Optimization And Experimental Study On Mechanical Properties Of Al 2024 Hybrid Metal Matrix Composites Reinforced With Tic And Cr

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Abstract- *Aluminium metal matrix composites (MMCs) have gained importance in engineering applications due to of their good properties such as light weight, low density, high stiffness, high resistance to corrosion, high strength and good structural rigidity. Aluminium 2024 based hybrid metal matrix composites are being used in the field of aerospace, automobile and marine applications.*

In this project work, Al 2024 as metal matrix and TiC,Cr as reinforced material have been investigated. The composites were fabricated by using stir casting method.

The fabricated materials have been tested to find mechanical properties such as hardness, tensile, corrosion test and microstructure analysis. The experimental result shows that tensile strength and hardness have been increased while weight percentage of TiC and Cr with Al 2024 verified. The microstructure analysis shows the even distribution of particles and some agglomerations of TiC and Cr. Purpose of the present study is to study and compare the mechanical properties of Al 2024 hybrid metal matrix composites with pure alloy of 2024.

Keywords- Aluminium 2024, hybrid metal matrix composites, TiC and Cr.

I. INTRODUCTION

Composites or composite materials are available in nature or engineered fusing two or more materials with considerably different chemical and physical properties which remain distinct at microscopic or macroscopic level within the finished structure. The constituent material is basically of two categories: reinforcement and matrix, the matrix supports the reinforcement against mechanical and environmental damage by surrounding and maintaining their relative position, while the reinforcement bestow physical properties and special mechanical such as dielectric, strength, stiffness etc.

Fibers or particles embedded in matrixof another material are the best example of modern-day composite materials, which are mostly structural. Laminatesare composite material where different layers of materials give them the specific character of a composite material having a specific function to perform. Fabricshave no matrix to fall back on, but in them, fibers of different compositions combine to give them a specific character. Reinforcing materialsgenerally withstand maximum load and serve the desirable properties

II. METHODOLOGY

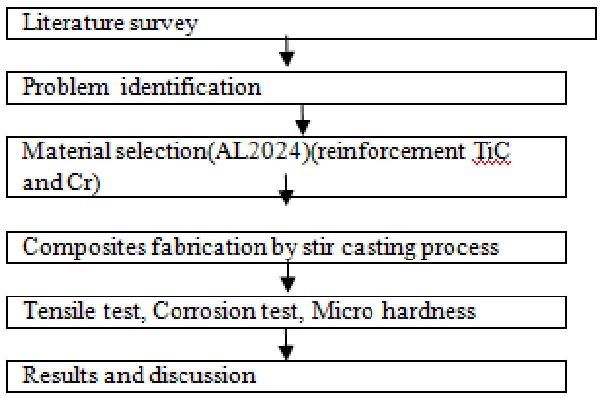


Figure 2.1 Experimental Methodology

III. MATERIAL DESCRIPTION

ALUMINIUM 2024
CHROMIUM (Cr)
TITANIUM CARBIDE(TiC)

MATRIX MATERIAL

Aluminium, the second most abundant metallic element on the earth, became an economic competitor in engineering applications recently. The metal matrix selected for present investigation is Al 2024. Aluminium 2024 material shown in figure 3.2.Al 2024 is a precipitation toughening aluminium alloy, enclosing magnesium and silicon as its major alloying components. The mechanical properties of Al2024 rest on the temper or heat treatment of the material.

FIGURE 3.2 ALUMINIUM 2024

TITANIUM CARBIDE

Titanium Carbide is taken as one of the particulate reinforcement for the composite considering the facts that it has good wettability with Al, high hardness, and high temperature stability. It leads to greater affinity for molten aluminum and reduced tendency for particle agglomeration.

CHROMIUM

it is the first element in the group six. it steely- gray ,lustrons, hard and brittle metal which takes high polish, resists tarnishing , and has high melting point. The chromium is used to reduced the corrosion resistance.

IV. EXPERIMENTAL WORK

FABRICATION OF COMPOSITES

The experimental setup of stir casting essentially consists of an electric furnace and a mechanical stirrer.Stir Casting is a liquid state method of composite materials fabrication, in which a dispersed phase (ceramic particles, short fibers) is mixed with a molten matrix metal by means of mechanical stirring The liquid composite material is then cast by conventional casting methods and may also be processed by conventional Metal forming technologies.The stir casting machine set up at GCT, Coimbatore is shown in figure 4.1.

Figure 4.1 Stir casting setup

Stir Casting is characterized by the following features

- Content of dispersed phase is limited
- Distribution of dispersed phase throughout the matrix is not perfectly homogeneous

1. There are local clouds (clusters) of the dispersed particles (fibers);
2. There may be gravity segregation of the dispersed phase due to a difference in the densities of the dispersed and matrix phase.

FACTORS TO BE CONSIDER DURING STIR CASTING

In order to achieve the optimum properties of the metal matrix composite, the distribution of the reinforcement material in the matrix alloy must be uniform, and the wettability or bonding between these substances should be optimised. The porosity levels need to be minimised, and chemical reactions between the reinforcement materials and the matrix alloy must be avoided.the figure 4.3 shows the solidified sample in the die and figure 4.4 shows samples.

Figure 4.3 Solidified sample in the die

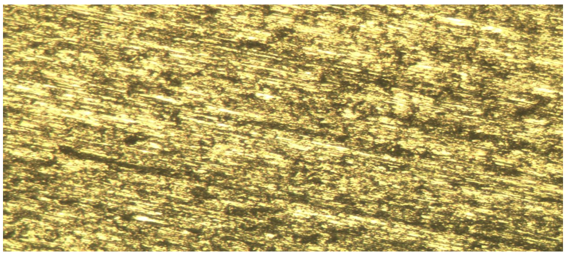
Figure 4.4 Casted samples

The aluminium composite material reaches completely liquid state at the temperature of about 750°C and the completely melted aluminium hybrid composite is poured in to the permanent metal die and subjected to solidification to produce the required specimen. Figure 4.3 shows the solidified composite material in die cavity. The samples casted are shown in figure 4.4. Thus all samples were casted as per experimental plan.

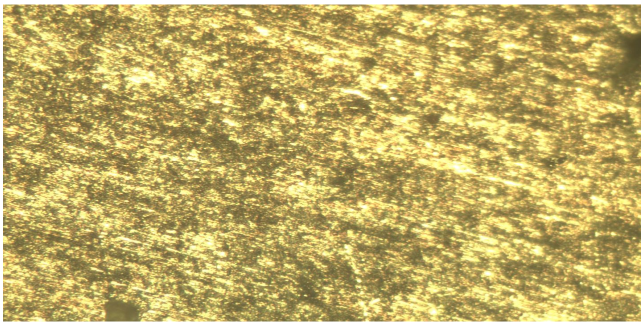
V. RESULTS AND DISCUSSION

5.1 MICROSTRUCTURE

The micrograph of the samples is shown in figure 5.1. The micrograph clearly reveals the absence of dendritic morphology in all the composites under investigation. The dendritic structure can be modified during casting which is influenced by many factors such as dendritic fragmentation, restriction of dendritic growth by the particles, and thermal conductivity mismatch between the particles and melt. The figure 5.1 shows the microstructure of the specimen



SAMPLE A



SAMPLE B

Figure 5.1 Microstructure of sample A and B

Dendritic fragmentation can be attributed to the shearing of initial dendritic arms by the stirring action. It was also found that the perturbation in the solute field due to the presence of particles can change the dendrite tip radius and the dendrite tip temperature. These effects give rise to a dendrite to cell transition as the density of particle is increased. Also the length of the dendrite is reduced in the presence of the particles. Ceramic particles also act as a barrier for dendritic growth and this phenomena is more pronounced if the cooling rate is high. In this work reported that the particle can be assumed to act as a barrier to the dendritic growth.

Overall analysis of structure indicates that the reinforced particles are uniformly distributed in the alloy matrix. The good bonding between particles and alloy matrix is also revealed in the microstructural analysis. Moreover, porosity is at minimum level and not observed in the optical examination, although clustering is seen at some places in the composite. The most prominent feature observed in all composite in the absence of dendritic growth which is accounted for better stir casting processing of composites.

5.2 MICRO HARDNESS

Micro hardness testing is a method of determining a material's hardness or resistance to penetration when test samples are very small or thin, when small regions in a composite sample to be measured.

5.2.1 VICKERS HARDNESS

The Vickers hardness test method consists of indenting the test material with a diamond indenter, in the form of a right pyramid with a square base and an angle of 136 degrees between opposite faces subjected to a load of 200 grams. The following table shows the micro hardness for different types of specimens.

Figure 5.2 Hardness testing specimen

Table 5.1 Micro Hardness

Sample	Trial1	Trial2	Trial3	Average value HV
Sample A	130	130	131	130
Sample B	136	137	137	137

The hardness value of the sample B is slightly higher than the sampleAso,the sample A and B are higher the normal value.

5.3 TENSILE TEST

The following table 5.2 shows the tensile value of the different types of the specimen.the figure 5.2 is show the specimen after the failure has happened.

Because the tensile strength is easy to determine and is a quite reproducible property, it is useful for the purposes of specifications and for quality control of a product. Extensive empirical correlations between tensile strength and properties such as hardness and fatigue strength are often quite useful. For brittle materials, the tensile strength is a valid criterion for design.

Figure 5.3 shows the specimen is after failure of specimen by applied the tensile load on the specimen. The tensile load of specimen breaking is noted in the table .And the value of normal aluminium alloy lesser than the composite.

Figure 5.3 Tensile specimen after failure

Table 5.2 tensile test value

Sl.no	Sample	Yield stress(N/mm)	Elongation %	Tensile strength(N/mm2)
1	A	88.213	6.23	103.234
2	B	88.324	6.56	105.567

The value of the tensile strength is increased as per the normal value of the aluminium 2024.

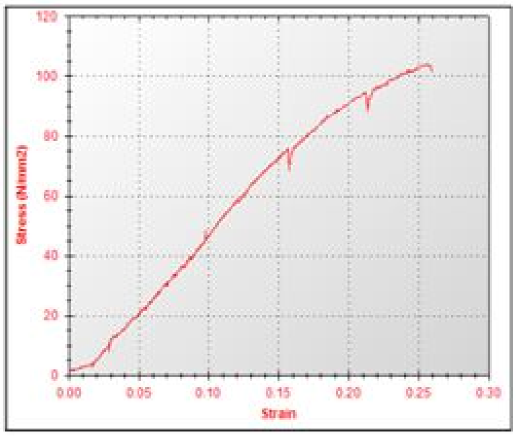


Figure5.4 effect of different samples on tensile strength

.Yield strength

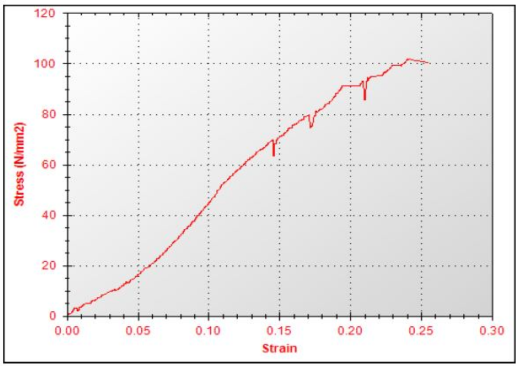


Figure5.5 Effect of different samples on yield strength

In figure 5.4 showed the sample 2(95 wt% of AL 2024 ,3 wt%TiC and 2 wt% chromium) composition have yield better tensile and rather than the pure alloy of AL 2024,while ductility of composite is lesser that unreinforced.Yield strength or yield point of a material is defined as the stress at which a material begins to deform plastically. Piror to the yield point the material will deform elastically and will return to its original shape when applied stress is removed.the graphical representation of yield strength of the different samples are shown in fig5.4

4.3 CORROSION

The rate of corrosion is the speed at which any given metal deteriorates in a specific environment. The rate, or speed, is dependent upon environmental conditions as well as the type, and condition, of the metal.

4.3.1 CORROSION RATE

mpy = 534 x (W / DAT)

Where,

W = weight loss in milligrams ,D = metal density in g /cm^3, A = area of sample in sq.inch T = time of exposure of the metal sample in hours

Table 5.3 Corrosion Rate

Sam ple	Area (sq.in ch)	Dens ity (g/c m3)	Befo re weig ht (gra ms)	Afte r weig ht (gra ms)	Wei ght loss (gra ms)	Corro sion rate (mpy)
A	4.1	2.77	14.5 56	14.2 37	0.31 9	0.329
B	4.1	2.77	15.0 98	14.8 99	0.19 9	0.194

The 95% of AL2024,3% TiC and 2% Cr composition had less corrosion rate compare with pure alloy of AL 2024.

VI. CONCLUSION

The conclusions were drawn based on the experiments conducted to study the mechanical properties of AL2024 hybrid metal matrix composites with TiC and chromium.

- Composite material of AL 2024 reinforced with TiC and Cr particulates was successfully fabricated by using stir casting method.
- Based on the experiment result the hardness ,tensile strength were increased while percentage weight of TiC and Cr with Al 2024 are varied.
- From the results it is observed that the microstructure of the dual particulate reinforcements have shown an impact in hardness and tensile of composite combinations. The microstructure analysis shows fairly even distribution of particles and some agglomerations of TiC and Cr and also corrosion rate were increased.

From this 95 wt% of A l2024 , 3wt% TiC and 2 wt% Cr composition have yield better mechanical properties

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