Contents list available at Science Letters

Science Letters

journal homepage: http://www.scienceletters.org/

Modeling and Comparative Analysis of Connecting ROD

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ARTICLE INFO

Article History
Received 14April 2021
Revised 28 June 2021
Accepted 25 July 2021
Available Online 29 June 2021

Keywords:
Connecting Rod,
IC Engine,
Mechanical Properties,
Stress Analysis,
ANSYS,
3D Model,
CATIA V5.

ABSTRACT

A Connecting Rod is one of the most important components of an IC Engine of a vehicle. After considering the mechanical property of a connecting rod, it directly influence the trust ability and longevity of the engine, the rigidity of the connecting rod acted upon the alternative applied loads which must be guaranteed in its design. So it is required very much to untangle the model of connecting rod through the stress analysis using ANSYS software. In this paper, firstly the 3D models of this engine part are built in the software "CATIA V5" and are then transferred to "ANSYS". The analysis of a connecting rod throws distortion and stress analytically which provides a conceptual support to enhance the design by weigh reduction.

1. Introduction

Introduction of Connecting Rod and Designing Software

The modern power train is right now being come up against a collection of conflicts with reference to emissions, fuel consumption and noise as well as vibration level. These collected conflicts have forced to establish the approaches that assure the appreciable fuel economy, depress the exhausted emissions along with high specific power that enhance the mechanical performance of the engine through the development of light weight of engine with its parts. The stress analysis of a connecting rod of an engine would contribute a worthwhile conceptual justification for the weight reduction and improvement of engine design. Based on these analysis results, the conceptual ideas have been developed which reduces the weight of the connecting rod to a possible extent, without affecting the performance of the engine of a vehicle.

In the present work, the analysis techniques use multibody simulation tools for accurately predicting the operating loads practically acting on the engine components. The 3D model of a connecting rod system, obtained from CATIA V5 software, is analyzed in multibody dynamics simulation software named ADAMS/VIEW to assess the motion and loads acting on a connecting rod of an engine. Finite element model of the connecting rod from HYPERMESH is exported to ANSYS for Static analysis through which the deformation and stress distribution on the connecting rod of an engine is to be determined.

Importance and Application of Connecting Rod

It is called the Backbone of an engine of a vehicle. There is a very much importance of a Connecting Rod in an engine. Connecting Rod rotates the crank shaft which helps the engine to move on or any vehicle to rotate its wheels. The purpose of a Connecting Rod is to provide fluid movement between the piston and crank shaft.

Importance of Designing Software for Connecting Rod

A Connecting Rod is a Shaft which connects a piston to a crank or a crank shaft in reciprocating engine of a vehicle.

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DOI: 10.46890/SL.2020.v02i06009

Together with the crank, it forms a simple mechanism that converts reciprocating motion into rotating motion of a vehicle. Earlier mechanism, such as the chain, could only impart pulling motion. Being rigid, a Connecting Rod may transmit either a push or a pull, allowing the Connecting Rod to rotate the crank through both halves of a revolution. In a few two- stroke engines the Connecting Rod is only required to push a vehicle.

So the designing of connecting is very important for the working of engine or a reciprocating engine of a vehicle.

Analysis of Connecting Rod in ANSYS

Finite Element Method

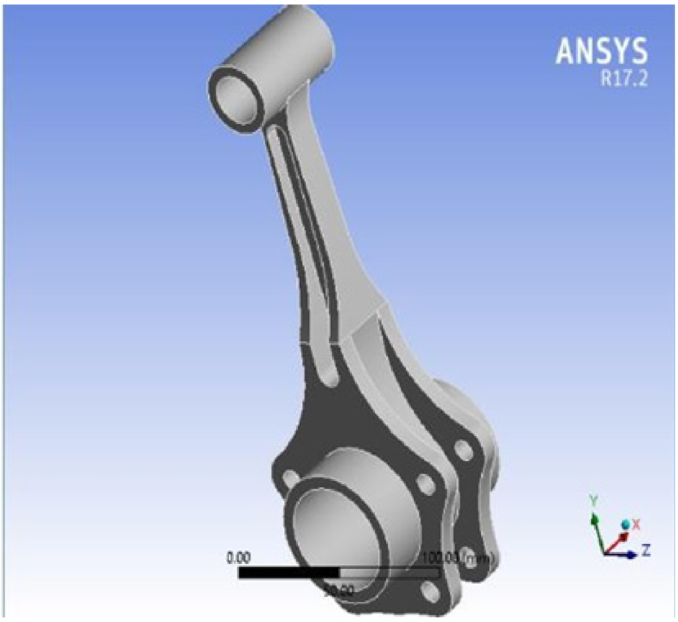
In present analysis Finite Element Method (FEM) is a numerical method for estimate the stress in a connecting rod. For designing the connecting rod with optimum economical cost and limitations, the numerical simulation is the best tool. Finite element analysis provides a way for easy and inexpensive study of random pairs of input parameters along with the design conditions and manufacturing conditions to be evaluated.

Model Construction

The connecting rod created in designing software CATIA V5 through reverse engineering technique has been exported to multibody dynamics simulation software named ADAMS/VIEW environment to perform the kinematic as well as dynamic analysis to determine the displacements, velocities, accelerations and forces acting on each of the part of a Connecting Rod. Dynamic simulations were carried out in ADAMS at varying speeds and applied loads to determine the above mentioned effects. The FE model created was subjected to static structural analysis after assigning suitable material properties and boundary conditions.

Importing Connecting Rod model to ANSYS.

Firstly, simplifying the model of the connecting rod in the stress analysis it is necessary to use the computer resources. The designing model was generated by CATIA V5 software. Few small design features that had hardly affect for the



simulation outcomes, like rounding chamfering and filleting features, were abridged in the model. Then the model was imported to ANSYS software for final dynamics simulation.

Testing Process of Connecting Rod Model to ANSYS.

Units.

TABLE 1

Unit System	Metric (mm, kg, N, s, mV, mA) Degrees rad/s Celsius
Angle	Degrees
Rotational Velocity	rad/s
Temperature	Celsius

Model (A4): Geometrical Aspect.

Table 2. Model (A4) > Geometry

TABLE 2
Model (A4) > Geometry

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	C:\Users\sharma\Desktop\fem analysis of student\manish itr.IGS
Type	Iges
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	96. mm
Length Y	285.5 mm
Length Z	112. mm
Properties	
Volume	3.15e+005 mm³
Mass	2.268 kg
Scale Factor Value	1.
Statistics	
Bodies	1
Active Bodies	1
Nodes	3621
Elements	1713
Mesh Metric	None
Basic Geometry Options	
Solid Bodies	Yes
Surface Bodies	Yes
Line Bodies	No
Parameters	Independent
Parameter Key	ANS;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	Yes
Compare Parts On Update	No
Attach File Via Temp File	Yes
Temporary Directory	C:\Users\sharma\AppData\Local\Temp
Analysis Type	3-D
Mixed Import Resolution	None
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

Table 3. Geometry and Properties of Connecting Rod

Basic Geometry Information	
Object Name	Part 1
State	Meshed
Graphics Properties	
Visible	Yes
Transparency	1
Definition	
Suppressed	No
Stiffness Behavior	Flexible
Coordinate System	Default Coordinate System
Reference Temperature	By Environment

continued..

Behavior	None
Material	
Assignment	Gray Cast Iron
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	96 mm
Length Y	285.5 mm
Length Z	112 mm
Properties	
Volume	3.15e+005 mm^3
Mass	2.268 kg
Centroid X	-3.8888e-003 mm
Centroid Y	42.73 mm
Centroid Z	-1.8351e-004 mm
Moment of Inertia Ip1	13702 kg.mm^2
Moment of Inertia Ip2	1951.6 kg.mm^2
Moment of Inertia Ip3	13612 kg.mm^2
Statistics	
Nodes	3621
Elements	1713
Mesh Metric	None

Virtual Topology.

TABLE 4
Model (A4) > Virtual Cells

Object Name	*Virtual Topology*
State	Fully Defined
Definition	
Method	Automatic
Behavior	Low
Advanced	
Generate on Update	No
Simplify Faces	No
Merge Face Edges	Yes
Lock Position of Dependent Edge Splits	Yes
Statistics	
Virtual Faces	22
Virtual Edges	36
Virtual Split Edges	0
Virtual Split Faces	0
Virtual Hard Vertices	0
Total Virtual Entities	58

Coordinate System.

TABLE 5
Model (A4) > Coordinate Systems > Coordinate System

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

Mesh.

TABLE 6
Model (A4) > Mesh

Object Name	*Mesh*
State	Solved
Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Relevance	0
Shape Checking	Standard Mechanical
Element Midside Nodes	Program Controlled
Sizing	
Size Function	Adaptive
Relevance Center	Coarse
Element Size	Default
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Automatic Mesh Based Defeaturing	On
Defeature Size	Default
Minimum Edge Length	1.41420 mm
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
Advanced	
Number of CPUs for Parallel Part Meshing	Program Controlled
Straight Sided Elements	No
Number of Retries	Default (4)
Rigid Body Behavior	Dimensionally Reduced
Mesh Morphing	Disabled
Triangle Surface Mesher	Program Controlled
Topology Checking	No
Pinch Tolerance	Please Define
Generate Pinch on Refresh	No
Statistics	
Nodes	3621
Elements	1713
Mesh Metric	None

Static Structural.

TABLE 7
Model (A4) > Analysis

Object Name	*Static Structural (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Static Structural
Solver Target	Mechanical APDL
Options	
Environment Temperature	22. °C
Generate Input Only	No

TABLE 8
Model (A4) > Static Structural (A5) > 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	Off
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	C:\Users\sharma\Desktop\fem analysis of student\connecting rod analysis_files\dp0\SYS\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	nmm

TABLE 9

Model (A4) > Static Structural (A5) > Loads

Object Name	*Frictionless Support*	*Force*
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	1 Face	
Definition		
Type	Frictionless Support	Force
Suppressed	No	
Define By		Components
Coordinate System		Global Coordinate System
X Component		0. N (ramped)
Y Component		-100. N (ramped)
Z Component		0. N (ramped)

FIGURE 1
Model (A4) > Static Structural (A5) > Force

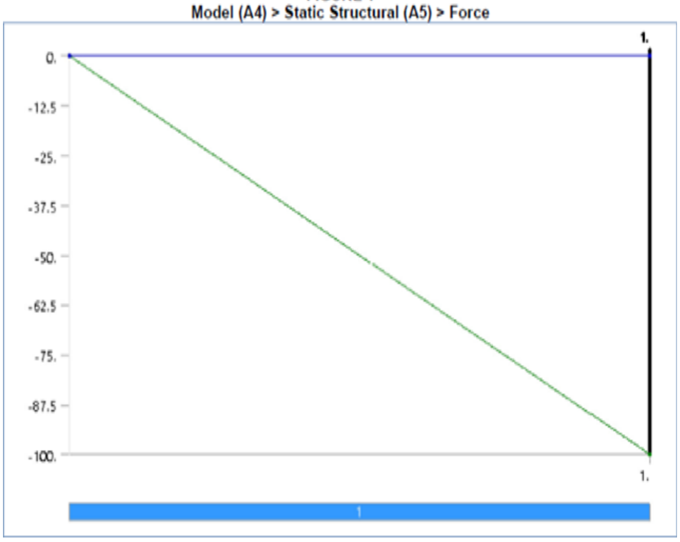


TABLE 10
Model (A4) > Static Structural (A5) > Solution

Object Name	*Solution (A6)*
State	Solved
Adaptive Mesh Refinement	
Max Refinement Loops	1.
Refinement Depth	2.
Information	
Status	Done
MAPDL Elapsed Time	11. s
MAPDL Memory Used	265. MB
MAPDL Result File Size	1.6875 MB
Post Processing	
Beam Section Results	No

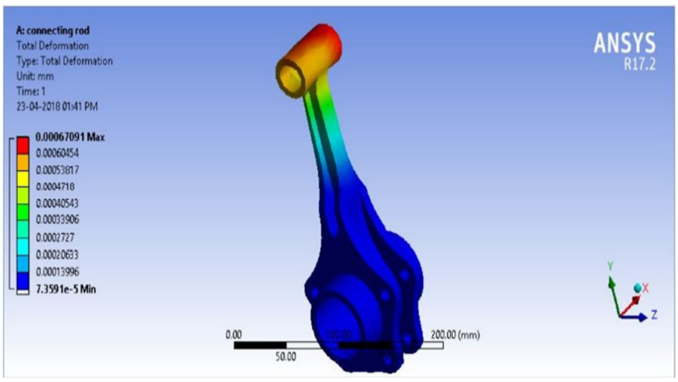
TABLE 11
Model (A4) > Static Structural (A5) > Solution (A6) > Solution Information

Object Name	*Solution Information*
State	Solved
Solution Information	
Solution Output	Solver Output
Newton-Raphson Residuals	0
Identify Element Violations	0
Update Interval	2.5 s
Display Points	All
FE Connection Visibility	
Activate Visibility	Yes
Display	All FE Connectors
Draw Connections Attached To	All Nodes
Line Color	Connection Type
Visible on Results	No
Line Thickness	Single
Display Type	Lines

TABLE 12
Model (A4) > Static Structural (A5) > Solution (A6) > Results

Object Name	*Total Deformation*	*Equivalent Elastic Strain*	*Equivalent Stress*
State	Solved		
Scope			
Scoping Method	Geometry Selection		
Geometry	All Bodies		
Definition			
Type	Total Deformation	Equivalent Elastic Strain	Equivalent (von-Mises) Stress
By	Time		
Display Time	Last		
Calculate Time History	Yes		
Identifier			
Suppressed	No		
Results			
Minimum	7.3591e-005 mm	1.5947e-008 mm/mm	6.1465e-004 MPa
Maximum	6.7091e-004 mm	7.3014e-006 mm/mm	0.78179 MPa
Minimum Occurs On	Part 1		
Maximum Occurs On	Part 1		
Information			
Time	1. s		
Load Step	1		
Substep	1		
Iteration Number	1		
Integration Point Results			
Display Option		Averaged	
Average Across Bodies		No	

Total Deformation Analysis.

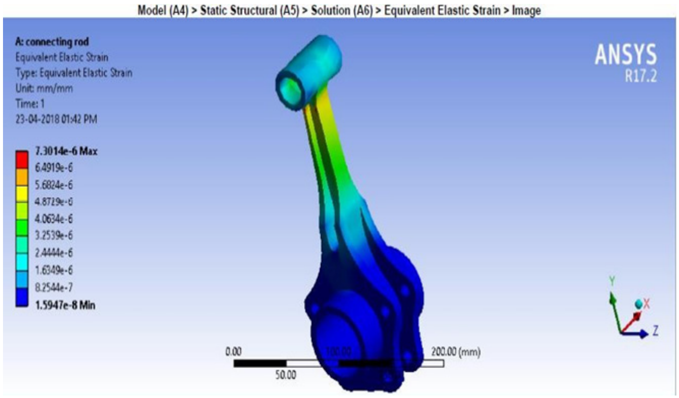


Strain Analysis.

Table 13. Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Elastic Strain

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]
1.	1.5947e-008	7.3014e-006

Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Elastic Strain > Image

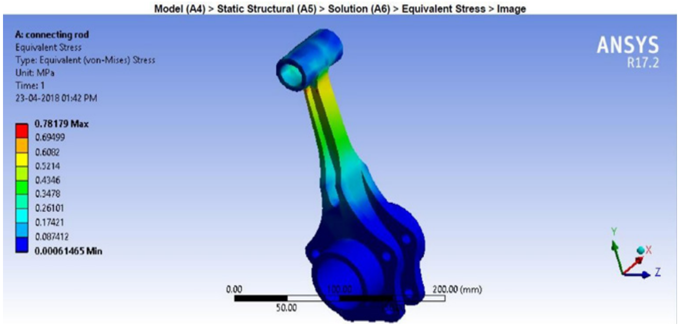


Stress Analysis.

Table 14. Stress Data for Stress Analysis

Time [s]	Minimum [MPa]	Maximum [MPa]
1.	6.1465e-004	0.78179

Model (A4) > Static Structural (A5) > Solution (A6) > Equivalent Stress > Image



Material Data (Gray Cast Iron) & (Magnesium Alloy).

Table 15. Gray Cast Iron > Constants < Magnesium Alloy

Density	7.2e-006 kg mm^-3	1.8e-006 kg mm^-3
Coefficient of Thermal Expansion	1.1e-005 C^-1	2.6e-005 C^-1
Specific Heat	4.47e+005 mJ kg^-1 C^-1	1.024e+006 mJ kg^-1 C^-1
Thermal Conductivity	5.2e-002 W mm^-1 C^-1	0.156 W mm^-1 C^-1
Resistivity	9.6e-005 ohm mm	7.7e-004 ohm mm

Table 16. Color

Material	Red	Green	Blue
Gray cast Iron	161	161	161
Magnesium Alloy	235	234	183

Table 17. Compressive Ultimate Strength

Material	Compressive Ultimate Strength MPa
Gray Cast Iron	820
Magnesium Alloy	0

Table 18. Compressive Yield Strength

Material	Compressive Yield Strength MPa
Gray Cast Iron	0
Magnesium Alloy	193

Table 19. Tensile Yield Strength

Material	Compressive Tensile Yield Strength MPa
Gray Cast Iron	0
Magnesium Alloy	193

Table 20. Tensile Ultimate Strength

Material	Tensile Ultimate Strength MPa
Gray Cast Iron	240
Magnesium Alloy	255

Table 21. Isotropic Secant Coefficient of Thermal Expansion

Material	Zero- Thermal-Strain Reference Temperature °C
Gray Cast Iron	22
Magnesium Alloy	22

Table 22. Isotropic Elasticity

Material	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
Gray Cast Iron	1.1e+005	0.28	83333	42969
Magnesium Alloy	45000	0.35	50000	16667

Table 23. Isotropic Relative Permeability

Material	Relative Permeability
Gray Cast Iron	10000
Magnesium Alloy	10000

Conclusion

In this research paper, we have performed the stress, strain and deformation analysis of a Connecting Rod of an I.C. Engine of a Vehicle. We have considered the Connecting Rod because it is one of the most important parts of an IC Engine and whose deformation may cause malfunctioning of an I.C.

Engine.

In this research paper we have also compared the manufacturing materials like Grey Cast Iron and Magnesium Alloy of a Connecting Rod for a better decision on selection of a production material of a Connecting Rod.

After research and comparative analysis, we can conclude the main result of this research paper on behalf of below mentioned points:

1) As per the comparative study on behalf of Factory of Safety of a Material, we have first concluded that the production material named Grey Cast Iron plays an important role in comparison of Magnesium Alloy during manufacturing process of a Connecting Rod.

2) Finally we concluded that the Grey Cast Iron has better property and performance than Magnesium Alloy on the aspects of various mechanical properties like stress, strain and deformation, which will always play a major role of safety of production material during manufacturing of a Connecting Rod and also after manufacturing regarding life safety during its utilization by a human life.

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