Investigation on Mechanical Properties of Aluminum with Copper and Silicon Carbide Using Powder Metallurgy Technique

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ABSTRACT

This project is to investigate the performance of Aluminum with different composition of Copper and Silicon Carbide in producing alternative material for engineering application. Powder Metallurgy (P/M) is a manufacturing process in which powders are compacted in a die to attain the final product. Aluminum (Al) is a light weight material, but pure Al does not possess a good strength. To achieve the strength, Copper (Cu) and Silicon Carbide (SiC) powders are blended at required proportions. Al along with Cu & SiC shows good mechanical properties. As the adding of silicon Carbide higher and higher the BHN value is increased.

KEYWORDS: Powder Metallurgy, Al, Cu, Sic, BHN, and Density

INTRODUCTION

In conventional manufacturing processes such as forming, casting, machining etc., the raw materials used are often in the form of solid materials or solids melted to liquid state. A new class of manufacturing process, called powder metal forming has emerged in recent times. Powder forming utilizes metal or alloy powders as raw materials in order to obtain finished parts of high precision and accuracy, at competitive costs. Considerable saving in raw material could be achieved in powder forming, as very little after-machining is required for the formed powder metal components. Aluminum alloys are alloys in which aluminum (Al) is the predominant metal. Aluminum alloys are widely used in engineering structures and components where light weight or corrosion resistance is required. Aluminum-magnesium alloys are both lighter than other aluminum alloys and much less flammable than alloys that contain a very high percentage of magnesium. Aluminum- Copper Alloys, Copper may not be strong, but it is not easy to break due to its high toughness. The typical alloying elements are copper, magnesium, manganese, silicon, tin and zinc [8]. The efficient P/M process delivers excellent dimensional precision, consistent and homogenous material performance, and net shape capability that requires only minimal secondary finishing [4]. This property comes in handy for piping and tube applications [8]. The Objective of this project is to increase the Hardness of aluminum Alloy.
1.1. Literature Review:

- [5] A lot of smart possessions are reported for the engineering implication of Al and its alloys. They are mentioned as good mechanical strength and corrosion resistance, low density and cost advantage depending on the manufacturing method higher thermal and electrical conductivities. The claim and fabrication of light weight and near net shape high-quality Al alloys by Power metallurgy practice has enlarged, in particular, for the aerospace and automotive purposes.

- [6] The addition of Cu between the butt joint up to 3g (0.25wt.%) resulted in increased ultimate tensile strength (UTS), yield strength (YS) and hardness with a marginal decrease in ductility, this can be attributed to precipitation strengthening by copper precipitates. In the post-weld annealed condition, the weldments made by the addition of 2g Cu (0.18wt. %) possess slightly superior ductility compared to all other Conditions. This can be attributed to the equated morphology of fusion zone grains in the FSS welds. There is a marginal improvement in the hardness of FSS weldments with 3g Cu (0.25wt. %) addition in post-weld annealed condition. This is due to precipitation hardening effect of copper.

- [1] In the powder metallurgy process, the industrial pieces are produced through compacting powder in the frame and sintering within a controlled setting disadvantage is the production of a workpiece with poor mechanical properties due to its porosity. The smaller powders go down and also higher strengthened products are achieved using smaller powder sizes,(Squire, 1947 and Park et al., 2004 and Gibbs-Thomson, 2003 and Fillabi et al., 2008). Sintering temperature, pressure, keeping time, powder density, and bits’ size are the most important parameters on which the hardness of the produced piece is dependent on. The researchers have shown that the effects of the parameters on the hardness are very intricate and their influence may change when the size of the particle decreases.

MATERIALS AND METHOD

Material composition: Aluminum alloy composition is Aluminum 90% - 95% and Copper 5% and Silicon Carbide 1% - 5%. Example sample 1 contain Aluminum 90%, Copper 5% and Silicon Carbide 5%.

2.1 Mixing and Blending:

A single powder may not fulfill all the requisite properties and hence, powders of different materials with wide range of mechanical properties are blended to form a final part. The Powders Al, Cu, SiC are taken in the ratio of 90:5:5 by weight. The powders are blended and mixed in the ball milling for 8 hours continuously. The ball mill consists number of ceramics balls. This balls are used in order to achieve fine and uniform mixture of Al, Cu and SiC powders.

2.2 Compacting:

The blended powders are compacted using circular die with uniaxial load with the help of Universal Testing Machine (UTM). The diameter of the die is 25mm. The powders are poured in the opening of die. After that the load is applied on the punch with the help of UTM for compacting the powders. The different loads applied on the punch for compaction is 250 KN. The compaction is carried out with and without influence of lubricant. The lubricant used in this experiment is Castrol oil. Aluminum powder is softer than iron based powder materials which allow for compaction at low pressures resulting in less wear and exceptional tooling life. The compacted specimen is shown in the below figure.

![Compacted Specimen](image-url)
2.3 Sintering:

Sintering is conducted in specially designed continuous furnaces with excellent temperature control which includes de-lubrication, sintering, and gas quench sections. Sintering temperatures are relatively low (typically at about 600 °C) and the atmosphere is 100% high purity nitrogen. Each furnace is capable of producing millions of parts annually.

RESULT AND DISCUSSION

Fig.2: Methodology

The purpose of adding Cu and Sic with Al to increases the hardness value of the specimen. As the hardness value is increased gradually. Hardness test conducted with an applied load of 150kg.

Table 1: Results for various composition

<table>
<thead>
<tr>
<th>Sample</th>
<th>Composition(Al:Cu:SiC)</th>
<th>BHN</th>
<th>Density(g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90:5:5</td>
<td>62.4</td>
<td>2.7971</td>
</tr>
<tr>
<td>2</td>
<td>91:5:4</td>
<td>61.1</td>
<td>2.7542</td>
</tr>
<tr>
<td>3</td>
<td>92:5:3</td>
<td>60.6</td>
<td>2.8005</td>
</tr>
<tr>
<td>4</td>
<td>93:5:2</td>
<td>59.4</td>
<td>2.7648</td>
</tr>
<tr>
<td>5</td>
<td>94:5:1</td>
<td>58.2</td>
<td>2.7869</td>
</tr>
</tbody>
</table>

The density and hardness of specimen is taken and plotted in the table. As the table shows clearly that the Brinell Hardness Number(BHN) is high for sample 5 that is 90:5:5 composition. When the silicon carbide composition is increased then value of hardness is increased. As for the density obtained 2.8005 g/cm³.

Fig.2: Graph BHN Vs Samples
Conclusion:

From the result and discussion it is concluded that the hardness and density is increased with the different composition. In this experiment Al-cu & SiC powders are compacted and sintered in the different combinations. The result obtained that the sample 1 contain 90:5:5 have the higher hardness number than any other composition. The density obtained is 2.8005 g/cm$^3$ which is nearly to the theoretical value. From the result it is clear that the adding of SiC lead to increases the hardness value of the sample.

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