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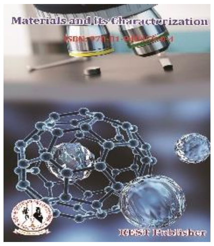

An Investigation into the Properties of Connecting Rods Produced with Very Small Particles and Aluminum Alloy

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Abstract: *In the current study, an effort has been made to create metal matrix composites employing Al2024 as the matrix material, Si3N4 particulates, and K2TiF6 reinforcement using liquid metallurgy, in particular stir casting technology. The addition degree of reinforcement is adjusted in 4-wt% stages, ranging from 4 to 8%. In an effort to increase wettability and distribution, reinforcing particles for each composite were warmed to a temperature of 500oC and then disseminated in three-step increments rather than all at once into the vortex of molten Al2024 alloy. By obtaining samples from the casting's centre and doing microstructural investigations and SEM analysis on them, the aforementioned composite materials' microstructural characterization was completed. To determine the degree of improvement, the produced composite's tensile, impact, and fatigue properties were examined both before and after the addition of Al2024 particles. The composites' microstructural analysis revealed very uniform Si3N4 particle distribution and some degree of grain refinement in the specimens. Si3N4 and other phases were found, according to SEM analysis. Also, it was discovered that the composite's Tensile and Impact strength rose as the filler content did.*

Keywords: *Al2024 Alloy;* Si_3N_4*; Yield Strength; Tensile Strength; Elongation Percentage; Impact Strength; FEA; Fatigue Strength.*

1. INTRODUCTION

Due to the incorporation of tiny reinforcement particles into the matrix, metal-matrix composites (MMCs) are among the most promising materials for achieving improved mechanical qualities like hardness, Young's modulus, yield strength, and ultimate tensile strength [1]. Because to their superior physical and mechanical qualities, aluminum- matrix composites (AMCs) reinforced with discontinuous reinforcements are being used more frequently in the automotive, military, aerospace, and electrical industries [2]. In engineering applications such as the transportation and construction industries, where excellent mechanical qualities like tensile strength, fatigue strength, impact strength, hardness, etc., are critical, 2024 Al-alloy is one of the most popular Al-alloys. To enhance the characteristics of the 2024Al alloy, a variety of materials are being employed as reinforcements, including SiC, Al2O3, B4C TiB2, ZrO2, SiO2, and graphite. However, the use of Al2O3 or Si3N4 particle reinforced aluminium alloy matrix composites is steadily expanding in the automotive and aircraft industries for pistons, cylinder heads, connecting rods, etc. where the tribological properties of the materials are crucial. Compared to other aluminium alloys, aluminium 2024 alloy has superior hardness and fatigue resistance. By including other reinforcements, this can be improved even further [3]. Si3N4 has a higher density than the Al2024 alloy. They provide the MMC with some solid reinforcement. In order to address the demands for lighter materials with high specific strength and stiffness for numerous applications in various industries, metal-matrix composites (MMCs) have been created. Aluminum Metal Matrix Composites (MMCs) have been used more and more recently in nearly every industrial area as engineering materials. Because to their enhanced qualities, such as a high strength to weight ratio and good wear resistance, aluminium MMCs are preferred to other traditional materials in the aerospace, automotive, and marine industries. Si3N4 has a higher density than the Al2024 alloy. They provide the MMC with some solid reinforcement. Due to their increased qualities, such as a high strength to weight ratio and good wear resistance, aluminium MMCs are preferred to other conventional materials in the sectors of aerospace, automotive, and marine applications. To gauge the degree of improvement, the produced composite's hardness and tensile characteristics were assessed both before and after the addition of Si3N4 particles. The composites' microstructural analysis revealed somewhat uniform distribution and considerable degree of grain refinement in the specimens. MMCs are produced using the liquid phase processing method, which involves melting the base alloy and reinforcement at 500oC before fully mixing them together during the stir casting process. The Si3N4 particles in the molten metal are distributed uniformly thanks to the stir casting process. resulting in the mechanical behaviour of the MMCs being uniform.

2. WORKFLOW DIAGRAM

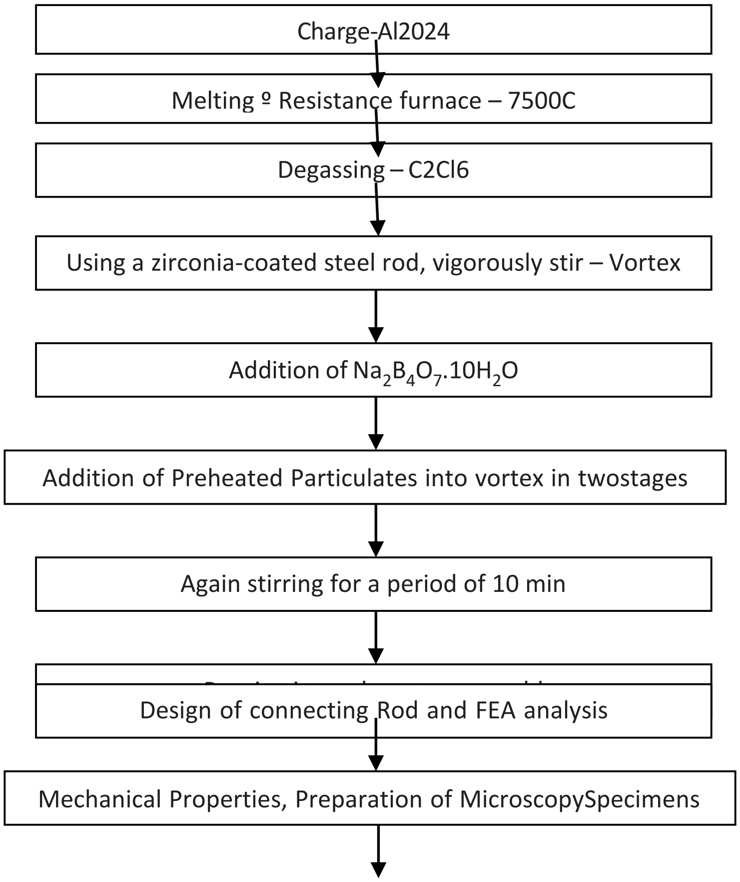


FIGURE 1. Methodology Flowchart

Connecting Rod Design

TABLE 1. Parameters of Connecting Rod

	Description	Parameters	Dimensions
1	Connecting rod Thickness	t	3.2mm
2	Section Width	B=4t	12.8mm
3	Section Height	H=5t	16mm
4	Bigger End Height	1.1H to 1.125H	17.6mm
5	Smaller End Height	0.9H to 0.75H	14.4mm
6	Smaller End Inner diameter	S_I	17.94mm
7	Smaller End Outer diameter	S_O	31.94mm
8	Bigger End Inner diameter	B_I	23.88mm
9	Bigger End Outer diameter	B_O	47.72mm

The standard parameters used to design the connecting rod are shown in Table 1. The 2D drawing of the connecting rodis shown in Figure 2.

Pressure Calculation for 150ccEngine

For the present study we have considered the 150ccengine.
The 150cc engine is 4-stroke air cooled typeBore size = 57mm
Stroke = 58.6mm
Total Displacement = 149.5 CC
Maximum Power at 8500 rpm = 13.8 bhp
Maximum Torque at 6000 rpm = 13.4 Nm
Compression 0 Ratio = 9.35/1
C_8H_{18} petrol 0 density = 737.22 kg/m^3
= 737.22 x 10-9 kg/mm^3
Temperature = 60^{o}F = 288.855º K
Mass = Density x Volume
= 737.22 x 10-9 x 149.5 x 103
= 0.11 kg
C_8H_{18} Petrol molecular weight is 114.228 g/mole
We know that from Gas Equation,
PV = MxrxtxR
PV = Rx/Mw
PV = 8.3143/114228 = 72.76
P = {(0.11 x 72.786 x 288.85)}/(149.5 x 10000)
Pressure = 15.5 MPa.

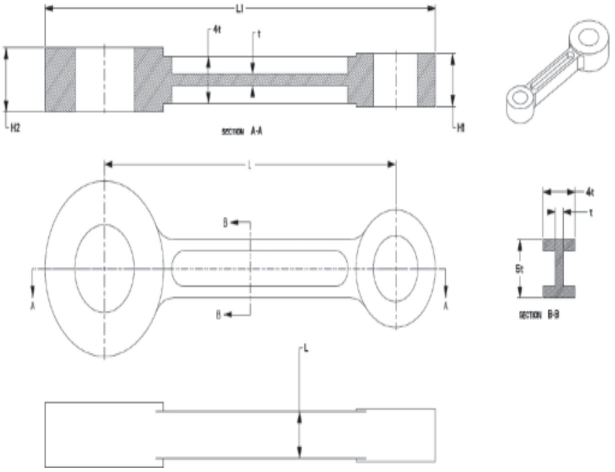
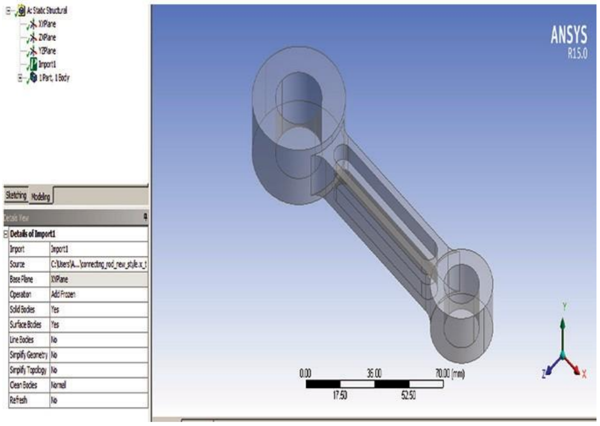


FIGURE 2. Connecting rod in 2D illustration



Details of Import1	
Import	Import1
Source	C:\Users\A...\connecting_rod_new_style.x_t
Base Plane	XYPlane
Operation	Add Frozen
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Simplify Geometry	No
Simplify Topology	No
Clean Bodies	Normal
Refresh	No

Figure 3. Model imported into Ansys

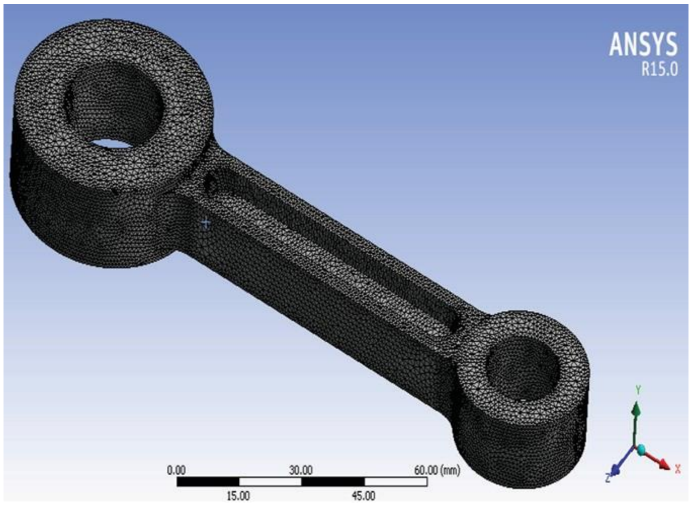


FIGURE 4. A variety of notes and components were produced in the mesh connecting rod.

3. RESULTS AND DISCUSSIONS

Method steps for determining the fatigue life

1. Add the material to the connecting rod after importing the model from CAD to FEA.
2. Dissect the body into its constituent pieces. Mesh the object to divide the body into smaller parts. Improve the for best results.

Indicate the Boundary circumstances.

a. Fix the smaller dia.

b. Apply 15.5 MPa of pressure (value taken from the calculation)

4. LIFE OF FATIGUE FOR VARIOUS MATERIALS

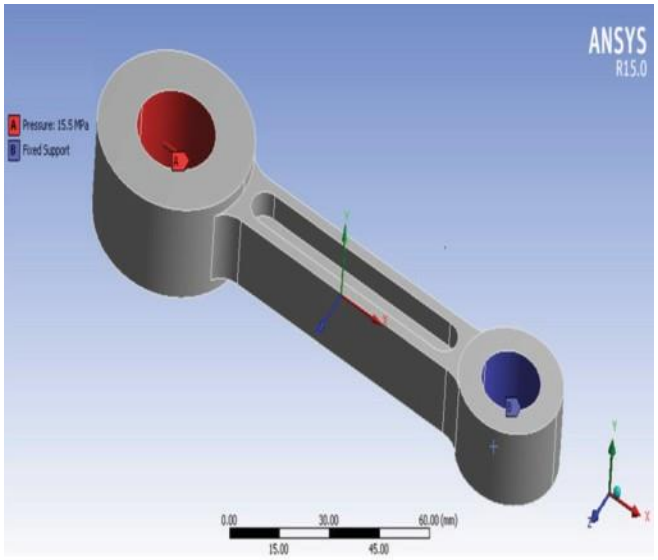


FIGURE 5. Applying boundary conditions

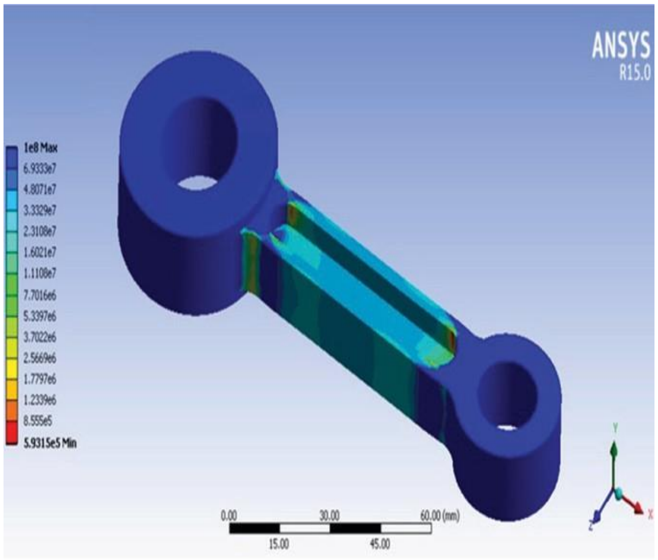


FIGURE 6. Weariness life

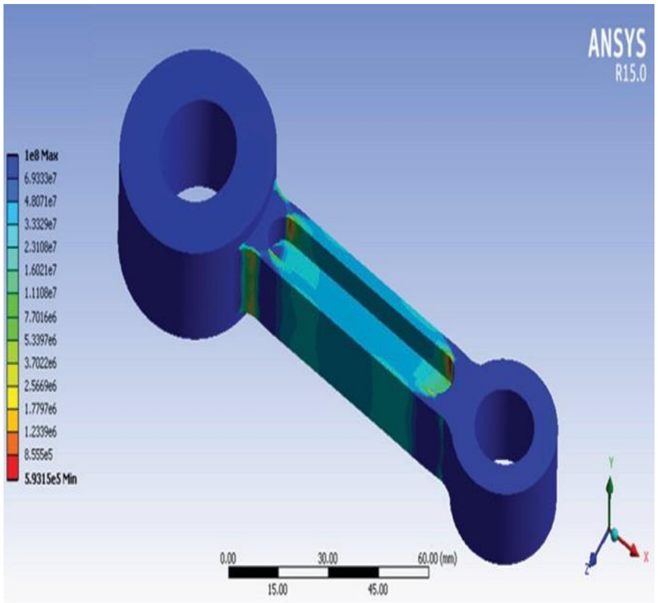


FIGURE 7. Steel for Structures

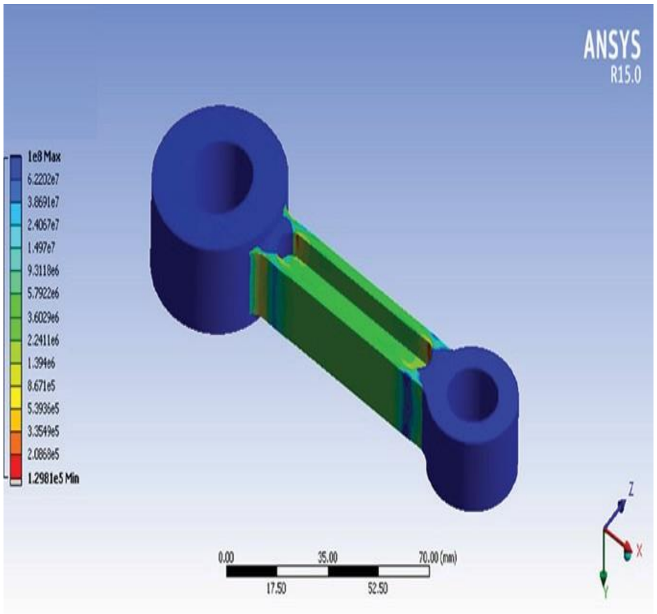


FIGURE 8. Aluminium 2024 Alloy

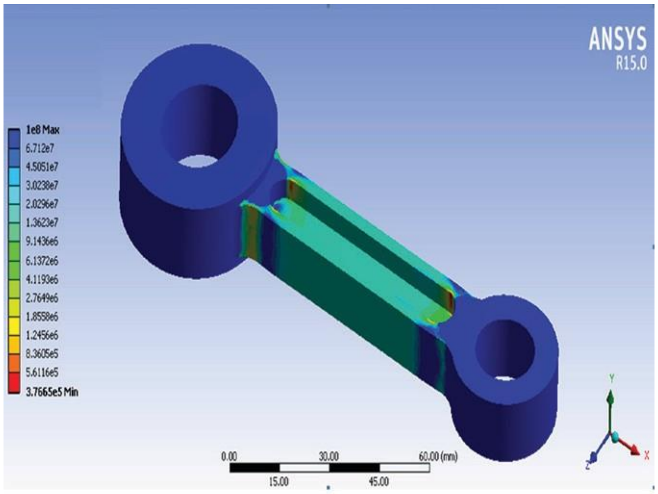


FIGURE 9. Aluminum 2024 + 8% Si_3N_4

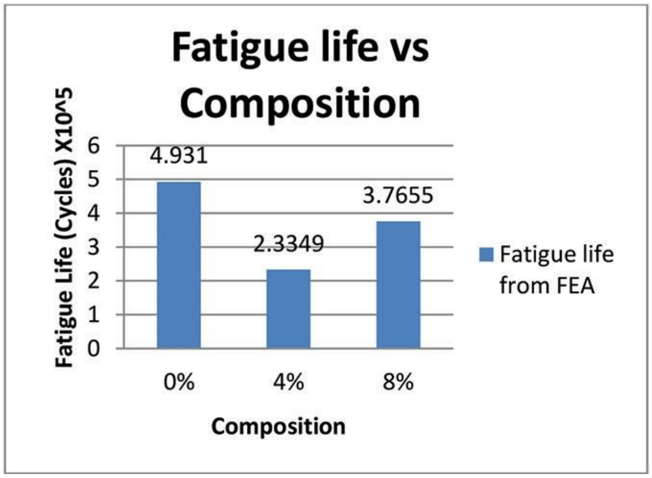


FIGURE 10. With regard to Al2024 and Si3N4 weight percentages of reinforcements, fatigue life (cycle)

5. CONCLUSIONS

The following are the findings of the most recent investigations into the synthesis and characterization of stir-cast Al2024-Si3N4 composites: Aluminum-based metal matrix composites have been successfully made using the melt stirring process with two-step reinforcing and preheating of particles. Al2024 - Si3N4 composites with 4 and 8 wt% reinforcement were successfully made by stir casting. A scanning electron microscope was used to look at the Al2024 - Si N matrix, and it revealed a uniform distribution of reinforcement particles. SEM pictures of the composites showed the primary -Al dendrites and eutectic copper with Si3N4 separated at inter-dendritic areas. Si3N4P's weight percentage has increased. The produced composite has a higher ultimate tensile strength as compared to Al2024 alloy. The composite has a greater number for ultimate tensile strength, which also varies depending on the reinforcement. The connecting rod constructed of steel, aluminium 2024 alloy, and composite aluminium 2024-si3n4 underwent fatigue analysis (FEA), and it was discovered that the composite would have a longer fatigue life than the aluminium 2024 alloy.

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