Effect of Addition Percentage Zn on Mechanical Properties of Alloy Zn - Al.

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Abstract

Aluminum is a light metal that has good corrosion resistance and good electrical conductivity. Aluminum usage is expected in the future still widely open both as the main material and supporting materials with the availability of aluminum seeds in the abundant earth. By looking at the importance of the role of material selection in the advancement of manufacturing and assembling industry, the writer considers it necessary to conduct scientific publication on alloy material with various laboratory testing processes. The purpose of this research is conducting mechanical testing and metallographic testing on some type of percentage of Zinc-Aluminum material. The writer considers to conductalloying of Zinc-Aluminum using sand casting technique with alloy composition: 1. Zn 25% - Al 75%, 2. Zn 50% - Al 50%., 3. Zn 75 % - Al 25%. The method used in this study is to calculate and analyze the influence percentage of Zn addition to mechanical properties of aluminum-zinc alloys (Al-Zn). However, now its use is very widespread even it is difficult to describe how the development aviation industry without aluminum. Aluminum is a highly stable oxide that cannot be reduced by reducing other metals. For aluminum-zinc alloys (Al 75% - Zn 25%) it can be seen that the greater the stress value, the greater the strain value. This is influenced by the value of loading and extension that occur. For aluminum-zinc alloys (Al 50% - Zn 50%) it can be seen that the greater the stress value will be followed by increasing the strain value, this is influenced by the loading and extension values that occur. For aluminum-zinc alloys (Al 25% - Zn75 %) it can be seen that the greater the stress value followed by an increase in the value of strain, this is influenced by the value of loading and extension that occurred.

Keywords: Aluminum and Zinc Alloy

Introduction

Aluminum is a light metal that has good corrosion resistance and good electrical conductivity. Aluminum usage is expected in the future is still widely open both as the main material and supporting materials with the availability of aluminum seeds in the abundant earth. Aluminum can be used for household appliances, aircraft materials, automotive, ships, construction and others. Aluminum products are produced through casting and forming processes.

The process of aluminum formation can be done in various ways, one of them by using metal casting method, Surdia (2000).

Research purposes

This research is performed to:

• Conduct mechanical testing and metallographic testing of several types of percentage of Zinc-Aluminum material to know the mechanical properties and micro structure of foundry product.

• Describe the testing processes undertaken to determine the mechanical properties of a material or a material alloy.

Benefits of research

The research benefits are as follows:

• It is expected to explain the importance of knowing the strength of the material before its use so that it can later be accepted in the market in accordance with the consumer's wishes.

• The results are expected to be one of the literature materials about the mechanical properties of Zinc-Aluminum alloys

• As a literature material for the study of similar specimens from some other aluminum alloys.

Scopes of problem

Given the many opportunities for the determination of Zinc-Aluminum alloy composition and the properties of the material alloy, the writer considers it necessary to define the limitations of the discussion in this paper:

a. Conduct alloying of Zinc-Aluminum alloy with sand casting technique with alloy composition:

1. Zn 25% - Al 75%
2. Zn 50% - Al 50%.
3. Zn 75% - Al 25%

b. Testing the specimen through tensile testing, hardness testing with Rockwell method and looking at the microstructure of the alloy through metallographic testing to determine the mechanical properties.

Research methods

The method used are as follows:

a. Literature review

Literature review is a reference and blend of writers in conducting research, by using a library that supports the title object above. In this way, the authors compare some literatures that can help and facilitate the processing of data that has been obtained at the time of testing.

b. Experimental Method

The experimental method is by testing the specimen of aluminum-zinc alloy to know the mechanical properties of the alloy.

LITERATURE REVIEW

Aluminum Material (Al)

Aluminum (Al) including non-ferrous metals, has a silver white color. Aluminum is the most abundant element on earth and includes relatively new non-ferrous metals because the technology to purify it from its oxidation has just been discovered. Nevertheless, now its use is already very widespread even it seems difficult to describe how the development of aviation industry without aluminum.

The reduction of aluminum can only be done by electrolysis so that the properties of aluminum have a high joining power to oxygen because it is said that it is easy to oxidize (rust), but the oxygen formed on the surface will protect it from atmospheric attack so that in reality it has excellent rust resistance. It is caused by a thin layer of aluminum material.

The aluminum material is also one of the lightest metals with bauxite content composed of 60% alumina (granite $A1_2O_3$, $3H_2O$ and diesel $A1_2O_3$, H_2O), with the properties of forged, clay, light weight, has high heat conduction properties and additionally also as a conductor good electricity, capable of being poured.

The use of aluminum material is usually to make cooking utensils, electronics, automobile industry and aircraft industry. For aluminum alloy point of 500-660°C, density of 2.7 kg/m^3, 10-35% tenacity and Aluminum-Zinc and other alloying elements can improve the mechanical properties and heat resistance of 100-200°C and the temperature of crystal 150°C.

Zinc Material (Zn)

Zinc is a bluish-white metal made from zinc beans with sphalerite seed content (ZnS), its nature can be forged, good corrosion resistance, its strength is low, its melting point is only 420°C thereby increasing the low temperature of zinc become brittle. The component that used at high or low temperature should not be made from zinc because this material has a tendency to experience creep even at room temperature.

The largest portion of zinc production (40%) is used for coating steels to prevent corrosion. Zinc is more anodic than iron, so in a corrosive medium the zinc will be ingested first and the iron will be protected from corrosion as long as zinc is not exhausted. This coating is called galvanizing, spraying or sheardizing.

Another use of zinc that consumes almost (25%) of zinc production is the alloying element in brass. For this zinc purity is very decisive, by using pure zinc brass easier hotwork.

As an engineering material with a low melting point, so does zinc alloy. Zinc alloy is widely used to make castings with die casting. Low pouring temperatures do not easily damage molds made from metal, which are expensive.

Zinc is one type of heavy metal that is widely used for buildings. Liquid point of zinc material 419-785°C with specific gravity 7.14 kg/m^3, 2-10% ductility and temperature of crystallizing 70°C.

The zinc metal is easy to mold with a relatively low cost, clean and flat surface. Zinc is also able to be combined with other alloying elements such as aluminum, copper, and magnesium with the addition of small amounts.

Physical Properties and Mechanical Properties of Alloys

Physical Properties

The physical properties of aluminum and its alloys are the behavior of the material due to heating up to melt, generally the physical properties to note is the material structure. In the presence of heat and cold treatment, in general, aluminum and alloy materials show changes in material structures that are closely related to physical properties.

Likewise loading will provide changes to the structure of the material will also contribute to changes in its physical and mechanical properties.

Mechanical properties

The mechanical properties of aluminum alloys are treated from aluminum resistance to tensile, twist, friction, pressure, scratching charges, both static and dynamic loads under certain conditions.

Then the main factors determining the mechanical properties can occur due to loads, static or dynamic loading conditions, loading frequency, rate or loading speed, duration of loading, environmental conditions (temperature and atmosphere).

In a variety of aluminum or aluminum alloy construction, certain parts are always subjected to loading with different loading conditions. Given the loading experienced by the material, the material will provide a reaction illustrating the behavior of material properties such as loading factors on materials, loading conditions, timing and loading environments.

From the practical realities of aluminum or aluminum alloy materials will show the behavior and resistance to the burden experienced in certain traits such as strength, brilliance, elasticity, plasticity, toughness, suppleness, plasticity, tenacity, hardness and others include:

1. Strength

Ability to resist form changes when external forces occur, tensile strength is one of the properties of materials that can be used to estimate material characteristics in planning a study. Tensile strength can be determined by conducting tensile testing, in which the properties of the material are directly proportional to the inverse comparison force of the initial cross-sectional area.

2. Elasticity

Elasticity is a material property that is defined as the ability of a material to receive strain in certain circumstances, then return to its original shape when the load is released.

3. Persistence

Tenacity is a metallic nature that will deform permanently at the time of loading and after loading is removed.

4. Plasticity

Plasticity is the property of a material when a fixed deformation occurs, the initial incidence of deformation is characterized by hardening of atoms or molecules in the material.

Aluminum and its alloys will undergo static deformation because of their low strength due to distortions that occur so that the atoms or molecules are increasingly shifting.

5. Brittleness

This situation will occur when a material does not undergo plastic deformation if burdened, this property will appear on the metal undergoing cold work so that when loaded there will be no deformation until breaking.

The Casting Process

Casting definition

Casting is one of the processes of metal formation with the addition of alloying elements to produce materials that have certain shapes, characteristics and mechanical properties.

Sand casting technique is casting with mold used in the form of wet sand or dry sand. Silica sand is a type of molding sand that is commonly used because of its refractory properties, it is cheap and easy to obtain. In order to give plastic properties to the molded sands, a number of water and binders such as clay which are usually already contained in the sand or are still added when necessary. To create a mold, a patternthat can be made from wood, metal, or plastic cork (styrofoam) is placed in the molding frame divided into two parts: the upper part is called cup and the bottom is called drag (see Figure 1).

To make the existing product hole required core. The core is usually made of sand with a special binder which in its manufacture requires roasting to dry.

It is intended to obtain high ductility so that the core is not easily broken or exposed to erosion during installation or when pouring. Besides the other important parts of the mold are: pouring plate (pouring basin), the channel system namely the descending channel (sprue) and the inlet (gate). To avoid the shortage of liquid metal due to shrinkage when the freezing process takes place the mold is usually equipped with a backup system reservoiris often called riser.

In general, aluminum-zinc refinement process using sand casting method can be done like the following scheme:

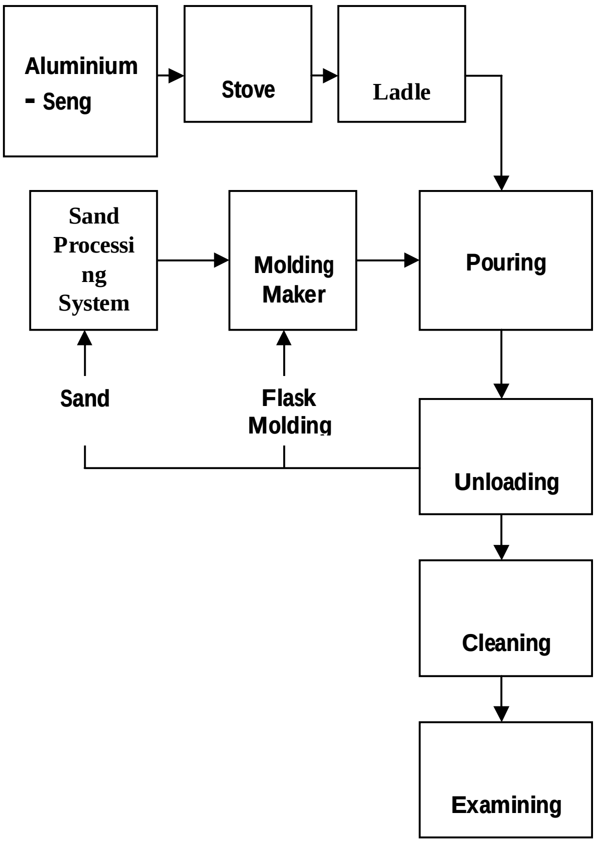

Figure 1 Flowchart of the manufacturing process cast products with sand casting

Tensile Testing

To know the mechanical properties of the material from the casting of aluminum-zinc alloy, it is necessary to do tensile testing in order to know the tensile strength of the material under test.

In the tensile testing of one end of the test piece is clamped firmly and the one end is clamped which is connected to the load measuring device, the test object strain is seen in its relative motion. The stress required to produce a strain is measured using hydraulic, optical or electromagnetic methods. The important dimensions of a tensile test object are:

1. The initial length (L_0) is the actual length.

2. Area of cross section (A_0) is the actual cross-sectional area.

3. The extension that occurs (L_C) is the extension of the specimen due to the given loading.

4. Sectional area that occurs (A_C) is the cross-sectional area of the specimen due to the given loading.

The elongation consists of two parts: elastic extension and plastic elongation, the elastic part occurs as a result of the elongation followed by the elongation time, the plastic strain includes uniform deformation along the uniformly increasing part and a local deformation called necking occurs. The deformation process ends with the breaking of the specimen in the descending area as in the following figure.

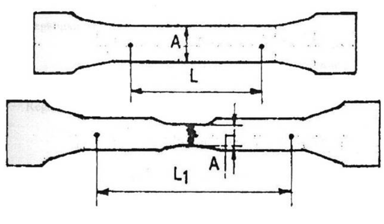

Figure 2 Specimens before and after test pull

The parameters of other mechanical properties are determined as follows:

A. Extension (ΔL)

Extension of the length of the measurement after the fracture is reduced by the initial measuring length:

Extension (ΔL) = L_C - L_0 (mm)

B. Sectional Area (A)

The width of the cross-section is multiplied by the thickness of the specimen

Area of cross section (A) = W x t (mm^2)

C. Strain (ε)

Strain occurring is the ratio between the length increase with the length of the first stem:

$$\text{Strain } (\varepsilon) = \frac{\Delta L}{L_0} = \frac{L_C - L_0}{L_0} \text{ x } 100\%$$

Stress (σ)

The nominal / maximum stress held by the test rod before the fracture caused by the tensile stress which is the ratio between the load and the initial cross section:

$$\text{Stress } (\sigma) = \frac{P}{A_0} \ (\text{kgf/mm}^2)$$

D. Elasticity

The elasticity is when the rod is stretched and subjected to strain but when the tensile load is removed the rod returns as before then the rod is said to be elastic.

E. Modulus of Elasticity (Young Modulus)

Modulus of Elasticity (Young Modulus) is to determine the relationship between load and strain, the cross section of the rod must be known then the working stress can be determined.

So, the ratio between stress and elastic strain called the Elastic Modulus (Young Modulus) is known:

$$\text{Modulus of Elasticity} = \frac{\sigma}{\varepsilon}$$

F. Proportional Limits and Elastic Limits

Occurs when it comes to a point of proportional limit of stress proportional to strain then the results of the graph show a straight line, if limit of elastic stress is no longer proportional to the strain. At this limit the load is removed then the length of the rod will return as it was in the original state. It can be considered that the elastic limit and the proportional limit are not different.

G. Yield Point

If the working load on the test bar continues until beyond the elastic limit there will be a sudden stretch extension of a test bar, this is called the yield point. It is where the strain increases even though there is no increasing in stress (occurs only in soft steel). For some nonferrous alloys of the threshold limit (yield point), it is difficult to detect its limit value, so it can be stated that the yield limit is 0.02% (Figure 3).

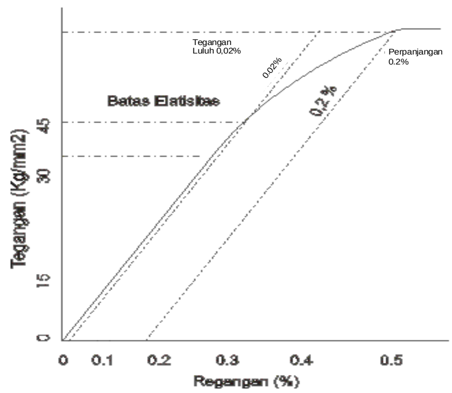

Figure3 Specify the boundary area yield 0.02%on the stress-strain curve

RESEARCH METHODS

Due to the vastness of research methodology, we conduct research by providing research steps to make it easier in the research process undertaken. The research methodology is planned as follows:

A. Literature review

B. Perform data collection testing

Once the importance of the mechanism of research conducted on the analysis of the effect of percentage of Zn worship on the mechanical properties of Zn-Al alloys with sand casting foundry method it is necessary to pay attention and understand the steps.

This data collection test is conducted to obtain the desired properties in the research, before doing the research of aluminum alloy casting should pay attention to the following steps:

1. Preparation of aluminum-zinc material.

2. Weighing the material by using the volume calculation scales.

3. Preparation of mold sand.

4. Preparation of mold model.

5. Preparation of a fusion kitchen.

6. Melting of aluminum-zinc alloy material

7. Casting of aluminum-zinc alloy materials.

8. Mold unloading.

Based on the steps of research methods that are planned on the research methodology above it can provide an overview of the research procedures undertaken.

In this research, aluminum-zinc material will be melted by sand casting technique, this foundry smelting technique uses a melting kitchen equipped with gas combustion system and air mixing.

The materials used in this research consist of SAP aluminum and SAP zinc plates with research and work procedures such as schematic flow diagram below:

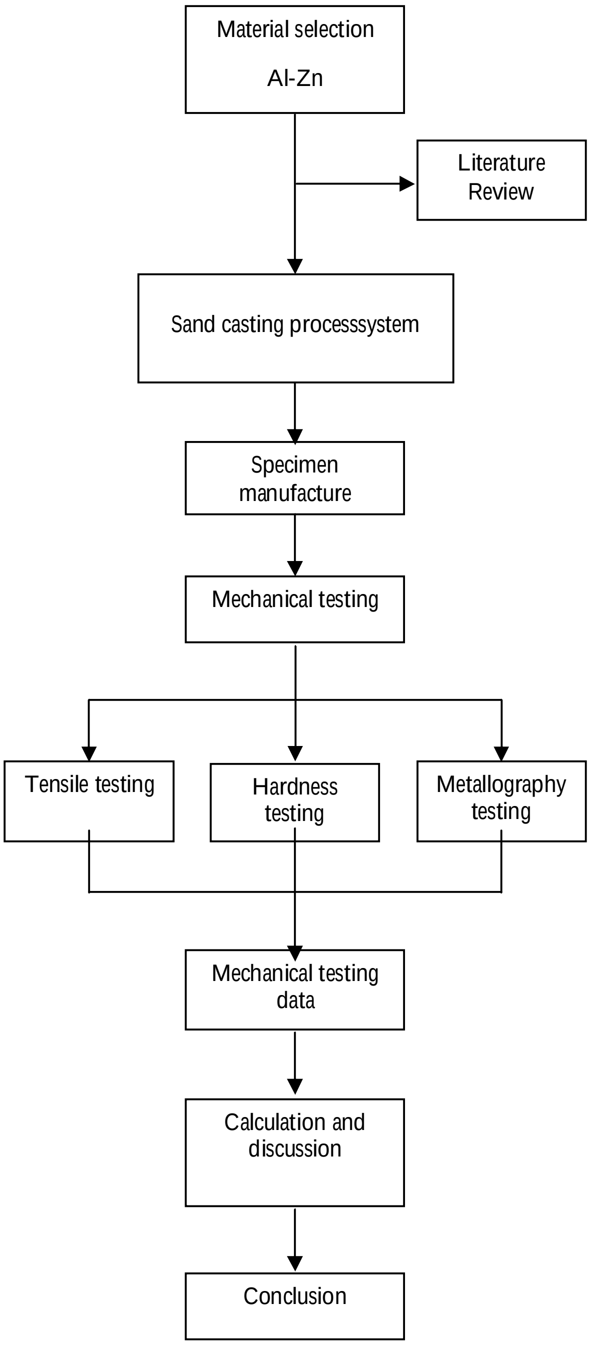

Figure 4 Research Flowchart

DATA ANALYSIS

The result of research conducted from aluminum-zinc alloy casting process by sand casting method in analyzing the data of the research result, it is done mechanical testing with three testing processes that are tensile testing, hardness testing and metallographic test.

Tensile Testing

In the tensile test, it is known that the initial data of the test specimens are L_0, W_0, and t_0 where the specimen is in the form of plates. The specimen data after breaking including L_C, W_C, and $T_C$and so on, so that in the tensile test process can be known the initial load. Maximum load and broken load. Similarly, the data can be used to calculate the strength of the stress and strain and the cross-sectional reduction that occurs as follows:

1. Calculation of Aluminum-Zinc Alloys (Al 75% - Zn 25%)

Specimen I:

A. Data before test pull:
- Initial length L_0 = 60 mm
- Initial width W_0 = 13 mm
- Thickness T_0 = 11 mm
- Cross-sectional area $A_0 = W_0 \times T_0$
$= 13 \times 11\ mm^2 = 143\ mm^2$

B. Data after tensile test
- Maximum load, P_{max} = 357,3726 kgf
- Length after broken L_C = 65,2471 mm
- Width after broken W_C = 12.90 mm
- Thickness after broken T_C= 10.85 mm

Cross section after broken $A_C = W_C \times T_C$
$= 12{,}90 \times 10{,}85 = 139{,}97\ mm^2$

C. Stress calculation (σ)

$$\sigma = \frac{P}{A_0} = \frac{357{,}3726}{143} = 2{,}499\ kgf/mm^2$$

D. Strain Calculation (ε)

$$\varepsilon = \frac{\Delta L}{L_0} = \frac{L_C - L_0}{L_0} \text{ x } 100\ (\%)$$

$$\varepsilon = \frac{5.2471}{60} \text{x}100 = 8.75\%$$

Other calculations can be seen in the appendix (Table 2)

Hardness Testing

In this test, the determination of hardness value is not done by Rockwell (Cone) method, where in the test process an urgent object is pressed into the test specimen the depth of agglomeration remains a measure of hardness, which at the same time can be read on the measuring clock

Given that in this test the material or alloys to be tested has a soft type of material, the scale used is the C scale, where the indenter used is from diamond cones with a given load of 150 kgf.

The results of hardness testing are as follows:

A. Test results for aluminum - zinc alloy (Al 75% - Zn 25%)

Specimen 01 = 30.5 kgf/mm^2

Specimen 02 = 32.5 kgf/mm^2

Specimen 03 = 33 kgf/mm^2

B. Test results for aluminum-zinc alloy (Al 50% - Zn 50%)

Specimen 01 = 32 kgf/mm^2

Specimen 02 = 34 kgf/mm^2

Specimen 03 = 32 kgf/mm^2

C. Test results for aluminum - zinc alloys (Al 25% - Zn 75%)

Specimen 01 = 34 kgf/mm^2

Specimen 02 = 33 kgf/mm^2

Specimen 03 = 35.5 kgf/mm^2

Metallographic Testing

In the process of metallographic testing of aluminum - zinc alloy (Al - Zn), it is of course expected to know the properties of the alloy by looking at the microstructure through the surface smoothing of the test specimen by rubbing technique and giving the etching solution prior to the shooting.The composition for the etching are as follows:

- For Aluminum (Al) using symbol 3 (2 ml HF, 3 ml HCl and 190 ml H_2O)
- For Zinc (Zn) using symbol 200 (A-40 g CrO, 3 g NaSO, and 200 ml H O or B-40 g CrO, 200 ml H_2O).

Conclusion

The conclusions of the research are:

1. In the tensile test it has been shown that the higher percentage of zinc addition (Zn) in the alloy (Zn-Al), the higher the alloy strength (Attachment Table 05, 06 and 07. The result of tensile test)

2. The greater the percentage value of Zn addition to the alloy (Zn-Al) it will have a high strain value or the alloy will be more clay and vice versa will be that the smaller the percentage of Zn in the alloy will be brittle or the value of the strain will be low. Appendix; Graph of stress and strain)

3. The greater the percentage value of adding Zn to the alloy (Zn-Al) will have a high strain value (Appendix; Table 08) of hardness test and graph attachment of specimen tensile stress)

4. With the added percentage of zinc (Zn) value in alloys (Zn-Al), gives a considerable effect on the mechanical properties of the alloy.

Suggestions

1. To be more perfect and accurate research undertaken to note include:

a. Calibrate the measuring instrument or scales before use

b. Observe carefully the size of mixing the required materials

c. The need for digital measuring devices on tensile testing and hardness testing tools for more accurate test results.

2. In order to more perfect the results of the study, it is necessary to multiply the

specimen for each composition of the alloy to be tested.
3. Facilities and other supporting facilities need to be considered considering the foundry process is very determine the results of casting.
4. The foundry should consider the type of material and environmental conditions to produce a perfect material.
5. For the sake of perfect test results for mechanical properties it needs to be equipped again with other mechanical testing methods such as impact testing.

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