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IMPROVEMENT OF PROPERTIES ENHANCEMENT OF ADDED NANO SIC TO ALUMINA FOR AUTOMOBILE APPLICATIONS

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Abstract:
Automotive industry is constantly making efforts to the development and application parts that are light weight, and which at the same time possess excellent mechanical and tribological properties. The oberst Beam Method is a classical approach for vibrational analysis of a composite cantilever beam. In this work, the composite beam is made of Aluminium 6061 But here the object of OBM is limited to find Frequency Response Function (FRF) and Damping Ratio of Al 6061 with different compositions of SiC (10%, 15%, 20%, 25%) In this, after setting up the Oberst test rig the effects of various parameters on experimental results are cross checked in an attempt to improve the accuracy of the estimated material properties. The main parameters affecting the quality of the measured data are identified by repeatable measurements. Then tests are carried out on the oberst test rig to determine the effect of the amplitude of the excitation force given to the specimen to be tested.

1.0 Introduction to Composite Materials:

A composite material is a combination of two materials with different physical and chemical properties. When they are combined they create a material which is specialised to do a certain job, for instance to become stronger, lighter or resistant to electricity. They can also improve strength and stiffness. The reason for their use over traditional materials is because they improve the properties of their base materials and are applicable in many situations.

Types:

- Some common composite materials include:
- Ceramic matrix composite: Ceramic spread out in a ceramic matrix. These are better than normal ceramics as they are thermal shock and fracture resistant
- Metal matrix composite: A metal spread throughout a matrix
- Reinforced concrete: Concrete strengthened by a material with high tensile strength such as steel reinforcing bars
- Glass fibre reinforced concrete: Concrete which is poured into a glass fibre structure with high zirconia content
- Translucent concrete: Concrete which encases optic fibres

Advantages of Composite Materials

- Low costs compared to metals
- Design flexibility
- Resistance to a wide range of chemical agents
- Low weight
- Durability
- Electric insulation
- High Impact strength

Characteristics of Composite Materials:

The nature and morphology of the composite materials depicts their performance and characteristics that can be assessed. Some factors for example intrinsic properties, structural arrangement of the reinforcing particles in the matrix system and the relations between the constituents are of great significance. The intrinsic properties of reinforcements and matrix system decide the general order of properties that will play an important role in the composite. The interaction between the constituents of a composite sets the new characteristics which are very crucial for the automotive and aerospace applications.

Connecting rod:

The connecting rod is very important part of an engine. Working of the connecting rod is to transmit power of piston to crank pin. Connecting rod has two ends one is pin end and other is crank end. Pin end is attached with piston.

The big end (crank end) is attached to the crank pin by a crank shaft. The function of crank shaft is to transmit the reciprocating motion of piston into rotary motion.

Fig-1 Schematic diagram of connecting rod

2.0 LITERAURE REVIEW

S. Baskaran, V. Anandkrishnan [1] Aluminum as a very light material is used as the main matrix element in the production of composite materials referred to as aluminum metal matrix composites (AMCs). Application of aluminum composite is widespread, from the military, automotive, flights until the space industry. AMCs compared with primary aluminum alloy have a good combination of mechanical and tribological properties. **Anthony Macke, Schultz B. F [2]** Aluminum based nanocomposites have increasingly gained attention as weight-saving functional materials with improved mechanical properties that can't generally be achieved by monolithic alloys. Carbide or nitride particles are added to aluminum matrix to confer superior hardness, wear resistance and dimensional stability at high temperatures. **Fazlur J. Rahman [3]** Aluminium metal matrix composites are gaining widespread acceptance for automobile, aerospace, agriculture farm machinery and many other industrial applications because of their essential properties such as high strength, low density, good wear resistance compared to any other metal. The present study deals with the addition of reinforcements such as graphite, fly ash, silicon carbide, red mud, organic material etc. to the Aluminium matrix in various proportions. **Bharath V, Mahadev Nagaral [4]** The applications of aluminium matrix composite materials are growing continuously in the field of automotive and aerospace because of their superior physical, mechanical and tribological properties as compared to base alloy. Composite materials with metal matrix material e.g. aluminium or magnesium are finding broad level applications in many industries because of their lower density, better wear and corrosion resistance, high strength to weight ratio, good formability, high hardness, high thermal shock resistance, high modulus, high fatigue strength etc. **L. Latu-Romain and M. Ollivier [5]** It was studied that effect of SiC particulate volume fraction and particle size on the fatigue behaviour of 2080 Al and found that increasing volume and decreasing particle size resulted in an increase in fatigue resistance P/M technology for sintered iron-based valve seats and valve guides was used and wear resistance was enhanced by the inclusion of copper and phosphorus to form hard inter-metallic phases **D. Djenkal, D. Goeuriot [6]** Aluminium based composites were reported the most frequently used ones and with possibilities of their use for manufacturing of the tribo-mechanical components and Al-SiCp composite for the production of cam, poppet valve guides and valve seat inserts by the use of powder metallurgy and liquid metallurgy techniques

3.0 MATERIALS AND METHODS

The traditional powder metallurgy technique, which consists of mixing, compaction and sintering, was employed to manufacture the samples. The chemical composition of aluminium powder is given in table Aluminum powder particles and silicon carbide nanoparticles were used as the raw materials for the Al6061–SiC nanocomposite. A new method of mixing was used to distribute nanoparticles in the matrix powder. The schematic of the preparation process was pictured in figure. First, 1, 2 and 3 wt % silicon carbide nanoparticles were dispersed in 50 mL ethanol by ultrasound-assisted stirring. Then aluminum powder was added to the mixture. After that, the slurry was processed by a planetary mixer The revolution speed was 2000 r/min and rotation speed was 800 r/min. After mixing for 90 s, the vacuum pump was turned on while the revolution and rotation were kept running to evaporate the ethanol for about 60 s. Then, the mixture was subjected to a vacuum oven for further drying. After that the powder mixture was pressed by cold isostatic pressing (CIP) at 400 MPa. The green compacts were about 100 mm × Ø105 mm, and subjected to a vacuum sintering furnace (ACME, Changsha, China) at 600 °C for 12 h at 0.1 Pa vacuum. Finally, the sintered composite was machined to 90 mm × Ø90 mm, preheated up to 500 °C and extruded with the extrusion ratio of 9:1. The final product was a plate with the width of 60 mm, thickness of 12 mm, and length of 800 mm

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Table: Chemical properties of aluminum alloy 6061

Aluminum, Al	95.8 - 98.6 %	95.8 - 98.6 %
Chromium, Cr	0.04 - 0.35 %	0.04 - 0.35 %
Copper, Cu	0.15 - 0.40 %	0.15 - 0.40 %
Iron, Fe	<= 0.70 %	<= 0.70 %
Magnesium, Mg	0.80 - 1.2 %	0.80 - 1.2 %
Manganese, Mn	<= 0.15 %	<= 0.15 %
Other, each	<= 0.05 %	<= 0.05 %
Other, total	<= 0.15 %	<= 0.15 %
Silicon, Si	0.40 - 0.80 %	0.40 - 0.80 %
Titanium, Ti	<= 0.15 %	<= 0.15 %
Zinc, Zn	<= 0.25 %	<= 0.25 %

Table: Material properties of aluminum alloy

Physical Properties	Metric	English
Density	2.6989 g/cc	0.097504 lb/in³
Chemical Properties	**Metric**	**English**
Atomic Mass	26.981154	26.981154
Atomic Number	13	13
Thermal Neutron Cross Section	0.215 barns/atom	0.215 barns/atom
X-ray Absorption Edge	7.9511 Å	7.9511 Å
	142.48 Å	142.48 Å
	172.16 Å	172.16 Å
	172.16 Å	172.16 Å
Electrode Potential	-1.66 V	-1.66 V
Electronegativity	1.61	1.61
Ionic Radius	0.510 Å	0.510 Å
Electrochemical Equivalent	0.3354 g/Ah	0.3354 g/Ah
Mechanical Properties	**Metric**	**English**
Hardness, Vickers	15	15
Modulus of Elasticity	68.0 GPa	9860 ksi
Poissons Ratio	0.36	0.36
Shear Modulus	25.0 GPa	3630 ksi
Electrical Properties	**Metric**	**English**
Electrical Resistivity	0.00000270 ohm-cm	0.00000270 ohm-cm
Magnetic Susceptibility	6.0e-7	6.0e-7
Critical Magnetic Field Strength, Oersted	101.9 - 107.8	101.9 - 107.8
Critical Superconducting Temperature	1.15 - 1.17 K	1.15 - 1.17 K
Thermal Properties	**Metric**	**English**
Heat of Fusion	396.9 J/g	170.8 BTU/lb
Heat of Vaporization	9462 J/g	4071 BTU/lb
CTE, linear	24.0 µm/m-°C	13.3 µin/in-°F
	@Temperature [illegible]	@Temperature [illegible]
	25.5 µm/m-°C	14.2 µin/in-°F
	@Temperature [illegible]	@Temperature [illegible]
	27.4 µm/m-°C	15.2 µin/in-°F
	@Temperature [illegible]	@Temperature [illegible]
Specific Heat Capacity	0.900 J/g-°C	0.215 BTU/lb-°F
Thermal Conductivity	210 W/m-K	1460 BTU-in/hr-ft²-°F
Melting Point	660.37 °C	1220.7 °F
Boiling Point	2519 °C	4566 °F

Table Material properties of SiC

Silicon Carbide, Alpha SiC

Categories: Ceramic; Carbide

Vendors: No vendors are listed for this material. Please click here if you are a supplier and would like information on how to add your listing to this

Printer friendly version; Download as PDF; Download to Excel (requires Excel and Windows)
Export data to your CAD/FEA program

Physical Properties	Metric
Density	3.10 g/cc
	3.21 g/cc
a Lattice Constant	3.0817 Å
c Lattice Constant	15.1183 Å
Mechanical Properties	**Metric**
Modulus of Elasticity	410 GPa
Compressive Strength	4600 MPa
Poissons Ratio	0.14
Fracture Toughness	4.60 MPa-m½
Shear Modulus	180 GPa
Electrical Properties	**Metric**
Magnetic Susceptibility	-0.00000640
Dielectric Constant	10.2
Band Gap	2.99 eV
Electron Mobility, cm²/V-s	400
Thermal Properties	**Metric**
Specific Heat Capacity	0.670 J/g-°C
Thermal Conductivity	77.5 W/m-K
	@Temperature 400 °C
	125.6 W/m-K
	@Temperature 20 °C
Melting Point	2097 °C

TEST METHODOLOGY:

Test specimens were fixed like cantilever and impact test was carried out to determine the Frequency Response Function and damping ratio. One end of the sample was fixed in bench vice with the help of C-clamp and another end was free. Accelerometer was put on fixed-end side of the sample. It was excited by Impact hammer having inbuilt force sensor and response was collected by accelerometer. Then LANXI Data Acquisitions System receives signal from accelerometer to determine Frequency Response Function and damping ratio. (Position of sensor and impact hammer are shown in Fig. The frequency range of measurement is DC – 1.6 kHz)

TENSILE TEST

Type of test – Tensile

Machine Model – TUE-C-600

Figure: Ultimate tensile testing machine

Tensile testing, also known as tension testing is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under normal forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics.

HARDNESS TEST

Figure: Hardness test

TEST DETAILS

Test Reference – IS 1586:2000

Type of Hardness – HRC

Machine Model – 2008/073, MRB 250

Sample ID – Hardness Test at Weld Zone

Hardness is a characteristic of a material, not a fundamental physical property. It is defined as the resistance to indentation, and it is determined by measuring the permanent depth of the indentation.

Material properties:

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Aluminum alloy 6061 + SiC 10%
Aluminum alloy 6061 + SiC 15%
Aluminum alloy 6061 + SiC 20%
Aluminum alloy 6061+ SiC 25%

Design of automobile component connecting rod:

A connecting rod is a machine member which is subjected to alternating direct compressive and tensile forces. Since the compressive forces are much higher than the tensile force, therefore the crosssection of the connecting rod is designed as a strut and the rankine formula is used.

Parameter	Value
Length of connecting rod	150
Outer diameter of big end	56
Inner diameter of big end	48
Outer diameter of small end	32
Inner diameter of small end	24

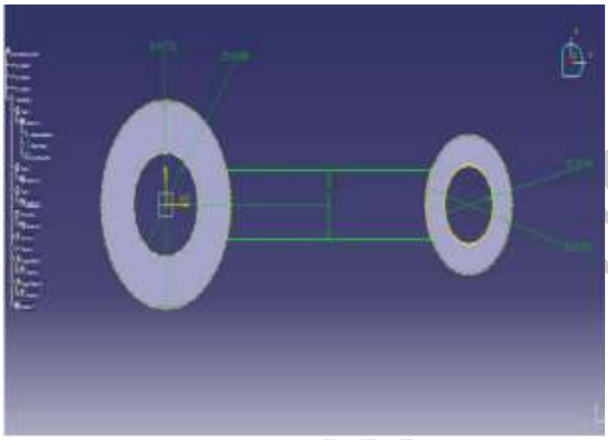

Figure: Making of Stem Pad

STATIC ANALYSIS OF CONNECTING ROD

A static analysis calculates the effects of steady loading conditions on a structure, while ignoring inertia and damping effects, such as those caused by time-varying loads. A static analysis can, however, include steady inertia loads (such as gravity and rotational velocity), and time-varying loads that can be approximated as static equivalent loads (such as the static equivalent wind and seismic loads commonly defined in many building codes).

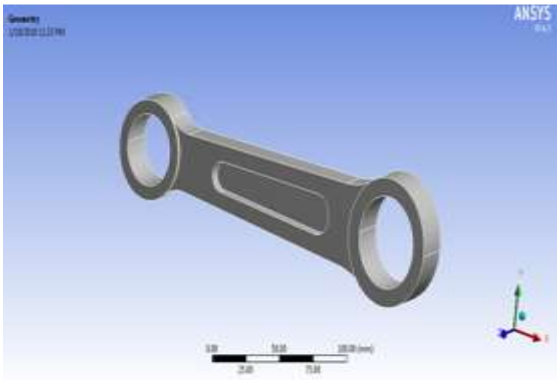

Figure: geometric models

Select mesh on left side part tree → right click → generate mesh →

Figure: meshing model

Select static structural right click → insert → select pressure and fixed support → Select displacement → select required area → click on apply → put X,Y,Z component zero →

BOUNDARY CONDITION:

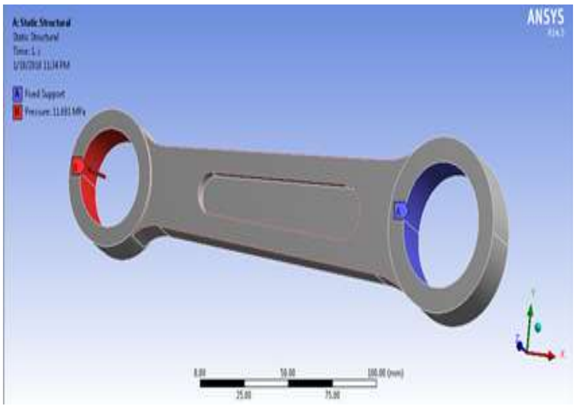

Figure 4.3 static structural models

Select force → select required area → click on apply → enter rotational velocity

Select solution right click → solve → Solution right click → insert → deformation → total → Solution right click → insert → strain → equivalent (von-mises) →

Solution right click → insert → stress → equivalent (von-mises) →Right click on deformation → evaluate all result

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MATERIAL- ALUMINUM ALLOY 6061 + SiC 10%

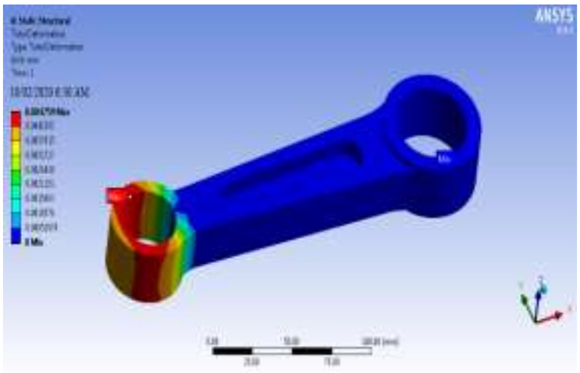

Figure: Total deformations

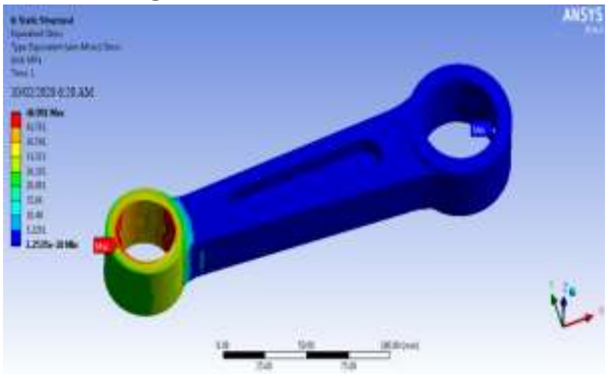

Figure: equivalent von mises stress

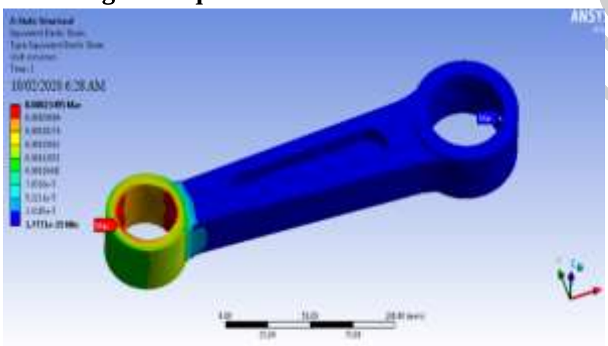

Figure: equivalent elastic strain

MATERIAL- ALUMINUM ALLOY 6061+ SiC 15%

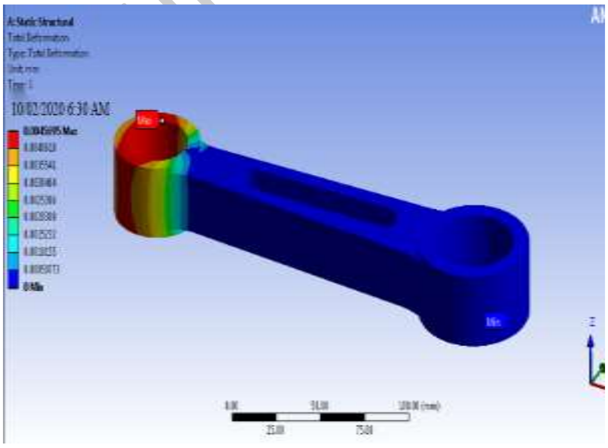

Figure: Total deformations

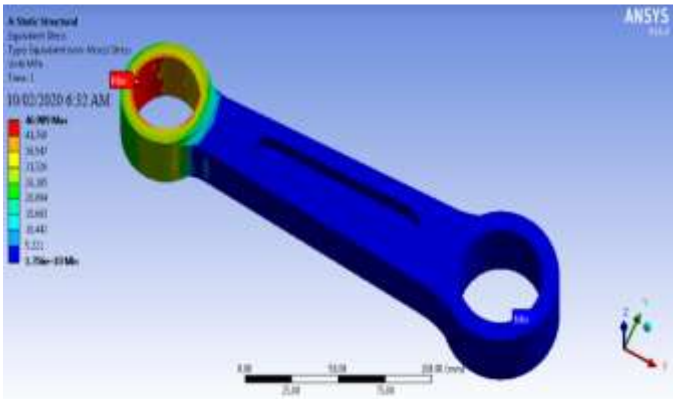

Figure: equivalent von mises stress

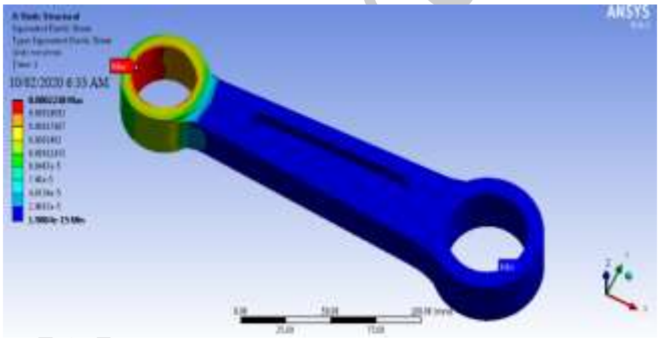

Figure: equivalent elastic strain

MATERIAL- ALUMINUM ALLOY 6061 + SiC 20%

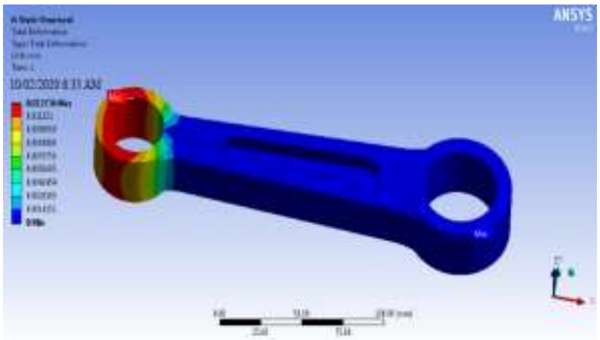

Figure: Total deformations

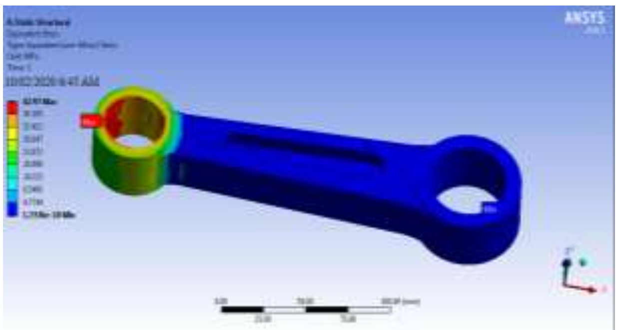

Figure: equivalent von mises stress

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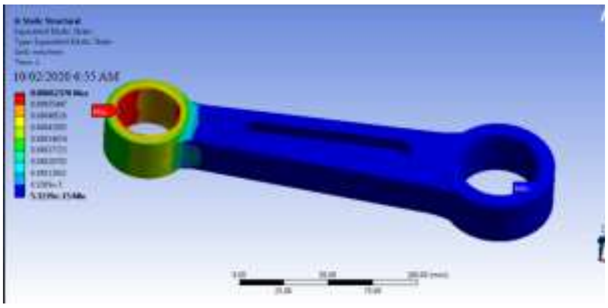

Figure: equivalent elastic strain

MATERIAL- ALUMINUM ALLOY 6061 + SiC 25%

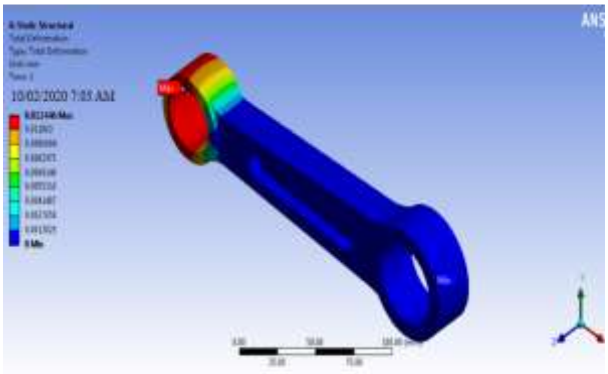

Figure: Total deformations

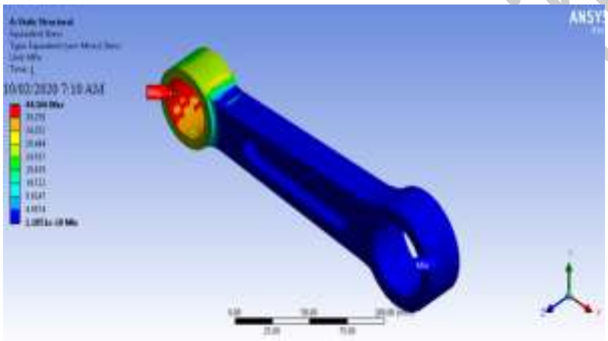

Figure: equivalent von mises stress

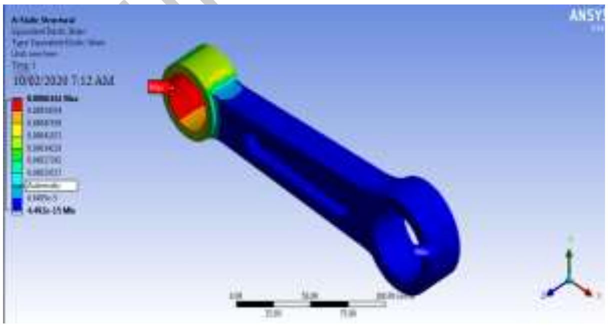

Figure: equivalent elastic strains

THERMAL ANALYSIS OF CONNECTING ROD

MATERIAL- ALUMINUM ALLOY 6061 + SiC 10%

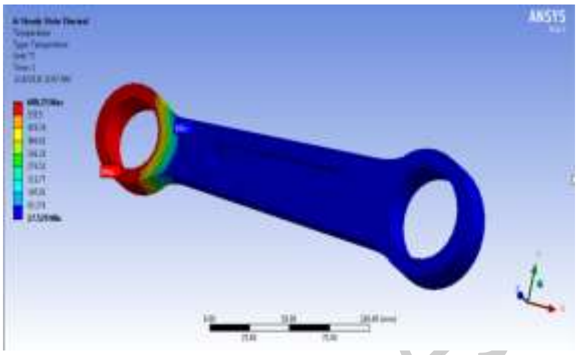

Figure: 4.15 Temperature distributions

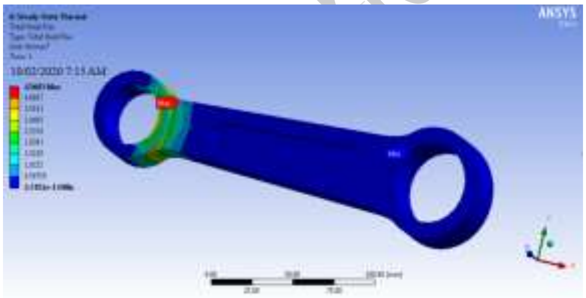

Figure: heat flux

MATERIAL- ALUMINUM ALLOY 7075 + SiC 15% + BFG 10%

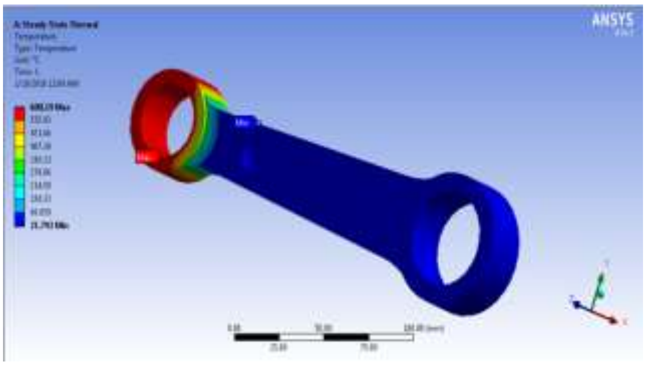

Figure: Temperature distributions

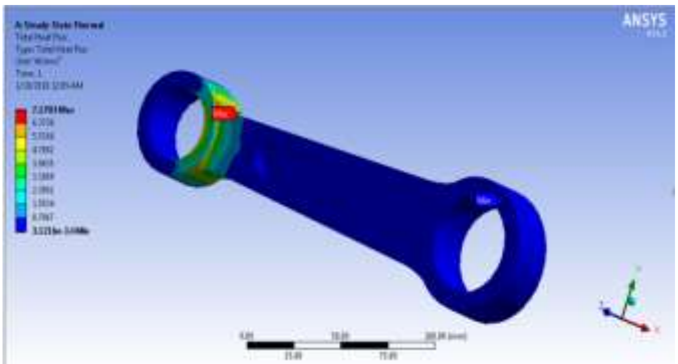

Figure: heat flux

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MATERIAL- ALUMINUM ALLOY 6061 + SiC 20%

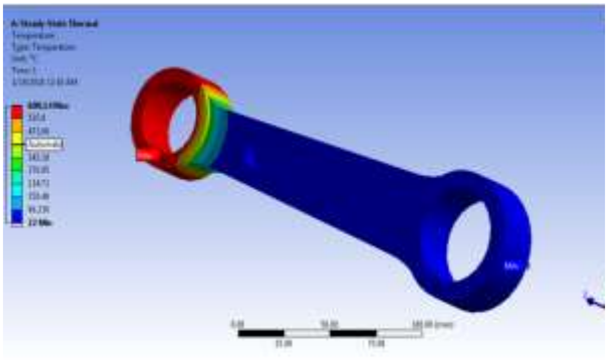

Figure: Temperature distributions

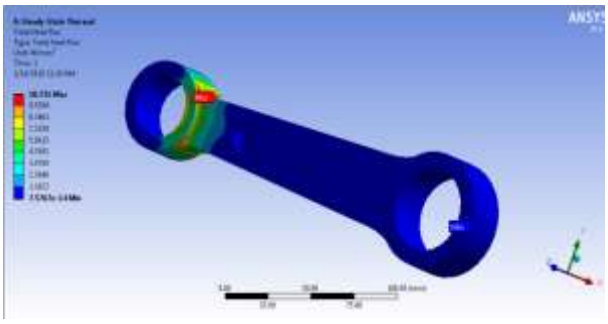

Figure: heat flux

MATERIAL- ALUMINUM ALLOY 6061 + SiC 25%

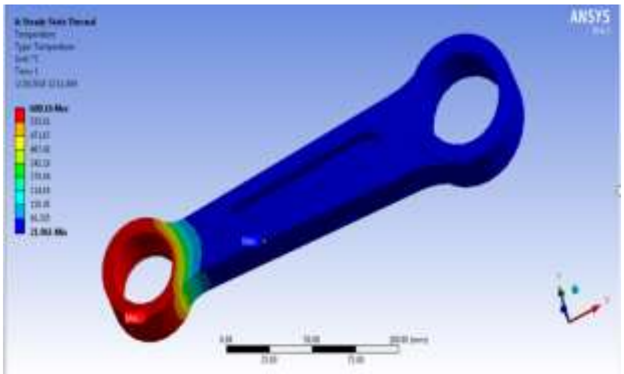

Figure: Temperature distributions

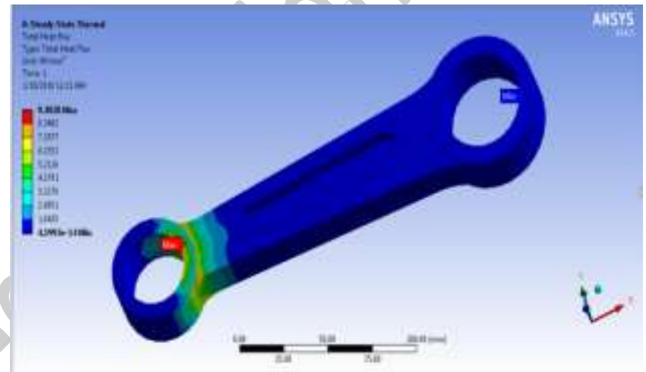

Figure: heat flux

Table 4.1 static structural analysis

Models	Materials	Deformation (mm)	Stress (MPa)	Strain
Connecting rod	Aluminum alloy 6061 + SiC 10%	0.004759	46.981	0.00023495
	Aluminum alloy 6061 +SiC 15%	0.0045695	46.989	0.0002238
	Aluminum alloy 6061+ SiC 20%	0.012736	42.97	0.00062378
	Aluminum alloy 6061 + SiC 25%	0.012446	44.166	0.0006161

Table: Thermal analysis:

Models	Materials	Deformation (mm)	Stress (MPa)	Strain
Connecting rod	Aluminum alloy 6061 + SiC 10%	600.25	17.529	4.5683
	Aluminum alloy 6061 +SiC 15%	600.19	2.792	7.1703
	Aluminum alloy 6061+ SiC 20%	600.14	22	10.731
	Aluminum alloy 6061 + SiC 25%	600.16	21.961	9.3828

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TEST RESULTS:

Fig.: Frequency Response Function of Aluminium 6061 with 10% sic

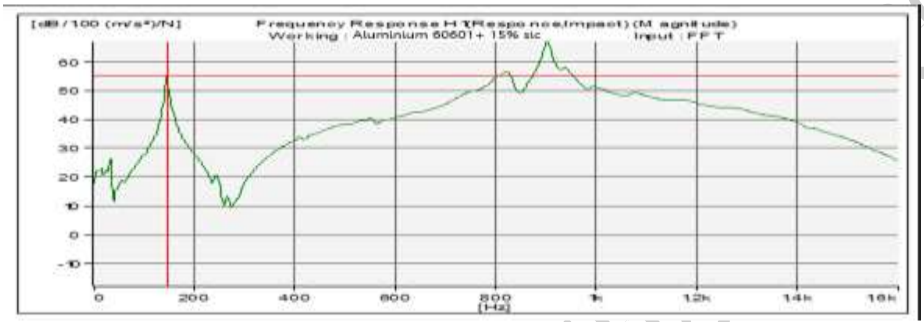

Fig: Frequency Response Function of Aluminium 6061 with 15% Sic

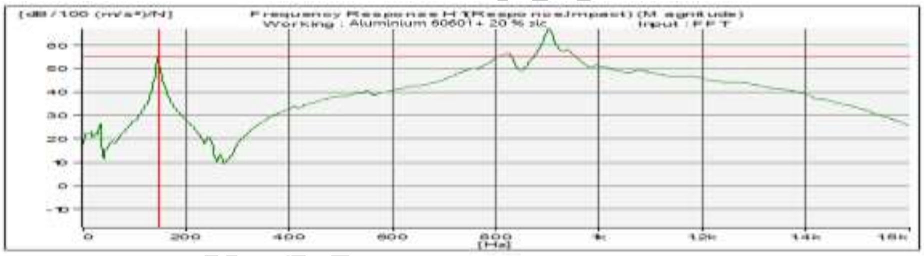

Fig: Frequency Response Function of Aluminium 6061 with 20% Sic

Fig: Frequency Response Function of Aluminium 6061 with 25% Sic

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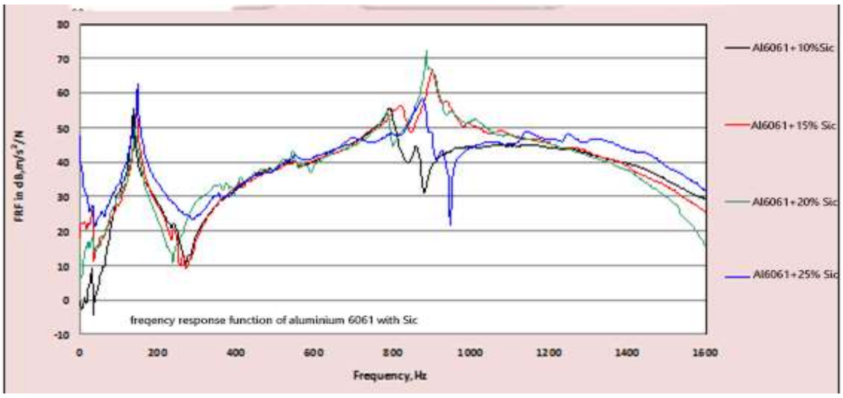
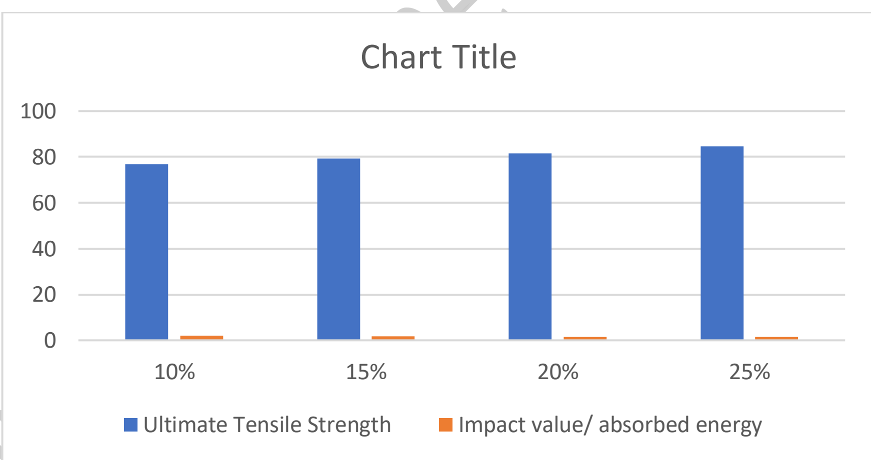


Fig.6: Comparison of Frequency Response Function of Aluminium6061 materials with composition of Sic

Table 4.1 Tensile and Impact Test Results

Wt% of AL6061+SiC	Ultimate Tensile Strength	Impact value/ absorbed energy
10%	76.761	2
15%	79.301	1.63
20%	81.412	1.5
25%	84.521	1.33



Graph: Effect of AL6061 + Sic Tensile Strength

Table: Hardness test results

Al6061+ SiC	Impression1	Impression2	Impression2	Average
5%	87.3	88.5	89.6	88.46
10%	86.8	87.7	87.7	87.40
50%	85.9	86.5	87.3	86.56
20%	84.6	85.9	86.8	85.7

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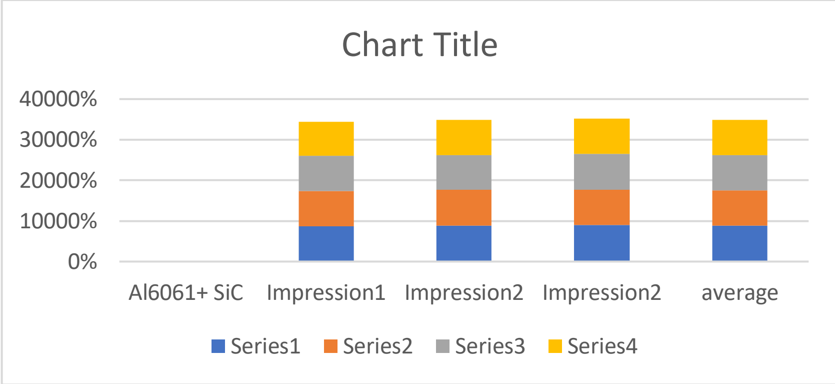
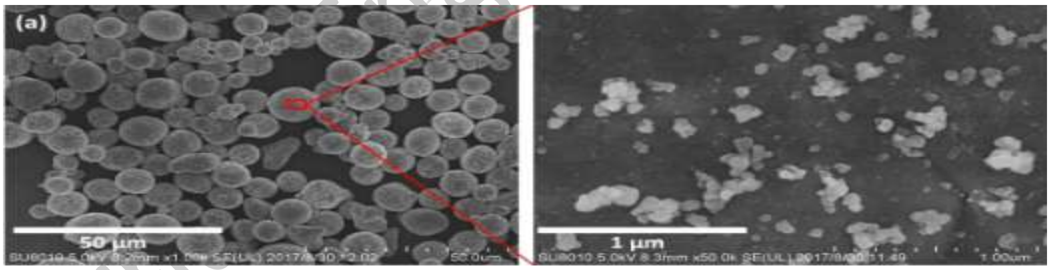


Graph: Effect of AL6061 + Sic hard ness Strength

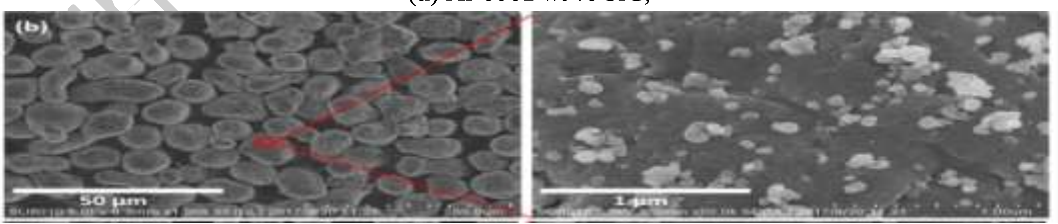
Figure: Remaining Samples of Tensile Strength, Impact Test, Hardness Test

Characterization of the As-Mixed Composite

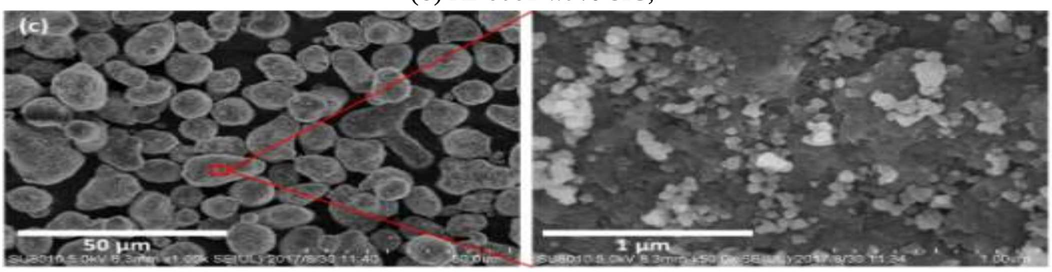
The effect of the mixing process on the distribution of the nanoparticles on the surface of the aluminium powder was studied using SEM. The morphology of the aluminum powder particles and silicon carbide (SiC) nanoparticles as-received is shown in figure The inserts were the particle-size distribution of the aluminium and silicon carbide. figure shows the composite powder after the mixing process.



(**a**) Al-6061 wt % SiC;



(**b**) Al-6061 wt % SiC;



(c) Al-6061 wt % SiC.

CONCLUSION

The main initiators of growth in demand nanocomposites are increasing car production and increasing demand for lightweight materials. It is expected that the implementation of the structural and operating parts increase the rate because composites act as an excellent substitute for metal parts;

Increasing importance is attached to reducing the weight of vehicles because of improving fuel economy, then to improve vehicle performance and reduce emissions. Based on the review of literature predicts an increase in demand for nanocomposites in the automotive industry in the coming years;

This experimental evolution of Aluminum6061 and Silicon composites leads to the following conclusions:

- Production of Al6061-Silicon composite was completed successfully.
- In the Oberst beam test, from Frequency Response Function we conclude, Modal frequency and Damping ratio at 3rd mode increases with increase the wt% of SiC (10%,15%,20%,25%)
- The finite element analysis (FEA) is a powerful computational tool for analyzing complicated structures. It can reduce prototype parts producing and the number of physical tests to shorten the development cycle and reduce the development investment; i.e., it saves much time, effort and cost.

Based on these outcomes, it is recommended that DRSS powder reinforced with polyester composite materials are suitable for internal structural automotive panel applications

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