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Effect of 10% Zn Addition on Fabrication of Al Alloys on Mechanical Properties, Crystal Structure and Micro Structure

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ABSTRACT

Aluminum-based alloy are one of the most alloy beneficial in the industry. Therefore, the research is done on the effect of Zn addition on Al alloys fabrication using powder metallurgy method. The composition of 0% and 10% Zn with sintering temperature varied: 550°C, 600°C, and 650°C respectively at that temperature held for 1 hour. Characterization includes: measurement of hardness, SEM analysis, and XRD analysis. The result of XRD analysis from the results of the rietveld refinement phase using the match program it is found several phases is Al, Zn and ZnO. From the result of SEM analysis it is found that the reaction between Zn and Al so as to form solid solution phase on the addition of 10% Zn with 650°C sintering temperature. From the result of characteristic of mechanical properties, the highest hardness is 99,5 HD at 10% Zn addition for all sintering temperatures. With the addition of Zn the mechanical properties is increasing.

Keywords: Pure Aluminum, Zinc, Powder Metallurgy, Mechanical Properties, Crystal Structure and Micro Structure.

I. INTRODUCTION

Materials technology and aluminum processing is widely used as raw materials in the field of machining, construction, and automotive components. Aluminum often replace other metals with the same function. This occurs when the product must have light properties, a good conductor of heat, and a low melting point. Because it has low meltingpoint and favorable properties, aluminum is also widely used as raw material of casting process.[4] The use of aluminium as a metal every year is second only to steel andiron, the highest among non-ferrous metals.[6].

Aluminum is remarkable for the metal's low density and for its ability to resist corrosion due to the phenomenon of passivation. Structural components made for aluminum and its alloys are vital to the aerospace industry and are important in other areas of transportation and structural materials. The most useful compounds of aluminum, at least on weight basis, are the oxides and sulfates[2].

For the commercial need, pure aluminum is too soft so that cannot fulfill the requirements such as strength and hardness that are still too low. In addition to the mechanical properties, the elements of alloys that can be used include: Cu (Copper), Mg (Magnesium), Si (Silicon), Mn (Manganese), Zn (Zinc), Ni (Nickel) and so on either individually or simultaneously. The effect of alloying elements on the improvemet of the properties of aluminum include : Zinc (Zn) can increase casting on aluminum , but can also reduce anti- corrosion properties and cause cavity defects in casting if the zinc content is too high.[4].

Zinc (Zn) is the fourth most metal that widely used in the industrial world after steel, aluminum, and coper.

According to its use steel from corrosion, as an element casting of zinc to brass, as an alloy element in copper, aluminum, and magnesium, as wrought zinc alloy, and for chemically materials. Zinc has many effects on alloys that increase strength at room temperature and corrosion resistance. Zinc helps to increase fluidity but can push micro porosity during casting.[1].

The addition of elements such as Zn, Mn and chromium with relatively small amounts will improve the strength and resistance to corrosion.[5].The addition of Zn up to 10% in Aluminum produces a lower friction factor up to 0.02 and facilitates heat-proofing capabilities.[5]. Al-Zn Alloys are included of the heat treatment. Usually into the Al-Zn alloy added Mg, Cu, and Cr. Tensile strength can be achieved more than 50 kg/ mm^2, so this alloy is also called ultraduralumin. In contrast to its tensile strength, its welding properties and corrosion resistance are less favorable.[3].

Until now, research on the effect of increasing the addition of zinc (Zn) with Aluminum (Al) with powder metallurgy process is still lacking. This is the background of this research conducted. There are several methods used to synthesize aluminum (Al) with zinc (Zn),one of which is powder metallurgy include of mixing, printing, compaction with 4 ton load. This research will also be done sintering process after mixing and compaction. Sintering is a powder metallurgy method based on the diffusion of atoms. Diffusion will occur quickly if the high temperatures below the melting point of the material. The function of sintering is to change the properties of the material in sintering. Sintering is carried out at temperatures of 550°C, 600°C and 650°C for 1 hour.

Many factors influenced the mechanical properties of Al-Zn alloys, so this study used variations of 0% and 10% Zinc (Zn) addition and sintering temperature on Al-Zn alloys. The addition of zinc composition (Zn) and the variation of sintering temperature in this study is expected to improve the physical properties, mechanical properties and microstructure (XRD and SEM) in Al-Zn alloys.

II. METHODS AND MATERIAL

The method used in this research is powder metallurgy wich is carried out at the Center For Physical Development research (P2F) LIPI PUSPIPTEK Serpong. The initial preparation of the material using Al powder (pure analysis) and Zn powder (pure analysis). The research procedure is performed in the manufacture of Al alloys with the Zn addition is Al powder sintering at 550°C and Zn powder weighing which the composition of Zn 0% and 10% wt. Then both Al powder and Zn powder mixed until homogen. Pinting is done by dry pressing, mixed powder is placed in a mold with a diameter of 10 mm. the powder is put into the mold and pressured (compaction) with a hydraulic press capacity of 4 tons and held for 1 minute. andfinally sintering was carried out by heating the sample in vacuum furnace at a temperature of 550°C, 600°C, and 650°C which was held for 1 hour.

Research variables on the manufacture of alloy Al-Zn include raw material composition and characterization.

TABLE 1

Composition OfRaw Material
Aluminum (Al) : Zinc (Zn)

sample code	Aluminum (%wt)	Zinc (%wt)	Aluminum Mass (g)	Zinc Mass (g)
A	100	0	3	0
B	90	10	2.7	0.3

As for the characterization ofmaterials include: mechanical properties (hardness), Scanning Electron Microscope (SEM) and X-Ray Difractometer (XRD).

III. RESULTS AND DISCUSSION

The mechanical properties observed in Al-Zn alloy research are hardness (shore hardness) testing. To determine the hardness value of Al alloys with the addition of 10% Zn is done by hardness testing using durometer. The results of hardness testing are shown in Figure 1.

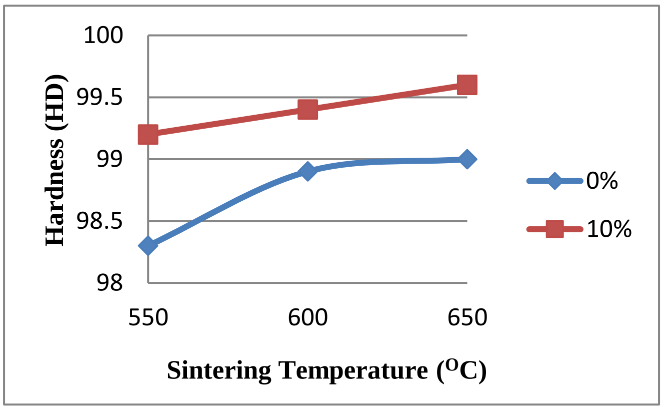


Figure 1 Graph of the relationship between hardness with the addition of Zn composition to various sintering temperatures.

The graph in Fig. 1 shows the results of the hardness testing that increases with the addition of Zn composition and with increasing sintering temperature. This is because the hardness value of Zn is 412 MPa which is higher than Al which is 245 MPa. The highest hardness value is 99,5 HD at the addition of 10% wt Zn for all sintering temperatures.

Figure 2.shows the shape of the Al-Zn alloy surface with the addition of Zn 0% for 550°C sintering temperature and 10% Zn for 550°C, 600°C, and 650°C sintering temperatures. In figure (a) can be seen the visible element of Al without the addition of Zn (0%) in the form of flat or flake, figure (b) is 10% Al-Zn with 550°C sintering temperature indicates Zn elements small-round shaped is attached to the Al element flat shaped, figure (c) is 10% Al-Zn with sintering temperature of 600°C shows Zn-shaped spherical element or large round attached to Al elements in the form of flat or flake, and figure (d) is 10% Al-Zn with sintering temperature 650°C shows there has been an interaction between the elements of Al with Zn marked by the melting of Zn elements so that enter aluminum slit (Al), this indicates the interaction on the sintering process. at heating temperature 650°C form solid phase solution where element of Zn soluble in element of Al.

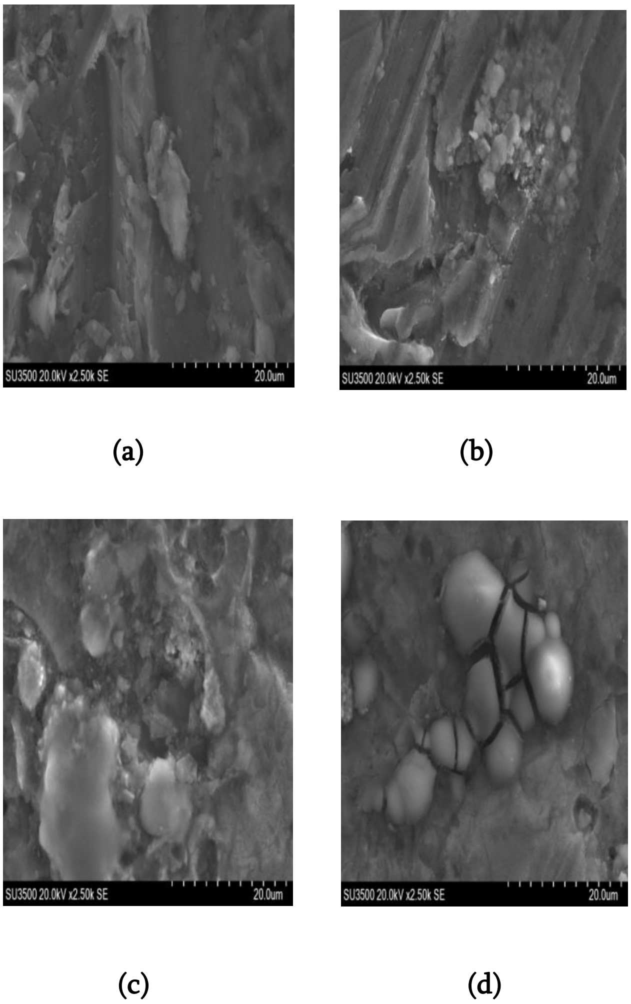
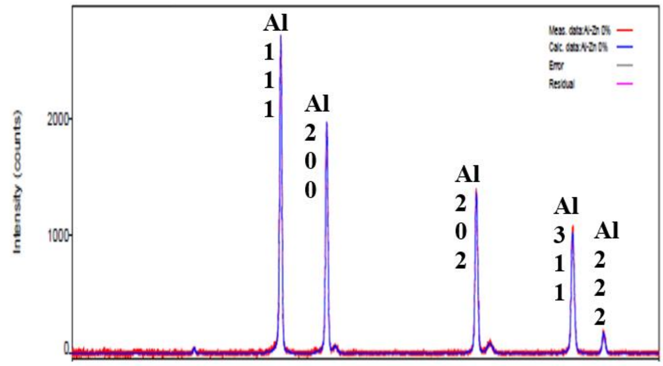


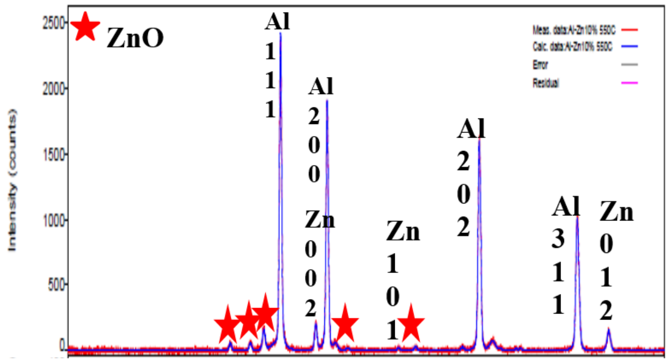
Figure 2. The shape of the surface of Al-Zn alloywith a magnification of 2500 x

(a) Al-Zn alloy 0% temperature sintering 550°C,
(b) Al-Zn alloy 10% temperature sintering 550°C,
(c) Al-Zn alloy 10% temperature sintering 600°C,
(d) Al-Zn alloy 10% temperature sintering 650°C.

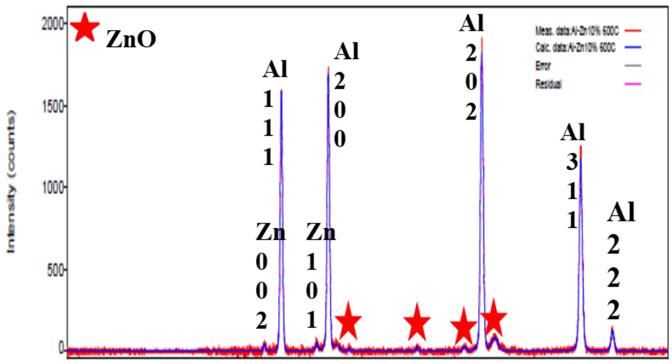
To be able to find out the phases formed at a sample that has been through the process of sintering, then the characterization of samples is done using X-ray diffractometer which is later analysed qualitatively. The process of the analysis done by matching data diffraction measurement results obtained from sample data with the results of x-ray diffraction in the ICDD database (International Centre for Diffraction Data). XRD analysis results shown in Figure 3.



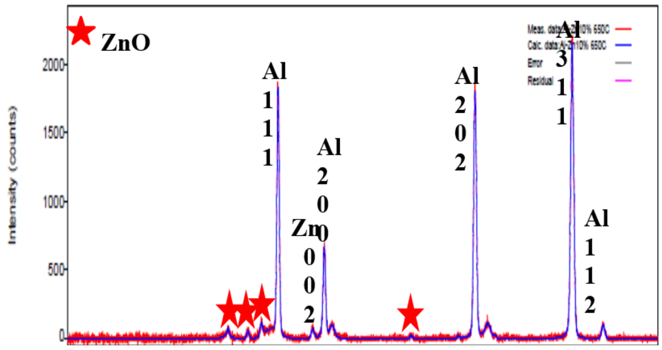
(a)



(b)



(c)



(d)

Figure 3 x-ray diffraction patterns of Al-Zn 0% and 10%

(a) sintering temperature 550°C

(b) sintering temperature 550°C

(c) sintering temperature 600°C

(d) sintering temperature 650°C

In the picture above shows the results of X-Ray Diffraction analysis (XRD). Figure (a) 0% Al-Zn sample with sintering temperature 550°C. From the XRD pattern image shows the highest peak among the peaks in the picture above is on hkl (111) with 2-theta 38.42. After rietveld refinement using Match program there are several peaks which are Aluminum (Al) dominant phase.

Figures (b), (c), and (d) show the results of XRD analysis on Al with the addition of 10% Zn at 550°C, 600°C, 650°C sintering temperature. After rietveld refinement using the Match program there are several peaks which are Aluminum (Al), Zinc (Zn) and ZnO phases. The formation of ZnO phase due to the entry of oxygen into the furnace during the sintering process so that the oxidation process of Zn. There appears to be no reaction of the two materials so that no alloys are formed.

IV. CONCLUSION

From the result of research of Al-Zn alloy making with powder metallurgy process can be taken conclusion result of XRD analysis obtained that result seen is phase of Al, Zn and ZnO. From the result of SEM analysis it is found that the reaction between Zn and Al so as to form solid solution phase on the addition of Zn 10% with 650°C sintering temperature. From the result of characteristic of mechanical properties, the highest hardness is 99,5 HD in addition of Zn composition 10% for all sintering temperatures. With the addition of Zn the mechanical properties is increasing.

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