CAD MODELLING AND COMPARATIVE DEFORMATION ANALYSIS WITH DIFFERENT MATERIALS OF AUTOMATIC CRANK SHAFT

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Abstract - *Connecting rod is one of the criitical additical of the complete engine meeting because it acts as a mediator among piston meeting and crankshaft. Also it faces numerous tensile and compressive hundred all through its lifestyles time. The important goal of this paper is to proposed one of a kind residences of varieous cloth used for the manufacturing of connecting rod. We are taking one of a kind varieties of connecting rod fabricated from solid steel, solid steel, aluminium-360, AIFA sic (Aluminium primarily based totally composite cloth strengthened with silicon carbide), magnesium alloy & Berylium ally, & examine their mechanical residences. In lates time it' s far very essential to lessen weight, stress, strain, Displacement at the same time as growing or keeping power of connecting rod. This hes entailed appearing an in depth load, deformation, fatigue, pressure and stress analysis. The connecting rod is a excessive quantity manufacturing from car side. Every autalysis. The connecting rod is a excessive quantity manufacturing from car side. Every automobile that makes use of an inner combustion engine calls for as a minimum one connecting rod. Failure and harm also are greater in greater pressure than different engine additives. Failure and harm also are greater in connecting rod, so identity and contrast of various substances for connecting rod may be very critical.*

Key Words*:LSHE, R134a, ANSYS WORKBENCH, SOLIDWORKS, VCR system, performance improvement.*

1. INTRODUCTION:

A connecting rod acts as a link between the piston assembly and crankshaft thereby converting the reciprocating motion of piston into the rotary motion of crank shaft. Around the globe connecting rod is produced in large quantity and furthermore it works under high tensile and compressive loads. Connecting rod, automotives should be lighter and lighter, should consume less fuel and at the same time they should provide comfort and safety to passengers, that unfortunately leads to increase in weight of the vehicle. This tendency in vehicle construction led the invention and implementation of quite new materials which are light and meet design requirements. Lighter connecting rods help to decrease lead caused by forces of inertia in engine as it does not require big balancing weight on crankshaft. So a connecting rod should be designed in such a way that it can withstand high stresses that are imposed on it. So its analysis is necessary.

2. LITERATURE SURVEY:

Farzin H. Montazersadgh et al., (2007). Crankshaft is a complex geometry in the internal combustion engine, which converts the reciprocating motion of the piston to a rotary motion with a four bar linkage mechanism. The crankshaft undergoes a large number of load cycles during its fatigue performance, durability and service life of this component has to be taken in the design process. Design and development of the crankshaft is an important issue in the manufacturing industry, in order to produce a less expensive component with the light weight,good fatigue strength with better fuel efficiency and higher power output.

Meng et al., (2011) carried out the static structural analysis and model analysis on four cylinder engine crankshafts and show the maximum stress, maximum deformation and unsafe areas were determined.

3. OBJECTIVE OF THE STUDY:

1. To create 3D CAD model of the crankshaft in SOLIDWORKS 2017.
2. Study the effects of the loads acting on the crankshaft under the considered loading conditions.
3. Comparison of the materials in ANSYS by using FEM tool for chooses the best material for crankshaft.

3.1 MATERIALS AND METHOD:

Engine specification:

This paper attention is on crankshaft; the geometry and the requirements of the crankshaft solely depend upon the engine. The specification of the engine and material chemical composition is used for the following table 1.

Table 3.1 Specification of the engine

Engine type	**4 stroke, Single cylinder, Air cooled engine**
Bore x Stroke	68 X 45 mm
Displacement	163 cm^3
Rated Output	2.83 KW @ 3,600 rpm
Maximum Torque	10.3 Nm @ 2,500 rpm
Compression Ratio	9.0: 1
Weight	15.1 Kg

3.2 CRANKSHAFT:

3.2.1 Material Compact weight and high structural rigidity is the key factors essential for all components of an IC engine AISI 1040 carbon steel has high carbon content and can be hardened by heat treatment followed by quenching and tempering to achieve 150 to 250 ksi tensile strength. AISI 1045 steel is medium tensile steel supplied in the black hot rolled or normalized condition. It has a tensile strength of 570 700 MPa and Brinell hardness ranging between 170 and 210. AISI 1045 steel is characterized by good weldability, good machinability, and high strength and impact properties in either the normalized or hot rolled condition. AISI 1045 steel has a low through hardening capability with only sections of size around 60 mm being recommended as suitable for tempering and through hardening. However, it can be efficiently flame or induction hardened in the normalized or hot rolled condition to obtain surface hardness in the range of Rc 54 Rc 60 based on factors such as section size, type of set up, quenching medium used etc. AISI 1045 steel lacks suitable alloying elements and hence does not respond to the nitriding process. The chemical composition of the crankshaft materials are used in this study as shown in table 2 and the physical and mechanical properties of used materials are shown in table 3.

Table 3.2 Chemical composition of selection materials % by weight

Designation	MATERIALS			
	AISI 1040	**AISI 1045**	**AISI 4140**	**AISI 4615**
Elements	Content (%)	Content (%)	Content (%)	Content (%)
Iron (Fe)	98.6-99	98.51-98.98	96.785-97.77	96.495-97.42
Manganese (Mn)	0.60-0.90	0.60-0.90	7.5-1.0	0.45-0.65
Carbon (C)	0.370-0.440	0.420-0.50	0.380-0.430	0.13-0.18
Sulfur (S)	≤ 0.050	≤ 0.050	≤ 0.040	≤ 0.040
Phosphorous (P)	≤ 0.040	≤ 0.040	≤ 0.035	≤ 0.035
Chromium (Cr)	-	-	0.80-1.10	-
Molybdenum (Mo)	-	-	0.15-0.25	0.20-0.30
Silicon (Si)	-	-	0.15-0.30	0.15-0.30
Nickel (Ni)	-	-	-	1.65-2

Table 3.3 Physical and mechanical properties

Designation	MATERIALS			
	AISI 1040	**AISI 1045**	**AISI 4140**	**AISI 4615**
Density(Kg/M^3)	7845	7870	7850	7850
Coefficient of Thermal Expansion (μm/M)(°c)	11.3	11.5	12.2	11
Young's Modulus (GPa)	210	206	210	205
Poisson's Ratio	0.26	0.29	0.30	0.29
Bulk Modulus (GPa)	140	163	175	162
Shear Modulus (GPa)	80	79	80.7	79
Isotropic Thermal Conductivity @ 0°c (W/Mk)	51.9	51.9	42.6	44.5
Yield Strength (MPa)	415	450	415	350
Ultimate Strength (MPa)	620	580	655	650

4.ALUMINIUM BASED COMPOSITE MATERIAL REINFORCED WITH SILICON CARBIDE: The aluminium and SiC powder of mesh size 300 & 75 microns respectively were purchased from F.S Corporation Lahore. Aluminium powder used as a matrix has following composition; 98 wt. %aluminium with the minor elements such as Si, Zn and Fe.Experimental procedure for this study involved the formation composite samples were reinforced with different wt.% of Silicon carbide (SiC), the table below comprises the details: **Table-4.1: Shows samples classification according to different weight fraction of reinforcements.**

Name of constituent	Wt.%	Sample ID
Aluminium	90	A
Silicon Carbide	10	
Aluminium	85	B
Silicon Carbide	15	
Aluminium	80	C
Silicon Carbide	20	

Fig. 4.1: Showing prepared composites samples after sintering and Heat treatment. It can be seen that only a slight variation in diameter is observed after sintering and the samples have diameters around 18-19 mm contrary to 20 mm initial diameter.

Density measurements were carried out according to ASTM B962-15 standard procedure which is primarily based upon Archimedes method of density measurements. For measuring the green density of the composite tablets, the tablets were first weighted in air in grams (mass A), and oil impregnated with Silicon oil for 4 hours at 85°C afterwards to close surface pores. After immersion and cooling to room temperature excess oil is wiped out through lint free cloth and the mass of the samples after oil impregnation was calculated in grams (mass B). Samples were weighted in water subsequently and deionized water was used at room temperature around 2832°C. The density of the sample was calculated by using equation 1;

$$D_g = \frac{A\rho_w}{B - F} \qquad (1)$$

Here, Dg = Density of sample, A = the mass of the green part or test piece in air in grams, B = the mass of the oil-impregnated green part or test piece, F = the mass of the oil- impregnated part/test specimen in water with the mass of the specimen support teared, w = the density of the water, g/cm^3. ρ

Hardness was found out using Vickers Hardness tester at a load of 3Kg and the dwell timewas 10 seconds. The porosity content of the composites was also evaluated by using equation 2.

$$E = 1 - \left(\frac{\rho s}{\rho t}\right) \quad (2)$$

where E= porosity (%), ρt = theoretical density (kg/m^3), ρs= actual density (kg/m^3) found out using Archimedes method.

4.2 DENSITY:

Density measurements of the prepared composites were carried out under ASTM B962- 15 standard test method. A significant change between un-sintered and sintered densities was observed with the addition of SiC particles and the trend continues with the increasing wt.% of SiC, it was attributed to shrinkage of pores during sintering [18]. The increase in density with the additions of hard reinforcement particles such as Silicon carbide (SiC) has been evident in figure 2 as the maximum density of 2.4 g/cm^3 was observed with addition of 20wt% of Silicon carbide (SiC).

4.3 POROSITY CONTENT:

Parts produced by powder metallurgy exhibit some porosity which cannot be neglected and same was observed in Al-SiC composites produced in this study as shown in Table-2. It appears very clear from the table that the porosity content was significantly reduced after sintering. The major reduction in porosity was obtained with 20wt% reinforcement. This is attributed to settling of small particles into interstitial sites.

Table-4.2: Table showing porosity content in un-sintered and sintered Al-SiCcomposites

Sample condition	Porosity Content			
	Pure Aluminium	10wt%	15 wt.%	20wt%
Un sintered	40.07	42.35	42.39	42.44
Sintered	18.38	17.88	15.21	14.02

4.4 SEM ANALYSIS:

Reinforcements distribution inside the matrix are essential to the final properties of composites prepared through powder metallurgy, to investigate distribution of reinforcements on composites SEM analysis was performed and it showed that particles were homogenously distributed, and porosity was reduced considerably after sintering.

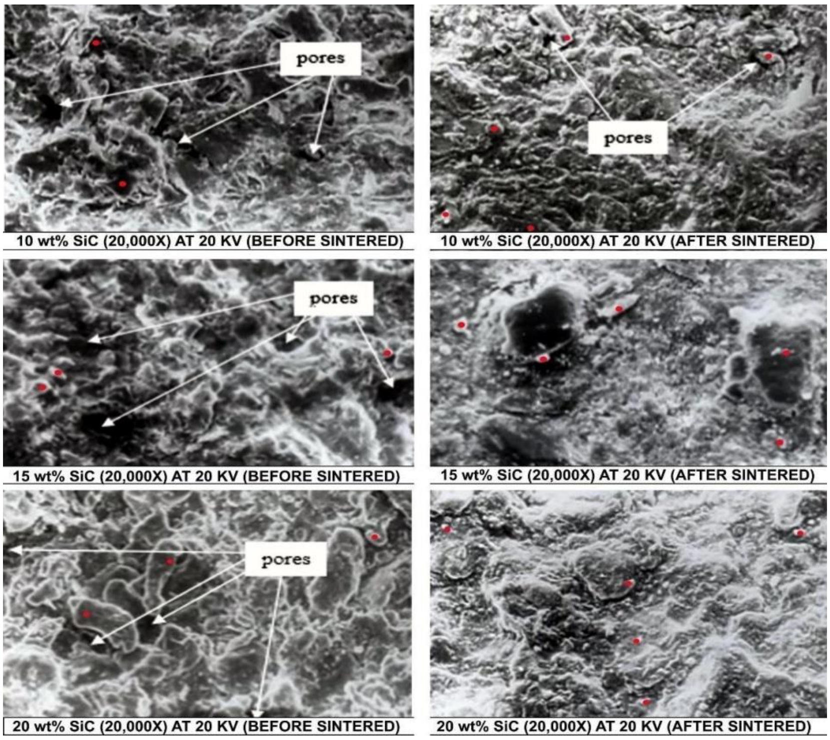
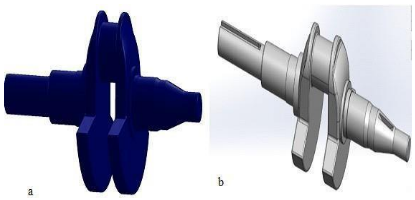


Fig. 4.2: Showing SEM micrographs of Al-SiC reinforced MMCs. The SiC particles are highlighted with reddots to show their appearance.

4.5 INITIAL MODELING: This paper utilized the highly accurate measurements of the steinbichler comet L3D scanner has resolution of 2Mpx and 1600 x 1200 pixels, measuring field of 400mm, measuring volume of 400x300x250 mm^3 and point to point distance of 259µm in order to obtain of an existing physical model crankshaft. The scanned model and CAD model as shown in Fig. 1 and side view of crankshaft before optimization as shown in Fig. 2.



5. METHODOLOGY:

1. Design the crank shaft.
2. Material selection.
3. Structure design.
4. Cad modelling.
5. Export to iges format.
6. Import to ansys.
7. Mesh the solid model.
8. Select the analysis method.
9. Put the input value of material.
10. Solve the values by the way of analysis method.
11. Take the result from result data sheet.

In our proposed work, we shall prepare the model of crankshaft in AUTO CAD and then save in the STEP format and perform statics structural analysis of crankshaft and evaluate the vonmisses stress and deformation occurring in crankshaft. In our research composite element structural member is analyzed using the software called ANSYS. Normally as in all other analysis software the structure is created and property is allotted to the structure that you had created. Then the load is applied to the structural member as required. At the end best material is choose by comparison of results through graph. The software's which is used in this research the detail of software is given blow.

GEOMETRIC MODELING AND FINITE ELEMENT ANALYSIS:

Sketching is valuable for making unpredictable limits or for following with a digitizer. Determine the article type (line, polyline, or spline), augmentation, and resilience before sketching.

5. 2 MODELING:

5.2.1 DESIGN CALCULATIONS:

In the design of the crankshafts, it is assumed that the crankshaft is a beam with two or more supports. Every crankshaft must be designed or checked at least for two crank positions, one when the bending moment is maximum, and the other when the twisting moment is a maximum. In addition, the additional moments due to the flywheel weight, belt tension and other forces must be considered.

5.3 CRANK SHAFT:

The crankshaft is an important part of internal combustion engine that converts the reciprocatingmotion of the piston into rotary motion through the connecting rod. The crankshaft consists of three portions

1. Crank pin
2. Crank web
3. Shaft.

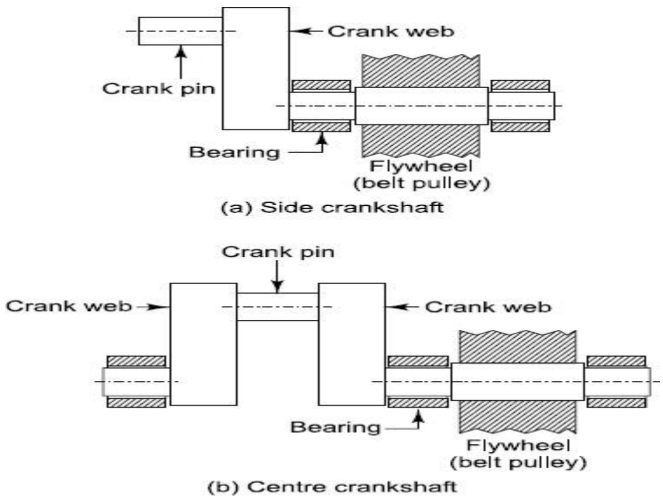


Figure 5.1 type

5.4 MATERIALS USED FOR CRANKSHAFTS:

The popular materials used for crankshafts are plain carbon steels and alloy steels. The plain carbon steels include 40C8, 45C8 and 50C4. The alloy steels used for making crankshafts arenickel–chromium steels such as 16Ni3Cr2, 35Ni5Cr2 and 40Ni10Cr3Mo6.

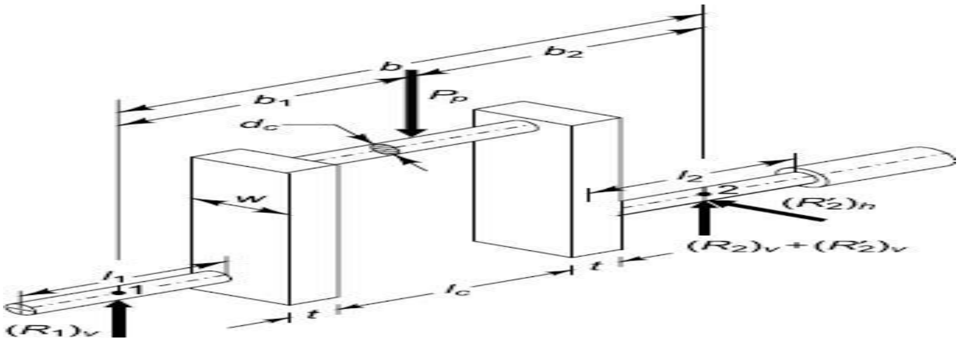
DESIGN OF CENTRE CRANK SHAFT:

A crankshaft is subjected to bending and torsional moments due to the following threeforces:

i Force exerted by the connecting rod on the crank pin
ii Weight of flywheel (w) acting downward in the vertical direction
iii Resultant belt tensions acting in the horizontal direction P_1 P_2
iv In the design of the center crankshaft, two cases of crank positions are considered. They are as follows:

Case I: The crank is at the top dead center position and subjected to maximum bending momentand no torsional moment.

Case II: The crank is at an angle with the line of dead center positions and subjected to maximum torsional moment. We will consider these cases separately to determine the dimensions of the crankshaft.



6. **FINITE ELEMENT ANALYSIS:** The finite element method (FEM), is a numerical method for taking care of issues of designing and mathematical material science. Common trouble zones of intrigue comprise primary examination, warmness exchange, liquid flow, mass delivery, and electromagnetic potential. The investigative association of those troubles for the most part calls for the solution for restriction esteem issues for midway differential conditions. The finite element technique definition of the issue outcomes in an arrangement of logarithmic conditions. The technique approximates the obscure potential over the domain. To tackle the issue, it subdivides an intensive framework into littler, much less complicated parts which can be referred to as finite factors. The basic situations that model those finite elements are then gathered into a bigger association of conditions that fashions the whole problem.

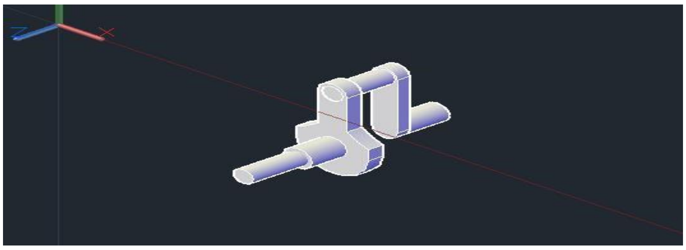
6.1 MESH GENERATION: ANSYS Meshing is a comprehensively precious, watchful, automated global elegance component. It makes the maximum suitable work for actual, gainful multiphasic publications of movement. a piece becoming for a particular examination can be made with a unmarried mouse click for all elements in a version. full controls over the alternatives used to make the paintings are open for the ace consumer who needs to align it. The energy of parallel managing is for that reason used to decrease the time you need to sit down tight for work age.

6.3 CAD MODELLING AND ANALYZING PROCEDURE:

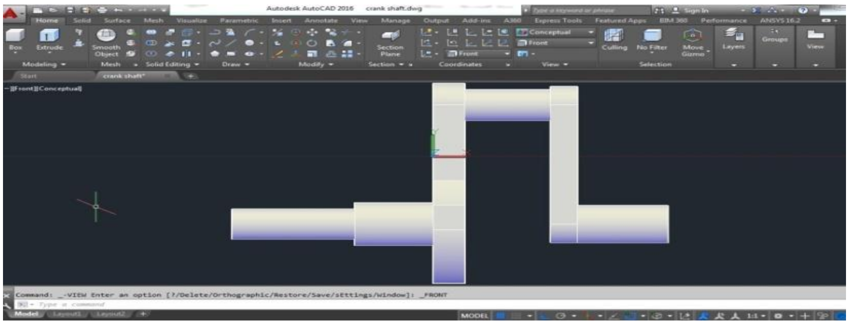
Crank shaft selection material:

1. Aluminium alloy
2. Stainless steel

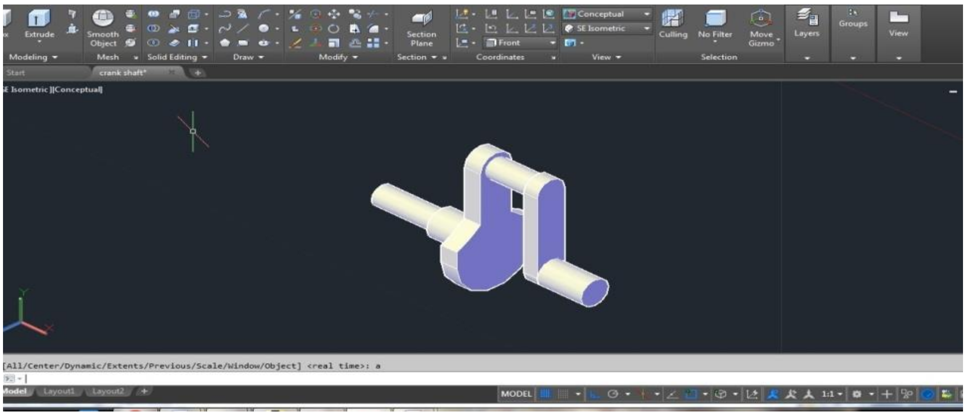
CAD DESIGN:



VERSION: AUTOCAD 2016

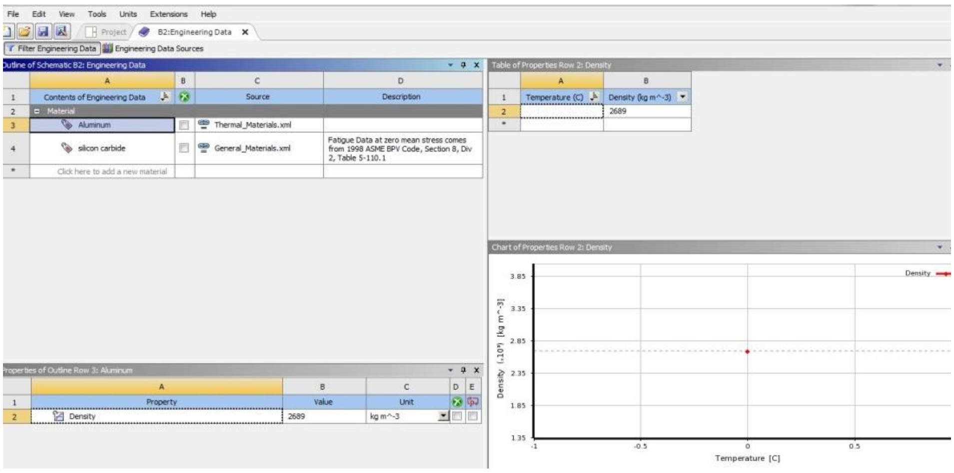


ISOMETRIC VIEW:

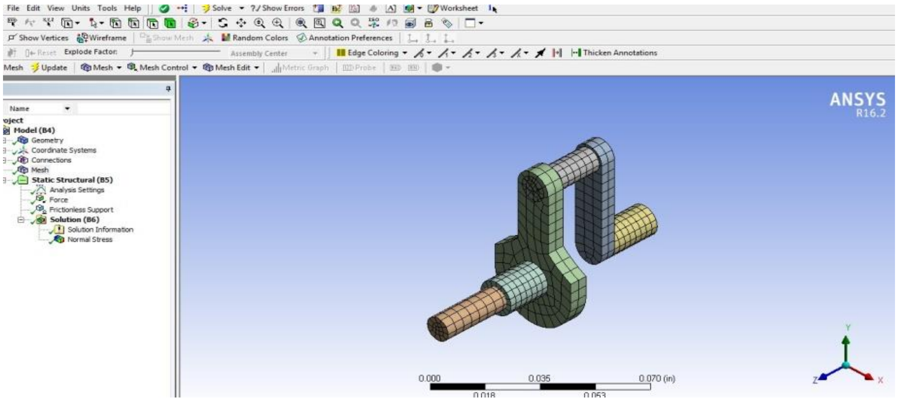


7.ANSYS WORKBENCH:

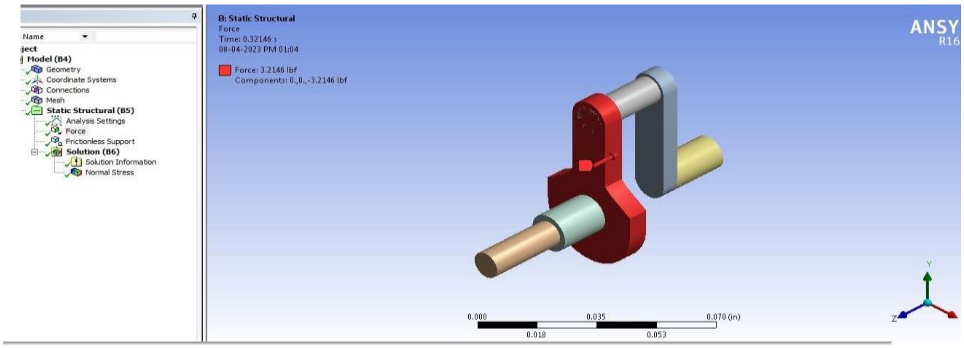
MATERIAL SELECTION: ALUMINIUM 360



MESH:



FORCE APPLY:



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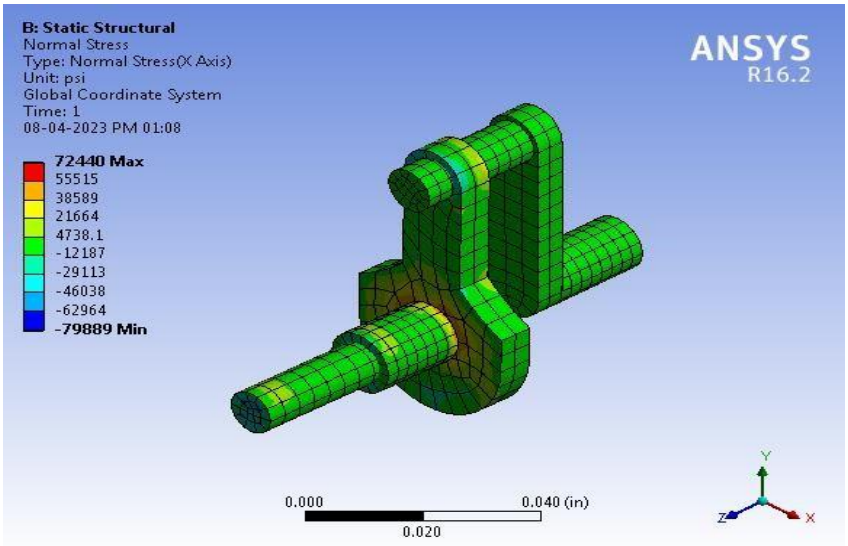

Normal Stress

Model (B4)

Unit System	U.S. Customary (in, lbm, lbf, s, V, A) Degrees rad/s Fahrenheit
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Fahrenheit

Geometry

TABLE 2
Model (B4) > Geometry

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	D:\2022-2023\paavai ME project\CRANK SHAFT\crank shaft.igs 1.igs
Type	Iges
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	3.4023e-002 in
Length Y	6.3459e-002 in
Length Z	9.2583e-002 in
Properties	
Volume	2.1198e-005 in³
Mass	6.0119e-006 lbm
Scale Factor Value	1.
Statistics	
Bodies	6
Active Bodies	6
Nodes	6171
Elements	1097
Mesh Metric	None
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Yes
Parameter Key	DS
Attributes	No
Named Selections	No
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes

Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	No
Compare Parts On Update	No
Attach File Via Temp File	Yes
Temporary Directory	C:\Users\Lenovo\AppData\Local\Temp
Analysis Type	3-D
Mixed Import Resolution	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

TABLE 3 Model (B4) > Geometry > Parts

Object Name	*Part 1*	*Part 2*	*Part 3*	*Part 4*	*Part 5*	*Part 6*
State	Meshed					
Graphics Properties						
Visible	Yes					
Transparency	1					
Definition						
Suppressed	No					
Stiffness Behavior	Flexible					
Coordinate System	Default Coordinate System					
Reference Temperature	By Environment					
Material						
Assignment	silicon carbide					
Nonlinear Effects	Yes					
Thermal Strain Effects	Yes					
Bounding Box						
Length X	9.6885e-003 in	1.1811e-002 in	3.4023e-002 in	9.3612e-003 in	1.3475e-002 in	1.1811e-002 in
Length Y	9.6885e-003 in	4.9659e-002 in	6.3459e-002 in	9.3612e-003 in	1.3475e-002 in	1.1811e-002 in
Length Z	2.497e-002 in	5.6982e-003 in	6.7753e-003 in	4.2711e-002 in	1.6622e-002 in	1.9203e-002 in
Properties						
Volume	1.8402e-006 in³	3.1699e-006 in³	8.7771e-006 in³	2.9385e-006 in³	2.3695e-006 in³	2.1032e-006 in³
Mass	5.2188e-007 lbm	8.9899e-007 lbm	2.4892e-006 lbm	8.3337e-007 lbm	6.7199e-007 lbm	5.9645e-007 lbm

Centroid X	0.13116 in		0.13117 in	0.13116 in	0.13117 in	0.13116 in
Centroid Y	1.6368e-002 in	-2.5558e-003 in	-1.4113e-002 in	-2.148e-002 in		
Centroid Z	-1.2485e-002 in	-2.7819e-002 in	-3.3876e-003 in	2.1356e-002 in	8.3112e-003 in	-4.027e-002 in
Moment of Inertia Ip1	2.9872e-011 lbm·in²	1.6952e-010 lbm·in²	6.7567e-010 lbm·in²	1.3001e-010 lbm·in²	2.2812e-011 lbm·in²	2.3263e-011 lbm·in²
Moment of Inertia Ip2	2.9876e-011 lbm·in²	1.234e-011 lbm·in²	1.5079e-010 lbm·in²	1.3002e-010 lbm·in²	2.282e-011 lbm·in²	2.3268e-011 lbm·in²
Moment of Inertia Ip3	6.01e-012 lbm·in²	1.77e-010 lbm·in²	8.0741e-010 lbm·in²	8.9597e-012 lbm·in²	1.4969e-011 lbm·in²	1.0208e-011 lbm·in²
Statistics						
Nodes	973	609	1133		1284	1039
Elements	180	88	176	216	245	192
Mesh Metric	None					

Coordinate Systems

TABLE 4
Model (B4) > Coordinate Systems > Coordinate System

Object Name	*Global Coordinate System*
State	Fully Defined
Definition	
Type	Cartesian
Coordinate System ID	0.
Origin	
Origin X	0. in
Origin Y	0. in
Origin Z	0. in
Directional Vectors	
X Axis Data	[1. 0. 0.]
Y Axis Data	[0. 1. 0.]
Z Axis Data	[0. 0. 1.]

Connections

TABLE 5
Model (B4) > Connections

Object Name	*Connections*
State	Fully Defined
Auto Detection	
Generate Automatic Connection On Refresh	Yes
Transparency	
Enabled	Yes

TABLE 6
Model (B4) > Connections > Contacts

Object Name	*Contacts*
State	Fully Defined
Definition	
Connection Type	Contact
Scope	
Scoping Method	Geometry Selection
Geometry	All Bodies
Auto Detection	
Tolerance Type	Slider
Tolerance Slider	0.
Tolerance Value	2.9322e-004 in
Use Range	No
Face/Face	Yes
Face/Edge	No
Edge/Edge	No
Priority	Include All
Group By	Bodies
Search Across	Bodies
Statistics	
Connections	4
Active Connections	4

TABLE 7

Model (B4) > Connections > Contacts > Contact Regions

Object Name	*Contact Region*	*Contact Region 2*	*Contact Region 3*	*Contact Region 4*
State	Fully Defined			
Scope				
Scoping Method	Geometry Selection			
Contact	1 Face			
Target	1 Face			
Contact Bodies	Part 1	Part 2	Part 3	
Target Bodies	Part 2	Part 6	Part 4	Part 5
Definition				
Type	Bonded			
Scope Mode	Automatic			
Behavior	Program Controlled			
Trim Contact	Program Controlled			
Trim Tolerance	2.9322e-004 in			
Suppressed	No			
Advanced				
Formulation	Program Controlled			
Detection Method	Program Controlled			
Penetration Tolerance	Program Controlled			
Elastic Slip Tolerance	Program Controlled			
Normal Stiffness	Program Controlled			
Update Stiffness	Program Controlled			

Pinball Region	Program Controlled
Geometric Modification	
Contact Geometry Correction	None
Target Geometry Correction	None

Mesh

TABLE 8
Model (B4) > Mesh

Object Name	*Mesh*
State	Solved
Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Size Function	Off
Relevance Center	Coarse
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge Length	5.6982e-003 in
Inflation	
Use Automatic Inflation	None
Inflation Option	Smooth Transition
Transition Ratio	0.272
Maximum Layers	5
Growth Rate	1.2
Inflation Algorithm	Pre
View Advanced Options	No
Patch Conforming Options	
Triangle Surface Mesher	Program Controlled
Patch Independent Options	
Topology Checking	No
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Extra Retries For Assembly	Yes
Rigid Body Behavior	Dimensionally Reduced

Mesh Morphing	Disabled
Defeaturing	
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Automatic Mesh Based Defeaturing	On
Defeaturing Tolerance	Default
Statistics	
Nodes	6171
Elements	1097
Mesh Metric	None

Static Structural (B5)

TABLE 9
Model (B4) > Analysis

Object Name	*Static Structural (B5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	
Environment Temperature	71.6 °F
Generate Input Only	No

TABLE 10
Model (B4) > Static Structural (B5) > Analysis Settings

Object Name	*Analysis Settings*
State	Fully Defined
Step Controls	
Number Of Steps	1.
Current Step Number	1.
Step End Time	1. s
Auto Time Stepping	Program Controlled
Solver Controls	
Solver Type	Program Controlled
Weak Springs	Program Controlled
Solver Pivot Checking	Program Controlled
Large Deflection	Off
Inertia Relief	Off
Restart Controls	
Generate Restart Points	Program Controlled

Retain Files After Full Solve	No
Nonlinear Controls	
Newton-Raphson Option	Program Controlled
Force Convergence	Program Controlled
Moment Convergence	Program Controlled
Displacement Convergence	Program Controlled
Rotation Convergence	Program Controlled
Line Search	Program Controlled
Stabilization	Off
Output Controls	
Stress	Yes
Strain	Yes
Nodal Forces	No
Contact Miscellaneous	No
General Miscellaneous	No
Store Results At	All Time Points
Analysis Data Management	
Solver Files Directory	E:\crank shaft_files\dp0\SYS-1\MECH\
Future Analysis	None
Scratch Solver Files Directory	
Save MAPDL db	No
Delete Unneeded Files	Yes
Nonlinear Solution	No
Solver Units	Active System
Solver Unit System	Bin

CONCLUSION:

The aim of the research is to study the fatigue failure analysis of crankshaft using finite element analysis. The stress-strain curve was a linear relationship obtained for this analysis to ensure that the maximum stress developed is under the safe permissible range of yield values. The results reported from this analysis stated that the failure began at the fillet region on the SiC material crank shaft was caused by the high bending stress concentration.

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