Wear and mechanical properties of Al-6%Cu-X%Mg alloy fabricated by powder metallurgy

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Abstract. It is projected to present the experimental results in wear and mechanical properties of aluminium alloys fabricated by powder metallurgy method. In this study, 6% of copper and the effect of magnesium (2%, 4% and 6%) in aluminium alloy were examined. From the results, the density and hardness values were decreased by increasing the magnesium. The abrasive wear test showed that the wear loss decreases when adding magnesium and increases with the increase in load and sliding distance. Optical microstructure shows that uniform distribution of elements.

Keywords. Aluminium, magnesium, powder metallurgy, hardness, microstructure

1. Introduction

The elemental copper can be introduced with addition of different elements such as (Al, Zn Cr, Ni, Sn, Pb, Nb, Be) in order to enhance the intrinsic properties of synthesized alloys [1]. Copper have different percentage of Aluminium that is incorporated as a major alloying element usually in the range 5% to 14% but other alloying elements such as Nickel, Manganese, Silicon and Tin with varying proportions, subjected to applications of Aluminum alloy. Aluminum - copper gives better mechanical properties which intermix with other alloying element for critical application. It was presented mass percentage composition of copper and aluminum alloys [2]. Powder Metallurgy processing is carried out for achieving high level of thermal and mechanical properties of alloys. For this purpose, various approaches such minimizing porosity level, decrease pores in the structure and suitable sintering temperature were utilized. Sintering activities by different routes under vacuum or Argon supply is accepted that to avoid grain growth in the structure. Wear is one of the most essential phenomenons that take place at a materials interface [3]. An important perfection in the surface value to uniform distribution of powder particles [4]. In adding up, magnesium alloys possess fine damping capacity, exceptional castability, and better machinability [5]. In the present attempt, the key intend is to study the prospect of the production of aluminium-copper-magnesium alloys by P/M technique.

2. Experimental procedures
2.1. Specimen preparation

Aluminium alloys are made-up by the P/M way. Aluminium is worn as the matrix material in the current revision. This matrix is selected because it provides an individual mixture of burly point and harm tolerance at major and cryogenic temperatures. Table 1 provides the details of composition. Powder mixtures with calculated concentration of 2, 4, and 6 vol. % Magnesium and 6% of copper are mixed by ball milling for 3 h, and be cold pressed uniaxially into cylindrical preforms (18mm dia and 25mm height) at pressures of ranging from 250 MPa. The immature preforms are heated to 510°C in a furnace, kept 1 hr for soaking.

Table 1. Details of reinforcements

| Sample No. | Al (%) | Cu (%) | Mg (%) |
|------------|--------|--------|--------|
| 1          | 94     | 6      | 0      |
| 2          | 92     | 6      | 2      |
| 3          | 90     | 6      | 4      |
| 4          | 88     | 6      | 6      |

2.2. Density and Hardness measurement

The theoretical density of Al alloy was calculated using the rule of mixtures. Hardness of sample was performed in Rockwell hardness tester at B scale with a ball diameter of 1/16 inch and a load of 100 kgf. The hardness test was performed in altered regions on the surface of sample. Table 2 shows the density and hardness (HRB) of the samples.

Table 2. Density and hardness value

| Sample No. | Density (g/cc) | Hardness (HRB) |
|------------|----------------|----------------|
| 1          | 3.0756         | 27.5           |
| 2          | 3.05636        | 26.2           |
| 3          | 3.03712        | 25.3           |
| 4          | 3.01788        | 24.1           |

2.3. Wear testing

Dry sliding wear tests were performed by via pin-on-disc (Ducom, model No: TR-201 apparatus) as per ASTM G99 standard. The contradict disc material be EN31 steel. Ahead of testing, pins and disc surface be cleaned by acetone. Every test be performed varying sliding distances of 500, 1000, 1500 and 2000m at constant load 20N and sliding speed 1m/s were employed. Following each test, the specimen and counteract face disk be cleaned with organic solvents to take out traces. The pin be weighed prior to and past testing to an accuracy of 0.1 mg to find out the full amount of wear loss.
3. Results and discussions

3.1. Metallographic analysis

Metallographic analysis offers a foremost feature manage as well as an essential methodical tool. The structure of grains, size, and distribution particles were observed using Olympus, model No. BX41M-LED microscope [5]. Figure 1a and 1b shows the microstructure of pure 0 and 6% Mg composition into Al alloy fabricated by powder metallurgy process.

![OM image of 0%Mg aluminium alloy](image_url)

**Figure 1a.** OM image of 0%Mg aluminium alloy
3.2. Density and hardness

Figure 2 shows the disparity of density of samples. It is experiential that there is diminish in density with enhance in Magnesium. Figure 3 shows the dissimilarity of hardness of the samples. It can be understood from Figure 3 that the hardness of the Al alloy was decreased with enhances in weight percent of Magnesium.

Figure 1b. OM image of 6%Mg aluminium alloy

Figure 2. Variation of density of samples
3.3. Effect of sliding distance

It is experiential that there is a decrease in coefficient of friction by means of increasing sliding distance for Al-Mg alloy at the various sliding distance 500, 1000, 1500 and 2000m respectively, constant load range 20 N and sliding speed 1m/s shown in table 3. Also Al-6C-6Mg alloy has less coefficient of friction compared to Al-6C-0Mg, Al-6C-2Mg and Al-6C-4Mg alloys. This is because of the variation of magnesium content. Also table 3 shows the disparity of wear loss with sliding distance at a steady sliding speed of 1 m/s and for a fixed constant load of 20 N. It is experiential that the wear loss faintly decreases with the addition of Magnesium into Aluminium alloy.

Table 3. Wear loss and Coefficient of friction at 20N and 1m/s

| Sample No. | 500m Wear loss (gm) | 1000m Wear loss (gm) | 1500m Wear loss (gm) | 2000m Wear loss (gm) | COF | COF | COF | COF |
|------------|---------------------|----------------------|----------------------|----------------------|-----|-----|-----|-----|
| 1          | 0.0017              | 0.0018               | 0.0019               | 0.0021               | 0.12| 0.13| 0.15| 0.17|
| 2          | 0.0014              | 0.0016               | 0.0017               | 0.0019               | 0.15| 0.16| 0.17| 0.18|
| 3          | 0.0001              | 0.0012               | 0.0014               | 0.0015               | 0.17| 0.18| 0.18| 0.19|
| 4          | 0.0008              | 0.0011               | 0.0012               | 0.0013               | 0.18| 0.20| 0.21| 0.22|

4. Conclusions
Al-6%-X%Mg alloy has been effectively residential by powder metallurgy technique. The density, hardness, optical microstructure and abrasive wear were evaluated. As compared with pure Al-6%cu aluminium alloy, the density and hardness of Al-6%cu-X%mg (X=2, 4, 6) alloy decreased. Optical microstructure analysis shows that uniform distribution of various elements. The addition of Magnesium contents to Aluminium alloy increases the wear conflict. The developed alloy has revealed superior wear resistance and less coefficient of friction when compared with matrix material.

5. References

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