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Homogenization Process for Aluminum As-Cast from Waste of Beverage Cans

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Abstract. Development an ingot originated from the waste of aluminum product had many the advantages and could reduce the cost of aluminum metal production compared to primary process from ore. In this research used the waste of beverage aluminum cans One of the manufacturing methods conducted recycling aluminum waste is the casting process, Commonly, the problem with this casting process was that they are not homogeneous in the as-cast due to segregation. So that in this study a homogenization process on recycling aluminum castings would be carried out to obtain more homogeneous mechanical properties and microstructure. The variables that influence during the homogenization process was heating temperature and holding time. The heating temperature for this was in range from 450 C to 550 C, and the holding time was 2 to 4 hours. Further the effect of the parameter would observe. The observation included mechanical properties, such as tensile strength and hardness, and Microstructure of the ingot. The operation temperature and holding time influenced to grain size and hardness of Aluminum. In general, increasing homogenization temperature would reduce mechanical properties.

Introduction

This project work aimed to reduce useless metal waste, especially Aluminum. Aluminum metal has some advantages such as lighter metal compared to steel, good formability, nontoxic material, and good corrosion resistant. These were the reason why Aluminum is commonly used as food and beverage packaging. The manufacturing of waste aluminum for daily life applications became necessary to reduce environmental pollution from the waste of metal materials. On the other hand, producing casting products from the waste of Aluminum metal could save energy. The energy savings reached more than 5% if compared using the ore processing. The most widely application of aluminum metal was used in transportation field while the use for food products is only about 13%. Despite the applications were fewer, the aluminum metal used for food products or packaging was suitable for any desired recycling and process route[1]. In this work the material, used the waste of beverage cans as recycling metal material. This materials was melted from aluminum metal scrap and cast them into desired products[2].

One of the manufacturing processes that conducted to get Aluminum product was carried out by casting process. The problem that often appears if we produce the products with casting process was inhomogeneity of the microstructure during the freezing process. This inhomogeneity could cause the mechanical properties of the product to be non-uniform in several parts in one cast product. This matter was not a beneficial because it can cause mechanical properties within one large area to another to be different. The heat treatment process usually applied to homogenize properties of metal materials. In wrought Aluminum type, Homogenization process is conducted before mechanical working, such as; rolling extrusion etc.[3]. In Alstruc calculated the processes of homogenization take place above 400 °C. This was the most common for the industrial aluminum alloys. The concentration of Mn in solid solution in AA3xxx series would develop after 8 h [4]. During homogenization the Aluminum metal experienced the change of structure within it [5]. A

research explained that if soaking time was raised, the micro hardness would increase[6]. In foundry of Aluminum, the heat treatment process was carried out to homogenize microstructure and reduce residual stress due to the different solidification during freezing time. This process was namely homogenization process. The heat treatment process which aims to homogenize the mechanical properties of casting.

Homogenization will be affected by the heating temperature. Besides that, the heating time will also certainly have an impact on the final structure that is formed[7]. For this reason, this research intends to analyze the effect of heating temperature and holding time on the microstructure and mechanical properties of the castings after homogenizing process. This recent work is expected that experiment can obtain the optimum conditions for homogenization aluminum products from recycled of beverage cans waste.

Experimental Method

They were pressed become small and dense cans and then heated using a gas furnace until melting. After melted completely, deoxidizer was added into liquid metal for binding the oxygen in molten metal to become an oxide and then removes it[8]. The chemical reaction formed as a slag form on the liquid metal surface and it was removed manually using a spoon. After the molten liquid surface was clean, it was poured into the mold and made become ten aluminum ingots for ten experimental conditions. One of the samples was taken for composition examination using X-ray fluorescence apparatus. The samples were also examined for microstructure. The observations used an optical microscope. For hardness test used the Vickers hardness machine to obtain preliminary data. From the results of the chemical composition test, it was found that the recycled product from beverage cans had aluminum composition with its main alloy Mg, as seen in table.1.

Table 1. Chemical Composition of Aluminum Ingot

Al Total	Mg	Cr	Fe	Mn	Si	Ti	Zn 2	Sn 2	Cu 2	Ni 2	Pb 2
	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]	[%]
96,529	1,862	0,020	0,281	0,831	0,097	0,019	0,102	0,008	0,183	0,069	0,001

The Aluminum ingot then is placed into a muffle furnace at a certain temperature and time for homogenization process. The operation temperatures are 450 to 550 C, while the holding times are for 2.3 and 4 hours. After that All the specimens was tested as previous test except chemical composition testing. Optical microscope observation for every specimen was also conducted to analyze microstructure feature after homogenization process.

Result and Discussion

In aluminum as-cast before homogenization treatment showed that the formation of precipitate structures gathers at the grain corner, which can be seen in Fig 1. This structure might be caused by non-homogenized distribution of the solute composition which cause the precipitates did not distribute evenly to all parts of the castings or grain boundary. During solidification, the liquid phase turned into solid phase and it would end at the corner of the grain. It was the reason that the formed precipitates were pushed to the last part of solidification process, it was grain corner. Uneven distribution would affect the advance process such as machining or forming process. For some types of aluminum, it could be increased strength by doing mechanical work. The precipitates that were not well distributed, caused the differences of strength in the base metal, and it was often cause initial cracking during mechanical loading.

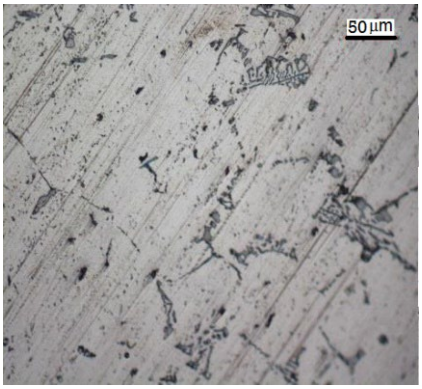
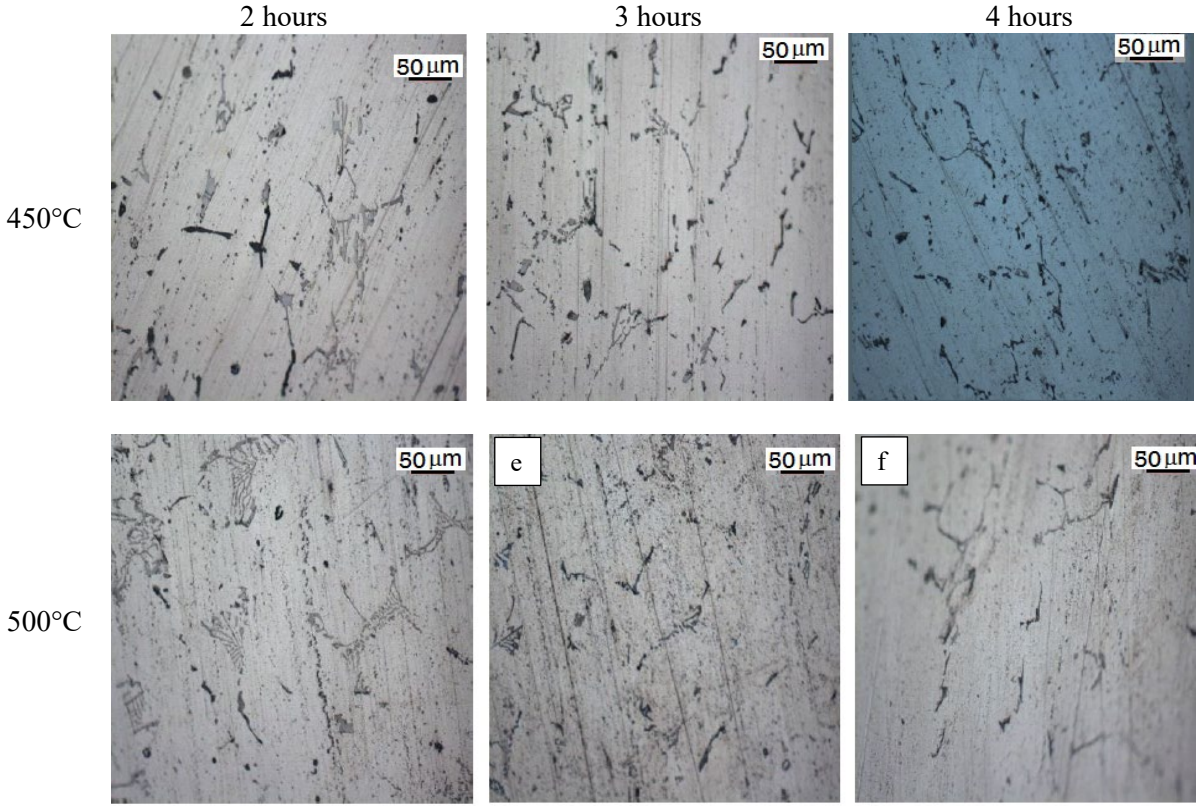


Figure 1. Micro structure of as cast recycled aluminum cans before homogenization

With the homogenization process, it assumed that the precipitates would more disperse. The precipitates began spreading not only concentrated in grain corner or grain boundary but also along the grain boundary or in grain, this can be seen in Figure 2. The higher the temperature and the longer the heating time, the precipitates were more distributed evenly at the grain boundary. At 2 hours of the heating time, some precipitate still appeared in the grain corner but at the longer heating time, the precipitate was more distributed along the grain boundary and in the grain. It was shown as the phase with dark color. But this condition was also followed by enlargement of matrix grain size. It was proved by the distance of the precipitates. At the highest temperature and longest holding time the precipitates less. These precipitates were reduced along with the longer heating process. It was possible because of the diffusion of alloy element in the precipitate to the aluminum matrix



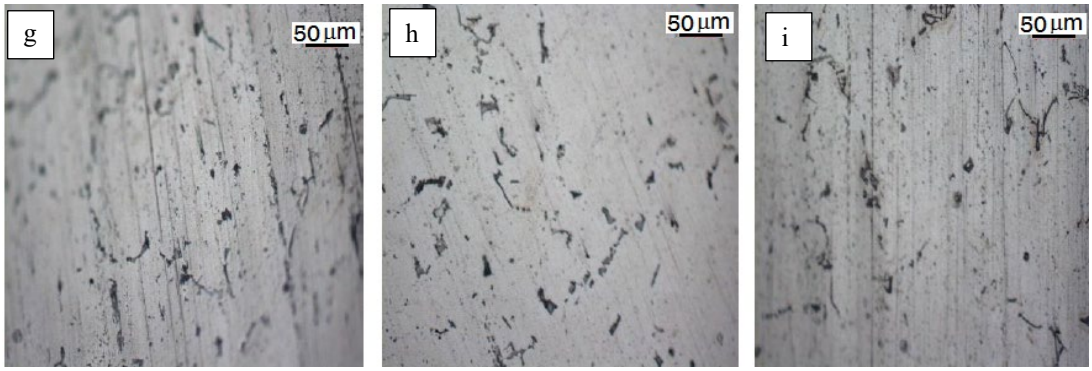


Figure 2. The microstructure of recycled aluminum cans after homogenization

From the results obtained, it was observed that the homogenization process affects the grain size of recycled as-cast aluminum beverage cans microstructure. The homogenization process carried out aims to eliminate segregation. It was expected to be achieved, if the precipitates dispersed homogeneously. Increasing the holding time and the operation temperature could increase the grain size and the grain shape was more equiaxed. Before homogenization process the average grain size was about 103,63 µm but at the higher temperature, the grain would growth and became bigger, This can be seen in Fig.3. The coarser grain can be reached at 550° with the holding time 3 hours, is 274,82 µm.

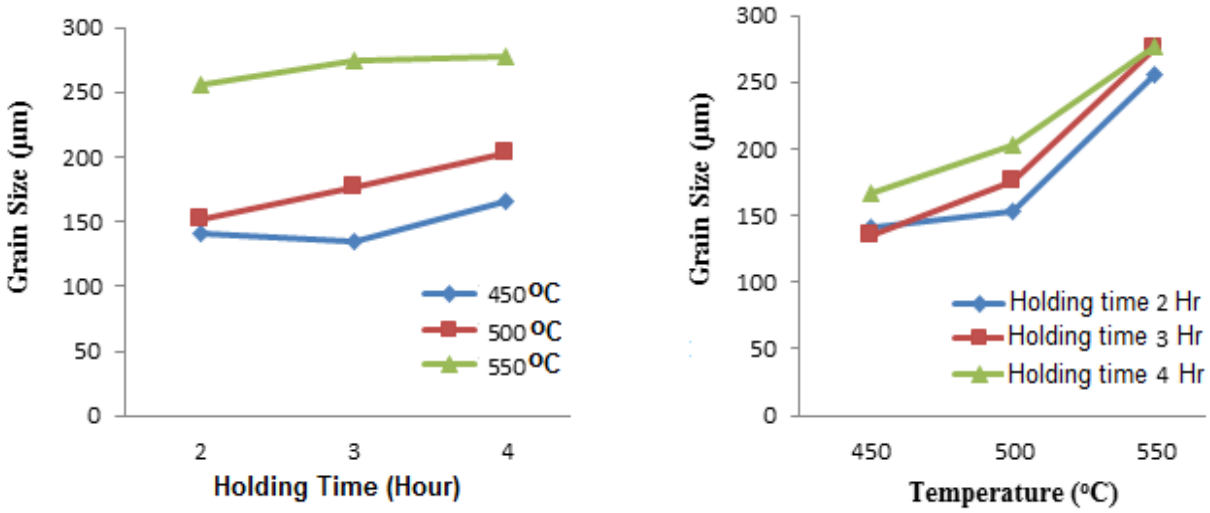


Figure 3. The grain size of homogenized at different temperature and holding time

In other studies explaining that the effect of homogenization on aluminum castings could reduce micro hardness. This occurs due to the grain size that enlarges during the heating process [7]. In this research, the higher temperature and the longer time, both affected to grain size of aluminum as cast. It can be seen in Fig. 4 that the value of hardness was influenced by applied holding time and heating temperature. From the all of the process showed that if the holding time and operation temperature increased then the hardness value would be down.

Homogenization process in this work, the fact could reduce the hardness of the aluminum ingot. Before homogenization process, the hardness of ingot aluminum was 75,23 HV. For comparison to initial hardness, the decreasing of hardness value between aluminum as cast recycled beverage cans and after the homogenization process could reach until 40% for holding time 4 hours and operation temperature 550°C. This condition couldn't reach similar result as previous research [3]. This might

be caused by the aluminum material type. This type was not a heat treatable aluminum and the higher hardness could be obtained by other method. In this work concluded that the optimum operation temperature was 400°C, confirm from previous research[4], but for optimum holding time, it should be perform further experiment for confirmation.

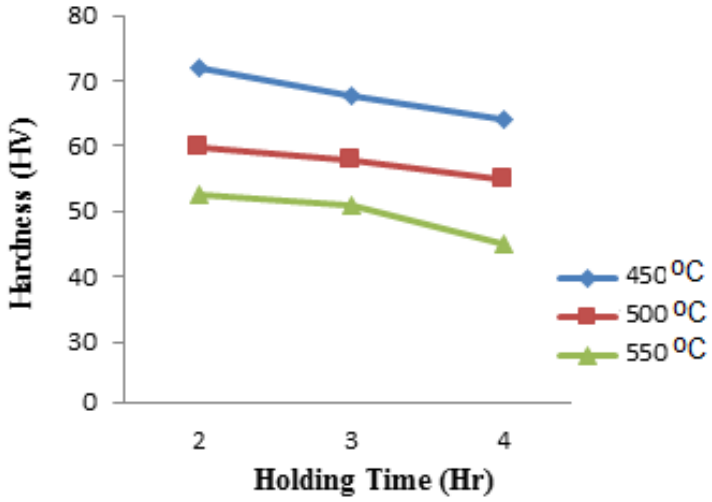


Figure 4. The Hardness of as-cast aluminum in vary homogenization time

Conclusion

The homogenization process could reduce the hardness value of aluminum as-cast recycled. And the decreasing could reach until 40%. This occurred because of the growth of the aluminum grain. Increasing homogenization temperature and holding time made the grain size coarser. The optimum homogenization might around 450°C. Homogenization temperature variations also affected to the microstructure. The higher the temperature, the more grain size formed equiaxed grains and the precipitates distributed evenly. This similar condition also could be seen in longer holding time.

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