Development and Study of the Tensile Properties of Aluminium-AA2618 Alloy/ White SiC Metal Matrix Composites

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ABSTRACT

The present research involved the accumulation of aluminium AA-2618 alloy, weighed along with calculated amounts of increasing weight percentage of white SiC particulates. The composites were separately prepared by combining the matrix material and the reinforcements by using Stir Casting technique before the individual specimens were machined to specified standard testing dimensions. Conduction of tensile tests of all composite test specimens followed. The results and conclusions were analyzed and compared with the individual results of other composite specimens and the base alloy of the same category to help determine the nature of the trends that arise due to the incremental addition of reinforcement particulates into the matrix material in order to determine their potentiality for application in various industrial fields and sectors.

Keywords: *Aluminium AA-2618 alloy, SiC, Metal matrix composites, Tensile test*

1. INTRODUCTION

The two types of constituent materials of all known composites are known as matrix material and reinforcements. The matrix material is usually the material with the largest volume fraction, inside which the reinforcement material(s) are embedded. With the addition of SiC particulates as reinforcements to the aluminium alloy matrix, certain mechanical properties of the produced composite get enhanced [1]. A uniform distribution of the SiC reinforcement particles leads to the enhancement of the mechanical properties of the composites [2]. Among the different processes available to manufacture composite materials, Stir casting remains the most economical method which can be adopted [3 & 4]. However, it should be noted that during the manufacturing of composites using stir casting technique, process parameters such as location of the stirrer, stirring speed and processing temperature have a significant impact on the final mechanical properties of the composites [5]. Applications using Aluminium MMC technology will continue to grow in the future through many industries such as Automobile, Aerospace, Electronic, Research and Development, Military, Defence, Manufacturing and Construction industries due to their improved mechanical and tribological properties or combinations of properties [6].

2. EXPERIMENTAL PROCEDURES

2.1. Selection of matrix material

The present research involves the selection of Aluminium AA-2618 alloy as the matrix material. The alloy was popularized due to its malleable strength-to-weight, durable, and ductile nature. It is easily machineable and possesses good anti-corrosive properties. Practical applications of the alloy are included in aerospace, aviation, defense and automobile sectors. Its chemical composition is tabulated in Table 1 below.

Table 1: Chemical composition of AA-2618 alloy in percentage

Al	Cu	Fe	Mg	Si	Ni	Ti
93.7	2.3	1.1	1.6	0.18	1	0.07

2.2. Selection of reinforcement

White Silicon Carbide (SiC) powder is selected as the reinforcement material for the current research over black SiC powder due to its greater purity and thus, better properties. Some key properties of SiC which make it a desirable reinforcement material include low density, high strength, low thermal expansion, high thermal conductivity, high Young's modulus, chemical inertness and high hardness.

2.3. Preparation of composites

The composites' castings were prepared by Stir casting method. Collected aluminium AA-2618 alloy was melted in the furnace to liquidus temperature (450^{o}C). The temperature was increased to 680^{o}C. The alloy was allowed some time to melt, following which the temperature was slowly raised to 800^{o}C. The reinforcement was preheated to 500^{o}C. The reinforcement was then added to the matrix melt in the furnace and stirred manually. Degreasing tablets (K_2TiF_6) were then added to the melt. Slag was then removed and the melt was thoroughly stirred. The melt was finally poured into the preheated die. The formed composites were allowed to cool for a few hours to room temperature before the cast was withdrawn from the die.

2.4. Tensile test

The test specimens were prepared according to the standard "ASTM E8M-15a". The testing took place using a Universal Testing Machine at room temperature. After yielding, the specimens failed, at which point the modulus of elasticity and the tensile strength were measured.

3. RESULTS AND DISCUSSIONS

3.1. Tensile test results

3.1.1. Yield strength

Figure 1 shows the trend in the values of yield strengths of the specimens with increasing weight percentage of the embedded reinforcements. Beyond a critical weight percentage of SiC reinforcements added to the matrix material, the reduction in the yield strength of the composite may be the result of the increase in the ratio of the formation of accumulates or clusters of SiC reinforcement particulates and matrix-reinforcement interface compounds at indefinite regions inside the aluminium alloy matrix. From the results, it can be concluded that, by adding SiC reinforcement particulates to the alloy to produce its composites, improved Yield strength is achieved due to the fact that the elastic modulus of the SiC reinforcement particles is much higher compared to the aluminium alloy matrix.

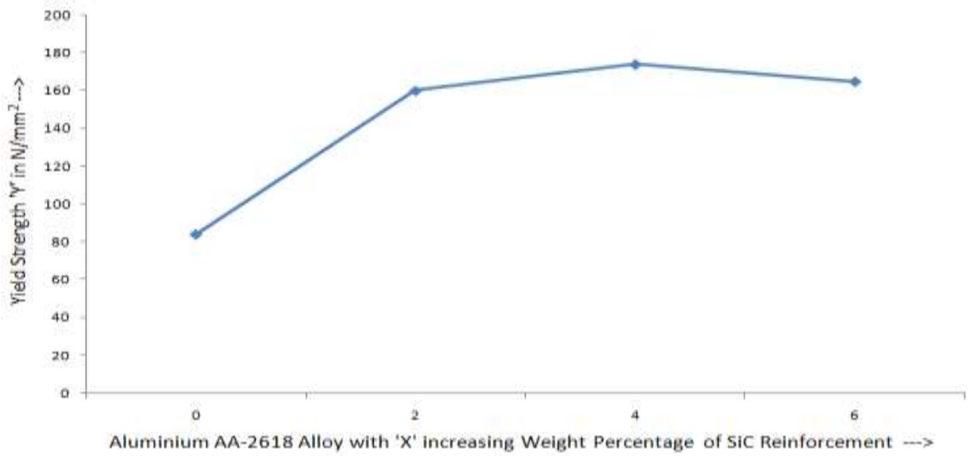

Figure 1: Effect of SiC reinforcements on yield strength

3.1.2. Ultimate tensile strength

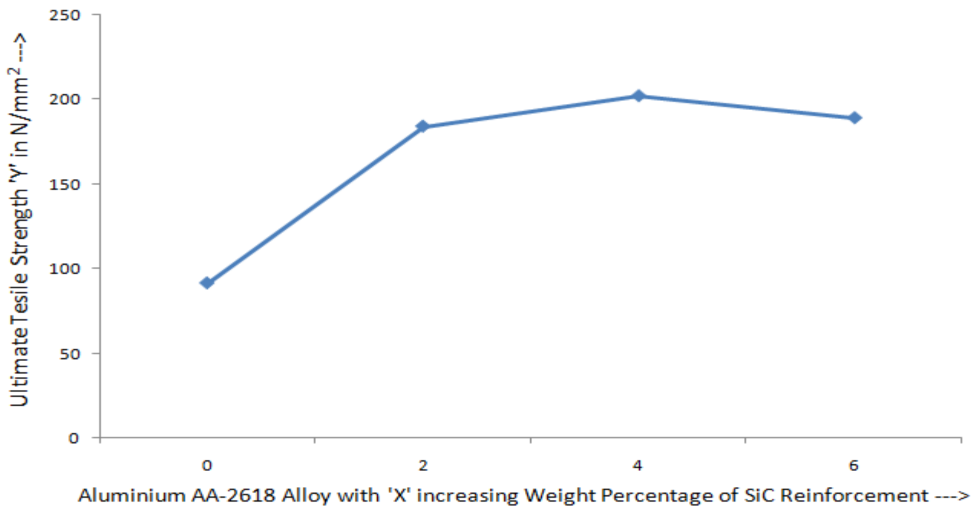

Figure 2: Effect of SiC reinforcements on ultimate tensile strength

The trend in the values of the ultimate tensile strengths of the specimens according to the incremental increase in the weight percentages of the reinforcements in the composites is as shown in Figure 2. It can be concluded from the results that, by adding SiC reinforcement particulates to the aluminium alloy matrix to produce its composites, improved ultimate tensile strength can also be achieved since the SiC reinforcement particles display superior elastic properties when compared to its aluminium base alloy matrix counterpart. However the formation of agglomerations or accumulations of SiC reinforcement particulates and the reaction compounds at the matrix-reinforcement interface of the composite with further addition of reinforcements reduces the overall ultimate tensile strength. This conclusion was made evident by the marginal decrease in the ultimate tensile strength of the composite with 6 % weight ratio of

SiC reinforcements compared to the composite with 4 % weight ratio of reinforcements when the test results were analyzed.

3.1.3. Percentage of elongation

The trend in the values of the percentages in elongation of the specimens according to the incremental increase in the weight percentages of the reinforcements in the composites is as shown in Figure 3. Overall, it can be concluded that, with the embedding of SiC particles as reinforcements in the aluminium AA-2618 base alloy matrix material, a decrease in the ductility of the composites is observed. The SiC reinforcement particles and the intermediate-phase reaction compounds contained in the matrix of the composite may have fractured more easily, which led to the fracture of the composite. Other factors such as increased porosity and blow-hole content, non-uniform distribution of the reinforcement particles within the alloy matrix, internal physical and geometrical defects due to improper casting etc. have also contributed to the reduction in the percentage of elongation of the fabricated composite specimens with the addition of the reinforcement material into the matrix material to a certain extent.

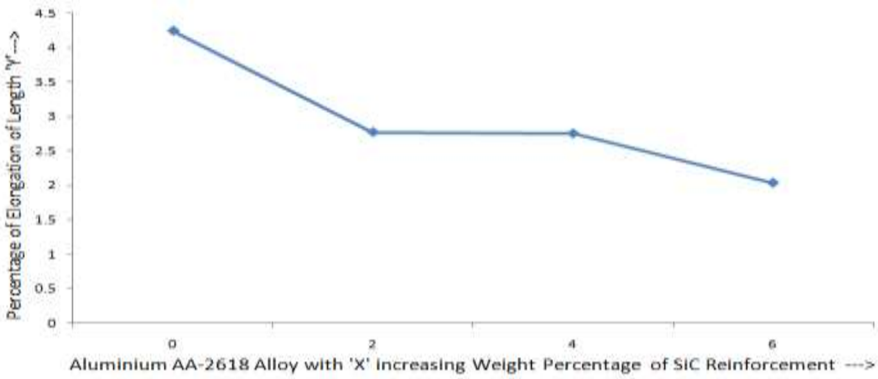

Figure 3: Effect of SiC reinforcements on elongation

4. CONCLUSIONS

The following conclusions were realized from the current research:-

- The composite materials with aluminium AA-2618 alloy as the matrix material and varying weight percentages of Silicon Carbide powder (0 % to 6 % in increasing steps of 2 %) as reinforcements were prepared successfully by using Stir Casting (Liquid Metallurgy) method with resulted in a uniform distribution of the reinforcements within the alloy matrix.

- The composite tensile test specimens' Yield strength improved with the incorporation of SiC reinforcements into the alloy matrix material, with the highest value recorded by the composite with 4 % weight of added SiC reinforcements.

- Due to the incorporation of SiC particulate reinforcements into the aluminum alloy matrix material, the ultimate tensile strength and hardness of the produced composite specimens also improved. The highest ultimate tensile strength was recorded by the composite with 4 % weight of added SiC reinforcements, while the hardest specimen is the specimen with 6 % weight of SiC reinforcements.

- Elongation ratios showed decreased results upon the addition of the reinforcement into the matrix material of the manufactured composites when compared to their base alloy values alone. Among the composites, the specimen with 2 % weight of SiC reinforcements elongated the most.

- For applications involving parts which must possess good tensile properties, the aluminium AA-2618 matrix material reinforced with 4 % weight of white SiC particulates can be used.

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