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THE EFFECT OF ADDING USED LUBRICANT ON USED ALUMINUM BEVERAGE CANS CASTINGS ON THE HARDNESS VALUE

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ABSTRACT

The purpose of this study is to study the effect of adding chemical elements contained in used lubricants which burn in cylindrical tube moulds on the hardness of aluminum alloys. Chemical elements in used lubricants have increased the hardness of aluminum alloys. The hardness of aluminum alloy which is not added with used lubricant, then the hardness is 57, 982 BHN, while by adding 6 ml used lubricant, the average hardness value is 61,439 BHN while adding 12 ml, the average hardness value decreases to 61, 271 BHN. This decrease is not too large, but it is noted that the value of hardness tends to decrease. When compared to the difference in the magnitude of the chemical composition between the sample pieces that are not so large, it can be said that the casting of bars is homogeneous.

Keywords: aluminum alloy used lubricant, chemical content, hardness number.

1. INTRODUCTION

Hardness of aluminum is influenced by many factors, one of which is the chemical composition factor contained in the aluminum metal used. The composition of the constituent metal is strongly influenced by elements that are combined onto aluminum. The existence of elements contained in aluminum can be caused by various factors that are either intentionally added or unintentional. The intentional thing can be in the form of special treatment by adding a certain number of elements that can be combined with aluminum metal. Whereas unintentional things can occur due to negligence or accidental process during aluminum smelting so that the entry of other elements enters into the constituent elements of aluminum metal.

The effect of adding other elements in the aluminum alloy has changed the hardness of the aluminum alloy, by adding Be to the aluminum alloy (Rejaeian *et al*. 2015). Likewise, the element Li added to aluminum alloys has changed the hardness of aluminum alloys (Karamouza *et al*. 2013.) In recent years a lot of research on the hardness of aluminum alloys, (Curle, Cornish, and Govender 2016), (Deng, Wang, and Jin 2017), (Jahangiri *et al*. 2017), (Mostafa, Hameed, and Obayya 2017), (Moussa, Waly, and Amin 2018), (Narayan and Rajeshkannan 2017), (Pérez-Bustamante *et al.* 2014), (Tiryakio and Robinson 2015).

The use of aluminum needed by humans every year is quite high, the aluminum produced is mostly obtained from secondary sources, the impact is that aluminum extraction by recycling aluminum is now widely applied (Schlesinger 2007). Recycling of used aluminum is very effective in reducing the use of bauxite, coke, petroleum and aluminum fluoride (Totten and Mackenzie 2003).

Aluminum in the industrial world especially machinery must have some good physical properties. Hardness is the ability of a metal to accept repetitive stresses or friction loads. The demand to meet aluminum needs is very high, what is needed is aluminum which is capable of receiving several types of loading, it was conveyed by (Bradbury *et al*. 2014) and (Gottardi, Tocci, and Pola 2017).

2. MATERIALS AND METHODS

Melting aluminum cans is done using crusible steel. The fuel used is used lubricant mixed with kerosene. Aluminum material used is beverage cans of a similar brand, which is issued by the Cocacolacompany. Used aluminum beverage cans can be recycled. Material is purchased from used goods collectors, then is washed to remove all types of impurities that have been thereafter crushed to make it easier at the time of smelting. After the molten aluminum is poured into a cylindrical steel tube mold with a diameter of 5 cm and a height of 30 cm.

Melting temperature must be achieved at least 700^{o}C, while pouring temperatures are maintained at 600^{o}C. This high temperature is expected to heat and burn used lubricants in the tube. In the first stage, some tubes were filled with aluminum liquid without a used lubricant, some other tubes were given 6 ml and 12 ml.

This pouring has burned used lubricants and this is another advantage that heating in the tube continues. After a while, the fire that comes out of the top of the tube starts to shrink and slowly goes out. At the time of initial pouring, the tube wall looks red due to an increase in temperature and this is heating due to burning of the lubricant. This burning flame crept up to the surface of the tube, which has thus heated up the aluminum liquid entering the tube. Under these conditions, it is estimated that the fire has heated up the bottom of the tube where the molten aluminum which has dropped in temperature has risen again. In such cases it can be said that the combustion fire has given additional heating to the molten aluminum entering the tube mold. Used lubricating oil is taken from used oil collectors in several motorbike and car repair shops, which are then mixed into one until it mixes well. Some of the heavy metals contained in used oil are Co, Ni, Cu, Cr, Fe, Cd and Pb(Al-Nozili, Abeed, and Ahmed 2014).

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The melting design and the approximate direction of the aluminum melting temperature decrease which has increased again can be seen in Figure-1. Samples to be measured are taken from several height positions of aluminum castings in the tube. At the bottom of the castings is the first part to receive the combustion heat of used lubricating fuel.

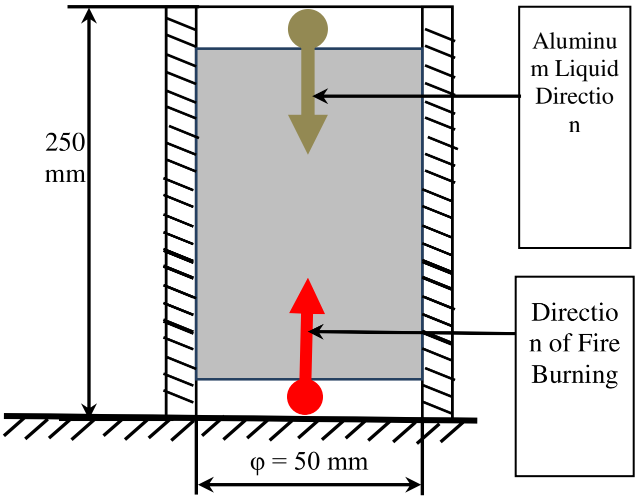

Figure-1. Mold and directions fire tube heating.

3. RESULTS AND DISCUSSIONS

Chemical composition testing and Brinell hardness testing performed on casting product height position. The test is performed on the two front side sample pieces, namely the top and bottom. Aluminum bars are obtained after the cylinder tube mold is dismantled. The aluminum bar is cut into 6 (six) parts.

The top part is discarded because of the remaining dross, and the bottom part is discarded thin because of the irregular surface shape due to the combustion fire.

Composition of chemical samples

Chemical element testing is done using a spectro analyzer, and the elements have 6 (six) main elements which are read, namely Al, Mn, Fe, Cu, Zn and Pb. Samples are measured for 6 (six) layers of cut from the smelting mold, see Figure-2. Test results of the composition of recycled aluminum cast products for used beverage cans in tubes without used lubricants (wo - without) and partially given used lubricants 6 ml (w6 - with 6 ml) and 12 ml (w12 - with 12 ml) are shown in Table-1, where u's code is side-up and b is bottom.

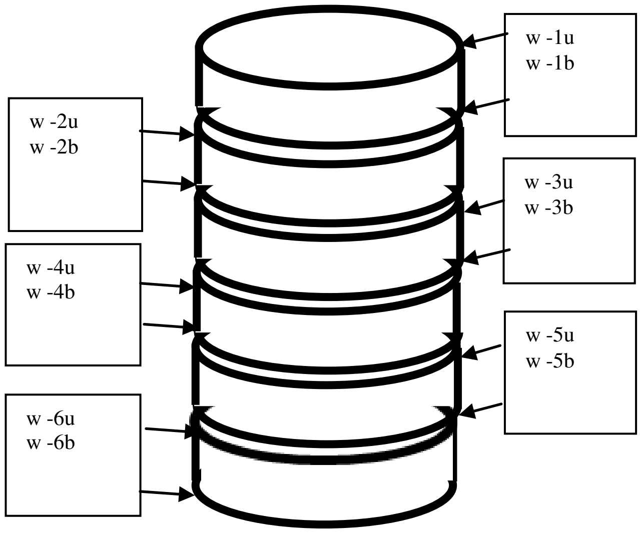

Figure-2. Sample pieces.

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Table-1. Chemical content (%).

	Al	Mn	Fe	Cu	Zn	Pb
wo						
wo-1u	98,21	0,724	0,782	0,173	0,106	0,005
wo-1b	98,597	0,594	0,483	0,152	0,17	0,004
wo-2u	98,419	0,766	0,507	0,191	0,111	0,006
wo-2b	98,26	0,791	0,641	0,178	0,125	0,005
wo-3u	98,294	0,832	0,547	0,192	0,13	0,005
wo-3b	98,388	0,709	0,589	0,191	0,118	0,005
wo-4u	98,156	0,822	0,698	0,176	0,142	0,006
wo-4b	98,42	0,741	0,532	0,158	0,144	0,005
wo-5u	98,274	0,803	0,61	0,152	0,157	0,004
wo-5b	98,366	0,779	0,465	0,129	0,257	0,004
wo-6u	98,216	0,777	0,564	0,146	0,292	0,005
wo-6b	97,958	0,742	0,677	0,165	0,452	0,006
wo-ave	98,297	0,757	0,591	0,167	0,184	0,005
w6						
w6-1u	97,777	0,748	1,03	0,19	0,246	0,009
w6-1b	98,229	0,779	0,659	0,199	0,128	0,006
w6-2u	98,33	0,774	0,567	0,203	0,12	0,006
w6-2b	98,21	0,843	0,638	0,198	0,104	0,007
w6-3u	98,417	0,746	0,542	0,174	0,116	0,005
w6-3b	98,398	0,75	0,556	0,17	0,119	0,007
w6-4u	98,2	0,766	0,556	0,173	0,299	0,006
w6-4b	98,287	0,82	0,557	0,179	0,15	0,007
w6-5u	98,062	0,834	0,637	0,199	0,26	0,008
w6-5b	97,73	0,835	0,675	0,173	0,581	0,006
w6-6u	97,806	0,746	0,713	0,178	0,548	0,009
w6-6b	98,098	0,756	0,614	0,181	0,345	0,006
w6-ave	98,129	0,783	0,645	0,185	0,251	0,007
w12						
w12-1u	97,286	0,914	1,29	0,311	0,189	0,01
w12-1b	97,694	0,585	1,26	0,26	0,194	0,007
w12-2u	97,982	0,745	0,824	0,277	0,163	0,009
w12-2b	98,153	0,759	0,709	0,215	0,156	0,008
w12-3u	98,136	0,733	0,754	0,217	0,152	0,008
w12-3b	98,16	0,724	0,702	0,214	0,191	0,009
w12-4u	98,17	0,709	0,774	0,211	0,127	0,009
w12-4b	98,087	0,762	0,746	0,245	0,152	0,008
w12-5u	98,052	0,792	0,777	0,216	0,153	0,01
w12-5b	98,082	0,757	0,777	0,231	0,144	0,009
w12-6u	97,977	0,789	0,84	0,232	0,153	0,009
w12-6b	98,16	0,724	0,732	0,224	0,152	0,008
w12-ave	97,995	0,749	0,849	0,238	0,161	0,009

VOL. 15, NO. 6, MARCH 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

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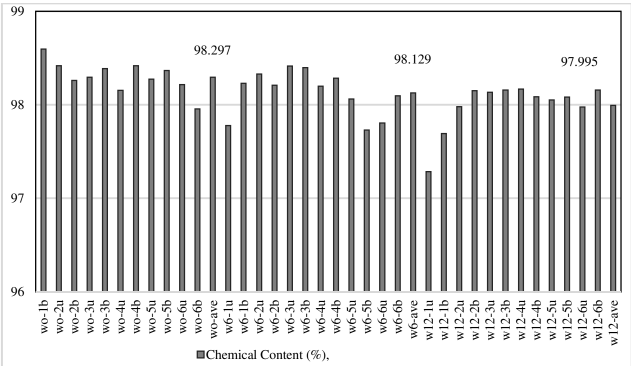
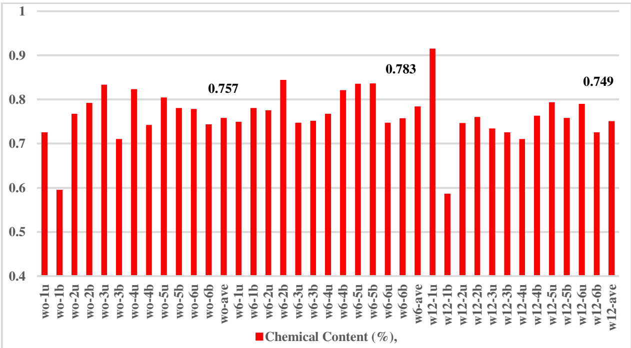
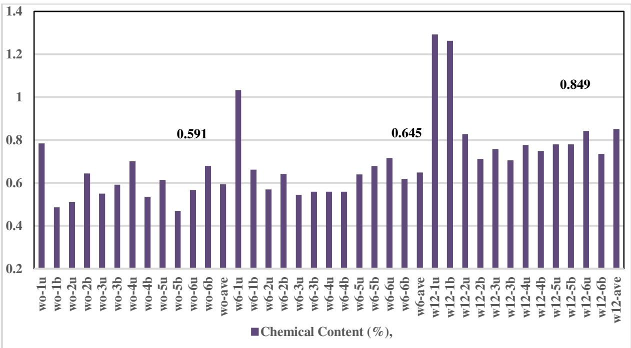
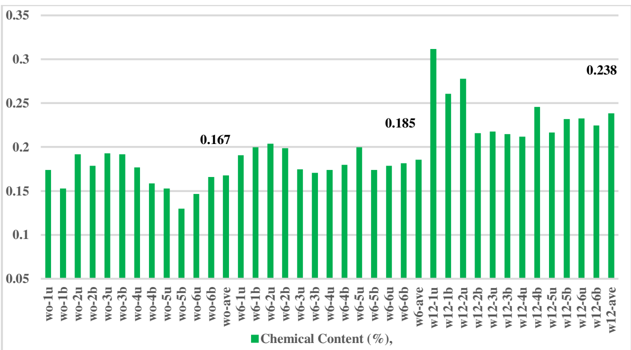
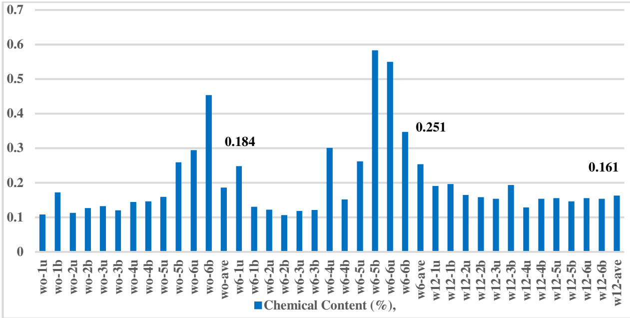
For simplicity it can be made in the form of images per element as in Figure-3.











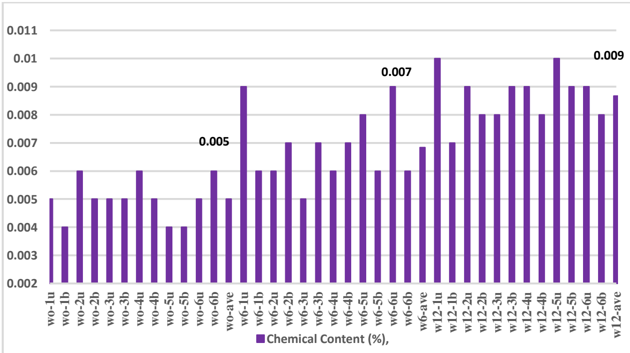


Figure-3. Chemical content in wo, w6 and w12.

From Table-1 and Figure-3, an increase in the chemical element Fe for samples burned with used lubricants can be seen. There is also a significant increase in Cu element and the increase is in accordance with the large amount added to the steel cylinder tube mold. When compared with the increase in the Pb and Cu elements, in the sample after being burned with used lubricants, the relationship of the three elements namely Fe, Cu and Pb becomes clear. When compared with the increase in Pb and Cu elements, in the sample after being burned with used lubricants, the relationship of the three elements, Fe, Cu and Pb, it becomes clear that the increase of these elements is expected to be obtained from the burning of used lubricants at temperatures around 600°C (pouring temperature which is then followed by the removal of Cu and Pb elements from the used lubricant), then it can simply be said that the total elemental sum increases for the Cu and Pb elements. When observed, the increase in Fe element is not only the Fe content in used lubricants but is also thought to be due to a small portion of the cylindrical steel tube walls being eroded and becoming part of the non-bound element of the aluminum alloy sample, although it is unlikely to be an alloying element of aluminum, but the Fe element this is read by a measuring device. The burning of the steel cylinder tube wall is indicated by the onset of burning red color as shown in Figure-4. It is interesting to note that, the chemical content distribution profile has a similar pattern. So between sample pieces from each other, in one tube has chemical content that is not much different. So it can be said that the material made is relatively homogeneous.

Figure-4. Reddish walls of cylindrical tube.

Hardness

The number of samples for the hardness test is the same as the number of composition tests, which is 6 (six) samples. Hardness testing with steel ball penetration on the surface of the aluminum sample is carried out at the top and bottom of the sample. The number of points tested is 5 (five) points. The test results are made in graphical form as shown in Figure-5.

From Figure-5 it can be seen that the magnitude of the value relative hardness varies. The results show that for a given sample without lubricating, hardness value varies, so it can be seen the average value is large enough that BHN 57.982. While the provision of used lubricating oil as much as 6 ml, the average value of the hardness is 61.439. By adding as much as 12 ml, a decrease in average hardness value becomes 61.271 BHN. This decrease in value is a question, because with the increase of Pb in the aluminum sample, naturally the sample becomes softer, because Pb has a low hardness. So by itself can be expected should an increase in hardness.

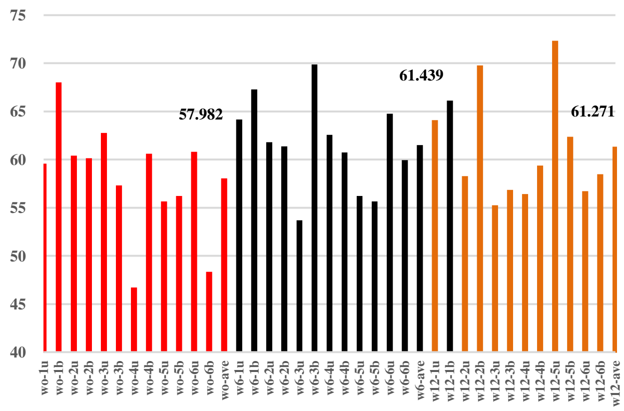


Figure-5. Brinell hardness number.

This decrease in value is a question, because with the increase of Pb in the aluminum sample, naturally the sample becomes softer, because Pb has a low hardness. So by itself can be expected should an increase in hardness. However, when compared to the Fe and Cu elements which increase in value, naturally the sample of aluminum which is given a used lubricant which is burned increases its hardness. In such cases, the elemental content seems to play a significant role for change, but in fact the elemental content does not provide a sign of a large increase.

By adding 12 ml of burnt used lubricant, there is a decrease in hardness. This is in accordance with research (Rejaeian *et al*. 2015), where the addition of other elements in an alloy will change its hardness value, this occurs when A380 aluminum alloy is added with the element Be. The effect of adding Li has affected the hardness of aluminum alloy (Karamouz *et al*. 2013).

The magnitude of the combustion fire that initially occurred at the bottom leads to the top of the tube through or against the inflow of aluminum liquid, see Figure-1. The fire path that leads to this can be expected to cause bonds between aluminum atoms to become weak.

In this case there has been an obstacle in strengthening the bonds between atoms, in other words the natural cooling process for liquid aluminum has slowed. It can be said that the greater fire current with greater addition, passing through liquid aluminum has decreased the hardness of the sample.

4. CONCLUSIONS

The analysis has concluded that the results of ordinary casting and casting with the addition of used lubricants have different hardness values. It can be concluded that adding used lubricants has increased the Pb element which is estimated to be obtained from the combustion of used lubricants, and has increased the Fe element in the aluminum sample content due to the use of steel cylinder tubes as molds. On the other hand, the addition of excess used lubricant in the cylinder tube has reduced the value of the hardness of the sample due to the addition of Cu and Fe elements from the burnt used lubricant. The decrease in hardness in the sample that was given a 12 ml sample is estimated due to the opposite fire current towards the aluminum liquid which is poured into the cylindrical tube.

ACKNOWLEDGMENTS

Acknowledgments to the Sriwijaya University who has provided research funding through seed research contracts profession number: 0109.10/UN9/SB3.LP2M.PT/2018 financial year 2018. Thanks are also extended to PT. Pusri (Persero) which has provided facilities to test the composition of the material.

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