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Analysis of Connecting Rod Made by using Micro Si_3N_4 Particulates Reinforced with Al2024 Alloy

Rachepalli Nochitha[*1], Pramodkumar S Kataraki[1], Dharshan K[3], A F Zubair[4] and Ayub Ahmed Janvekar[5]

[1]School of Mechanical Engineering, REVA University, Bengaluru, India. [*]Email: noci10071995@gmail.com / pramodkumar.sk@reva.edu.in
[3]PG Scholar, Dr Ambedkar Institute of Technology, Bengaluru, India.
[4]Intelligent and Smart Manufacturing Centre, Center for Mechanical Engineering Studies, Universiti Teknologi MARA, Penang Branch, Malaysia.
[5]School of Mechanical Engineering, Vellore Institute of Technology, Chennai, Tamil Nadu 600127, India.

Abstract

In the present work, an attempt has been made to synthesize metal matrix composite using Al2024 as matrix material with Si_3N_4 particulates and K_2TiF_6 reinforcement using liquid metallurgy route in particular stir casting technique. The addition level of reinforcement is being varied from 4-8% in steps of 4 wt%. For each composite, reinforcement particles were preheated to a temperature of 500ºC and then dispersed in steps of three into the vortex of molten Al2024 alloy rather than introducing all at once, thereby trying to improve wettability and distribution. Microstructural characterization was carried out for the above prepared composites by taking specimens from central portion of the casting by microstructural studies and SEM analysis. Tensile, Impact, and Fatigue properties of the prepared composite were studied before and after addition of Al2024 particulates to note the extent of improvement. Microstructural characterization of the composites has revealed fairly uniform distribution of Si_3N_4 particulates and some amount of grain refinement in the specimens. SEM analysis revealed the presence of Si_3N_4 and other phases. Further, the Tensile and Impact strength of the composite found increased with increased filler content.

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

1.0 Introduction

Metal-matrix composites (MMCs) are most promising materials in achieving enhanced mechanical properties such as: hardness, Young's modulus, yield strength and ultimate tensile strength due to the presence of micro-sized reinforcement particles into the matrix [1] and Aluminum-matrix composites (AMCs) reinforced with discontinuous reinforcements are finding increased use in automotive, military, aerospace and electricity industries because of their improved physical and mechanical properties [2]. Among Al-alloys, 2024Al-alloy is widely used in engineering applications such as transport and construction sectors where superior mechanical properties like tensile strength, fatigue strength, impact strength, hardness etc., are essentially. A number of materials such as SiC, Al_2O_3, B_4C,

**Corresponding author*

TiB_2, ZrO_2, SiO_2, Si_3N_4 and graphite are being used as reinforcements to improve the properties of 2024Al alloy. However, the applications of Al_2O_3 or Si_3N_4 particle reinforced aluminum alloy matrix composites in the automotive and aircraft industries is gradually increasing for pistons, cylinder heads, connecting rods etc. where the tribological properties of the materials are very important Aluminum 2024 alloy has good toughness and fatigue resistant compared to the other alloys of Aluminum. This can be further enhanced by additions of different reinforcement [3]. The density of the Si_3N_4 is high compared to the Al2024 alloy. These form a good reinforcement in the MMC.

Metal-matrix composites (MMCs) have been developed to meet demands of lighter materials with high specific strength and stiffness for different applications in various sectors. In recent times, the application of Aluminium Metal Matrix Composites (MMCs) as engineering materials has exceedingly increased in almost all industrial sectors. Aluminium MMCs are preferred to other conventional materials in the fields of aerospace, automotive and marine applications owing to their improved properties like high strength to weight ratio, good wear resistance etc. The density of the Si_3N_4 is high compared to the Al2024 alloy. These form a good reinforcement in the MMC.

Aluminum MMCs are preferred to other conventional materials in the fields of aerospace, automotive and marine applications owing to their improved properties like high strength to weight ratio, good wear resistance etc.

Hardness and tensile properties of the prepared composite were determined before and after addition of Si_3N_4 particulates to note the extent of improvement. Microstructural characterization of the composites has revealed fairly uniform distribution and some amount of grain refinement in the specimens

Liquid Phase processing is a technique in which MMC's are created by melting the base alloy and reinforcement are preheated to 500^{o}C, and then both are mixed thoroughly by stir casting process. This stir casting process helps in uniform distribution of Si_3N_4 particulates in the molten metal. Thus bringing uniform Mechanical behaviour of the MMC's.

2.0 Work Flow Chart (Fig.1)

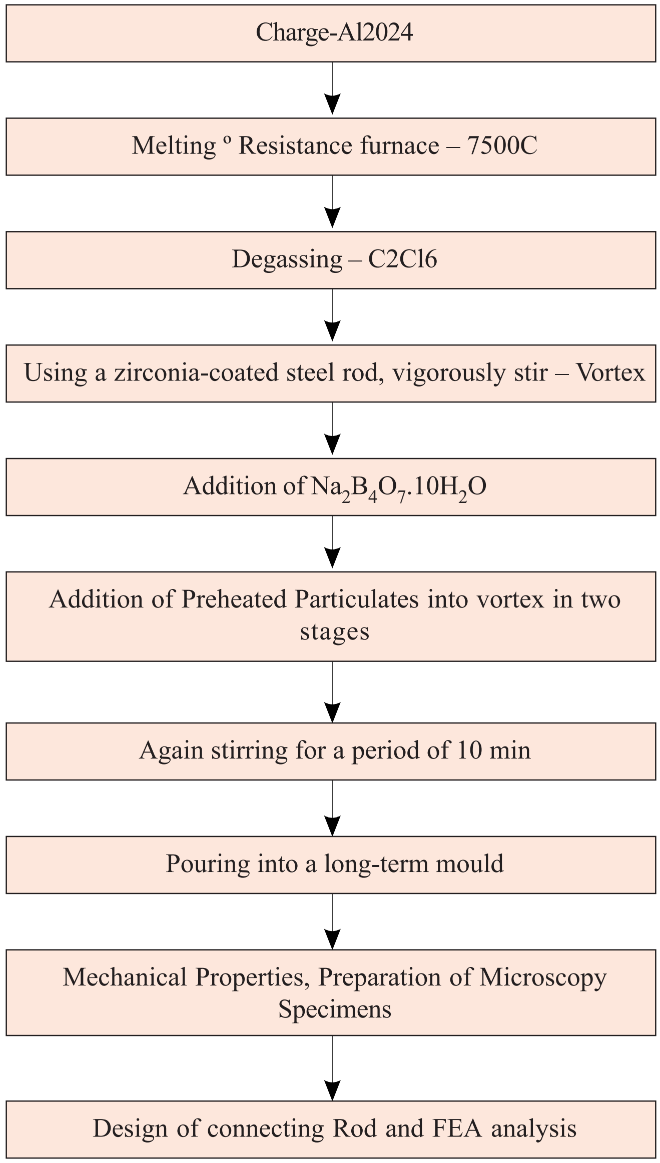

Figure 1: Methodology Flowchart

3.0 Connecting Rod Design

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

3.1 Pressure Calculation for 150cc Engine

For the present study we have considered the 150cc engine.

The 150cc engine is 4-stroke air cooled type

Bore size = 57mm

Stroke = 58.6mm

Total Displacement = 149.5 CC

Maximum Power at 8500 rpm = 13.8 bhp

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

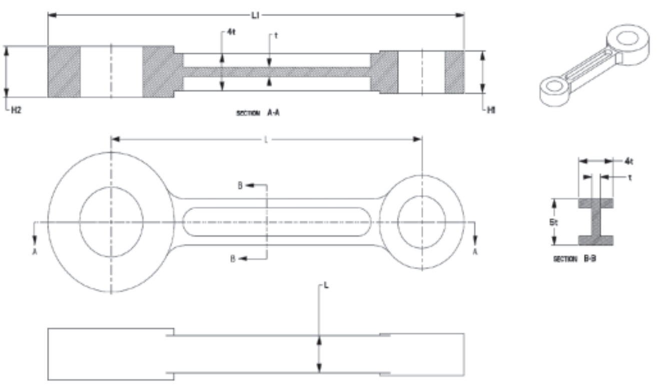

Figure 2: 2D drawing of connecting rod

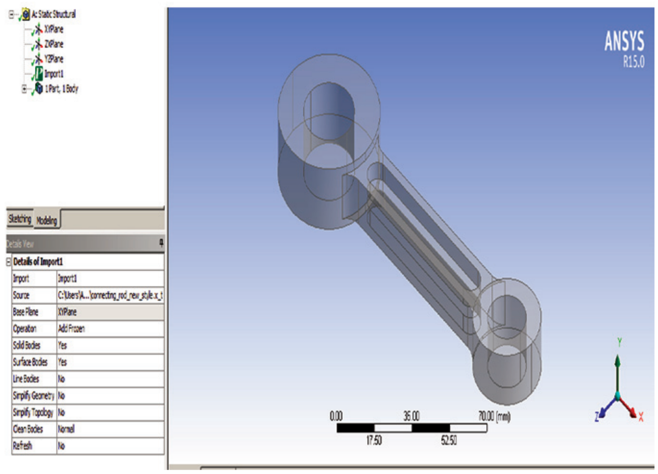

Figure 3: Imported model in ansys

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 × 10-9 kg/mm^3

Temperature = 60ºF = 288.855º K

Mass = Density × Volume

= 737.22 × 10-9 × 149.5 × 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/MwPV = 8.3143/114228

= 72.76

P = {(0.11 × 72.786 × 288.85)}/(149.5 × 10000)

Pressure = 15.5 MPa.

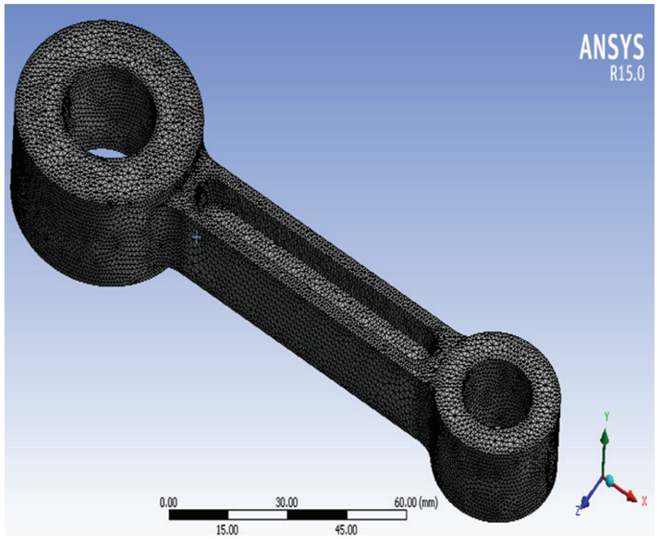

Figure 4: Number of note and elements created in the meshed connecting rod

4.0 Results and Discussions

4.1 Steps in finding the Fatigue life using FEA Method

1. Import the model from CAD to FEA and assign the material to connecting rod.
2. Discretize the body into small elements. Mesh the object to divide the body into small elements. Refine the for good results.

1.1 Define the Boundary conditions

a. Fix the smaller dia.

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

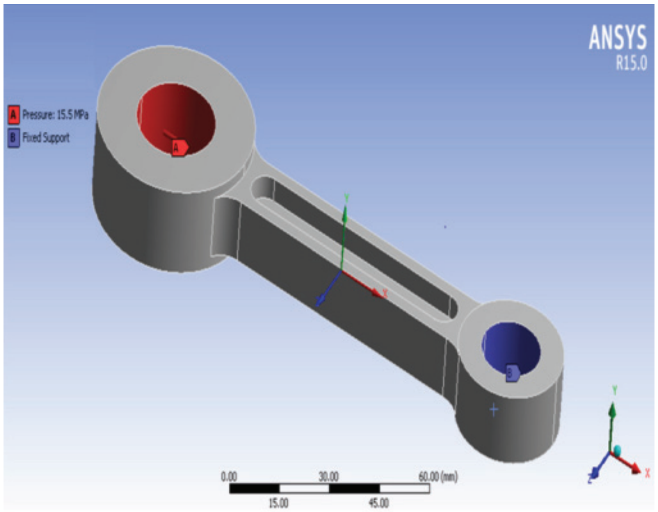

Figure 5: Boundary conditions applied

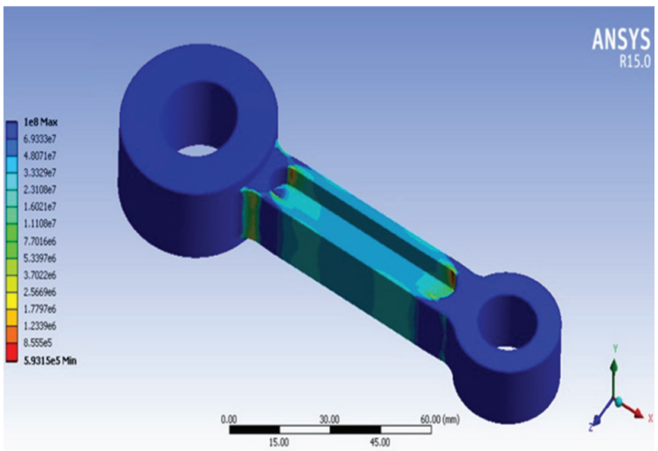

Figure 6: Fatigue life

4.2 Fatigue life for different materials.

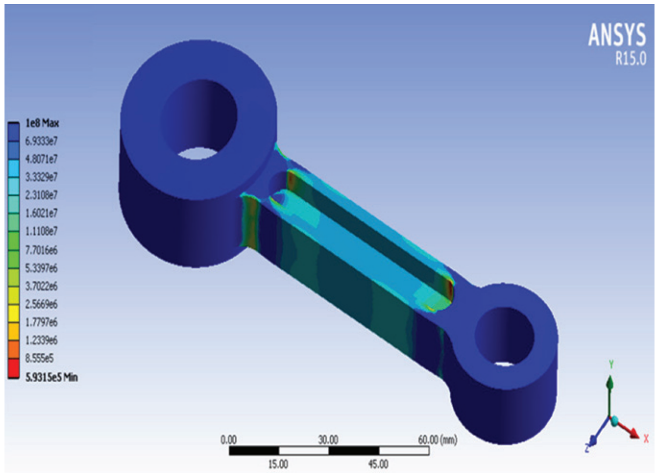

Figure 7: Structural Steel

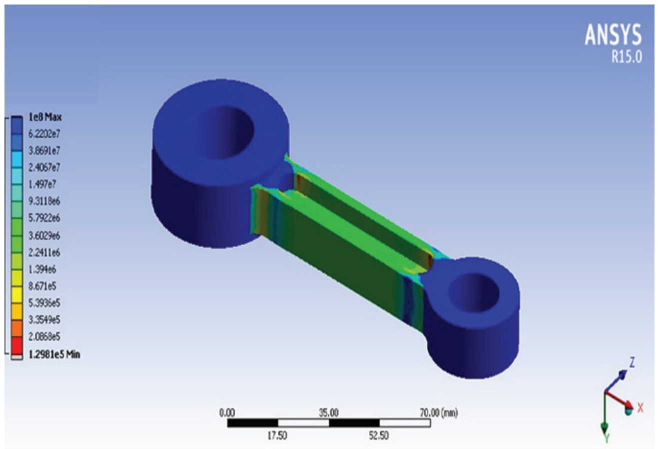

Figure 8: Aluminium 2024 Alloy

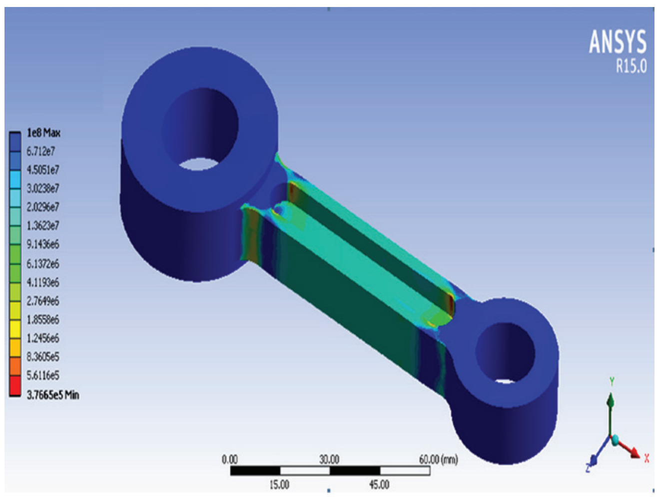

Figure 9: Aluminum 2024 + 8% Si_3N_4

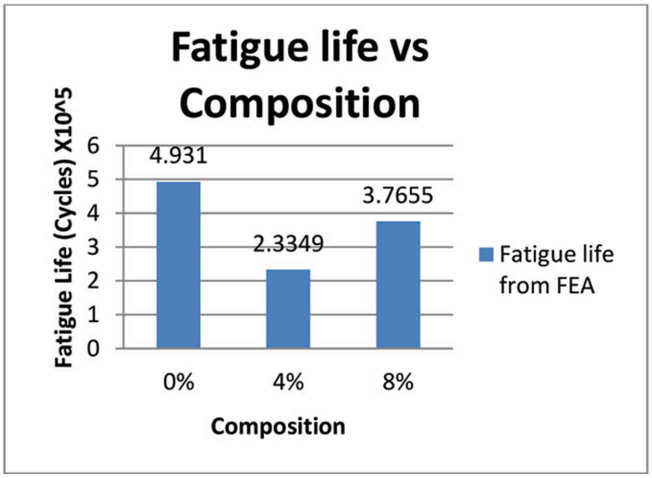

Figure 10: Fatigue Life (Cycle) with respect to Al2024 and Si_3N_4 wt% of Reinforcements

5.0 Conclusions

The following are the results of the current investigations on the synthesis and characterization of Al2024 - Si_3N_4 composites using the stir casting process:

- Melt stirring method with two-step reinforcement and preheating of particles has been effectively used to create aluminum-based metal matrix composites.
- Stir casting was used to successfully create Al2024 - Si_3N_4 composites with 4 and 8wt% reinforcement.
- The Al2024 - Si_3N_4 matrix was examined using a scanning electron microscope, which exhibited a consistent distribution of reinforcement particles.
- The primary α-Al dendrites and eutectic copper with Si_3N_4 separated at inter-dendritic regions were seen in SEM images of the composites. With increasing weight percentage of Si_3N_4P,
- When compared to Al2024 alloy, the manufactured composite has a greater ultimate tensile strength. Furthermore, ultimate tensile strength varies depending on the reinforcement, with the composite having a higher value.
- Yield strength of prepared composite is higher compared to Al2024 alloy. Further, Yield strength changes with the different reinforcement and it is higher in the composite.
- The impact strength got better with an increase in Si_3N_4 content up to 4%, then better with an increase in Si_3N_4 particulates of 8%.
- The fatigue test conducted and the hybrid composite Al2024 - Si_3N_4 shows a superior strength compared to Al2024 alloy.
- Fatigue analysis (FEA) conducted for the connecting rod made of steel, Aluminum 2024 alloy and composite Al2024-Si_3N_4, it found that the composite will give more fatigue life compared to the Al 2024 alloy.

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