Effect of Aging to the Hardness of Aluminum Beverage Cans with Addition of Used Lubricant

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Effect of Aging to the Hardness of Aluminum Beverage Cans with Addition of Used Lubricant

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Abstract— This study discusses the results of smelting of beverage cans poured into a tube mold, 5 cm in diameter and 30 cm high containing 6 ml, 12 ml of used lubricant, and without used lubricant as a comparison. Samples were treated with quench heat at 550 ºC for 2 hours and aging at 175 ºC for 1, 3, and 5 hours, respectively, to determine their effect on material hardness. From the analysis, it has been shown that the maximum aging time to increase the hardness of the material with and without the addition of used lubricant is 3 hours, then decreased after 5 hours. As well as the addition of used lubricants, the results show the hardness of aluminum material has decreased.

Keywords— Aluminum beverage cans, Heat treatment - Aging, Used lubricant, Hardness.

1. Introduction

In 2020, global consumption of aluminum products is expected to double along with the growth of industry or urbanization of China, India, Russia, and Brazil, while Asia is expected to grow by 60% [1]. The most significant percentage of beverage cans are made of aluminum because it has a unique property that can hold carbon dioxide in carbonated drinks. However, aluminum must go through many processes to change from its initial state into a commercial product, so that aluminum production is expensive and uses a lot of energy [2].. According to Bulei, Todor, and Kiss [3], recycling is a modern concept in waste management, so that it can reduce waste, and materials can be used more efficiently. This is also in line with what was stated by [4], which says that recycling of solid objects is an effective method to create an environmentally friendly country. The mechanical properties of recycled beverage cans are calculated to get the benefits of the recycled results. Tafti, Sedighi, and Hashemi [5], explained that mechanical strength is an essential factor in the metal industry, and aging heat treatment can improve the mechanical properties of processed specimens. The mechanical properties of the composite (Al/0.5% glass-reinforced) are higher after being heated than in the initial sample, most likely due to second phase precipitation during aging, which covers the surface at the particle-matrix interface [6]. This was also explained by [7], who stated that an increase in mechanical properties and wear resistance of aluminum matrix composites was achieved by adopting suitable heat treatment. Many aging methods have been proven to increase material hardness. This is evidenced from the results of research conducted by [8] showing that aging time can increase the hardness of aluminum alloy 2024 T3, where the effects of microphotographs show the particles formed more refined with increasing aging time which causes material hardness to increase. This was also expressed by [9] in his research on the effect of heating and aging on aluminum alloy material A356 showed an increase in hardness and strength. Another study conducted by [10] explains that there is a difference in the effect of artificial aging and natural aging on aluminum alloy 7075 that in artificial aging at first, the hardness decreases and then increases at a specific time until it reaches a peak and then falls again while the hardness of the material in natural aging has increased until a specific time becomes relatively stable. In his research, [11] also concluded that the duration of aging is a significant factor that affects the mechanical properties of the resin. The conclusion was also expressed by [12], which revealed that time and temperature had an essential role in the process of increasing alloy hardness. In his maximum research, hardness was achieved in the aging cycle by heating 180-290°C with a time of 15-18 hours.

2. Research Methods

2.1 Materials

The sample materials used recycled Coca-Cola Company cans, which were melted at 750 °C, which has been poured into 25 cm high steel tube molds and 5 cm in diameter. Before pouring aluminum, the melt is carried out into the tube has been filled with used lubricant as much as 6 ml and 12 ml, respectively. As well as a comparison, aluminum fusion has also been poured into steel tube molds without used lubricants. Whereas previously used lubricants have been taken from vehicle repair shops, which were first deposited to reduce water content, then filtered to remove impurities.

2.2 Heat Treatment

All of the samples used were square, 3 cm long, 2.5 cm wide, and 1 cm thick. Then the sample has been divided into four groups. One non-heat treatment group and 3 sample groups were heat-treated at 550 °C for 2 hours then quenched with water, followed by artificial aging at 175 °C with a holding time of 1, 3, and 5 hours, see fig. 1. Codification of the samples is made as follows: S1 is a sample with Six ml waste lubricant, which gets heat aging treatment for 1 hour. SN samples are Non-heat treatment. T3 sample with the addition of Twelve ml of waste lubricant, which gets heat treatment aging for 3 hours. Whereas WO5 is a sample With-Out addition of waste lubricant that gets heat treatment aging for 5 hours.

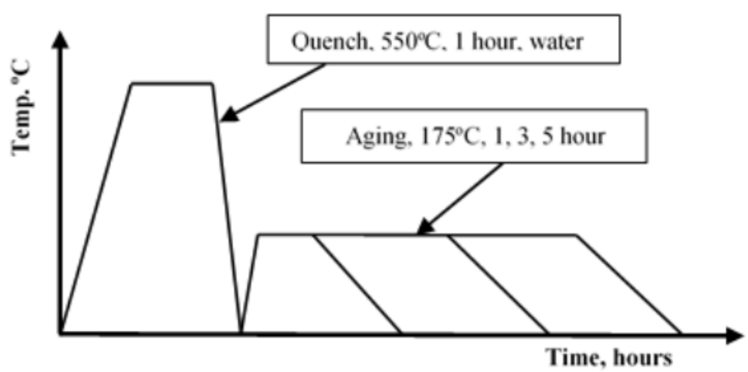

Fig. 1: Heat treatment for samples

2.3 Hardness Testing

Hardness testing has been carried out 4 points above the sample surface. The sample hardness value has been calculated on average, using the Brinell Hardness method. The diameter of the steel indenter is 5 mm, with a load that has been given 500 kg, which has been stressed on the surface of the samples. The hardness testing machine that has been used is the Brinell Hardness Tester type BH-3CF.

3. Results and Discussion

The results of the average hardness testing of aluminum material before and after aging heat treatment are shown in Fig. 2.

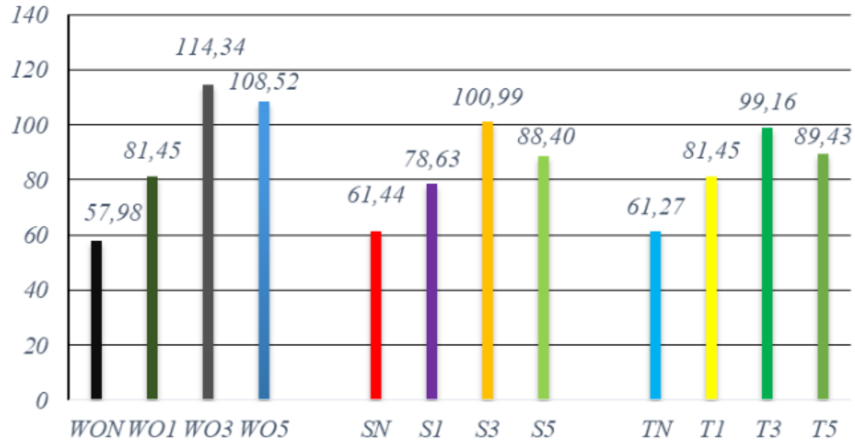

Fig. 2: Brinell Hardness Number

From Fig. 2, it can be seen that the three groups of WO, S, and T graphs have the same shape, namely an increase in the value of hardness after heat treatment, aging. Brinell Hardness Number (BHN) for WON, SN, and TN have been studied previously [13]. For samples without the addition of used lubricant without WON heat treatment, the hardness value was 57.98 BHN; the hardness value increased to 81.45 BHN for the WO1 sample after recording the heat treatment for 1 hour and increased again to 114.34 BHN after receiving heat treatment for 3 hours. However, after receiving a more extended heat treatment that is for 5 hours, the sample hardness tends to decrease and become 108.52 BHN. For samples that received added lubricants, the pattern of sample hardness also showed the same thing, namely increased hardness up to samples that were treated with heat aging for 3 hours, and then dropped after being treated with heat aging for 5 hours. The results of this study are in line with the results of the study [14], which show that hardness increases with increasing aging time to a certain point and then decreases, so more time will reduce the level of hardness. In his research, the best aging time is between 4-6 hours and decreased significantly when the aging time is 6-8 hours. The reduction in hardness can be caused by excess aging time, which can reduce material hardness. Other research conducted by [15] also shows that when aging is continued for a longer time, then the hardness of the material decreases, because when the size of the precision exceeds the critical value, it can make dislocation movements easy and cause strength to decrease. The same thing was expressed by [16], which stated that variations in hardness and electronic conductivity depend on emotions before aging. Hardness is reduced with a reduction in temperature and aging time. However, the results of this study are not in line with the results of research conducted by [17], which shows that hardness will decrease with increasing aging. Likewise, with what was stated by [18], who explained that hardness increased initially, but decreased after 5 hours.

4. Conclusion

Analysis carried out concluded that the difference in aging time of aluminum beverage cans with the addition of 6 ml and 12 ml of used lubricant and without used lubricant would increase hardness with increasing time, and decrease again after 3 hours of aging time, even though the aging time of 5 hours the decrease does not seem too significant. As well as variations in the addition of 6 ml, 12 ml of used lubricants showed an influence on the value of the hardness test results obtained over the long aging time carried out. So from the analysis, it can be concluded that the maximum aging time to increase the hardness of aluminum beverage cans with and without the addition of used lubricant is 3 hours. With the addition of used lubricants, aluminum material hardness has decreased.

5. Acknowledgments
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