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The Effect of Smelting Temperature and Quantity of Flux on Aluminum Recovery Yield

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Abstract. *Aluminum cans are widely used as food and beverage containers because of their properties. In practice, the consumption of canned drinks in the world and those recycled is not comparable. There are many challenges in recycling aluminum cans, one of which is the low yield of aluminum due to the formation of slag.*
From a literature study, it is known that the smelting temperature and the flux weight that added to the aluminium melt have an effect on the aluminum yield.Therefore in this research was conducted to smelt with 3 temperature variations were 720 ^{o}C, 740 ^{o}C and 760 ^{o}C and 3 flux weight variations were 0.5%; 0.75% and 1% based on weight of the aluminium can. The result show that experiment with melting temperature 760 ^{o}C and with weight flux of 1 % given highest recovery yield of 88.18% (388 grams).

Keywords : *Aluminium can, smelting temperature, flux weight, recovery yield*

1 Introduction

Aluminum cans are widely used as food and beverage containers because they are relatively strong, lightweight, easily shaped and corrosion resistant. Pure aluminum possesses a tensile strength of 90 MPa (Azo Materials,2005) makes aluminum easily formed[1]. Aluminum has different properties than iron and steel, when the aluminum surface contacts with air, will naturally form a layer of aluminum oxide that will protect the aluminum from corrosion (BBC, 2005)[2]. However, after the food or drink is consumed then the drink cans will be thrown into trash cans. The consumption of canned drinks worldwide reaches 6700 cans of drinks per second or 200 billion cans of drinks per year (The World Counts,2017)[3]. One solution to overcome the amount of garbage cans is to recycle the beverage cans.

At the moment, an average of 113,200 aluminum cans is recycled every minute of the world (ThinkCans,2017)[4]. Trash cans are one of the most sought after waste types by scavengers and collectors, which will then be given to the aluminum recycling industry for recycling. After the recycling process is done, the garbage cans will be printed into the ingots needed for example for the manufacture of new beverage cans.

In practice, there are various problems with the recycling of aluminum cans. Some of the problems that occur are low yield recycled or aluminum yields. The recycle yield is the overall efficiency of the mass of the product produced compared to the mass of the melted material, while the aluminum yield is defined as the efficiency of the aluminum mass produced compared to the mass of the melted aluminum feedstock. Thus the value of the aluminum yield can also show how much of the loss (loss) of aluminum produced from recycling. A low yield or recycling efficiency occurs because the fused product has a large amount of waste, which is a slag. Slag is caused by the reaction between molten aluminum and oxygen in the air, forming aluminum oxide. The slag causes a loss for the aluminum recycling industry, since the energy of smelting required to melt aluminum is considerable, and the slag also removes the economical value of the aluminum.

In a previous study conducted by Suhendra, the yield of recycling of beverage cans with the addition of drossing flux at higher melting, increased from 52.5% to 57.5% (increased by 5%) to smelting the lid and for fusing cans increased from 54.7% to 59.1% (increased 4.4%). The increase in recycle yield is obtained due to the effect of drossing flux. The recycled cans yield a higher yield from 55.2% to 59.1% (increased 3.9%) [5]. This is because some paint content contain oxygen compounds that will react with aluminum and form Al_2O_3 (slag). Similarly, with aluminum yields, recycling of beverage cans with the addition of drossing flux during smelting resulted in higher yields, which increased from 54.02% to 59.04% (increased 5.02%) for smelting the lid and for cans smelting from 55.1% to 59.5% (up 4.4%). While the aluminum yield on recycled canned body can also produce higher yield with 55.71% to 59.5% (increase 3.8%).

The formation of the slag also has another negative effect, namely the low aluminum gain due to the presence of liquid aluminum trapped in the slag. To overcome this, the addition of drossing flux during the melting is done. According to Gallo & Neff(2008), drossing flux is designed to help separate aluminum trapped in the oxide layer[6].

2 Research Method

Preparation of Aluminium Can

Raw materials used were beverage cans of SPRITE (250 ml). Before cutting process, paint on the body of the cans exfoilated by rubbing using sandpaper grade 150. The cutting process is done by separation of the body and cover cans by means of manual cutting using scissors. Then done cutting the cans into small size (area of about 4 cm^2). Tools and other raw materials are prepared such as flux, crucible and mold.

Smelting Process

Before starting the smelting process, crucible should be coated. This coating process aims to avoid the diffusion of Fe-C to liquid aluminum. Fe-C content is obtained from the crucible material itself. The coating process is done by mixing the coating material with diesel (20% - 40% solar from the mix). Then apply with a coating of the blend of coating on the inner surface on a crucible until evenly distributed, as shown in Figure 1. After that, the combustion or heating on the crucible until the coating layer is dry. In this preparation, heating is carried out for 90 minutes using LPG stoves (as can be seen in Figure 1.)

Figure 1. Coating application process on crucible (left) and heating process of crucibel (right)

For the melting process, 3 flattened cans are placed in a crucible first. The crucible is inserted into the Electric resistance furnace and closed using small openings and large openings, then enter the desired temperature figure (720 ^oC, 740 ^oC, 760 ^oC) into the Temperature Control so that the engine will start and start heating the furnace. When the furnace reaches a temperature of 670 ^oC, the first fluxing with flux is used as much as one-third of the desired flux mass (0.5%, 0.75%, 1%). When the furnace reaches the desired temperature, stirring and adding raw materials or beverage cans are cut into small pieces. The addition of raw material is done with a duration of 30 seconds per entry through a small opening of the furnace, then the small openings of the furnace are closed and waited for 1 minute, then the subsequent feedstock ingredients are done until the raw material runs out with a total of 440 grams per experiment. It aims to avoid the occurrence of temperature drop in the furnace. After all ingredients enter, a second fluxing is performed as much as one-third of the desired flux mass. After the second fluxing, held holding time for 20 minutes. Fluxing third or last done when holding time has been running for 10 minutes. After that is done pouring liquid aluminum into the mold. Just prior to casting, slag taking is done using a filter. The purpose of this slag retrieval is to separate the aluminum looking with the slag so as to facilitate the pouring process, wherein the slag does not co-exist or prevent pouring.

3 Result and Discussion

From the result of weighing the result of recycling of beverage can with 9 experiment types, calculation of yield of recycle was made so that the data as in Table 1.

Table 1. Recovery yield percentage

Experiment (Smelting Temperature, Flux Weight)	**Recovery Yield [%]**	**Slag Percentage [%]**	**Weight Loss [%]**
720^{o}C 0.5%*	53,4	43,2	3,4
720^{o}C 0.75%*	27,9	62	10,1
720^{o}C 1%	73,6	25	1,4
740^{o}C 0.5%	84,5	11,8	3,7
740^{o}C 0.75%	81,6	17,5	0,9
740^{o}C 1%	78,4	18,6	3
760^{o}C 0.5%	82,9	13,6	3,5
760^{o}C 0.75%	75,9	22,3	1,8
760^{o}C 1%	88,1	10,9	1

*) Not included in the calculation because of inconsistency

Based on Table 1 The percentage of recycled yields on experiments of temperature 760 ^{o}C is higher than the samples in experiments with temperature of 720 ^{o}C and 740 ^{o}C with total sample mass of 1087 gram. In addition, the experimental sample with the use of a 1% flux mass of smelted tin mass has a higher recycle yield than the sample in the experiment with the use of a 0.5% and 0.75% flux mass with a total sample sample mass of 1057 grams. This shows that the melting temperature has an effect on the yield of recycling. Weight loss gotten from the experiment was expected from the filtering process which is using manual process, and from the gas came out from the hole above of the furnace used. Experiment 1 and 2 is not included in the calculation because after got result from experiment 1 and 2, the intensity of stirring is considerably need to be added, as stirring will affect velocity of reaction in the aluminium melt [7]. Usage of flux also have a recommendation to stir fluks after being added to make sure the flux is evenly distributed to the layer of dross[8].

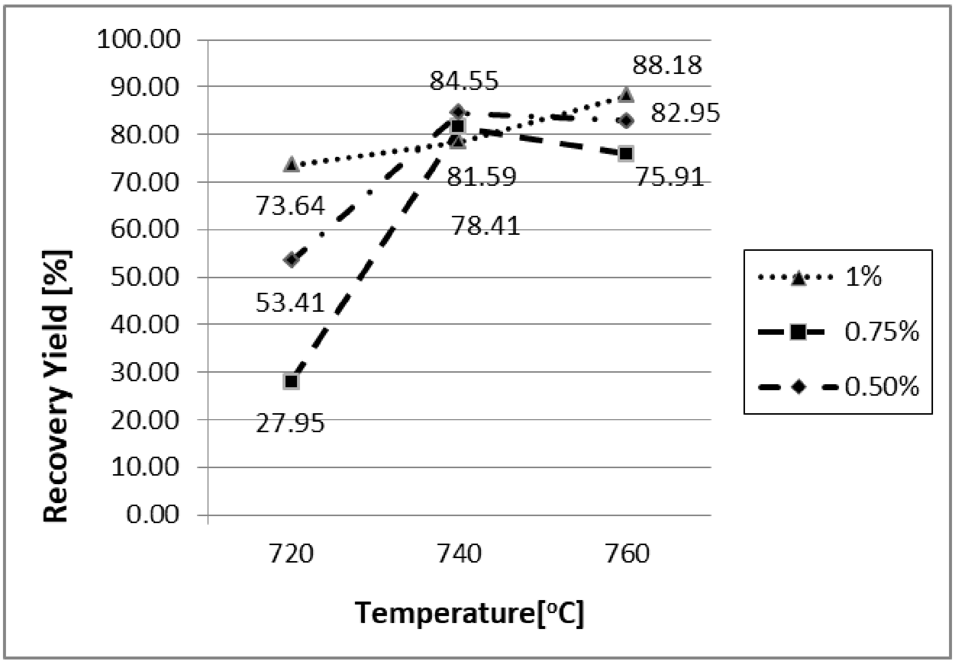

Figure 2. The recovery yield graph of aluminum recycling with 3 variation of melting temperature and 3 flux weight variations

Figure 2 shows the effect of temperature and mass of flux on the yield of recycle of the melt. At melting with a temperature of 720 ^oC to 740 ^oC with a flux mass of 0.5% and 0.75% found recycled yield increased from 28% and 53.4% to 81.6% and 84.5% but increased temperature further to temperature 760 ^oC found recycled yield decreased to 75.9% and 83%. Smelting with temperature 720 ^oC to 740 ^oC with 1% flux mass increased from 73.6% to 78.4% and further temperature increase to 760 ^oC temperature found recycled yield rose to 88.2%. Significant recycling yield increases in 2 experiments with melting temperature of 740 ^oC were influenced by increased levels of Mn and Fe in the experiments, level of Mg in the experiment is decreased in all experiment, magnesium in the aluminium cans affecting their corrosion resistance, strenght and hardness of the aluminium cans[9].

4 Conclusion

From the results of recycling of beverage cans has been studied, the melting temperature has an effect on the recycled yield where the total Subtotal of the experiment using the temperature of 760 ^oC yields the highest recycled yield, as well as the flux mass, the yield data of recycling the highest was obtained in the experiment using a temperature of 760 C and a 1% flux mass.

Similarly, the yield of aluminum, smelting with 1% flux mass with a variation of 3 melting temperatures gives an average yield of Al which is not much different from the initial Al yield. This happens because the addition of flux mass will help the oxide layer peel process better so that more Al can be saved from dross.

5 References

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