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FABRICATION, TESTING AND ANALYSIS OF ALUMINIUM 2024 METAL MATRIX COMPOSITE

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Abstract

In the field of material science and engineering, there is a great impact ever since the invention of composites materials. High strength and lightweight remain the winning combination that propels composite materials into new arenas. The composite materials replace conventional materials like steel, cast iron and aluminum alloys by its superficial properties. As literatures were collected, it could be found that metal matrix composites are under serious consideration as potential candidate materials to replace conventional materials in aerospace and automotive applications. In this project, composite material based on aluminum alloy (Al 2024) reinforced with 10% volume fraction of Silicon Carbide Particulates (SiC) and 5 % volume fraction of Graphite particles is produced by stir casting method. The fabricated composite is tested in order to find tensile strength and hardness and analysis is carried out using Ansys software version 10.0. to study on cracking behaviour.

***Keywords**:* Al 2024, Metal Matrix Composite, Stir casting, Ansys

1. INTRODUCTION

In an advanced society like ours we all depend on composite materials in some aspect of our lives. Fiber glass, developed in the late 1940s, was the first modern composite and is still the most common. It makes up about 65 per cent of all the composites produced today and is used for boat hulls, surfboards, sporting goods, swimming pool linings, building panels and car bodies. Composites exist in nature. A piece of wood is a composite, with long fibres of cellulose (a very complex form of starch) held together by a much weaker substance called lignin. Cellulose is also found in cotton and linen, but it is the binding power of the lignin that makes a piece of timber much stronger than a bundle of cotton fibres. In engineering materials, composites are formed by coatings, internal adhesives and laminating. An important metal composite is clad metals. Thermostatic controls are made by roll-bonding a high expansion alloy such as copper to a low expansion alloy like steel. When the composite is heated it will deflect to open electrical contacts. Ply wood is a similarly common composite. Since wood is weaker in its transverse direction than its long direction, the alternating grain in plywood overcomes the transverse deficiency.

Composite materials are formed by combining two or more materials that have quite different properties. The different materials work together to give the composite unique properties, but within the composite the

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materials can be differentiated since they do not dissolve or blend into each other. Composites are made up of two materials namely **matrix** and **reinforcement**. The matrix or binder surrounds and binds together a cluster of fibres or fragments of the stronger material (reinforcement). In Metal Matrix Composites (MMCs), ceramics or metals in form of fibres, whiskers or particles used to reinforce in a metal matrix. Most commonly used matrixes are aluminum, magnesium, copper, titanium and zinc. The most commonly used reinforcements are silicon carbide, alumina, boron, graphite and fly ash. The strengthening effect of the reinforcements in composites depends on the orientation of the reinforcements to the direction of the loads.

1.1 OBJECTIVE

The objectives of this project are

- To fabricate Metal matrix composites with the base metal as Aluminum reinforced with a Volume of 10 % of Silicon carbide particulates and 5 % of graphite particulates by Stir casting method.
- To study the cracks using ANSYS version 10.0 software

2. FABICATION METHOD

2.1 STIR CASTING

The stir casting technique was used to fabricate the composite specimen as it ensures a more uniform distribution of the reinforcing particles. This method is most economical to fabricate composites with discontinuous fibers or particulates. In this process, matrix alloy (Al 2024) was first superheated above its melting temperature and then temperature is lowered gradually below the liquidus temperature to keep the matrix alloy in the semisolid state. At this temperature, the preheated Sic particles of 10 % (by weight) and graphite particle of average size of 23 µm and 45 µm respectively were introduced into the slurry and mixed using a graphite stirrer. The composite slurry temperature was increased to fully liquid state and automatic stirring was continued to about five minutes at an average stirring speed of 300-350 rpm under protected organ gas. The SiCp particles help in distributing the graphite particles uniformly throughout the matrix alloy. The melt was then superheated above liquidus temperature and finally poured into the cast iron permanent mould for testing specimen. The specification of the fabricated billet composite is150 mm length and 50 mm width and a thickness of 20 mm .The composite metal after been ejected from the mold is then rolled in a hot rolling machine up to 15 passes. This is done in order to help in distributing the silicon carbide particulates in the metal matrix and thereby improving the mechanical properties.

Figure 1: Experimental setup for fabricating composite material

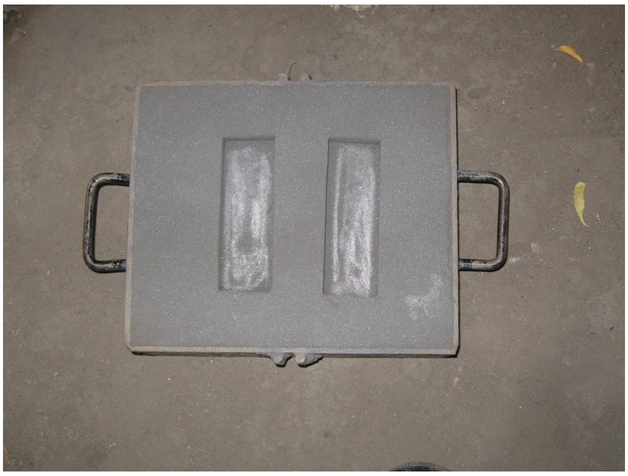


Figure 2: Mould setup

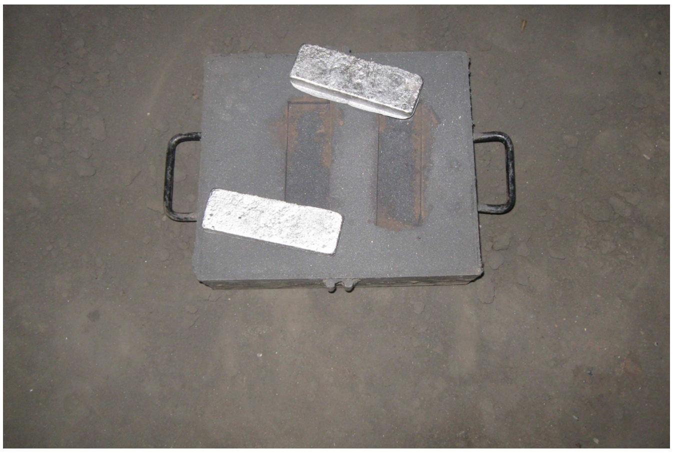


Figure 3: Fabricated composite metal ejected from the mould

3. COMPARISONS OF THE OBTAINED RESULTS

3.1 MECHANICAL PROPERTIES

3.1.1 TENSILE TEST:

As far as the tensile test is concerned the comparison is given below in the table,

S.No	Composition	Yield Strength in KN	Tensile Strength in KN
1	Al-2024	76	93
2	Al-2024 10%SiC+5%Gr	95.10	98.34

Table: 1 Comparison of Tensile Test

3.1.2 STRENGTH:

The yield and tensile strengths of Al 2024/SiC+Gr composite are comparatively higher than the conventional Al 2024 metal.

3.1.3EFFECT OF AL MATRIX ALLOY:

The Al matrix used for the Al 2024/SiC+Gr composite was the most important factor affecting yield strength and ultimate tensile strength of these Al 2024/SiC+Gr composite. Tests showed that Al 2024/SiC+Gr composite had higher strength but lower ductility.

3.1.4 HARDNESS TEST:

Based on the readings obtained in the hardness test under 'B' scale reading the results are shown in tabulation

S.No	Composition	Hardness Number
1	Al-2024	47
2	Al-2024 10%SiC+5%Gr	57

Table: 2 Comparison of Hardness Number

As shown in the tabulation, the hardness of the material as compared to Al-2024 is relatively higher in Al-2024 10%SiC+5%Gr composite.

4. STRESS INTENSITY FACTOR:

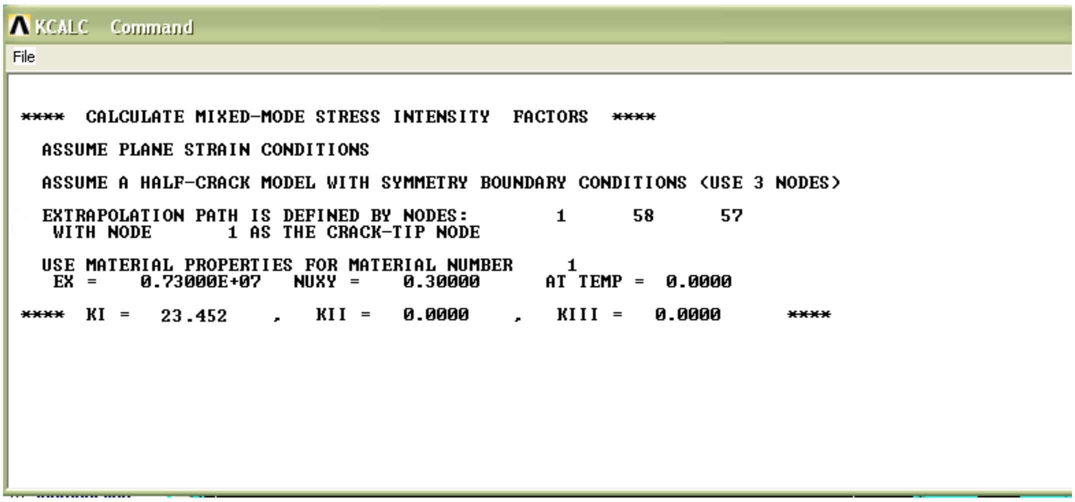
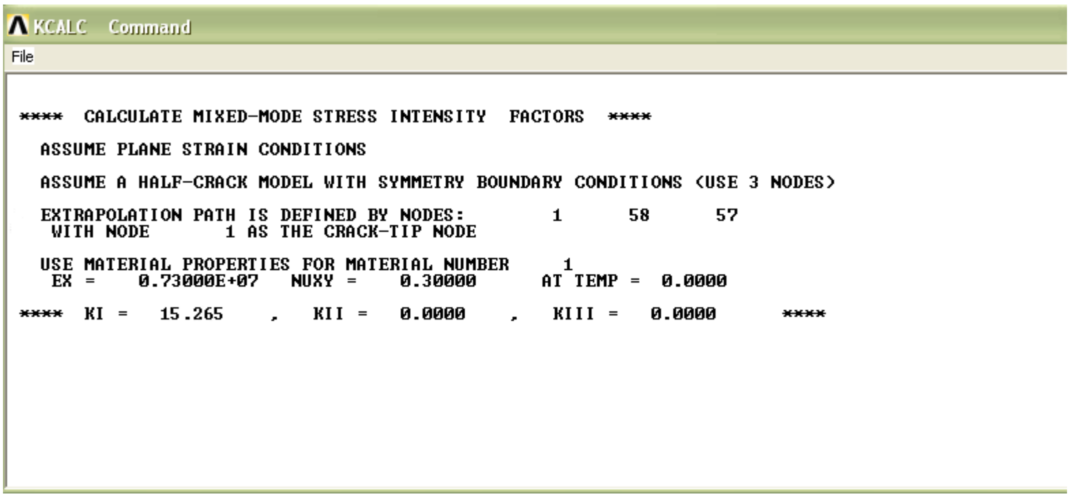


Figure 4: Stress Intensity factor of Aluminium 2024


KCALC Command
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**** CALCULATE MIXED-MODE STRESS INTENSITY FACTORS ****
ASSUME PLANE STRAIN CONDITIONS
ASSUME A HALF-CRACK MODEL WITH SYMMETRY BOUNDARY CONDITIONS (USE 3 NODES)
EXTRAPOLATION PATH IS DEFINED BY NODES: 1 58 57
WITH NODE 1 AS THE CRACK-TIP NODE
USE MATERIAL PROPERTIES FOR MATERIAL NUMBER 1
EX = 0.73000E+07 NUXY = 0.30000 AT TEMP = 0.0000
**** KI = 15.265 , KII = 0.0000 , KIII = 0.0000 ****

Figure 5: Stress Intensity factor of composite material

From the above figures the Stress intensity factor for Al 2024 is higher when compared with the composite material fabricated and hence this reveals that the stress distribution across the crack tip plastic zone is smaller than the conventional Al 2024 metal leading to minimal stress at the crack tip of composite material which is fabricated.

4.1 DYNAMIC ANALYSIS:

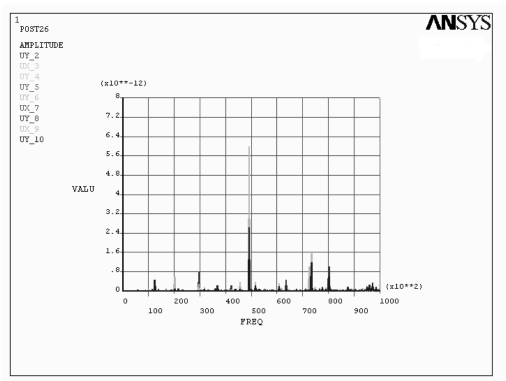

Figure 6: Analysis of aluminum 2024

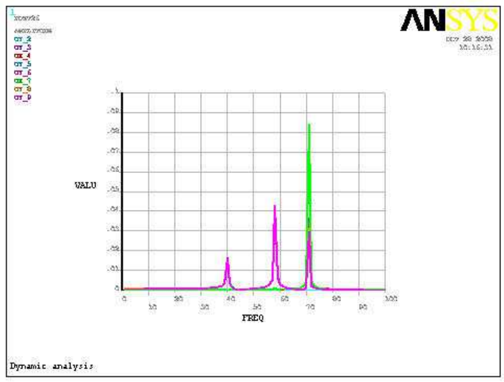

Figure 7: Analysis of composite

From the graph, it shows that the dominant peak value in Al 2024 is 49 KHz whereas in Al-2024 10%SiC+5%Gr the peak value is about 79 KHz. This proves that the life expectancy of the composite involving in crack can withstand more than that compared to the life of the Al 2024.

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4.2 STRESS – STRAIN CURVE

The Stress – Strain curve is depicted below,

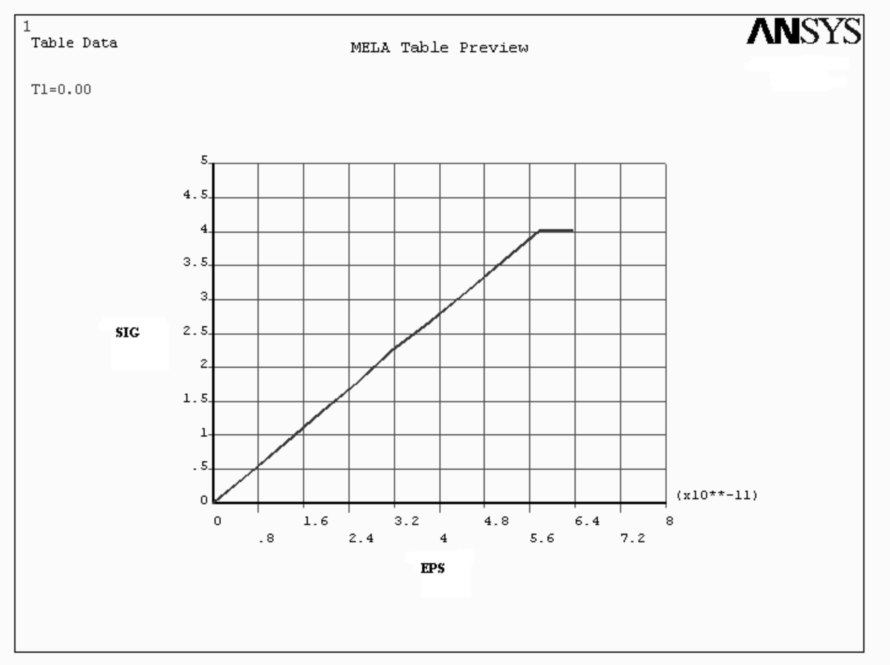

Figure 8: Stress – Strain Curve

From the above stress-strain graph the material is linear up to 2 N/m^2, from then it is nonlinear in nature. This is expected at near crack tip region. But the ultimate tensile strength of Aluminium 2024 + Sic 10% and Gr 5% is about 98 N/m^2. So even though there is a nonlinear material there is no further cracking in the crack tip region for this loading until the stress near the crack tip exceeds or equals to maximum tensile strength of the material.

5. CONCLUSIONS

The tensile test and the hardness test were conducted and the mechanical properties were determined. The experimental results that were found are been compared with the conventional Aluminium 2024 and with the Composite material were one can see that the composite material plays a dominant role than the Aluminium 2024 with respect to its strength, ductility and hardness.

Dynamic analysis is a very important investigation when it comes to the composite materials, where these can exhibit diversity in material properties as well as shapes. The main idea of this work is to perform analysis which gives the information about cracks and the locations of the damages on composite materials.

In real life situations doing a dynamic analysis on structures requires great skill and experience, because the excitation force which is dynamically given on the structure should be chosen very carefully and the excitation point is also plays very important role in dynamic analysis. By doing the computer simulation of dynamic analysis gives us the variety in choosing excitation signal as well as the excitation points.

In this work the modal analysis is done for finding modal frequencies which are very useful to do the frequency analysis which requires the range of frequencies in the system vibrates more (natural frequencies). After doing the frequency analysis the next step is to perform a static analysis or dynamic analysis depending

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on the requirement. Finding the damages in the materials is of course a very important non-destructive testing which dealt with ease here with computer simulation by using dynamic analysis. Not only finding the damages but the location of damages is always required in process.

6. FURTHER APPROACH TO THE WORK

This work leads to very appealing thoughts about dynamic analysis. This work is carried out to find the crack location and the life expectancy of the composite material model. This work will certainly help in those types of situations where a small part of the structure is to be examined. But doing analysis for the whole structure is often required. There are many factors concerned with cracks but those factors should be accounted for higher studies in this perspective. Further dynamic analysis can be done such as transient dynamic analysis through which velocity – time, Displacement – time plot graphs can help more about to learn cracks in deeper sections.

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