EVALUATION OF TENSILE STRENGTH AND CORROSION BEHAVIOUR OF AL 7075/TiB2/CR2O3 COMPOSITE

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ABSTRACT

Reinforcing Aluminium with other metals to form a composite, improves the physical and chemical properties of it. In this study, Aluminium which forms the base matrix is stir casted with various weight percentages of Cr₂O₃ and TiB₂. The properties corrosion in acidic medium and tensile strength of the composites, are tested using experimental methods and finally analyzed.

Keywords: Reinforcing Aluminium, Cr₂O₃ and TiB₂

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1. INTRODUCTION

Ever ending researches in the field of composite materials have made a lot of improvements in the properties of the materials. Most popular among them are Aluminium based composites, because of their extensive applications in various fields like automobile and aerospace. The reason for all comes down to its abundance and less cost and ease of its production. It is mainly manufactured using stir casting process. Aluminium parts are mostly used in mechanical parts, subjecting it to a variety of loading conditions and oxidants that try to corrode it. As long as durability and reliability are considered, its corrosion resistance and tensile strength have to be improved, making it resistant to all the abuse during the application.
Hashim et al. [6] made a study that the main factors affecting the quality of the composite material during manufacturing are holding temperature, the speed of stirring, impeller size and its shape. Şafak et al. [17] reported that when Aluminium was treated with Schiff bases its ability to adsorbe inhibitors can be increased. A study made by Brabazon et al. [3] shows that mechanical stir casting can be used instead of gravity die casting when simple shapes are only needed. A study was done by Ezatpour et al. [4] made an observation that by combining the process of extrusion during the fabrication of Al-Al₂O₃ composite, will increase the distribution of reinforcements and decreases the porosity. McDanel [13] made a study that by adding SiC whiskers to Al6061, the resultant composite will show an increase in ductile strength. The study done by Jokhio et al. [7] concluded that by adding Al₂O₃ particles in Aluminium 7000, series will increase its elongation and tensile strength. According to the study made by Kumar and Dhiman [9], the specific wear rate of Al7075 can be decreased by adding hard ceramic and solid graphite. The work done was by Padmavathi and Ramakrishnan [14] describes that the addition of multiwall carbon nanotube and Silicon Carbide in Aluminium 6061 will decrease the wear rate under mild wear conditions. A study made by Alaneme and Bodunrin [1] shows that the addition of Alumina in Aluminium 6063 will improve the corrosion resistance in H₂SO₄ medium. Lakshmi et al. [11] made a study and concluded that TiB₂ even at submicron size can be created in Aluminium matrix by the exothermic reaction between Titanium and Boron salts. According to Ravisankar et al. [16], the incorporation of SiC in Aluminium 7075 will improve its microhardness and tensile strength. A study made by Subramaniam et al. [18] observed that the addition of Boron Carbide and coconut shell fly ash in Aluminium 7075 matrix will improve its hardness, tensile strength, and impact strength. The work done by Raturi et al. [15] shows that the addition of nano Aluminium Oxide in Aluminium 7075 matrix will improve its wear rate and mechanical properties. The incorporation of Red Mud in Aluminium 6061 matrix will decrease its hardness as described by Lokesh et al. [12]. Suresh and Moorthi [19] made an observation that the addition of TiB₂ in Aluminium 6061 will improve its mechanical and wear properties. From the study made by Kumar et al. [8], it has been observed that the mechanical properties and coefficient of friction of Aluminium 7075 can be increased by adding SiC as reinforcement. According to the study made by Kumar et al. [10], the incorporation of Tungsten Carbide and short E glass fiber will decrease the wear rate of Aluminium 7075. The study made by Aranke et al. [2] reveals that the addition of reinforcement multiwall carbon nanotube in Aluminium 7075 matrix will reduce the wear loss. Verma and Vettivel [20] made an observation that the mechanical properties of Aluminium 7075 can be improved by the addition of Boron Carbide and rice husk ash as reinforcement. According to Gireesh et al. [5] who studied the effect of incorporation of aloe vera powder in Aluminium 7075 matrix concluded that the mechanical properties of base material aluminium 7075 have improved. Since Aluminium composites find a variety of applications it’s important to blend different materials with Aluminium and analyze the properties. This work focuses on the evaluation of corrosion rate and tensile properties of Aluminium 7075 composite with Cr₂O₃ and TiB₂. The composite was produced using stir casting process since it’s the most simple and cost effective method.

2. EXPERIMENTAL METHOD

Aluminium7075 constitutes the base matrix of the composite, due to the wide applications and advantages of it. Alloying it with other compound adds to the strength and resistance to corrosion.

The process used in the manufacturing of the composite is stir casting, the reason being the process an economical and efficient one among others. Aluminium 7075 has a density of 2.65
grams per centimeter cube while that of Titanium Bromide and Chromium Oxide is 4.5 and 5.2 grams/cc. Three different composites having 4%, 6% and 8% weight percent of Cr₂O₃ were prepared while the weight percentage of TiB₂ remained to be 12% in all the three. The weight percentage composition of reinforcements are mentioned in Table 1.

Heating to a temperature of 550°C gives semi solid state Aluminium alloy, where there is a probability for oxidation. Degassing was done for a span of about 4 minutes to protect the alloy from oxidation. The reinforcing materials were also preheated to a temperature of 400°C. The reinforcements (preheated) were added to the melt and stirring was simultaneously carried out for 2 minutes at 250 to 450 rpm. Then the slurry was reheated to a temperature of 750°C and stirring was again done for 2 minutes. This ensures homogeneous distribution of reinforcement in the matrix. The liquid metal was cooled and solidified at room temperature in a metallic mould. The workpiece of the required dimensions was taken from the mould.

<table>
<thead>
<tr>
<th>Samples</th>
<th>TiB₂ Weight %</th>
<th>Cr₂O₃ Weight %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample 1</td>
<td>12 %</td>
<td>4 %</td>
</tr>
<tr>
<td>Sample 2</td>
<td>12 %</td>
<td>6 %</td>
</tr>
<tr>
<td>Sample 3</td>
<td>12 %</td>
<td>8 %</td>
</tr>
</tbody>
</table>

3. SEM IMAGE ANALYSIS

![SEM Image of Sample 1](image.png)
Figure 2: XRD image of Specimen 1

Figure 3: SEM image of Sample 2
Evaluation of Tensile Strength and Corrosion Behaviour of Al 7075/Tib2/Cr2o3 Composite

Figure 4: XRD image of Specimen 2

Figure 5: SEM image of Sample 3
From the SEM image it can be clearly seen that the particles are uniformly distributed in Aluminium matrix. The presence of the materials can be ensured from EDX pattern. The images shows that the particles added during the manufacturing are present in the matrix. As the weight percentage of Cr$_2$O$_3$ was more in specimen 2, the EDX pattern was slightly varied as seen Figure 4 when compared to Figure 2. Similar variation can be seen in EDX pattern for specimen 3 as seen in Figure 6. From the SEM analysis figures it is clear that good mechanical bonding was achieved between the matrix and reinforcements. Since mixing of reinforcements was made on semi solid state of Aluminium, it ensures the proper mixing of reinforcements in Aluminium matrix. TiB$_2$ and Cr$_2$O$_3$ provide sufficient wettability with present matrix and this ensures good mechanical bonding with the matrix. In Figure 1 only lesser particles can be seen. But in Figure 3 and Figure 5 more particles can be seen. This is due to addition of more quantity of Cr$_2$O$_3$ particles in the Aluminium matrix. Since stirring was continued even after mixing reinforcements which ensures satisfactory distribution of reinforcements in Aluminium matrix.

4. DENSITY TEST
The material was weighed on an electronic scale. The difference in weight when in water was also measured. Then using the Archimedes principle, the density was calculated by taking the ratio of the original mass and the difference in mass. This was repeated for other specimens also.
5. TENSILE TESTING
The strength in tension was analyzed using the tension testing in a Universal Testing machine. The specimen was clamped in the UTM and was subjected to a controlled tensile load which was gradually applied. Extend of elongation and point of failure was recorded so as to carry out the calculations.

6. CORROSION ANALYSIS
Immersion test was equipped for testing the corrosion analysis of the specimen. The specimen was immersed in 90 ml of dilute HCl solution. The higher rate of corrosion in the HCl medium is the reason why it’s preferred over NaCl. The weight loss is calculated after keeping it
immersed in the solution. A decrease in the rate of corrosion was observed, as evident from the result, as the weight percentage of reinforcement was increased. More and more pores in the matrix material getting filled by the reinforcements were the reason for the reduction in corrosion rate. Lesser voids would be free as they get filled by reinforcements. The equation governing the corrosion rate is

\[ c = \frac{87.6 \times W}{\rho \times A \times t} \]

\( c \) = density in g/cm\(^3\)

\( W \) = loss of weight in mg

\( A \) = Area in cm\(^2\)

\( t \) = time period in hours

Factors like the shape of the reinforcement, type and size of it, manufacturing techniques and even environmental affect the rate of corrosion. Change in method of processing an alloy can affect its properties. Proper bonding between the matrix and reinforcements is a key factor governing many of the properties. Strong bonding leads to greater resistance to corrosion. All these put together tells that proper bonding of matrix and reinforcement, as well as the weight percentage of reinforcement present in the matrix, can proportionally increase the resistance to corrosion.

**9. CONCLUSION**

The present work has been concluded as follows

1. The metal matrix hybrid composites were fabricated successfully using stirr casting technique.

2. SEM image shows the dispersion of reinforcements in matrix phase were fairly uniform.
3. The tensile strength of the composite decreases when more Cr$_2$O$_3$ is added to the matrix.
4. The corrosion resistance increases with increase in weight percentage of Cr$_2$O$_3$.

REFERENCES


