Effect of Magnesium and *Copper* Addition in Aluminum 1100 on Tensile Strength and Microstructure

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ABSTRACT
In Indonesia there is abundant aluminum 1100 and aircraft structures also use aluminum because it has the advantage of light weight and good corrosion resistance, but aluminum 1100 itself has the disadvantage of being easily brittle. Testing will be carried out by melting aluminum 1100 and then adding several chemical elements, namely magnesium and *copper. The* addition of these elements can improve the mechanical properties of aluminum 1100. The final result of the tensile strength value in this study, the highest number is in specimen 12, namely with a variation in the composition of aluminum alloy (Al) 93.60%, copper (Cu) 4.9% and magnesium (Mg) 1.5% with a value of 75.96Mpa. While the results of the lowest tensile strength value obtained in specimen 1, namely with variations in the composition of aluminum alloy (Al) 94.90%, copper (Cu) 3.8% and magnesium (Mg) 1.2% with a value of 60.49Mpa. In specimen 7 to specimen 12, it increased by 14.28%.

Keywords: Aluminum 1100 alloy, mechanical properties

1. INTRODUCTION

Aluminum metal is widely used for machine elements, building construction, automotive components, aircraft components, office equipment, household appliances. The advantage of aluminum compared to other metals is that it has lightweight properties, easy to shape and good corrosion resistance. However, the properties of aluminum metal need to be improved again by means of various methods, including adding *magnesium* and *copper* elements to complement the deficiencies in aluminum. Aluminum is the most abundant element in the atmosphere, accounting for about 8% in nature. Aluminum is an element that has improved physical and mechanical properties of aluminum, high availability of raw materials, and better manufacturing techniques. Until now, aluminum alloys continue to increase following various industrial needs such as the commercial aircraft industry which requires materials with large sizes but does not reduce strength, light weight, long service life, low production costs, high failure tolerance, and good corrosion resistance.

100% pure aluminum does not contain any elements other than aluminum itself, but pure aluminum sold in the market never contains 100% aluminum, but there are always impurities hanging in it. Impurities that may be in pure aluminum are usually gas bubbles that enter due to incomplete melting and cooling/casting processes, mold material due to poor mold quality, or other impurities due to poor quality raw materials (for example in the aluminum recycling process). Generally, pure aluminum sold on the market is 99% pure aluminum, such as aluminum foil.

Aluminum has become a widely used metal after steel. This development is based on its properties of light weight, corrosion resistance, good strength and *ductility* (aluminum alloys), ease of production and economy (recycled aluminum). The most famous use of aluminum is as a material for aircraft skins, which take advantage of its lightweight and strong properties. Aluminum 2024 is known for its high strength due to the presence of copper, magnesium, and manganese alloys in aluminum 2024 that can improve the mechanical properties of aluminum.

Sanders (2001), states in its pure state aluminum is very soft, ductile and not so strong. Pure aluminum has a tension strength of 49 MPa. Aluminum has a shiny silver color, the color changes to light gray due to the formation of oxides when placed in the air. This oxide is very ductile and fire resistant. In its pure state, the melting temperature of aluminum is 660 ° C, for its alloy melting temperature between 520 ° C and 660 ° C.

Muhammad Nur Saiful (2021) examined the effect of variations in copper concentration on hardness and tensile strength values in 1100 aluminum castings. In the tensile test, the highest voltage was achieved with the addition of 6.5% copper, namely 91.76 MPa. While the lowest value was achieved at 0% copper addition, namely 66.40 MPa. The highest strain value with copper concentration of 4.5% is 0.039%. While the lowest is found in the addition of copper by 6.5%, namely 0.017%. In the Rockwell hardness test, the highest hardness value was obtained with the addition of copper by 6.5%, namely 69.1 HRB. While the lowest hardness value was obtained with the addition of copper at 0%, namely 57.03 HRB.

2. METHODS

2.1. Specimen Making

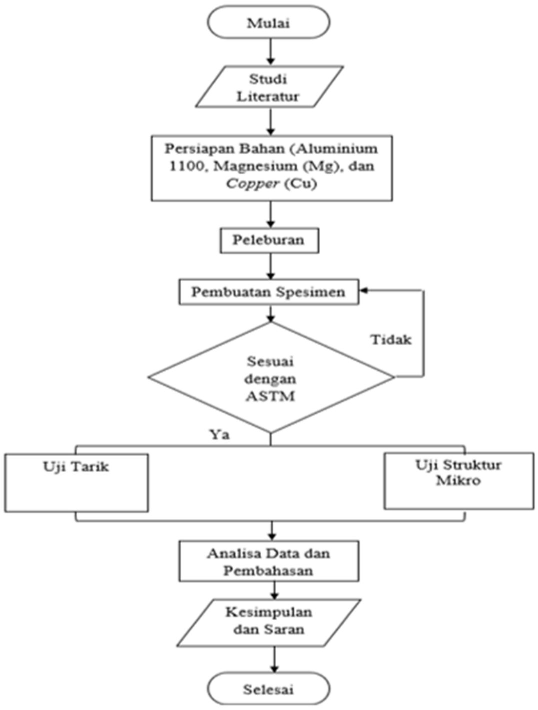


Figure 2. 1 Research Flow Chart

a. Tensile Testing Specimen

The test material needed for this research is in the form of a slab, which is then made into a test specimen by casting then formed using a cutting tool at the *Welding* and *Sheet Metal Shop* Hangar AMTO 147D/010 Aviation Polytechnic Surabaya. Testing with test specimen sizes in accordance with ASTM E8/E8M standards used in tensile testing. Sketches and sizes of materials that will be used as test objects for tensile, namely:

Gauge Length = 25 mm
Thickness = 10 mm
Width = 6 mm
Cross-Sectional Area = 36 mm
Grip Section Length = 30 mm
Grip Section Width = 10 mm
Fillet Radius = 25 mm
Overall Length = 100 mm

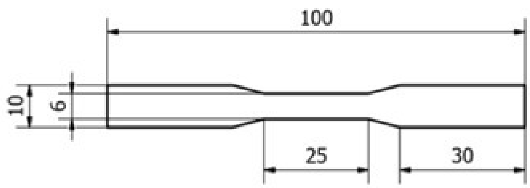


Figure 2. 2 Tensile Test Specimen Dimensions

b. Microstructure Testing Specimen

The test material to be used in microstructure testing is *Aluminum Alloy* 1100 which has been mixed with magnesium and *copper*, with test piece dimensions of 5 mm x 5 mm x 5 mm in accordance with ASTM E407 standards as shown below.

Length = 5 mm
Width = 5 mm
Thickness = 5 mm

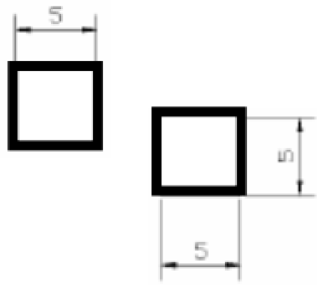


Figure 2. 3 *Charpy Impact* Test Specimen Dimensions

2.2. Tensile Test

This test is carried out to provide a safe point for the use of these materials for the needs of a production, so that this test will know the maximum load and maximum stress on the test piece. The tensile testing process is as follows:

1. Tensile test specimens are molded in accordance with ASTM E8
2. The specimen is mounted on the upper and lower clamps of the test apparatus. The lower clamp is raised and lowered at a slow speed, so that the test specimen is in the right position, so that the position of the specimen is completely vertical, then the clamp is tightened ...
3. The specimen is given a tensile load at a speed of 10 mm / second, so that the test specimen will experience an increase in length until the test specimen is broken or broken. The break is expected to occur at the gauge length of the specimen.
4. The data obtained is then recorded during the tensile testing process (load increase (P) and length increase (ε)) at specified intervals. The handle was set in the up position.
5. The results of the maximum tensile load and tensile

strength of the broken specimen are recorded. Slowly release the forward handle. Do not push the handle down, but let the handle move itself downward. The large needle on the scale will move as the handle moves downward. Wait for the large needle on the scale to stop on its own.
6. The result of length increase listed on the tensile testing machine is recorded after the specimen is broken.

Figure 2.4 Tensile Testing Machine

2.3. Microstructure Test

Microstructure testing aims to observe the micro*structure of* aluminum, especially to observe changes in the microstructure of the material after the addition of magnesium and *copper* elements. Microstructure testing includes the following steps:

1. The specimens were smoothed using sand paper.
2. Place the test specimen in the micro test tool.
3. Connect the micro test equipment to the computer.
4. Next, adjust the lens until the microstructure is visible.
5. After the image is clearly visible screenshoot or take a picture.
6. Observe the shape of the microstructure that appears.

Figure 2.5 Micro Testing Machine

3. RESULTS AND DISCUSSION

In this study, two tests were carried out, namely tensile testing and microstructure testing to determine the strength of the mechanical properties of *aluminum alloy* 1100 which has been mixed with Mg and Cu. *In* addition, the test results obtained data on the distribution of tensile strength and microstructure values.

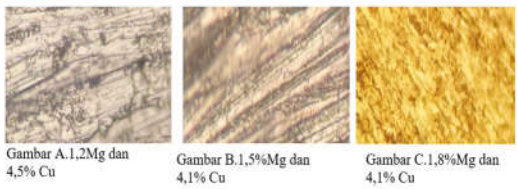
3.1. Tensile Testing Results

This test aims to determine the tensile strength and strain on the specimen. The specimens used in this test have variations of 1.2%, 1.5%, and 1.8% magenisum and 3.9%, 4.1%, 4.3%, 4.5%, 4.7% and 4.9% *copper*. The data of tensile testing results.

From the results of the ultimate stress tensile strength test, it can be seen that the graph rises due to the addition of Mg and Cu elements. Comparison of ultimate stress values in mixed materials between aluminum 1100 with variations of Mg and Cu results in the highest comparison value obtained from materials with a mixture of 1.5%Mg and 4.9%Cu with a result value of 75.96 MPa. So it can be concluded that the addition of magnesium and copper affects the ultimate stress tensile strength where the more the concentration of the mixture, the more it will increase.

3.2. Microstructure Testing Results

This test serves to determine the ferrite and pearlite content in the specimen. The specimens used in this test have variations of 1.2%, 1.5%, and 1.8% magenisum and 3.9%, 4.1%, 4.3%, 4.5%, 4.7% and 4.9% *copper*. Stages in conducting microstructure tests using the Dino Eye machine.



From the micro test results in Figures A, B, and C, it can be seen that Figure A has more porosity compared to Figures B and C. Likewise, picture C has a tighter density than pictures A and B. So from the results of this microstructure test, a conclusion can be drawn that the addition of Mg and Cu elements affects the shape of the microstructure.

4. CONCLUSION

The conclusions that I can get from the final project testing that I have done are as follows:

1. The effect of adding variations of Mg and Cu affects the microstructure where the more the percentage of addition, the less ferrite there is.
2. The results of the tensile strength value in this study, the highest number is in specimen 12, namely with variations in the composition of aluminum alloy (Al) 93.60%, copper (Cu) 4.9% and magnesium (Mg) 1.5% with a value of 75.96Mpa. While the results of the lowest tensile strength value obtained in specimen 1, namely with variations in the composition of aluminum alloy (Al) 94.90%, copper (Cu) 3.8% and magnesium (Mg) 1.2% with a value of 60.49Mpa.

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