Table 2: Composition (wt. %) of Actual ADC-12

EL	Mn	Fe	Cu	Mg	Si	Zn	Cr	Ti	Al
Wt %	0.52	0.17	0.01	5.1	0.16	0.03	0.09	0.04	Balance

2.2 Reason behind to choose Al as Alloying Element

As an elemental material, the basic properties of aluminium do not change with mechanical or physical processing. This means that aluminium is intrinsically sustainable: once produced, it can be recycled repeatedly without any loss in quality and reused in the manufacture of consumer and industrial products. In comparison, carbon-based organic compounds, such as wood, natural fibre and plastics, are composed of large molecules; repeated heating and cooling and/or mechanical processing destroys the bonding force and configuration within individual molecules, thereby changing the original properties of the material [5].

2.3 Reason behind to choose ADC-12 as Matrix Material

ADC-12 belongs to fifth series of Al. The 5XXX alloys have the best corrosion resistance of the aluminium casting alloys. They also polish to bright finishes and they tend to anodize with a pleasing natural aluminium appearance. The 5XXX alloys require more care in preparation and casting than lower-magnesium content alloys because they are more reactive in the presence of oxygen, moisture in the atmosphere, lubricants and the like. To avoid the ill effects of Fe phases on ductility, these alloys employing Mn to reduce die-soldering tendencies. They show potential for increased use for die casting large, thin-walled automotive body, chassis and suspension components that must have both strength and ductility without the stress and distortion that would surely be imposed when fully heat treating thin and rangy parts. The strength of the largely-binary 5XXX compositions is not, in fact, generally improved by heat treating; however, they have good strength and good ductility in the as-cast (F temper) and room temperature naturally-aged condition, and thus are now receiving well-deserved attention for large structural die castings that would be difficult to heat treat without developing residual stresses and distortion. The presence of Mn might overcome soldering issues, but reactive Mg still increases aggressiveness to tool steel, and die life is shorter than when casting lower-Mg Al-Si alloys [6].

2.4 Reinforcement Material

Silicon carbide particulates are used as reinforcement material. The powder was obtained from EGESAN. The type of the silicon carbide is F320. Density of silicon carbide is between 1.29-1.35 g/cm3 and the mesh size is 29.2 ± 1.5 μm. Surface chemical values are given in Table 3.

Table 3: Surface chemical values of F 320 silicon carbide

Product	% SiC	% Free C	% Si	% SiO_2	%Fe_2O_3
F240-	99.50	0.10	0.10	0.10	0.05
F800					

The structure of the silicon carbide is hexagonal 6H with some rhombohedra 15R and sometimes some hexagonal 4H.

2.5 Reason behind to Select SiC as Reinforcement Material

Ceramic silicon carbide (SiC) has excellent oxidation resistance, corrosion resistance, and low density even at high temperatures. These materials have been widely used in the engineering industry,chemistry, energy resources and military projects. Thus, this material has been used in advanced ceramics, as it combines the advantages of traditional ceramics, such as high hardness, heat resistance, and chemical inertness, with the ability to withstand a considerably tensile strength together with high specific hardness and chemical inertness at high temperatures [7].

3. Selection of Process

Stir casting process used as process for the fabrication of the testing specimen. Stir casting is the process in which mechanical stir is used for the mixing of the particle.

3.1 Reason behind to Select Stir Casting as Fabrication Process

Stir casting of MMCs is relatively inexpensive, and offers a wide variety of material and processing condition options. Generally, these composites consist of a metal matrix, which is melted during casting, and ceramic reinforcement which is added to the molten matrix material by a mechanical stirrer. This technology is relatively simple and low cost [1].

3.2 Al Based Mmc Preperation By Ultrasonic Stir Casting

An ultrasonic stir casting setup as shown in figure consisted of a resistance Muffle Furnace, stirrer assembly and probe assembly to synthesize the composite.The stirrer assembly consists of a stirrer which was connected to a variable speed vertical drilling machine with range of 80 to 900 rpm by means of a steel shaft. The stirrer was made by cutting and shaping a desired shape and size manually. The stirrer consisted of a four blades at an angle of 900 apart. Figure shows the photograph of the stirrer, mould and crucible. Clay graphite crucible of 2 kg capacity was placed inside the furnace. The graphical representation of stir casting is shown in figure.Approximately 1 Kg of alloy in solid form was melted at 800oC in the resistance furnace. Preheating of reinforcement (carborundum at 200oC) was done for one hour to remove moisture and gases from the surface of the particulates and to avoid high drop of temperature after addition of particulates. Stirring was initiated to homogenize the temperature & then adding the reinforcement into molten alloy. At every stage before and after introduction of reinforcement, mechanical stirring is carried out for a period of 10 min. The stirrer is located approximately to a depth of2/3 height of the molten metal from the bottom and run at a speed of 200 rpm. Thespeed of the stirrer is gradually raised to 800 rpm and the preheated reinforcement particles were added with a spoon at the rate of 10-20 g/min into the melt.

The speed controller maintained a constant speed of the stirrer, as the stirrer speed got reduced by 50-60 rpm due to increase in viscosity of the melt when particulates were added into the melt. After the addition of reinforcement, stirring is continued for 15 to 20 minutes for proper mixing of the prepared particles in the matrix. After this the stir is replaced by an ultrasonic probe for the proper dispersion of particulates in the matrix. Before the system boot work, must make sure the horn is preheated to higher than 5000C, the system frequency 20.40 KHz about. The melt was kept in the crucible for approximate half minute in static condition and then it was poured in the mould.

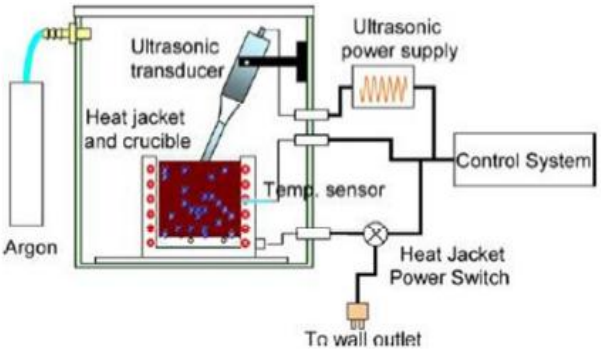

Figure 1: Schematic diagram showing the experimental setup of ultrasonic Stir Casting Method

Finger die was designed by conforming that tensile, compressive and hardness test specimen could be produced by a single casting process simultaneously. A finger die has been used for the casting of testing specimen.

Figure 2: Finger Die (Mild Steel)

4. Modelling

Connecting rod of TVS Scooty Pep Plus is selected for the present investigation. The dimensions of the selected connecting rod are found using Vernier calliper, screw gauge and are tabulated in the table1. According to the dimensions the model of the connecting rod is developed using *CATIA*. The modeled connecting rod is shown in fig1. It is imported in to design modeller of *Hyperworks 11.0.*

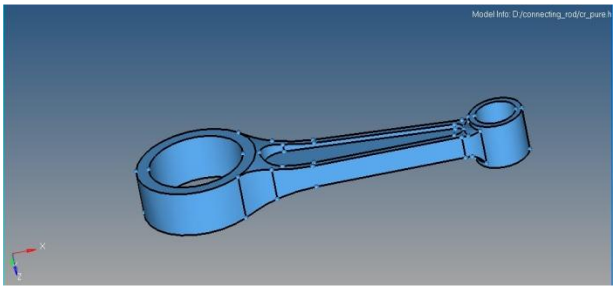

Figure 3: Model of Connecting Rod

Table 4: Specification of connecting rod

S NO.	Parameters	Values (mm)
1.	Length of connecting rod	94.7
2.	Outer dia. of big end	39.2
3.	Inner dia. of small end	30.2
4.	Outer dia. of small end	17.5
5.	Inner dia. of small end	13.2

4.1 Mechanical properties

Mechanical properties of three samples made (ADC-12, ADC-12+ 1% Micro SiC, ADC-12+2% Micro SiC, ADC-12+3% Micro SiC) were used for the finite element analysis of connecting rod. The mechanical properties of samples are listed in the table 5 [3].

Table 5: Mechanical properties of the Sample

Material	ADC-12	ADC-12+1% Micro SiC	ADC-12+2% Micro SiC	ADC-12+ 3% Micro SiC
Young's modulus (GPa)	70.3	73.2	74.1	75.4
Poisson's ratio	0.3	0.31	0.31	0.32
Density (gm/cc)	2.63	2.634	2.629	2.628
Tensile strength (MPa)	228.6	238.1	246.3	260.9
Compressive strength (MPa)	324	340.5	348.9	356.4

4.2 Meshing

The next stage of the modeling is to create meshing of the created model. The below said parameters are used for meshing. The mesh model of connecting rod is as shown in fig 4.

Type of Element: Tetrahedron
Number of Nodes: 742
Number of Elements: 1952

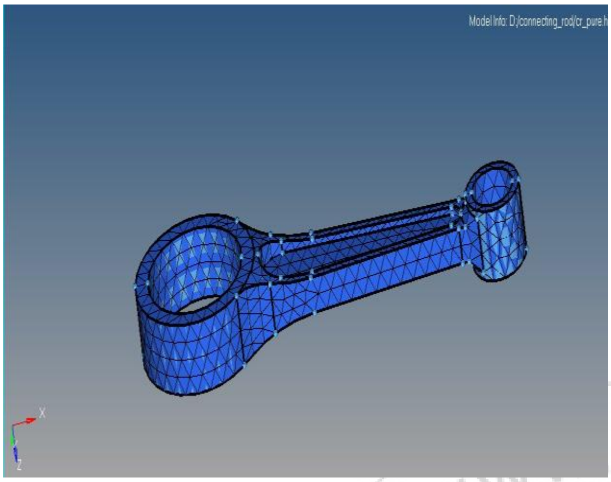

Figure 4: Mesh model of connecting rod

4.2 Load diagram of Connecting Rod

A CATIA model of connecting rod is used for analysis in HYPERWORKS 11 Analysis is done with the pressure of 3.15Mpa load applied at the piston end of the connecting rod and fixed at the crank end of the connecting rod. It is shown in Fig 5.

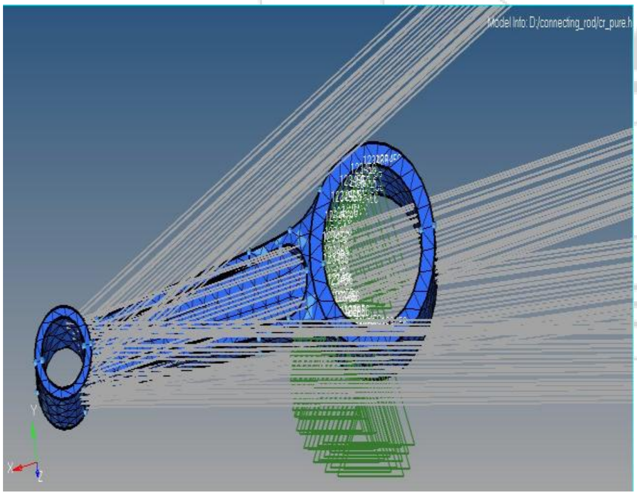

Figure 5: Loads and boundary conditions of connecting rod.

5. Result and Discussion

Various types of tests are performed such as Modulus of Elasticity Test, Tensile Test (Universal Testing Machine), Compression Test (Universal Testing Machine), Hardness Test (Brinell Hardness Test), and Density Measurement (By Archimedes Principle). Those tests are performed to analyse the change in material properties by the effect of different weight percentage of reinforcement on various properties of metal matrix composites.

Here two tests are discussed one is *hardness test* and second is *tensile test.*

5.1 Modulus of Elasticity Test

Table 6: Young's modulus

Material	Young's modulus (GPa)
ADC-12	70.3
ADC-12+ 1% Micro SiC	73.2
Adc-12+ 2% Micro SiC	74.1
Adc-12+ 3% Micro SiC	75.4

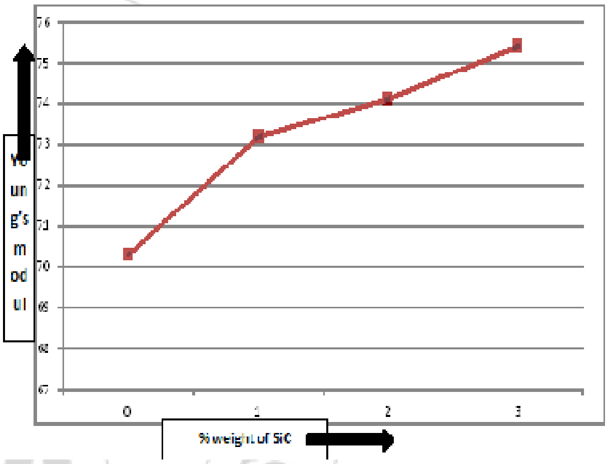

Figure 6: Plot of modulus of elasticity

5.2 Tensile Test

The tensile strength was measured with the help of Universal Testing Machine. The specimens were clamped between the fixed crosshead and the moving crosshead of the machine. Then the load was been tared and after it the pressure valve was released by which the moving crosshead move down and the sample came under the tension load after the yielding the sample break and at this point tensile strength was measured along with Young's Modulus. The tensile strength of the cast different weight % of SiC composites will be measured.The table 7 shows the tensile strength of the specimens.

Table 7: tensile strength (MPa)

Material	Tensile strength (MPa)
ADC-12	228.6
ADC-12+ 1% Micro SiC	238.1
ADC-12+ 2% Micro SiC	246.3
ADC-12+ 3% Micro SiC	260.9

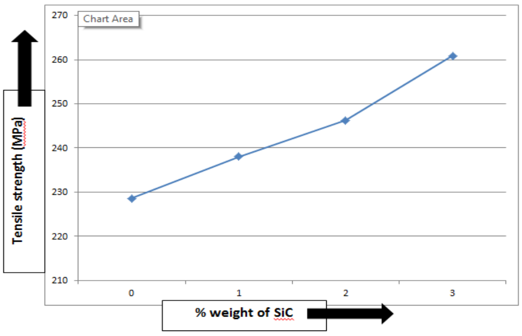

Figure 7: Plot of tensile strength

5.3 Compression Test

Compression tests were carried out on Al-SiC composite specimens with length to diameter ratio of 1.5. Tests were performed on universal testing machine (UTM) of 100 kN capacity. The samples were compressed between two flat plates and the maximum failure load was recorded. The table 8 shows the compressive strength of ADC-12 at different wt. % of SiC reinforcement with and without the help of probe.

Table 8: compressive strength

Material	Compressive strength (MPa)
ADC-12	324
ADC-12+ 1% Micro SiC	340.5
ADC-12+ 2% Micro SiC	348.9
ADC-12+ 3% Micro SiC	356.4

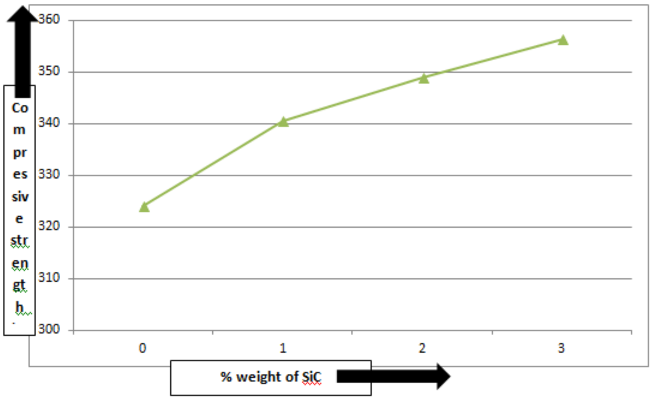

Figure 8: Plot of compressive strength

5.4 Hardness Test

Brinell Hardness Testing Machine is used for the hardness measurement.For measuring hardness of ADC-12 soft alloy, BHN scale is used. The specification of BHN scale is that the load applied on the smooth surface is 187.5 Kg and the indenter ball diameter 2.5mm is used. The dwell time was 8 seconds for each sample. The total five readings are taken from different points on the sample and average is calculated. The result of hardness test for alloy 5083 MMCs with wt.% variation of reinforcement SiC is shown in table 9.

Table 9: Hardness Test (BHN)

Sample	1	2	3	4	5	Avg.
0% SiC	60	59	57	56	59	58.2
1% SiC	63	63	58	58	61	60.6
2% SiC	66	66	59	60	63	62.8
3% SiC	68	69	60	61	64	64.4

5.4.1 Result and Discussion of Hardness Test of Sample

Figure 8, shows the hardness of ADC12- reinforced with SiC. It was observed that the hardness AMCs was increased by increasing wt. % of SiC.Hardness of composite depends on the hardness of reinforcement and the matrix. Coefficient of thermal expansion of SiC(8.103µm/moC) is less than that of aluminium alloy 5083(24.3µm/moC), an enormous amount of dislocations are generated at the particle- matrix interface during solidification process, which further increases the matrix hardness. Smaller ceramic particle reinforced composite have more particle- matrix interface as in case of alumina reinforcement compared to larger particle reinforced composite for same amount. Hence, the hardness of the composite increases with increase the wt. % of reinforcement.

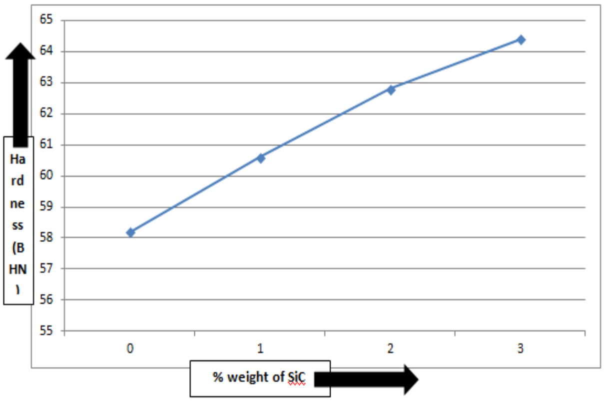

Figure 9: Plot of hardness

6. Analysis of Connecting Rod

For the finite element analysis 3.15Mpa of pressure is used. The analysis is carried out using Catia and hyperworks software. The pressure is applied at the small end of connecting rod keeping big end fixed. The maximum and minimum von-misses stress, shear stress, and factor of safety are noted.

(i) ADC-12

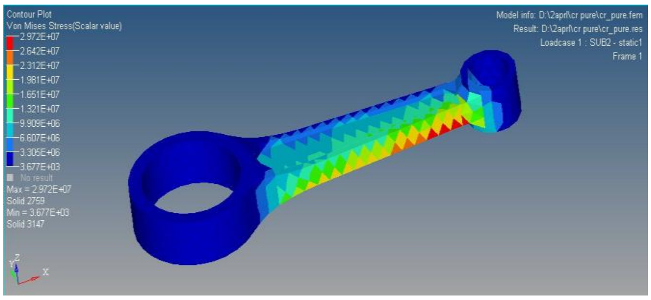

Figure 10: Von Mises stress on connecting rod for ADC-12

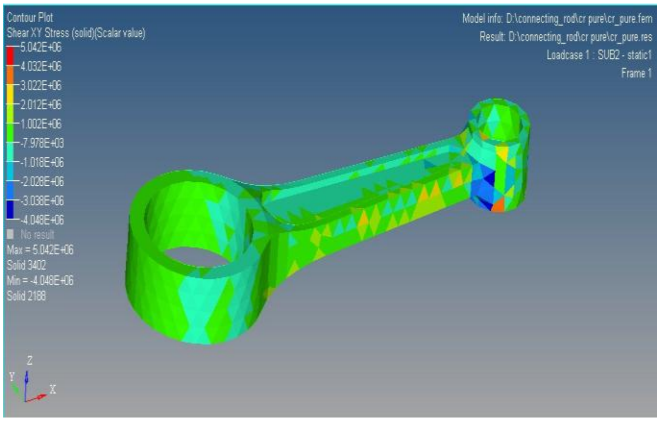

Figure 11: shear stress on connecting rod for ADC-12

(ii) ADC-12+1% Micro SiC

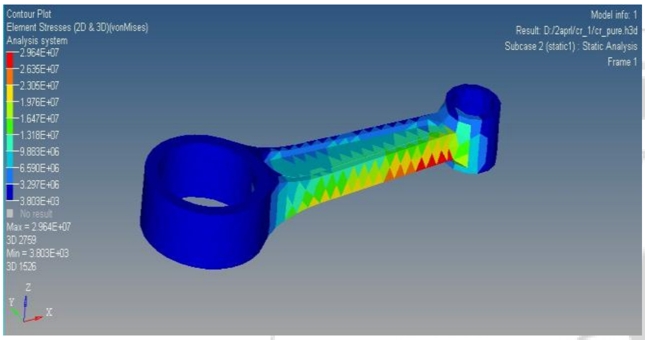

Figure 12: Von Mises stress on connecting rod

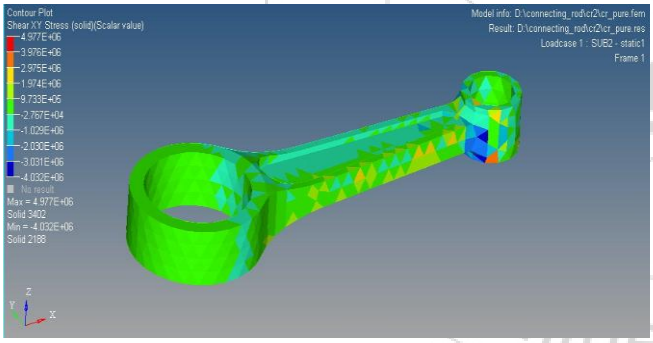

Figure 13: shear stress on connecting rod

(iii) ADC-12+2% Micro SiC

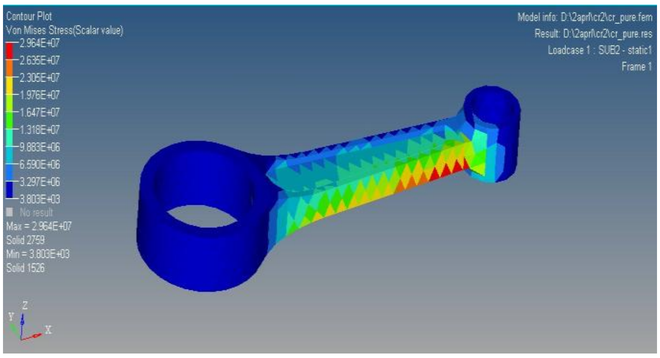

Figure 14: Von Mises stress on connecting rod

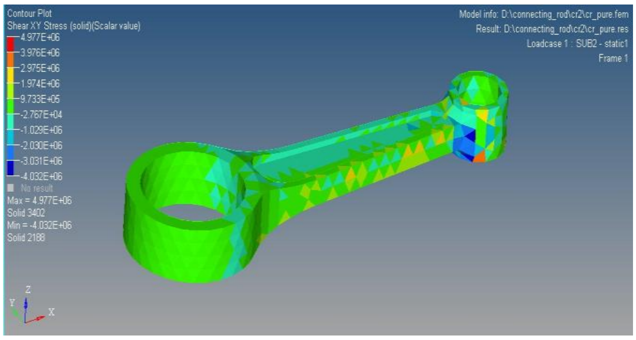

Figure 15: shear stress on connecting rod

(iv) ADC-12+3% Micro SiC

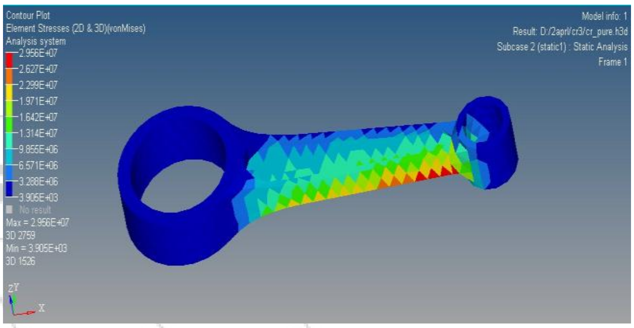

Figure 15: Von Mises stress on connecting rod

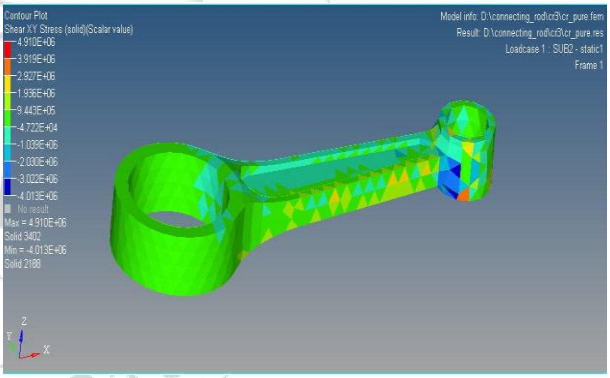

Figure 16: shear stress on connecting rod

From figures of Von Mises stresses, maximum stress occurs near the piston end of connecting rod and minimum occurs near crank end of connecting rod. From figures of shear stress, maximum shear stress occurs at piston end of connecting rod.

Table 10: Static analysis of connecting rod

Material	Induced stress (MPa)	Allowable stress (MPa)	Factor of safety	Margin of safety (MPa)
ADC-12	29.72	228.6	7.68	198.88
ADC-12+ 1% Micro SiC	29.64	238.1	8.03	208.46
ADC-12+ 2% Micro SiC	29.64	246.83	8.31	216.66
ADC-12+ 3% Micro SiC	29.56	260.9	8.83	231.39

6. Conclusion

The following conclusions are drawn as:

- From the study it was concluded that we can use SiC particle as reinforcement material with Al-5083 alloy as matrix material for having good properties.
- ADC-12composite’s tensile strength increased with increased wt. % of SiC mixed along with modulus of elasticity.
- Hardness increased by increasing the weight % of SiC in composites.
- Compressive strength increased by increasing wt. % of SiC.
- Density decreased with increase in wt. % of SiC.

Therefore it can be concluded that in ultrasonic Stir casting processing route the mechanical properties increased by increasing wt. % of SiC.

Also from the above table of static analysis, the stress induced by using Hyperworks is less than the material allowable limit of stress. So the model presented here is well for safe design under given loading conditions. From the static analysis the stress is found maximum at the piston end of the connecting rod.The results revealed that with the increasing wt. % of SiC both the strength and factor of safety increases. The weight of composite connecting rod is almost 1/3rd of the existing alloy steel connecting rod. It will ultimately reduce the inertia forces and vibrations.

7. References

[1] Hashim J., L. Looney and M.S.J. Hashmi, “Metal matrix composites: production by the stir casting method”, Journal of Materials Processing Technology, 92-93 , 1-7, 1999.

[2] Callister. W., Jr. “Fundamentals of Materials Science and Engineering”, ., John Wiley and sons, S162-S202, 2000.

[3] Martin I. Pech-Canul “Aluminum Alloys for Al/SiC Composites” J. composites, vol.24, No. 2, pp.11-123,ISSN 0789-2666, 2000.

[4] Surappa,M., “Aluminium matrix composites: Challenges and opportunities”, Sadhana Vol. 28, Parts 1 & 2, pp. 319–334, 2003.

[5] Jacobs James A. and Kiduff Thomas F., “Engineering Material technology”, New Jersey, Prentice Hall, 530-539, 1997.

[6] A.Sakthivel, R. Palaninathan , R. Velmurugan, P. Raghothama Rao “Production and mechanical properties of SiCp particle-reinforced2618 aluminum alloy composites” J Material Science 43:7047–7056 DOI 10.1007/s10853-008-3033-z, 2008.

[7] Amalina E., SyazanaBinti Ku and Mohd. Nazrir ,“Effect of weight percentage of Silicon carbide (SiC) reinforcement particles on mechanical behaviour of aluminium metal matrix composites”. University Malaysia Pahang, 1-39 (young modulus), 2008.