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Mechanical Properties of Castings Aluminium Waste which is Smelted in Simple Furnace with a Variety of Fuels

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ABSTRACT: In The aim of the research was to compare the mechanical properties of castings aluminium waste which is smelted in simple furnace with a variety of fuels. Smelting performed at a constant temperature of 750oC for each furnace. The sample of the castings is treated hot at 350 °C with the holding time of 2 hours. Raw materials from beverage cans samples that are smelted into crusible furnaces with a mixture of fuel between charcoal wood with coke (sample E) have the lowest tensile test value and after annealing heat treatment, the tensile test value increases, as the grains of the atoms turn into more regularly and create a new, stronger structure. When the results of this heat treatment process were compared to samples with mixed raw materials between Cable, Electric Iron Element, Beverage cans, Cooking ware and Rim, which were melted with mixed fuel between diesel oil and kerosene in crusible furnaces (sample F), the tensile test is lower. The lowest value of the impact test is found in the sample of beverage cans that is melted in a Crucible furnace with a mixture of charcoal and coke (sample E). The largest impact test value was obtained from the furnace process using used lubricating oil for cable mixed materials, Electric Iron Element, beverage cans and rim (sample C). The heat treatment performed gives a clear effect of the decline in the value of violence. Materials such as cables, Electrical Iron Elements, beverage cans, cookware and rims are melted in a Crucible furnace (sample F), the hardness decreases after heat treatment. Raw materials such as Cable, Electrical Iron Elements, Beverage Cans, Cookware and Rims, smelted in furnaces with used lubricating oils (Example C), have shown great mechanical properties greater than other samples.

KEYWORDS: Aluminum waste; furnaces; fuels; heat treatment; mechanical properties.

INTRODUCTION

Aluminum is one of the many metals found in everyday life. Some properties of aluminum are as follows: density 2,702 kg / dm³, melting point 660ºC, glossy color, corrosion resistance, non magnetic [1], and strong [2]. In addition to the nature of aluminum is also cheap and easy to obtain, so the use of aluminum as a base material such as beverage cans and motor vehicle rims from time to time increasing. As a result of the increased use of aluminum is also increasing the number of beverage cans and motor vehicle rims that are not used anymore so that new problems arise that is the buildup of used aluminum waste.

According to the Ministry of Environment's environment regulation No.13 of [3], article 1 point 1: Activity reduce, reuse, and recycle or reset garbage, to reuse garbage and recycling waste, hereinafter referred to as 3R activities are all activities which can reduce everything that can cause waste, waste reuse activities that are appropriate to use for the same function or other functions, and activities to process waste to be used as new products.

Therefore, it is necessary to recycle aluminum waste such as beverage cans, rims, cookware, Electrical Iron Elements and cables, so that it can be recovered well, all of which can be recycled 100, and 95% energy savings when compared with primary aluminum [5]

Metal recycling is usually carried out by recovering the scrap metal, where the scrap metal is heated to exceed the molten metal point. After the metal melts, then the pouring process is done. In some small industry-scale aluminum casting centers, some are using direct-burning stoves (furnaces) with fuel in the form of lubricant wastes. Some also use Crucible furnace (burning indirectly) fueled charcoal wood.

In addition, other studies utilize waste from used aluminum melting into Hydrogen Sulfide (H2S) which can be utilized as gas [6] and [7], and become materials for building rust-resistant concrete [8].

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RESEARCH METHODOLOGY

To examine the differences in mechanical properties between the castings of the two furnaces, the material properties of the castings will be compared and the heat treatment results of both materials. So that the product obtained from the castings better than the results of the initial castings. In other words, it is necessary to improve the mechanical properties of recycled aluminum materials from foundry industries or small scale industries.

Tools and Materials

The materials that are melted in this research are aluminum waste such as motor vehicle rims, beverage cans, Electric Iron Element, cable, cooking ware (pots and pans). According to Kaufman [9] beverage cans using aluminum alloy series 3004 and 3104. As for the vehicle rims using cast aluminum alloy with A356.0 series.

Material is purchased from pickers of used goods in the city of Palembang. Comparison of melted material in balanced percentage, eg 50% beverage cans mixed with 50% rim. The material is cleaned of all dirt that is attached by brushed and washed with clean water, then dried.

Smelting aluminum waste carried out in the furnace where the metal to be melted is heated to the melting point of 750oC [10]**.** Examples of melting furnaces include fire furnaces and Crucible furnaces.
Combustion system for aluminum metal smelting uses two methods. The first, by directly burning aluminum waste is by blowing a fire that is directed to aluminum wastes that are in a fireproof cement-fired furnace referred to as a fireplace (see Figure 1).
The second method, with indirect burning of the Crucible furnace, is by heating the bottom and / or crusible sides and the aluminum waste material is in the crucible (Figure [2, 3]). Crucible furnace made of iron made specifically for aluminum waste smelting with a capacity of 10 kg. So there are three (3) forms of aluminum smelting furnaces for small industry. The three forms of this furnace in small industrial scale are widely used for the manufacture of small and special loaded ship propellers for this research are made on a laboratory scale. Avoiding the occurrence of shrinkage during pouring, the distance of the sample mold is designed as close as possible to the furnace [11]**.**
The fuel in this research using a four types of fuel, both liquids and solids. For indirect combustion using charcoal wood charcoal, cokes (coalite), sub-bituminous coal (low rank coal) and diesel oil mixed with kerosene. Used lubricating oil from motorized vehicle engines is filtered to remove impurities with screen filtration systems made of stainless steel of size based on ASTM E-11-70. The calorific value of the fuel is measured with the brand-branded BPR-6400 receptor briquette referring to ASTM D4809.

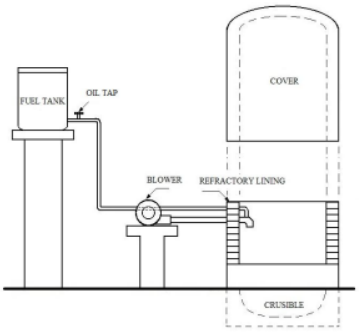

Figure 1. Fire Furnace.

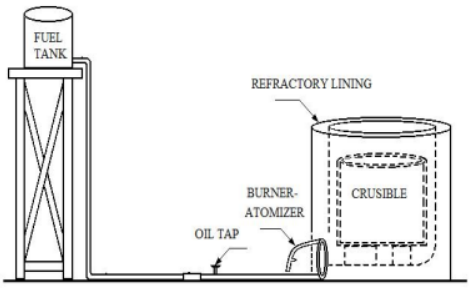

Figure 2. Crucible Furnace.

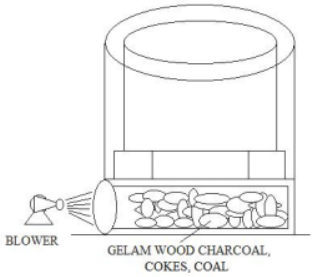

Figure 3. Crusible Furnace with Solid Fuel.

The process of fire ignition in the furnace flame is to make the initial function is to provide preheating the combustion chamber. This initial ignition using paper and lumber. At the time of the combustion chamber temperature has been hot, the blower is turned on and provides more oxygen to the combustion chamber. The oil tap is slowly opened and will become fine atoms in the form of fog so it is easily lit. While at the Crucible furnaces with used oil fuel, the fire turned the same way as in the furnace by means of fire.

Research planning as shown in Table 1, which made codification letter alphabet in order for the system to be simple tables and charts.

Table 1. Codification of Research Planning.

Codification of Raw Materials	Types of Aluminum Waste	Fuels		Type Combustion
		Types and Mixes	Calorific Value (kcal/kg)	
A	Rim + Beverage cans	Used Lubricating Oil	10.780	Furnace Fire
B	Beverage cans			
C	Cable, Electric Iron Element, Beverage cans, Cooking ware, Rim			
D	Beverage cans	Gelam Wood Charcoal	6.886	Crucible Furnace
E	Beverage cans	Gelam Wood Charcoal + Cokes	6.569	
F	Cable, Electric Iron Element, Beverage cans, Cooking ware, Rim	Solar + Kerosen	10.595	
G	Rim + Cooking ware	Sub-Bituminous Coal	6.453	

Test Sample

The mechanical properties test includes tensile, impact and hardness test after aluminum waste metal is melted and casted in a bar. The result of castings in the form of a beam looks like in Figure 4. Then made the manufacture of test samples referring to the Japanese Industrial Standard (JIS).

Figure 4. Blocks Aluminum Molten Results.

RESULTS AND DISCUSSION

From the test results calorific value fuels (Table 1) it can be seen that the calorific value of the used lubricating oil is greater than the calorific value of charcoal and other fuels, so that with the same weight can lead to heating of materials castings at the Crucible furnace is somewhat longer than the furnace of fire.

Waste lubricating oil and diesel fuel-kerosene mixture consisting of hydrocarbon element which is the main constituent of Carbon, Hydrogen, Oxygen, Nitrogen, Sulfur. Waste lubricating oil made vaporous first assisted with the blower, while the diesel-kerosene mixture made vaporous with the atomizer and the pressure is obtained based on the height difference between the position where the oil tank and the atomizer.

Some aluminum samples are given annealing heat treatment in order to remove residual stresses after casting. Heat treatment is a process for improving the properties of the metal by heating the castings to the appropriate temperature, then being left for some time at that temperature, then cooled to a lower temperature at an appropriate rate [12].

It is expected that the mechanical properties of the cast after receiving the heat treatment can be better than the result of casting without heat treatment because the residual stress has been removed. The heat treatment is carried out in an electric furnace at 350 °C which begins with heating 35 minutes to reach 350 °C, then held for two hours, after which it is cooled inside the furnace. Compositional testing was done with XRF Analyzer Spectrometry. The results of the composition testing of castings as shown in Table 2.

Table 2: The chemical composition of Castings.

Raw	The Chemical composition (%)								
Materials	**Al**	**Pb**	**Zn**	**Ni**	**Cu**	**Fe**	**Mn**	**Cr**	**Sn**
A	98.799	0.04	0.335		0.357	0.466			
B	98.416		0.23		0.468	0.355	0.417		
C	94.215	0.133	2.868	0.088	1.449	0.891		0.073	0.032
D	97.336	0.058	0.789		0.518	0.798	0.331	0.061	
E	95.393		0.227		0.396	3.451	0.511		
F	93.943	0,094	1.456	0.099	1.946	2.017	0.208	0.121	0.036
G	96.117	0.107	1.61		1.22	0.826			

From the results of the chemical composition can be seen the percentage of elements that exist within each furnace castings. In table 2 the percentage of all the elements when summed up does not reach 100% because there is still influence from some impurities which among others come from paint dye beverage cans, paint rim of motor vehicle and other impurities.

Tensile Test

From the tensile test results can be drawn tensile test graph for various codification of raw materials. The test specimen or sample is made according to JIS Z 2201 standard [13]. Each sample test was compared between heated and non-heat treated samples. The lowest tensile test value was 3.542 kg/mm^2 recorded in sample E. After heat treatment, an increase of tensile test value was 5,654 kg/mm^2. As a result of the annealing heat treatment process, the atomic grains become orderly and create a new stronger structure and if the heat treatment results are compared to the F sample, it is seen that the value of the tensile test is lower.

When considered from the groupings of raw materials of aluminum beverage cans that are melted, then by using a furnace, used lubricating oil (sample B) has a greater test value compared to other fused smelting using Crucible furnace. In this case it can be understood that by using a furnace, where the fire directly burns aluminum and the fire has burned most of the dirt on the surface of the cans such as paint etc. In addition, several chemical elements have been burned, thereby increasing the purity of used aluminum cast metal. To utilize recycled aluminum waste by recycling method which has the biggest tensile test value, C sample has the biggest tensile test value that is 10,096 kg/mm^2. The small tensile strength of some samples has reduced the tensile strength of aluminum due to the large amount of Fe [14].

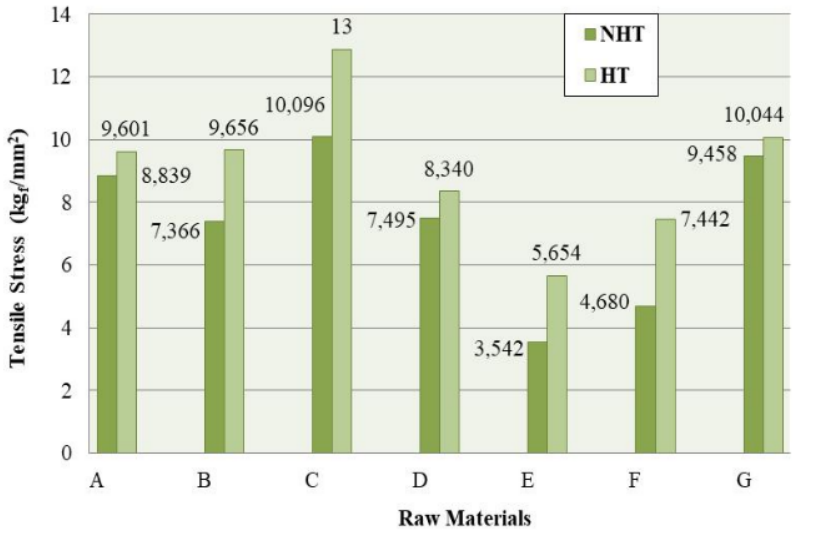

Figure 5. Tensile Test Charts of Heated and Unheated Raw Materials.

Impact Test

The impact test is conducted with the intention to know how much impact load can be received by the sample. The load is given by dropping the weight of the load suddenly against the sample until it breaks. The test sample of the casting product whether it has been given heat treatment or non- heat treatment should refer to the JIS Z 2202 standard test. [15].

This impact load measurement results can be seen in Figure 6. The samples were divided into two treatment that is heated and non-heat treatment. The lowest value of the impact test is 0.713 Joule, it is in sample E. While the largest test value is 2,853 Joules, from the test results of sample C. When compared, then sample B has a large impact value, that is 1,664 Joule, compared with sample E. Taking into account the value graph of this Impact it can be taken into account the increase in impact value when the heat treatment sample is carried out. The increase in the maximum impact value due to heat treatment is found in sample D. This increase occurs because of some chemical elements that have decreased the percentage due to high temperature heating. So it has a very significant effect on the impact value.

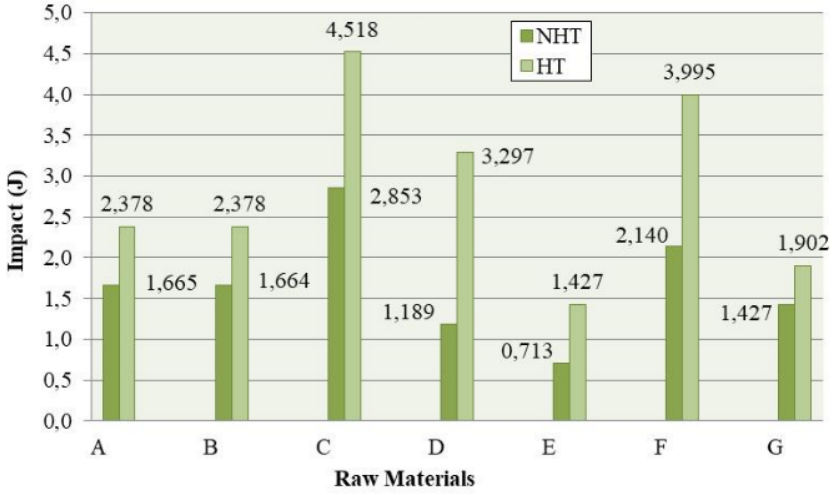

Figure 6. Impact Test Charts of Heated and Unheated Raw Materials.

Hardness Test

Figure 7 shows the beverage cans (samples B, D and E) have the lowest hardness values. While the greatest hardness value is on sample C. The heat treatment has given a clear effect, that is the decrease of hardness value. Materials such as cable, Electric Iron Element, beverage cans, cooking ware, reams smelted in Crucible furnace and made samples with code F (JIS B 7724) [16], decreased the hardness value by 36.78% after receiving heat treatment. The decrease in hardness values for heat treated samples is detrimental, but this is advantageous in terms of microstructure, since the arrangement of the atomic grains becomes more orderly. Annealing heat treatment with 2 hours hold time has made the sample better in terms of tensile test value and impact test. Casts with high Copper (Cu) content have increased the value of hardness and this corresponds to [17], Cu can increase the hardness of aluminum alloy materials.

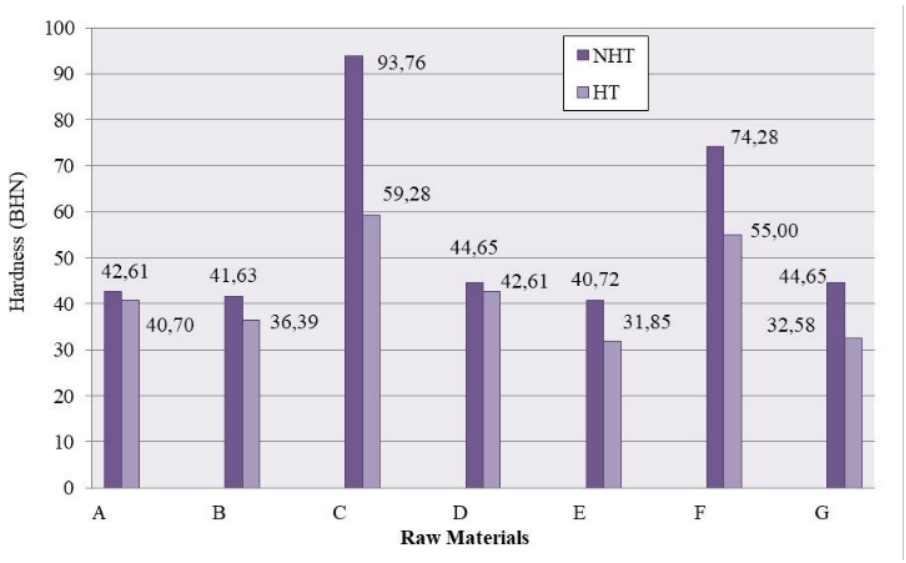

Figure 7. Hardness Test Charts of Heated and Unheated Raw Materials.

CONCLUSIONS

The aluminum waste raw materials used in this research have resulted in good mechanical properties. This can be seen from the various test values of mechanical properties performed on the sample. Sample C has shown greater mechanical properties compared to other samples. This is due to the direct combustion of the aluminum waste alloy, has burned all the dirt on the molten aluminum surface in the furnace, so that the cleanliness of the cast is better. The heat treatment of the sample has shown changes in the mechanical properties of the samples. The heat treatment of the sample has shown changes in the mechanical properties of the sample. Tensile test samples that received a heat treatment has increased in value, so does the value of impact, but differ on the value of hardness tends to decrease.

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