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Experimental Analysis of Fatigue Behaviour of Aluminium 2024 Reinforced with Graphite

Deekshith Samrat S A[1], M.R. Srinivasa[2], Dr. Y.S Rammohan[3], Sadashiva M[4]

[1] *PG Scholar, PES College of Engineering Mandya, Karnataka, India*
[2,4] *Assistant Professor,PES College of Engineering Mandya, Karnataka, India*
[3] *ProfessorBMS College of Engineering Banglore, Karnataka, India*
Corresponding Author: Deekshith Samrat S A

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ABSTRACT: Metal matrix composite of Aluminium alloy (Al 2024) reinforced with Graphite particulates was fabricated by stir casting technique. Aluminium alloy is selected as the matrix materials and graphite particulates were in co-operated with varying proportions of 0wt%, 0.25wt%, 0.5wt%, 0.75wt% and 1wt% and keeping all other parameters constant. Stirring was done to archive uniform distribution of reinforcement particulates and round shaped castings were made by pouring the composite mixture in sand mold. Tensile specimens as per ASTM standards were machined to find out the fatigue behavior composite. The behavior of composite material will shows the different properties after analysis. The properties will be changed for composite materials with respect to loads. The fatigue behavior of a material will changes for different for 0wt%, 0.25wt%, 0.5wt%, 0.75wt% and 1wt% graphite reinforcement.

Keywords: Aluminium 2024, Graphite,Fatigue,, Stir Casting.

I. INTRODUCTION

Composite materials are composed of various materials, which mix to provide grant properties superior to those of the individual constituents. The first reason composite materials are chosen for elements is attributable to weight saving for its relative stiffness and strength. As an example, carbon-fibre reinforced composite (CFRF) are often 5 times stronger than 1020 grade steel whereas having just one fifth of the burden. Aluminium (6061 grade) is much closer to weight to carbon-fibre composite, though' still somewhat heavier, however the composite will have doubly the modulus and up to seven times the strength. The composites trade is an exciting trade to figure in as a result of new materials, processes and applications are like mistreatment hybrid virgin and recycled fibres, quicker and a lot of machine-driven producing.

Comparing with all engineering materials, composites materials is having more specific strengths and with less weakness that will be determine in the specifying stage. A composite is well suits for all the correct material for each job. However, a significant search behind the event of composites material that will mix with the reinforcement and other various materials in order to modified as result to fulfil the specified final properties of an element.

Fatigue is a condition when the material breaks due torepeated loading (cyclic stresses) are applied below the ultimate strength of the material. In Fatigue failure the components are breaks due to repeated loading. Repeated loading condition the stresses are arrives the compound applied load is vary or fluctuate between maximum and minimum values. In static loading conditions, the applied load is gradually gives the sufficient time to develop the strain.In repeated loading it does not hold the good. Here machine is subjected to fatigue loading to stresses is found to fails the ultimate strength is much below and yield strength also very below. Stress is defined as the intensity of distributed forces that tend to resist change in shape of a body. The material properties are testing to relate the stress strain diagram by applying load gradually gives the sufficient time to develop the strain. KunioAsai [1] et.al, In this study authors have been conducted test on fatigue tests were performed under 12% Cr steel at high contact pressure is applied to line contact using the parameters of mean stress, contact pressure and material strength. In contact pressure increased, fatigue strength decreased and minimized when hertz average contact pressure increased about 1.5

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times 0.2% proof stress0.2% again higher contact pressure.The experimental results shows decreased in the length of non-propagating and increased the material strength.S. Sathishkumar [2] et.al, studied the aluminium alloy and Graphite particles are composited on the dry sliding wear behaviour and it evaluated using pin-on-disc tools. The materials were fabricated by using liquid casting technique. The Graphite particles are composites with 8 wt% is processed. The composite was casted by subjected to T6 heat treatmentThe 7075(Al) aluminium alloy is most effectively in self-lubricating material in the condition of dry sliding and Graphite particle are in lower range with 8wt%. It appeared to be optimum in Graphite. This work is mainly gives the information about analysis performs in the damages and cracks on the composites material.S. Eslamian [3] et.al, in this study fatigue may lead to crack initiation to small loads or prolonged operation of fatigue. Fatigue effects in the speed of nucleation and surface cracks and it is damaged. fatigue critical damaged in aircraft structure and problem spread in naval structural component it causes the root of fatigue crack nucleation in the machine components.

II. METHODOLOGY

In the present work Aluminium 2024 is used as a matrix material and Graphitepowder is used as reinforcement. The properties of the Al and Gr powder used are listed in the table 1and 2 respectively.

Table 1: Properties of Aluminum

AL-2024	
Properties	**Value**
Density	2.78 g/cm³
Melting point	500 °C
Ultimate Tensile Strength	469Mpa

Table 2: Properties of Graphite

Graphite	
Properties	**Value**
Density	2.26 g/cm3
Melting point	3600°C
Ultimate Tensile Strength	76Mpa

2.1 Development of Al-2024-Gr Composite

Aluminum 2024 alloy in initial melts at the melting temperature is 670c. Heating continued for 2 hour and added the Graphene. The percentage of Graphene are varying with 0%, 0.25%, 0.5%, 0.75%, 1% weight percentage of Graphene with aluminium and specimen is prepared. It converts the mixture from molten state and pours to mould box the specimen dimension is specified and allowance. Aluminium is used as a metal matrix material and Graphene is reinforcement with the weight ratio as a cast 0%, 0.25%, 0.5%, 0.75%, 1% and weight percentage of aluminium. By using stir casting method the specimen is too prepared. The raw material of aluminium is melts at the temperature of 670c and it is converting to molten state.Graphene is added by fixture and stirred gently for 7 minutes by clockwise and anticlockwise direction for uniform mixture of aluminium and Graphene.

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2.2 Specimen Dimention
In present work specimen dimenstion are-

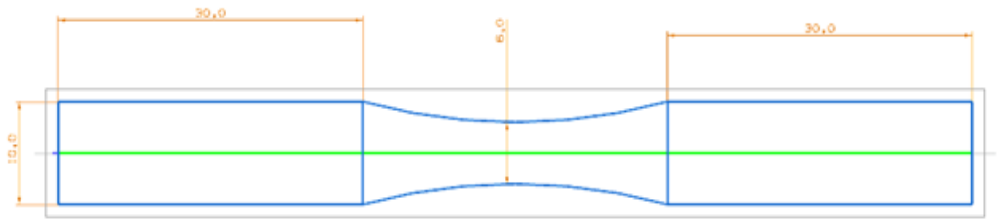

Figure: 3 -2D Diagram of specimen (All Dimention in mm)

Grip diameter = 10 mm,Grip length = 30 mm,Gauge diameter = 6 mm ,Guage Length = 30 mm
Total length = 90 mm

Figure 4: Fatigue Test Specimen

CNC machine is a sequential form of program it controls the machine instruction such as G-code and M-code and person can write the program and executed. In 3D printer case the printed part is sliced the instruction program and generated. 3D printer is use only the G-code.

III. EXPERIMENTATION

3.1 Fatigue characterization of the processed MMC

Fatigue test was conducted on the rotating beam testing machine as shown in the figure 5. The specimen used for the testing is prepared as per ASTM E466. The test is conducted by mounting a test specimen on the Rotating beam fatigue testing machine, which is operated at a constant speed of 2000 rpm with an applied load starting from 5Kg and the test is repeated for similar test specimen with same speed by applying lesser loads till it reaches the endurance limit.

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Fig 5: Rotating bending machine

The number of cycles required for specimen to fail is noted down for each loading condition and the stress corresponding to that load is calculated. Results obtained from rotating beam bending test for are useful finite life design calculations. For this S-N curve can be modeled by Basquin equation. $\sigma f = (A)(Nf)\ B$. This equation becomes linear when represented on log-log scale. This equation can be used for design calculations by determining constants A and B which are unique for a particular material.

Machine type	Rotatry BendingFatigue Tester
Make:	Magnam Engineers, Bangalore
Maximum bending Moment	up to 200 Kg-cm
Speed Range	1000 – 3000 r.p.m.
Prsent counter with speed	6 digit indicator
Maximum load applied	up to 20 kg
Specimen dimentions	Length 90 mm with neck (gauge) diameter 4, 6 and 8 mm.
Distance between load bearing point ti hinge bearing point	100 mm

Table 3: Specifications of Rotating Bending Machine

IV. RESULTS AND DISCUSSIONS

4.1 Fatigue Test Result

Load (Kg)	Load (MPa)	Cycle 0.00Gr	Cycle 0.25Gr	Cycle 0.50Gr
5	115.65	9872	12717	17437
4.5	104.09	30307	52313	88712
4	92.52	71312	136206	156414
3.5	80.95	312614	410721	482983
3	69.39	919995	956737	999756

Table 4: Fatigue Cycles with different Percentage of graphene Respected Load

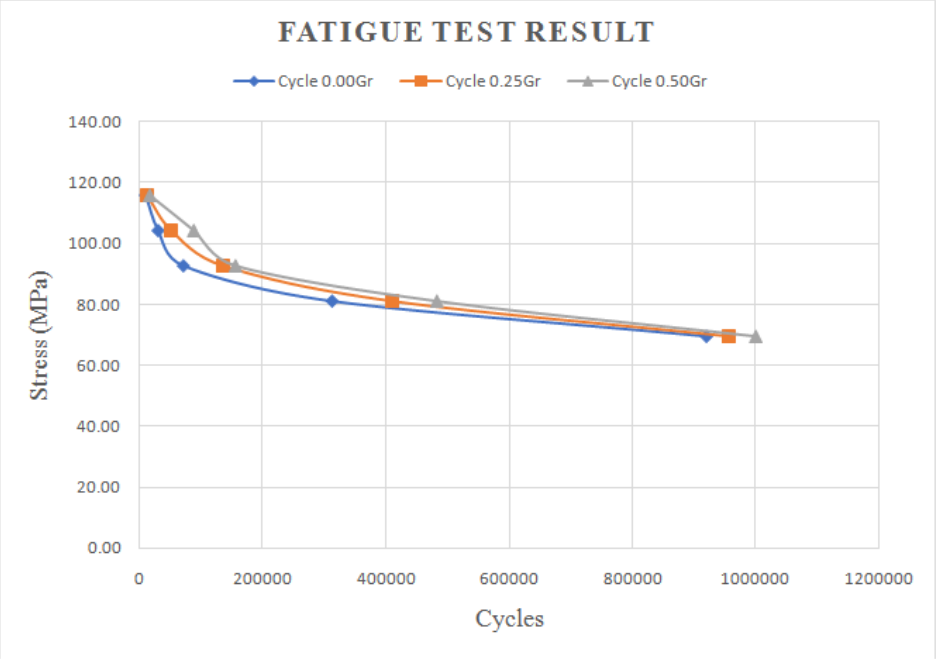

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Figure 7: Fatigue Test Result Graph- Stress Vs cycles.

4.2 Fatigue Analysis

Fatigue limit, endurance limit, and fatigue strength are all expressions used to describe a property of materials: the amplitude (or range) of cyclic stress that can be applied to the material without causing fatigue failure. Ferrous alloys and titanium alloys have a distinct limit, an amplitude below which there appears to be no number of cycles that will cause failure. Other structural metals such as aluminium and copper do not have a distinct limit and will eventually fail even from small stress amplitudes. In these cases, a number of cycles (usually $5*10^8$) is chosen to represent the fatigue life of the material.

Ultimate Tensile Strength (MPa)	Experimental Endurance limit (MPa)	Theoretical Endurance limit (MPa)
109.53	29.90	27.38
132.26	32.77	33.065
143.29	34.48	35.82

Table 5: Endurance limit table experimental and theoretical

Increase the reinforcement graphene (0.25% and 0.50% by weight) increase the endurance limit.

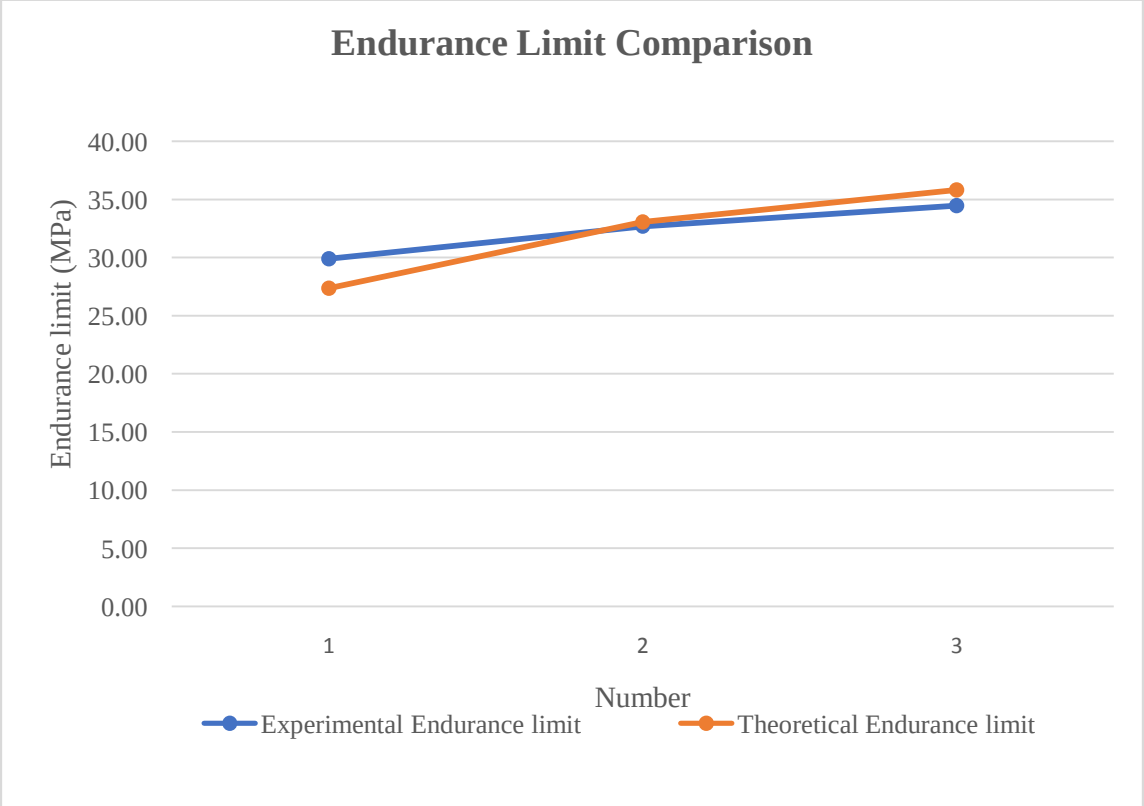

Figure 8: Graphical Representation for Experimental and Theoretical Endurance Limit

4.3 Dynamic Transient Analysis (Al+0.00Gr), (Al+0.25Gr) and (Al+0.50Gr)

Transient Analysis is done for Al6061 reinforcement with graphene varying percentage 0%, 0.25%, 0.50%. by weight for different load 3to 5 Kg.

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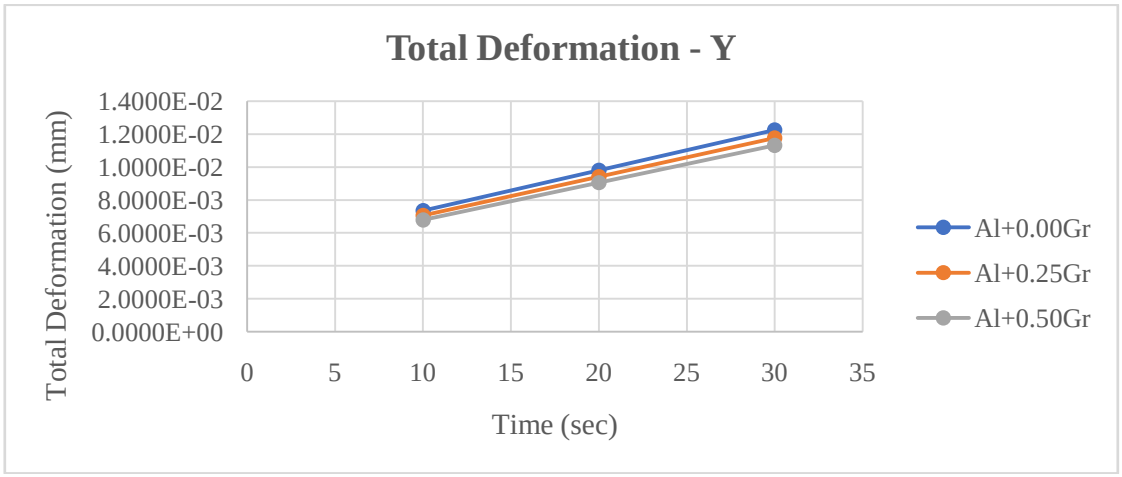

Figure: 9 total Deformation in Y Direction.

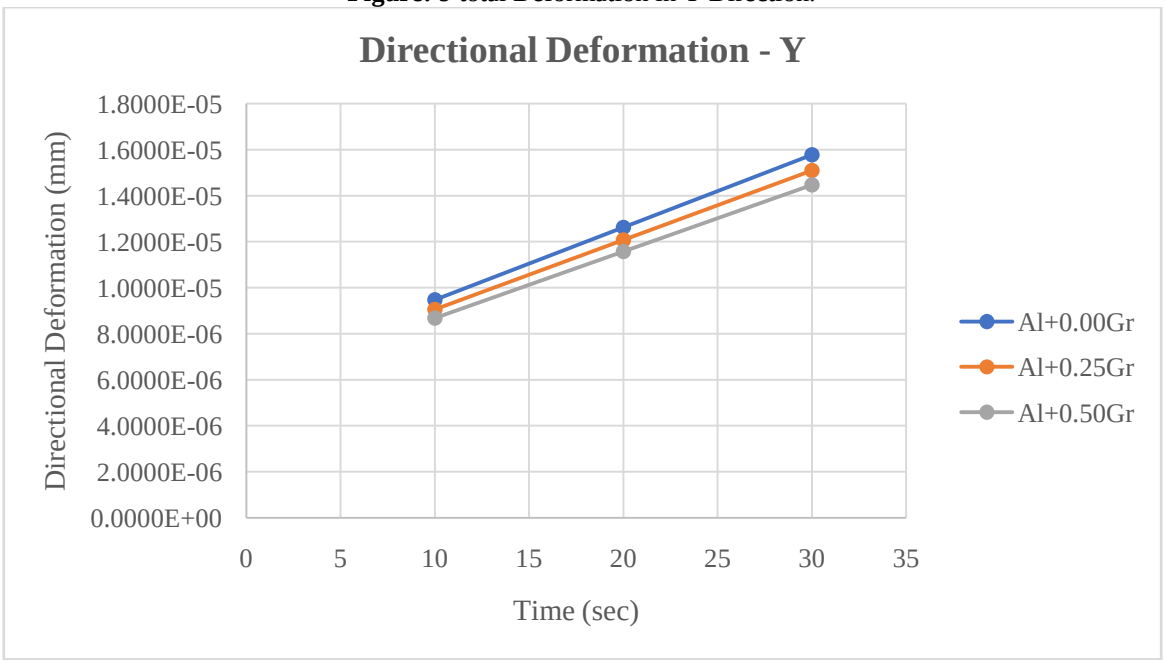

Figure 10: Directional deformation in Y Directional

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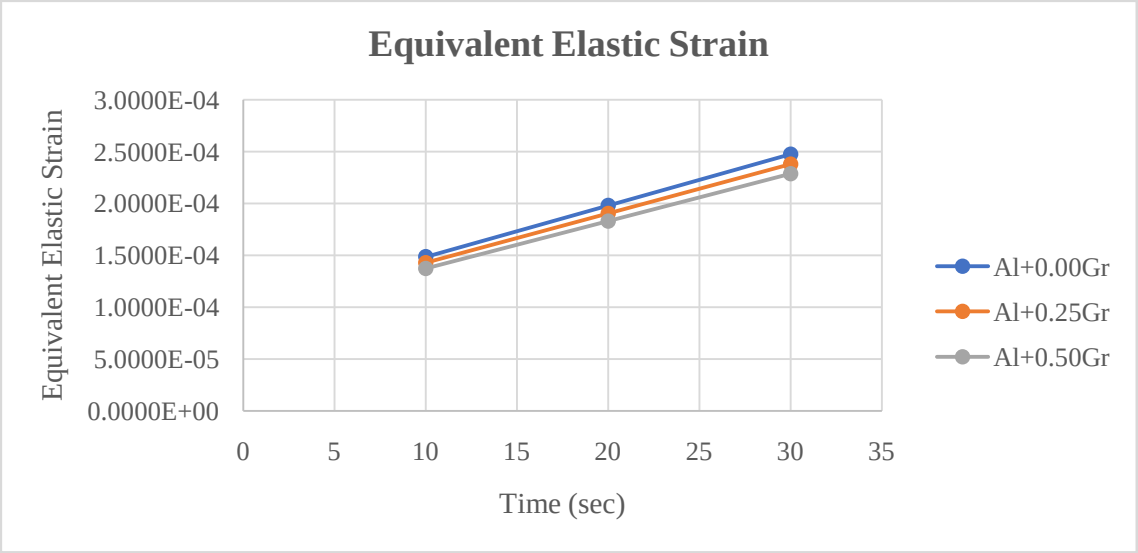

Figure: 11 Equivalent Elastic strain

Figure number 9,10,11 shows the increase the reinforcement decrease the deformation and strain in the specimen. Specimen deform chart with varying load with respect to time shown in figure 9 to 11.

V. CONCLUSIONS

From the above discussions it can be conclude that the Strength can be increase by increasing the percentage of Graphene as reinforcing material composite material. The property of graphene has a highest strength over the all known materials that's why increased the strength like ultimate tensile strength endurance limit. ANSYSanalysis also showed that the natural frequency of the material increases as percentage of graphene in the composition and transient analysis decrease the deformation and strain.

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