



PAPER • OPEN ACCESS

Design, Manufacture and Analysis of Al/SiC MMCs for Connecting Rod

To cite this article: S. Ramasubramanian *et al* 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **183** 012009

View the [article online](#) for updates and enhancements.

You may also like

- [The Structure, Stress and Modal Analysis of 1.6-Liter Gasoline Engine Connecting Rod Based on Finite Element Analysis](#)
Maoqun Zhang, Chao Zhao, Zhenqi Yan et al.
- [Dimensional structural mass optimization of forged steel connecting rod for aircraft piston engine](#)
M Helal, B F Felemban, A Alharthi et al.
- [Investigation of the stress state of the connecting rod of the oppositional compressor and evaluation of the probability of its trouble-free operation](#)
I M Petrova and M A Filimonov

ECS The Electrochemical Society
Advancing solid state & electrochemical science & technology

247th ECS Meeting
Montréal, Canada
May 18-22, 2025
Palais des Congrès de Montréal

**Abstracts due
December
6th**

Showcase your science!

Design, Manufacture and Analysis of Al/SiC MMCs for Connecting Rod

S. Ramasubramanian¹, M.Chandrasekaran², R.Sridhar³ and K.Karunakaran⁴

^{1,3,4}Research Scholar & Assistant Professor, ²Professor & Director

¹Department of Automobile Engineering, Vels University, Chennai, TN, India.

^{2,3,4}Department of Mechanical Engineering, Vels University, Chennai, TN, India.

E-mail: raams87@gmail.com

Abstract. The Metal matrix composite materials is particularly are widely used in automotive engineering applications. In this work discuss with production of Al/SiC composite and investigate it's suitability for the application on Connecting Rod. The results were compared with conventional material C70 Steel. The connecting rod is manufactured using the stir casting method. The basic properties were obtained by mechanical testing. The test results were used for FEA. The connecting rod is designed and meshed using solid works and hyper mesh, and then analysis is done used by ANSYS work bench 14.0 software. The results show that the composite connecting rod is more efficient than the conventional ones.

1. Introduction

In modern automotive IC engine, the connecting rod designed in steel. It's made up of titanium or aluminum for enhance the performance of engines. It is not a rigidly fixed at either end, so that the angle of contact at each end varies. The bigger end of the connecting rod is attached to the shaft and experiences tremendous stress from the reciprocating load takes place by the piston, and the load increases with every cycle and there is an enhanced speed of the engine. Generally the connecting rod is generally manufactured by forging from powder metal. Sudershan Kumar [1] suggested the aluminum boron carbide for carbon steel for connecting rod application. Since its factor of safety nearly theoretical value and improved the stiffness by about 48.55% and reduced stress by about 10.35%. Vivek [2] investigated about the induced stresses, and maximum stress at small end than the higher end. Since, the possibility of failure may occur the connecting rod is the fillet section of both ends. This work analyzed by pro-e wild fire 4.0 software and ANSYS using work bench 11.0 software. Pushpendra Kumar Sharma [3] reported that Weight is reduced using changing the material of the current forged steel connecting rod to crack able forged steel (C70). The dynamic loading based analysis on Al alloy using Finite Element Analysis by Ram Bansalin[4]. Pranav et al[5] conducted the static analysis and fatigue analysis and explored weight reduction possibility for a making of connecting rod and achieved the 9.24% maximum weight is reduction by suggesting the forged steel. In this study analysis used in ANSYS work bench 9 suggested by Pravardhan et al[6]. Rasekh et al [7] suggested to reduce the weight (10% lighter) and cost (25% less expensive) of the forged steel connecting rod. Conducted stress analysis on Mf-285 Connecting Rod using ANSYSv9, software. Hassan et al [8] is suggested the analysis using F-285connecting rod and reported that the higher pressure Stress is between the pin end and rod linkages, bearing cup and connecting rod Linkage and also the maximum tensile stress is incurred in lower half of pin end and between Pin end and



connecting rod linkages. The highest tensile stress was obtained in down part half of pin end and between Pin end and rod linkages. The wear resistance was achieved by Ghosh et al[9] by reinforcing SiC in Al₂O₃. In this research the Aluminum is reinforced with SiC by appropriate combination and to test its compatibility for the application.

2. Al/SiC MMCs for Connecting Rod

It is one of the powerful parts of a modern racing engine. The fault can come from any number of places, but the failure often occurs at the connecting rod because of the stresses involved and change over the linear motion of the piston to the rotary motion of the crankshaft. The each stroke, the connecting rod is stretched and pressed. In this pressure, plus another elements, can make the connecting rod to terminate. The broken rod is move through the engine block completely and run the engine, a condition known as "throwing a rod." The connecting rod often fails due to either of Over Reviving, Pin Failure, Stress Failure, Fatigue Failure or Hydro-lock. Manufacture of Al/SiC by Stir Casting methods shown in Figure 1. The liquid Infiltration Process involved in infiltration of a fibrous reinforcement, it's preformed using a liquid metal. Liquid-phase infiltration of MMCs is not straight forward; it's mainly trouble with wetting, ceramic reinforcement used as the molten metal.

The percolation of a fiber material to perform come about readily, reactions among the fiber and the molten metal may fall out which implication degrade the main properties of the fiber materials. The fiber coating is used to apply prior the implication, it is developing the leak and allows the control of interface reactions, which is improved and also generating some promotive results. This study even if, the weakness is that the fiber coating essential mot be unprotected the air prior to infiltration because surface oxidation of the coaing fall out. One liquid infiltration process is involving particulate reinforcement, known as Duralcan process it has been quite powerful and efficient. Ceramic particles and ingot-grade Al is blended and melted. The melt is agitated slightly above the liquids temperature around (600-700°C). The solidified is also under the secondary processing by rolling. The Duralcan process of producing the particulate composites by a liquid metal casting route involved and were 8-12 μm particles is used. For particles that are very small size (2-3 μm), result shows the very high interface region and a varying the viscous melt. In foundry-grade Metal Matrix Composite, high Si aluminum alloys (e.g., A356) is used to prevent the formation of the brittle compound Al₄C₃, which is formed from the interfacial reaction between Al and SiC, Al₄C₃ is particularly damaging to mechanical properties, toughness and corrosion resistance.

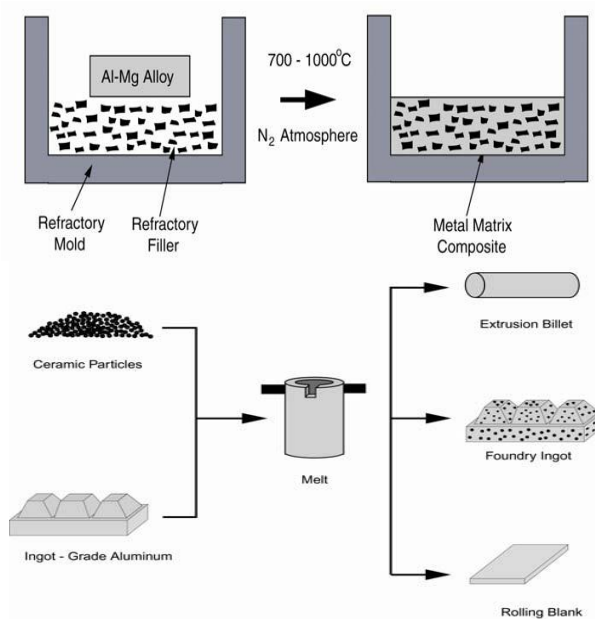


Figure 1. Stir casting technique for Al/SiC MMC

In this work the Aluminum reinforced using SiC and the ratios of Al 60% / SiC 40%, Al 75% / SiC 25% and Al 70% / SiC 30%. The properties is evaluated and furnished in Common physical properties in Table 2, Comparative Mechanical properties in table 3. The Dimensional parameter is shown in Table 4. The Lab Test results of Mechanical Properties were furnished in Table 5.

Table 1.Physical Properties of Al/SiC MMCs

Description of Properties	Quantity
Density (kg/m ³)	2784
Young's Modulus (MPa)	99974
Poisson Ratio	0.292
Co- efficient of thermal expansion (C ⁻¹)	16.002
Tensile Strength (MPa)	615.63
Compressive Strength (MPa)	400.3
Thermal Conductivity (Wm ⁻¹ K ⁻¹)	130
Specific Heat (Jkg ⁻¹ k ⁻¹)	919

Table 2.Mechanical Properties of Al/SiC MMCs

Composition (Vol.%)	Al75/ SiC25	Al70 / SiC3 0	Al60/ SiC40
Density (g/cm ³)	2.8	2.8	2.9
Young's Modulus (GPa)	115	125	150
Young's Modulus/Density (GPa-cm ³ /g)	41	45	52
Flexural Strength (MPa)	-	-	-
Co- efficient of thermal expansion	15	14	13
Thermal Conductivity (W/mK)	145	150	155

Table 3.Paramaters of Connecting Rod

Description of Parameters	Quantity
Length of connecting rod	124mm
Outer Diameter of Big end	40mm
Inner Diameter of Big end	30mm
Outer Diameter of Small end	18mm
Inner Diameter of small end	12mm

Table 4.Laboratory test report on C70 Steel Vs Al/SiC

Properties	C70 Steel	AlSiC:60/40
Tensile Strength(MPa)	966	107.8
Hardness	156 HV	125 HV
Temperature (Melting point)	632oC	858oC

3. Compatibility Analysis of Al/SiC MMCs

3.1 Modeling of Connecting Rod

The modeling was done by using ANSYS workbench 14.0 software (refer Figure 2). The stress, Strain, deformation and Thermal analysis is carried out. They are furnished for Al/SiC and for C70 respectively from the Figure 3 to Figure 10



Figure 2. Model of Connecting Rod

3.2 Stress analysis

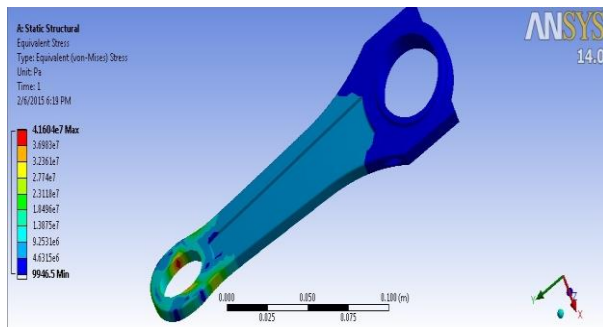


Figure 3. Stress analysis of Al/SiC

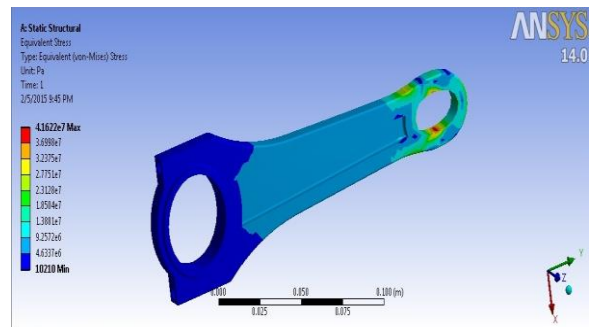


Figure 4 Stress analysis of C70 Steel

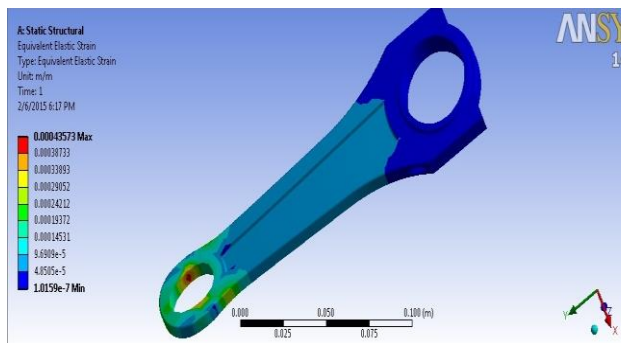


Figure 5 Strain analysis of Al/SiC

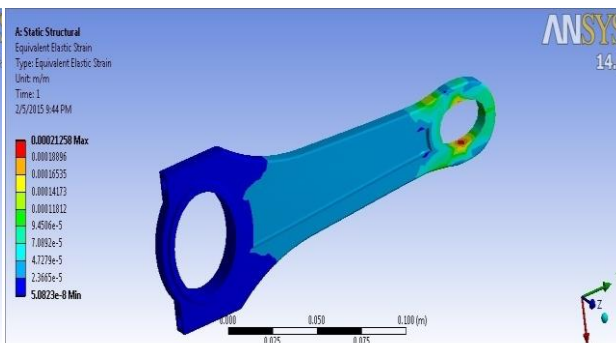


Figure 6 Strain analysis of C70 Steel

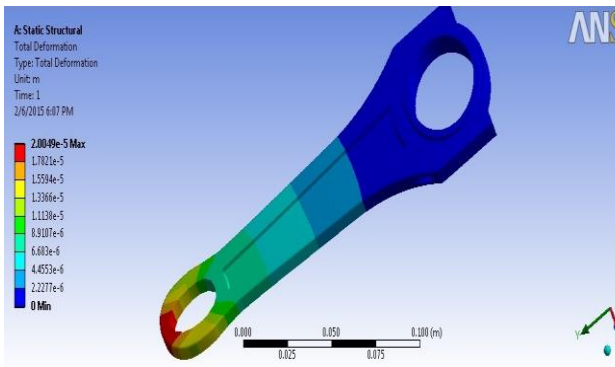


Figure 7 Deformation analysis of Al/SiC

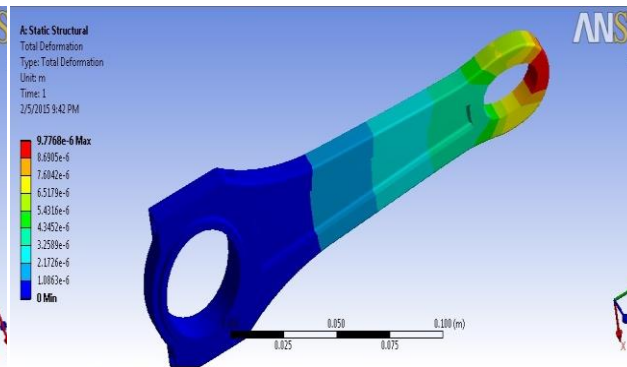


Figure 8 Deformation analysis of C70 Steel

3.3 Temperature Analysis

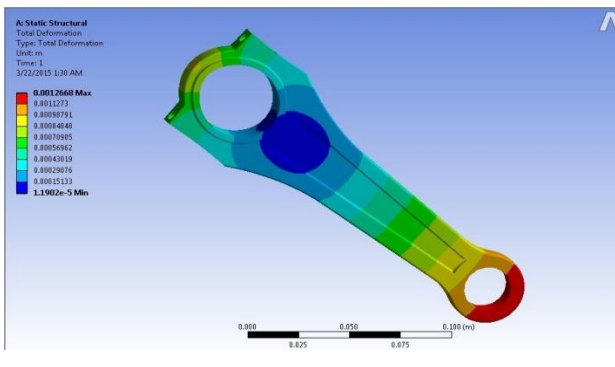


Figure 9 Temperature analysis of Al/SiC

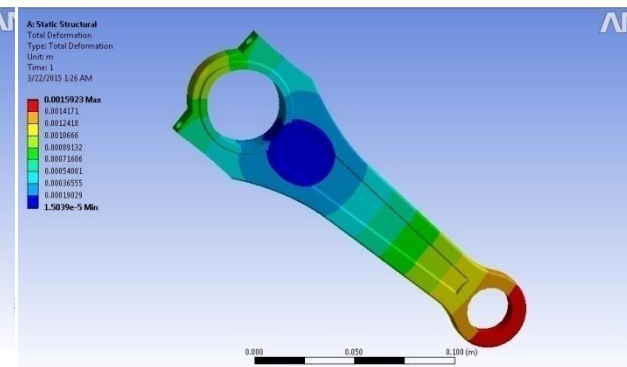


Figure 10 Temperature analysis of C70 Steel

3.4 Stress Analysis

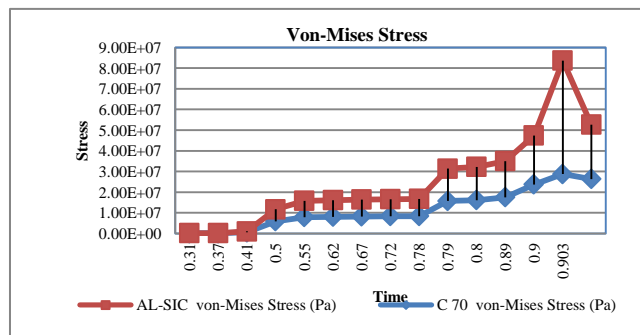


Figure 11. Strain Vs Time on Al/SiC and C70 Steel

3.5 Strain Analysis

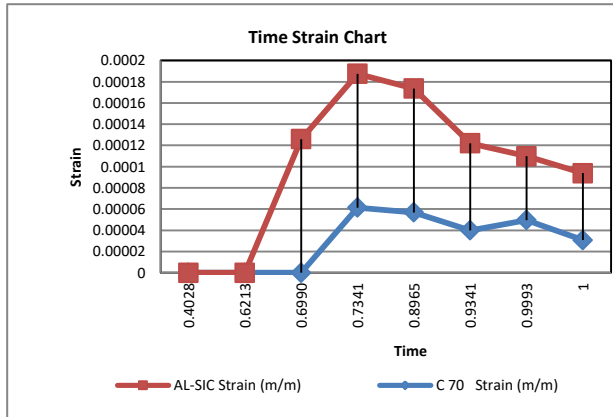


Figure 12. Strain Vs Time on Al/SiC and C70 Steel

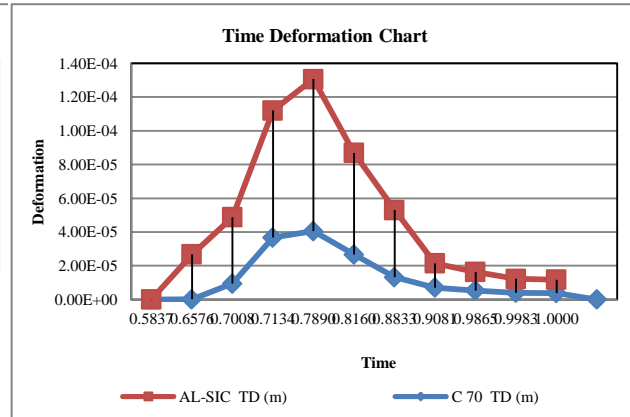


Figure 13. Deformation Vs Time on Al/SiC and C70 Steel

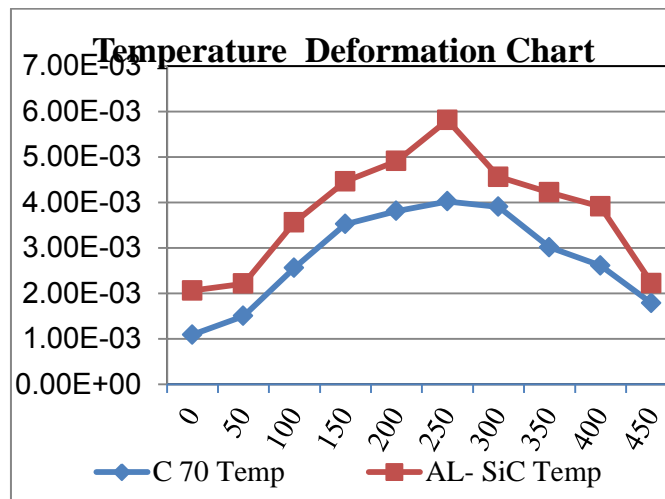


Figure 14. Temperature analysis of Al/SiC and C70 Steel

Table 5. Analytical results of ANSYS

Properties	Level	C70 Steel	Al60/SiC40
Stress	Max	4.16e7	4.16E7
Stress	Min	1.02e4	9.9e3
Strain	Max	2.13e-4	4.36e-4
Strain	Min	5.08e-8	1.02e-7
Deformation	Max	9.78e-6	2.005e-5
Deformation	Min	0	0
Temperature	Max	1.6e-3	1.3e-3
Temperature	Min	1.50e-5	1.19e-5

4. Conclusion

The manufacture of MMC with three different proportions was made. The proportions are Al60/SiC40, Al70/SiC30 and Al75/SiC25 through the Stir casting process. The proper estimation of properties was done with appropriate testing methods. Mechanical Testings, and required design analysis were discussed. Its based on the requirement Al60/SiC40 was identified. In further, the Al60/SiC40 MMC was subjected to the stress, strain, deformation and Thermal analysis with C70 steel. The results were analyzed.

- Al/SiC has less tensile strength than C70 Steel.
- Al/SiC has hardness nearer when compared to C70 Steel.
- Al/SiC can withstand more temperature than C70 Steel.

5. References

- [1] Sudershan Kumar K, Tirupathi Reddy K and Syed AltafHussan, 2012 Modeling and analysis of two Wheeler connecting rod, *International Journal of Modern Engineering Research* **2** (5) 3367-3371.
- [2] Vivek C pathade, BhumeshwarPatle and Ajay N Ingale, 2012 Stress Analysis of I.C. Engine Connecting Rod by FEM, *International Journal of Engineering and Innovative Technology* **1**(3) 12-15.
- [3] Pushpendra Kumar Sharma and Borse Rajendra R, 2012 fatigue analysis and optimization of connecting rod using finite element analysis, *International Journal Of advance research in Science and Engineering* **1**(1) 3367-337.
- [4] Ram Bansal, 2013 Dynamic simulation of connecting rod made of aluminium alloy using finite element analysis approach, *IOSR Journal of Mechanical and Civil Engineering* **5**(2) 01-05.
- [5] Pranav G Charkha and Santosh B Jaju, 2009 Analysis & Optimization of Connecting Rod, *Second International Conference on Emerging Trends in Engineering and Technology* .
- [6] Pravardhan S Shenoy and Ali Fatemi, 2005 Connecting Rod Optimization for Weight and Cost Reduction *SAE International*.
- [7] Rasekh M, Asadi M R, Jafari A, Kheiralipour K, 2009 Obtaining Maximum Stresses in Different Parts of Tractor (Mf-285) Connecting Rods Using Finite Element Method, *Australian Journal of Basic and Applied Sciences* **3** 1438-1449.
- [8] Hassan AM, Alrashdan A, Hayajneh MT, Mayyas AT, 2009 Wear behavior of Al–Mg–Cu based composites containing SiC particles *TribolInt* **42** 1230–1238.
- [9] Ghosh SK and ParthaSaha explains Crack and wear behavior of SiC particulate reinforced aluminium based metal matrix composite fabricated by direct metal laser sintering process *Mater Des* **32** 139–145.
- [10] Subrata Kumar Ghosh, ParthaSaha, 2011 Crack and wear behavior of SiC particulate reinforced aluminium based metal matrix composite fabricated by direct metal laser sintering process, *Materials & Design* **32**(1) 139-145.