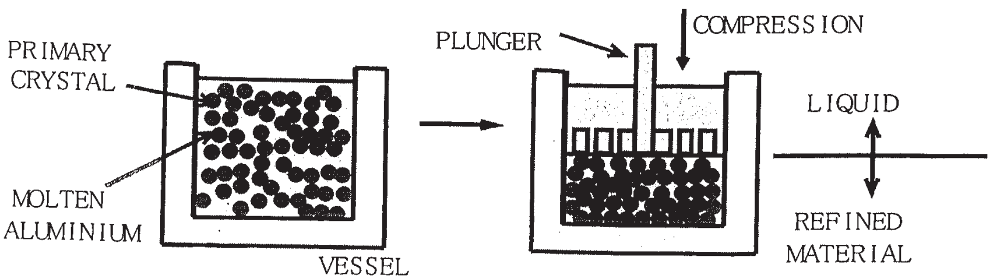

Fig. 1 A schematic illustration of the method

3.3 PROCEDURE

8kg/ch sample alloy heated to 850℃, in the resistance furnace, was poured into the heated vessel. The melt in the vessel was cooled down at cooling rate about 5℃/min to the experimental temperature in solid-liquid co-existing zone. Aluminum primary crystal in the semi-solid materials was separated by the plunger with some holes at several pressure. Weight and composition of refined material was measured.

4.RESULTS

4.1 Al-Si BINARY ALLOY

Fig.2 shows the effects of compression pressure on Si-removal efficiency compressed at the same temperature. Si-removal efficiency increases as the compressing pressure increases.

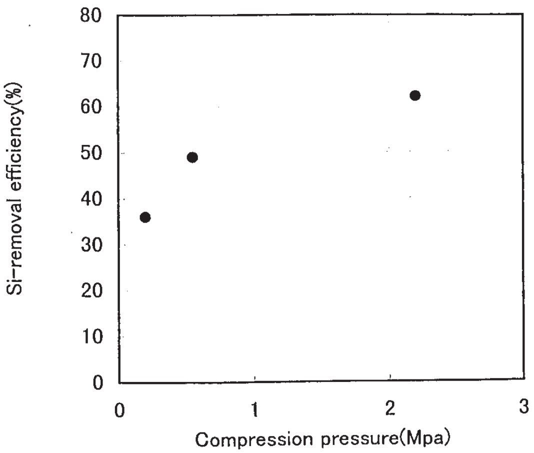

Fig. 2 Si-removal efficiency as function of compression pressure

4.2 RADIATOR SCRAP

Fig.3 shows one of the experimental results of radiator scrap. Si content was reduced from 1.0 to 0.6 mass percent and Fe was reduced from 0.6 to 0.4 mass percent. The presence of Fe and Mn creates intermetallic compounds in the solidification process, and decrease impurity removal efficiency. It was possible to remove Si and Fe from radiator scrap.

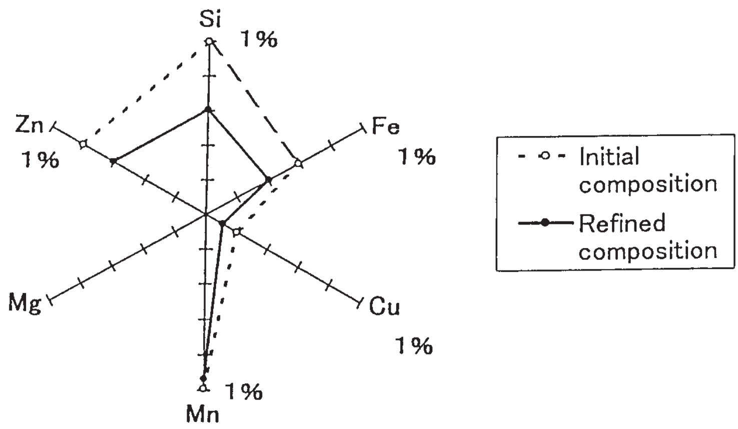

Fig. 3 Refining results (radiator scrap)

4.3 CAR SCRAP

Fig.4 shows one of the experimental results of car scrap. Si was reduced from 7.8 to 2.8 mass percent and Cu, Zn and Mg were also reduced. But Fe and Mn were condensed. In the alloy as car scrap containing high Fe, Mn and Si , Al-Si-Fe-Mn intermetallic compounds(Photo.1) were created in the range of solid-liquid co-existing temperature. They were distributed at random and it was difficult to separate them by this method.

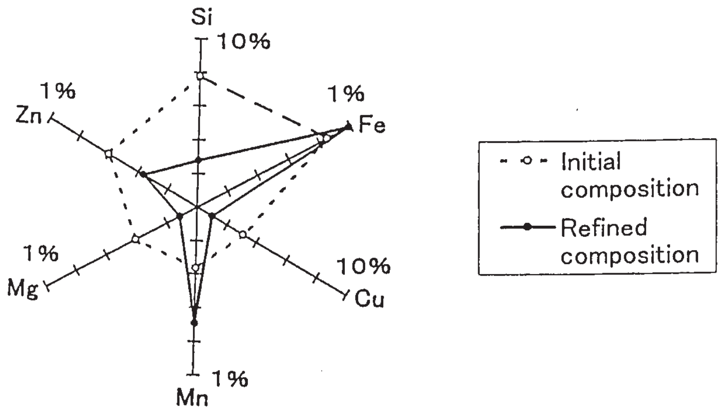

Fig. 4 Refining results (car scrap)

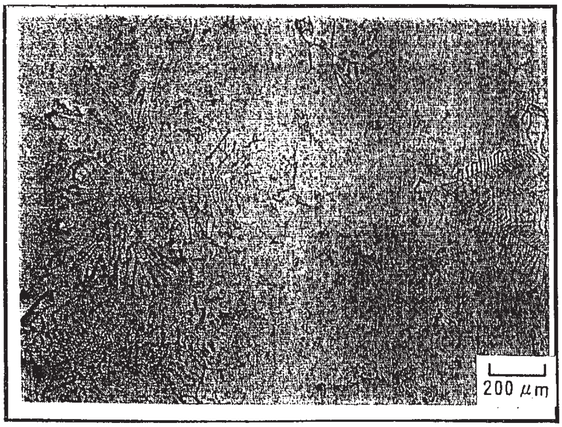

Photo. 1 The microstructure of refined car scrap. No etching.

4.4 DIRTY SASH SCRAP

Fig.5 shows one of the experimental results of sash scrap. Si was reduced from 0.66 to 0.32 and Fe was reduced from 0.76 to 0.28 mass percent and other elements were also reduced. It was possible to remove Si and Fe from dirty sash scrap.

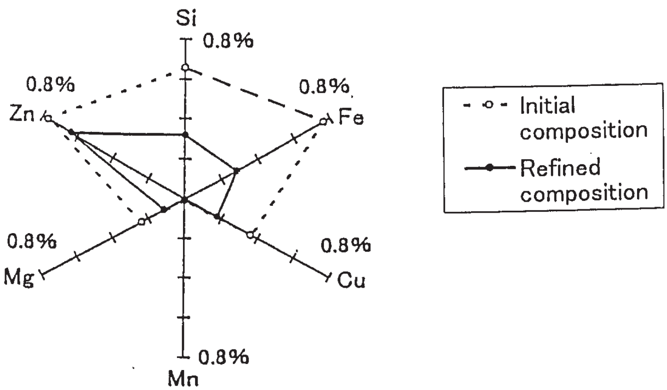

Fig. 5 Refining results (sash scrap)

5.CONCLUSION

New fractional crystallization method by compression pressure in semi-solid materials is proposed and applied to Al-Si binary alloy and several scrap. It is possible to reduce impurities as Si, Fe and Cu in the molten aluminum.

ACKNOWLEDGMENTS

This study is the part of ongoing "research and development of technology to promote recycling of non-ferrous metal materials" by New Energy and industrial technology Development Organization (NEDO).

REFERENCES

1. Lux.A.L and Flemings.M.C; Metall.Trans.B,10B(1979),71-78.
2. ALI.A.T, STUBINA.N.M, and TOGURI.J.M; Conserv.Recycl.,2(1989),87-98.