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AN INVESTIGATION OF COMPARATIVE STUDY IN CONNECTING ROD BY USING FINITE ELEMENT ANALYSIS

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ABSTRACT

Most of the automobile parts are connected with the help of connecting rod. More vibration occurs on the engines. This project deals with reducing the vibration and calculates the natural frequency of the engines. The top end of the connecting rod is connected with the bottom of the piston and the other end is connected to the bottom of the crankshaft. The crankshaft rotates some amount of energy transfers through connecting rod. The connecting rod and crankshaft are transfer few rotation motion to the piston. The piston is moving transverse direction, so it is necessary to find out natural frequency. The result of this research deals with the natural frequency of two different materials, namely Cast iron and stainless steel. The design of connecting rod is done with the help of CATIA V5R17 and modal analysis is done with the help of Ansys software. The result of model analysis i.e. natural frequency of two different materials is compared and results tell that the natural frequency of cast iron is less in comparison to stainless steel. Where the deformation in cast iron takes place in the10th layer of the node, whereas the deformation takes place in stainless steel in 8th layer itself. By this comparison, it is justified that natural frequency, i.e. deformation in cast iron is less in comparison with stainless steel.

KEYWORDS: *Connecting Rod, Modal Analysis, Ansys Workbench, Cast Iron & Stainless Steel*

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Original Article

INTRODUCTION

The Connecting rod transmits the power from the crankshaft to the piston. It transforms the rotation into linear motion. In this case, more fatigue occurs, results in performance the connecting rod. But material properties strength is weak. Connecting rods are a very much essential component of the engine. It is mainly used in the automobile field. Initially connecting rod was made of steel. Nowadays it has been replaced by copper, aluminium and copper alloys. Weight has been reduced in certain stages. This cause of deformation in boundary conditions of materialswe find the boundary loading conditions, where deformation occurs in the critical mode shape of frequencies. Cast iron is a good strength of materials which is useful in automobile fields. It has low density and good tensile stress. Mild steel is mainly used in automobile industries. having running conditions where there is more thermal stress induced. It is safe to use in the thermal heat process. While the Crankshaft is going downwards direction, more boundary conditions are acting in connecting rod. These boundary conditions are going to deform at certain stages of showing frequency results.

LITERATURE REVIEW

Mr. Liu, X. X., & Chen, M. (2014) investigated the modal frequency when crankshaft and connecting rod of a single cylinder I. C engine, using the analytical method process. Mr. Spencer, N. (2013) made a 3d model and analysed crankshaft in Catia v5 R16 and found out two results in modal analysis successfully and concluded the results in free frequency case of higher results and lower results.

Mr. Bin et al (2010) found out characteristics of inside the combustion chamber of a four-stroke engine. Fluid flow analysis was done by direct injection of the combustion chamber and material characteristics of the inlet and exhaust strokes are successfully investigated.

Mr. Zhang, Z., & Kumar, A. V. (2017) analyzed experimentally the working of engine water cooling systems of nanomaterials characterization and four stroke engine exhaust heat dissipated was successfully studied. Author used multi-walled Nano carbon tubes in a four-stroke engine. Found ok the results of engine performance and heat dissipated of the cyclic process was good to control heat dissipation.

Mr. Rakicet al (2017) investigated how to control the pollution of engine emission and waste on heat dissipation controls in the four-stroke engine at high power running conditions. Author studied how to less the power to use and more control on engine heat dissipation. He was shown a result of structural analysis of engine parts successfully.

Mr. Mia et al (2017) investigated and analyses the four-stroke internal combustion of V-engines with numerical calculation method of modal analysis. Various numbers of modelshave been dissipated in a V engine dissipated heat. Mr. Chandru et al (2017) used the computer package Mathcad software and successfully shown V engines with different number of nodes and virtual mode of engines.

Mr. Zhue Zhu et al (2017) has done a work on design and analysis of 4-stroke CI engine, 3D modelling in Catia software and analyzed in Ansys software. Three types of material properties used for investigation in engine works, which was compared the results and nominated fewer stress materials. Resolving the problems of studying this project identified four different direct injection methods to dissipate heat loss successfully.

Mr. Gopal et al (2017) investigated four-stroke diesel engine pistons for choosing different types of three materials and compared the results. The material characterization was successfully compared and also the optimization process of the same materials. This project was done in Ansys (optimization) and Catia software's are used.

Mr. Onyegiri, I., &Kashtalyan, M. (2017) researched the reduction of engine weight. They had used aluminium alloy in the cylinder head and nikasil coating was done on the cylinder bore. Finally the author showed in this research was successful in weight reduction.

Mr. El-sayedet al (2017) has investigated, 15 cc petrol engine pistons were made in solid works 3d modeling and applied different materials and analyzed also the help of solid works and showed better results. Mr. Bari et al (2017) has chosen aluminium alloy 2024-T361 to show the results of deformation shape, von misses stress, factor of safety successfully.

Mr. Kouroussis et al (2017) experimental setup was compared with computational fluid dynamics of Ansys software. The author identified problems of air fuel swirl is damage to the four stroke cylinder engine inside the chambers. The author calculated the numerical values to affect air fuel swirl enters the inside chamber ratio. The investigator analysed the piston model is done in CFD Ansys, which was showing the different mode shapes of piston crown results successfully.

MATERIAL PROPERTIES OF THE CONNECTING ROD

Cast Iron

Density	7200 kg m^{-3}
Coefficient of Thermal Expansion	$1.1e^{-005}C^{-1}$
Specific Heat	447 J kg^{-1} C^{-1}
Thermal Conductivity	52 W m^{-1} C^{-1}
Resistivity	$9.6e^{-008}$ ohm m
Young's Modulus Pa	$1.1e^{+011}$
Poisson's Ratio	0.28

Modelling and Analysis of the Connecting Rod Using Cast Iron

The important objective of this project is to find the natural frequency in different modes terms of the connecting rod using CATIA and ANSYS software. The model of the connecting rod is created in CATIA V5 R16 software. Computer-aided three dimensions interactive application is 3Dimensional software. This solid geometry was created by using 3-D drawings in CATIA part model. This CATIA 3D model is exported as a Para solid file to ANSYS software. Modelling of the connecting rod is done and imported in ANSYS workbench as a 3d part model. Imported 3d modelling is converted into meshing of solid 182 elements. Meshing is a process of splitting into subparts into the elements and controls. The split elements are processing a numerical problem-solving solution of the boundary conditions. The finite element analysis methods are going to solve the boundary value problems in different mode conditions in the analysis. External areas are divided into quadrilateral or triangle shapes occurs in the body.

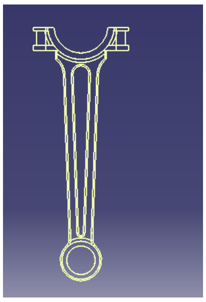


Figure 1: Catia 2-d Model

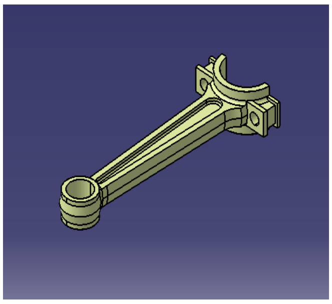


Figure 2: Catia 3-d Model

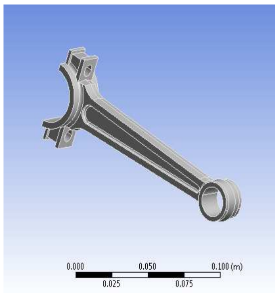


Figure 3: Import Ansys Model

The Catia 3 Dimensional model is imported into Ansys 12 workbenches. The workbench model can be analyzed through more features to analysis. We need a modal analysis of the connecting rod and to find natural frequencies of the different shapes. So we selected modal analysis of the component features.

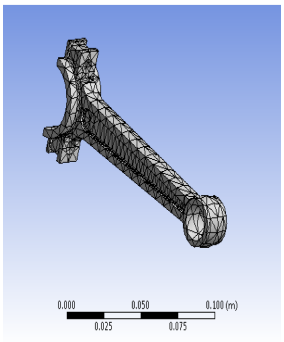


Figure 4: Ansys Meshed Model

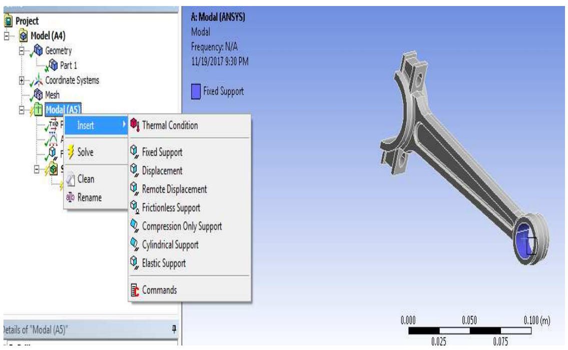


Figure 5: Ansys Fixed Support Model

Modal analysis component box is opened. Now Engineering data tools are opened and imported cast iron, stainless steel material properties. After importing material properties we can import connecting rod IGES files. Now selected the material properties of cast iron and meshed the model withsuitable meshing ratio.

Model (A4) > Geometry > Parts	
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
Material	
Assignment	Gray Cast Iron
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	0.159 m
Length Y	6.e-002 m
Length Z	2.8e-002 m

Table 1: Details geometry

Properties	
Volume	3.2904e-005 m³
Mass	0.23691 kg
Centroid X	6.4431e-002 m
Centroid Y	5.5004e-006 m
Centroid Z	1.0703e-006 m
Moment of Inertia Ip1	3.2161e-005 kg·m²
Moment of Inertia Ip2	5.6899e-004 kg·m²
Moment of Inertia Ip3	5.9012e-004 kg·m²
Statistics	
Nodes	8125
Elements	4533
Mesh Metric	None

Table 2: Position of Cast Iron

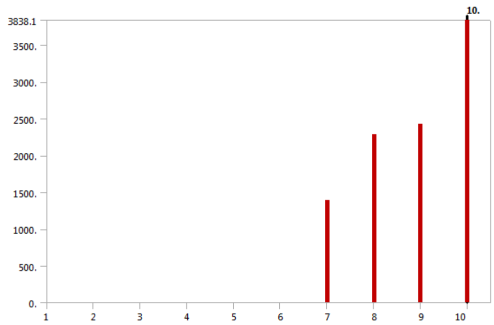
Model (A4) > Analysis	
Object Name	*Modal (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Modal
Solver Target	ANSYS Mechanical
Options	
Environment Temperature	22. °C
Generate Input Only	No

Table 3: Analysis Type

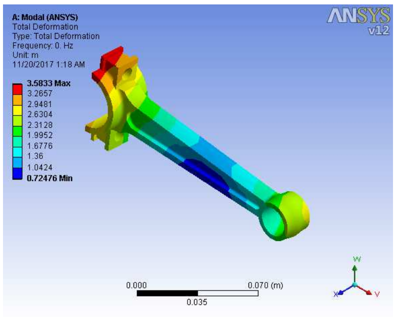
After the meshed modal we can change the number of modes in analysis type. Finally, we solved the problems for getting better natural frequency results.

Table 4: Natural Frequency of 10 Modes

Mode	Frequency [Hz]
1.	0.
2.	
3.	
4.	3.9784e-003
5.	5.756e-003
6.	6.9756e-003
7.	1387.3
8.	2285.3
9.	2420.8
10.	3838.1



Graph 1: Deviation of Different Modes



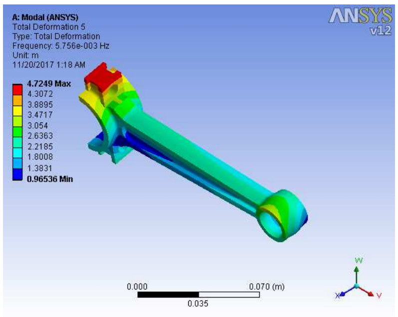
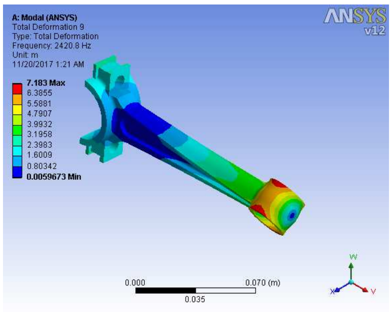


Figure 6: 1st Mode of Connecting Rod **Figure 7: 5th Mode of Connecting Rod**



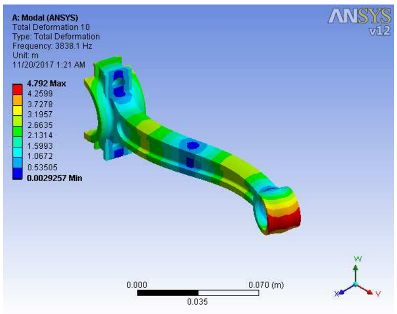


Figure 8: 9th Mode of Connecting Rod **Figure 9: 10th Mode of Connecting Rod**

After getting the results, we discussed to make the same model and analysis it, by changing its material properties of stainless steel.

Modeling and Analysis of the Connecting Rod Using Stainless Steel

Stainless steel

Density	7750 kg m^-3
Coefficient of Thermal Expansion	1.7e-005 C^-1
Specific Heat	480 J kg^-1 C^-1
Thermal Conductivity	15.1 W m^-1 C^-1
Resistivity	7.7e-007 ohm m
Young's Modulus Pa	1.93e+011
Poisson's Ratio	0.31

Model (A4) > Geometry > Parts

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
Material	
Assignment	Gray Cast Iron
Nonlinear Effects	Yes
Thermal Strain Effects	Yes
Bounding Box	
Length X	0.159 m
Length Y	6.e-002 m
Length Z	2.8e-002 m

Table 5: Details Geometry

Properties	
Volume	3.2904e-005 m³
Mass	0.23691 kg
Centroid X	6.4431e-002 m
Centroid Y	5.5004e-006 m
Centroid Z	1.0703e-006 m
Moment of Inertia Ip1	3.2161e-005 kg·m²
Moment of Inertia Ip2	5.6899e-004 kg·m²
Moment of Inertia Ip3	5.9012e-004 kg·m²
Statistics	
Nodes	8125
Elements	4533
Mesh Metric	None

Table 6: Position of Cast Iron

Model (A4) > Analysis

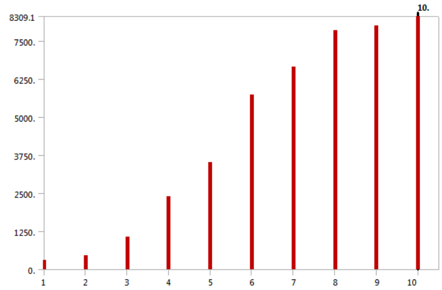
Object Name	*Modal (A5)*
State	Solved
Definition	
Physics Type	Structural
Analysis Type	Modal
Solver Target	ANSYS Mechanical
Options	
Environment Temperature	22. °C
Generate Input Only	No

Table 7: Analysis Type

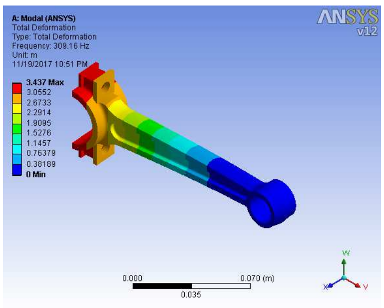
The same procedures we had followed in stainless steel. The stainless steel is more carbon and ductile property holding material.

Table 8: Natural Frequency of 10 Modes

Mode	Frequency [Hz]
1.	309.16
2.	469.88
3.	1062.9
4.	2384.2
5.	3516.1
6.	5723.5
7.	6647.2
8.	7838.3
9.	8001.8
10.	8309.1



Graph 2: Deviations of different Modes



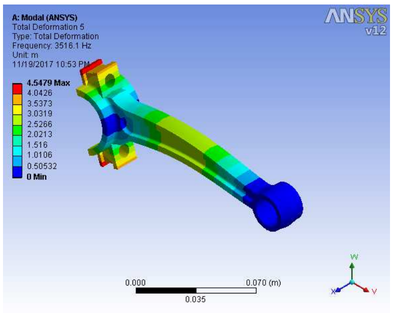
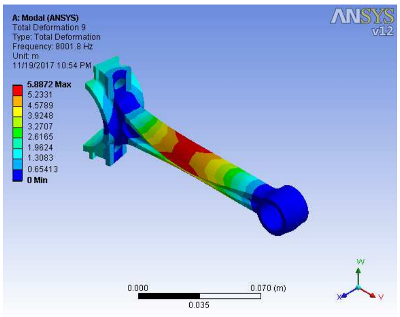


Figure 11: 1st Mode of Connecting Rod **Figure 12: 5th Mode of Connecting Rod**



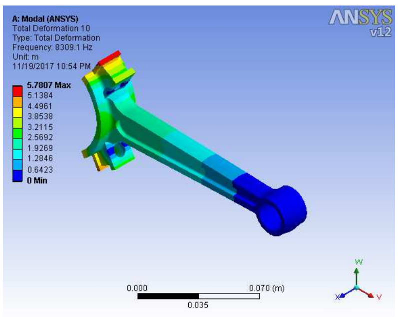


Figure 13: 9th Mode of Connecting Rod **Figure 14: 10th Mode of Connecting Rod**

COMPARISON OF RESULTS AND CONCLUSIONS

We choose two different types of material properties and analysed in the modal frequency of natural vibrations. The mostly cast iron parameter results are in positive. Cast iron's first three natural frequency values are zero tolerance. It means good material characterization is we are chosen. As the comparative result and their values are given below:

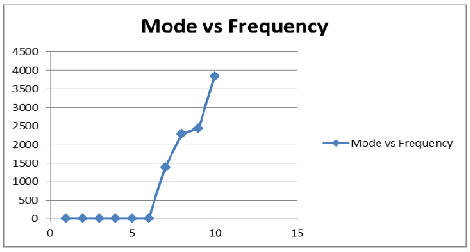
Cast Iron Results

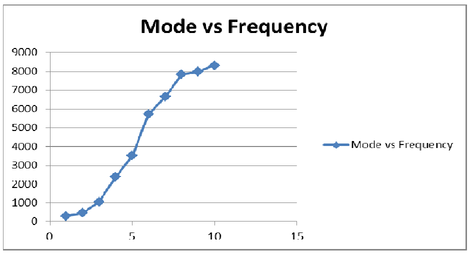
Total Deformation	1	2	3	4	5	6	7	8	9	10
Minimum	0.72476 m	0.97272 m	1.0913 m	0.94776 m	0.96536 m	0.80428 m	2.75e-002 m	2.6555e-002 m	5.9673e-003 m	2.9257e-003 m
Maximum	3.5833 m	3.9985 m	4.05 m	3.8225 m	4.7249 m	4.1502 m	4.6076 m	4.959 m	7.183 m	4.792 m
Reported Frequency	0. Hz			3.9784e-003 Hz	5.756e-003 Hz	6.9756e-003 Hz	1387.3 Hz	2285.3 Hz	2420.8 Hz	3838.1 Hz

Stainless Steel Results

Total deformation	1	2	3	4	5	6	7	8	9	10
Minimum	0. m					0. m				
Maximum	3.437 m	3.4093 m	5.8121 m	3.4602 m	4.5479 m	7.1422 m	3.877 m	6.216 m	5.8872 m	5.7807 m
Reported Frequency	309.16 Hz	469.88Hz	1062.9Hz	2384.2 Hz	3516.1Hz	5723.5Hz	6647.2Hz	7838.3Hz	8001.8Hz	8309.1 Hz

Cast Iron		Stainless Steel	
Compressive Ultimate Strength Pa	$8.2e^{+008}$	Compressive Ultimate Strength Pa	0
Compressive Yield Strength	0	Compressive Yield Strength	$2.07e^{+008}$
Tensile Yield Strength	0	Tensile Yield Strength	$2.07e^{+008}$
Tensile Ultimate Strength Pa	$2.4e^{+008}$	Tensile Ultimate Strength Pa	$5.86e^{+008}$





Graph 4: Cast Iron (Mode vs. Frequency Graph 5: Stainless Steel (Mode vs. Frequency)

CONCLUSIONS

The modal analysis for two different materials, namely cast iron and stainless steel is done with the help of ANSYS software and results tells that natural frequency, i.e deformation of cast iron is startingat 4thlayer (3.9784e-003 Hz) whereas in stainless it starts at 1st layer 309.16 Hz. By this comparison, it is clearly noted that the natural frequency of castiron is less when compared to stainless steel and result conclude that deformation in cast iron is less in comparison to stainless steel.

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