Investigation on mechanical behaviour of Al-6061 SiC Metal Matrix with Ni composite

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ABSTRACT

In today's world, the requirement of light, inexpensive, and quickly processed materials has increased to a great extent. Composite materials that main have their constituent part as metal are called Metal Matrix Composites (MMC). Reinforcement is used to improve different properties of the main material, such as wear resistance, hardness, fatigue resistance, friction coefficient, thermal conductivity, etc. Aluminium alloy (Al-6061) reinforced with silicon carbide and Nickel micro size particles and fabricated by using a stir casting process was investigated for its mechanical properties. The mechanical characteristics of the composition (Al-6061 - SiC - Ni) are studied by varying the Ni composition as 1wt% and 2wt% and 3wt% and by keeping the composition of SiC as 5wt%. The mechanical properties that were obtained by undergoing various tests were compared and studied. Their behaviour according to the various tests were tabulated and the results that are obtained were also plotted in a graph.

Keywords: Aluminium, Lightweight material, mechanical properties, silicon carbide

1. INTRODUCTION

The composite material is a material made from two or more materials with significantly different physical and chemical properties that when combined, produce material of distinguished properties. Dileep et al stated aluminium alloys play a vital role in engineering applications due to its low density when compared to other alloys and due to their mechanical properties like hardness, tensile strength, fatigue resistance, thermal conductivity, etc. In this paper Al-6061 is used as a base material which has its different characteristics is combined with SiC and Ni microparticles which also contains significant properties to produce a material of distinguishing characteristics. Generally, the Mechanical Properties of Aluminium got increased by about 87% by the addition of SiC as reinforcement and the addition of Nickel increases its strength and corrosion resistance of the material [1]. Pawel et al mentioned composite containing SiC and Ni can be used for high-temperature applications such as pressing, sintering etc. [2]. SiC and Ni as reinforcement are reinforced to the base matrix. Ni is varied from 1% to 3% by having SiC as constant and the mechanical properties were carried out. Next to steel we can prefer aluminium for the best mechanical property and easily available throughout the world. In this work aluminium is taken as matrix and silicon carbide is taken as reinforcement in different composition. The objective of the work is based upon mechanical testing.
2. EXPERIMENTAL PROCEDURE:

Ulhas et al described the stir casting are considered as one of the convenient methods and which is also commercially practised [3] to cast Aluminium metal matrix, simple, less expensive and can be used for mass production [4]. The melting temperature of Aluminium is about 660.3°C [5], Hence, initially, Al6061 bar is made into small pieces to make the melting process easier and the furnace is allowed to reach the temperature of about 850°C which takes about 1 hour. Later the melting temperature in the machine is also allowed to reach 800°C. Once the required temperature reaches, Al6061 is put into the furnace and the temperature is maintained for more than 1 hour to reach its molten state. The weighted proportion of the reinforcements (SiC, Ni) is added to the molten Aluminium manually and stirred by using stirrer for more than 30 minutes.

Once the stirring process is completed the molten Aluminium which contains SiC and Ni is made to pour into the mould. Ravindran et al explained the cast is removed from the mould after 24 hours and it is coated by wax for the next cycle of the casting process. Four samples were prepared to investigate the mechanical properties of Al-Sic-Ni composition. The percentage of composition of these samples were given in table 1 and the images of the tested specimen are shown in fig.1.

| Sample No | Percentage of Composition        |
|-----------|----------------------------------|
| 1         | Al(94%) + SiC(5%) + Ni(1%)       |
| 2         | Al(93%) + SiC(5%) + Ni(2%)       |
| 3         | Al(92.5%) + SiC(5%) + Ni(2.5%)   |
| 4         | Al(92%) + SiC(5%) + Ni(3%)       |

Figure 1: Tested specimens

3. RESULTS AND DISCUSSION:

The mechanical properties like tensile strength and compressive strength were investigate for all the four samples. Yield strength and Hardness were investigated for sample no.1,3 &4. The results are discussed below.

3.1 Tensile strength:

Four specimens of different proportions were properly machined according to the ASTM E8-16a standard and tested by using UTM. The tensile strength and Compression strength data of the specimens are given in Table 2.
On tensile strength analysis, it is found that the strength increases from sample 1 to sample 3, but suddenly there is a decrease in the strength when the Ni increases to 3%. So one more specimen with 2.5% of Ni has been made and checked for tensile and compressive strength. The results are showing decreases after 2% of Ni with Al composites for tensile strength and compressive strength increases. Research is going on this area on which there is a sudden decrease in the strength of the material when the percentage of Ni varies from 2% to 3%. The results were plotted and shown in fig. 2.

### Table 2: Mechanical properties of Al6061-SiC-Ni

| Sample No | Tensile Strength (MPa) | Compression strength (MPa) | Yield Strength (MPa) | Hardness (Vickers) |
|-----------|------------------------|-----------------------------|----------------------|-------------------|
| 1         | 95.94                  | 114.01                      | 82.6                 | 61                |
| 2         | 101.28                 | 164.48                      | 91.43                | 64                |
| 3         | 99.56                  | 173.92                      | -                    | -                 |
| 4         | 96.84                  | 185.01                      | 93.63                | 67                |

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**Figure 2.** Tensile and Compression strength for four samples with different content of Ni.

3.2 Compression strength:

Compression strength of the material is tested in ASTM E8-16a standard specimen. The results obtained were tabulated in table 2 and plotted in figure 1. On analysing the results, it is found that the compression strength increases as the Ni content in the composite increases. The sample containing 3% of Ni has more compression strength when compared to other samples.

3.3 Yield Strength:

Yield strength of the material is tested for various compositions and the results obtained were given in table 2 and the results were plotted in figure 3. It is found that Yield strength of the material increases as the percentage of Ni content increases from 1% to 3%. Hence, it is found that the Yield strength of the material greatly depends upon the reinforcement added to the matrix.
4.3.4 Hardness:

Hardness of the material plays a major role in the applications of the material in various sectors of mechanical field [6]. Hardness test of the specimen was carried out based on ASTM E3-11 (RA17) standard using Vicker’s micro-hardness testing machine. The results obtained were tabulated in Table 2 and plotted in Figure 4. From the graph, it is found that hardness of the material mainly depends on the reinforcement (Ni). As the percentage of the Ni increases hardness of the material increases drastically. In other words, the hardness of the material is directly proportional to the Ni content in the material.

**Figure 4.** Hardness for three samples with different content of Ni.

4. CONCLUSION:

Three different compositions of Al metal matrix composites were analysed. Tensile strength of the material increases when the Ni proportion varies from 1% to 2% and decreases from 2 to 3% of Ni. So, tried with 2.5% of Ni, again results are showing the strength decreases, when increasing more than 2% of Ni along with Al2O3. On analysis it is found that the material possesses good compression, yield strength and hardness. Thus, from the above research, the material with increasing % of Ni possess better compression, yield strength and hardness, whereas tensile strength has been reduced when increasing more than 2% Ni along with Al6061-SiC.
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