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TO PERFORM DESIGN & STATIC STRUCTURAL ANALYSIS ON CRANKSHAFT FOR AN AUTOMOBILE

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ABSTRACT

The crankshaft is an important component of an IC engine because it translates the piston's reciprocating action into rotary motion via the connecting rod. A crankshaft's strength should be sufficient to withstand the bending and twisting forces it is subjected to. This project describes the stress distribution of a crankshaft by manual calculations for different subjected loads and moments by considering different operating conditions such as maximum bending moment condition (without twisting moment" and combined twisting and bending moment condition (where torsion is maximum". Followed bythe CAD modelling using the dimensions obtained from hand calculations. Using commercial finite element analysis (software Ansys) the final model was analysed. In order to optimise component design at the early development stage, the results of stress analysis are significant. The examination of the crankshaft natural frequencies and the mode forms were explored. The analysis was modal. This load is applied to the ANSYS FE model and limits appropriate to the motor mounting conditions are implemented. The study is performed to locate the crucial position in the shaft.

1. INTRODUCTION

1.1 Introduction

Crankshaft is a portion of an engine used to transform the reciprocal movement into rotary motion, and it employs a cardboard throw and additional bearing surfaces to be coupled to each rotating movement. We know that during the operation of the engine it takes a large number of loads, fatigue performance and durability of the components must be taken into account during the design. The shaft includes the major components, crank pins, webs, counterweights and oil holes. The shaft contains It can be forged using a steel bar, which is mainly used by manufacturers today because of its smaller weight and its natural dampening..

Vanadium micro-alloyed steels are usually employed through forged crank-shafts as these steels can be air-cooled without extra thermal treatment after achieving high strength, with the exception of surface hardening of bearing surfaces. Currently, iron crankshafts are often utilised because carbon steels require an additional thermal process but with carbon steels they occur in cheaper manufacturing motors with less load-acting application.

Fig 1.1 Crankshaft

In favour of some motors the reciprocating mass of each piston and connecting rod must be provided with counterweights to improve the motor balance. These are usually moulded into the crankshaft, but seldom into sections that are bolted. While counter weights add significant weight to the crankshaft, it offers a smoother motor and allows for greater RPM rates.

1.2 Metals and Alloys

1.2.1 Metals

A metal is a typically hard, opaque, glossy material that has strong conductivity of electric and thermal power. Metals can generally be moulded, i.e. they can be permanently marked or squeezed out without rupture or crack as well as ductile or fusible. Generally, metals have high conductivity, high thermal conductivity and high density. The mechanical characteristics of metals include ductility, i.e. plastic deformation capacity. The hooke law for restore force, where the stress is linearly proportional to the strain, can be expressed as reversible elastic deformation of metals. Forces that exceed the elastic limit or heat can cause an object to be deformed permanently (irreversibly) termed as plastics or plasticity. As a result of this irreversible alteration in the atomic structure,:

- The action of an applied force (or work). The tensile (pulling) strength, compressive (pushing), shear, and twisting (twisting) forces may be used in the application of the force.

1.2.2 Alloys

An alloy is a blend of two or more elements in which a metal is the primary component. For practical application, the majority of pure metals is either excessively soft, brittle or reactive. The combination of various metal ratios called alloys affects the properties of pure metals for desirable attributes. The purpose of the alloys is in general to make the iron alloys less broken, harder, corrosion-resistant or to have a better colour and lustre than all the metal alloys in use today, both in quantity and commercial value, iron alloys.

Aluminum, titanium, copper and magnesium are also important metal alloys. Known for prehistoric bronze, copper alloys have given its name to the Bronze Age and today have a lot of applications, mostly electrical cable. The alloys of the other three metals have recently been produced and require electrolytic extraction procedures due to their chemical reactivity. For their excellent strength-to-weight ratios, aluminium, titanium and magnesium alloys are valued; magnesium may provide electromagnetic shielding as well. Alloys manufactured specifically for highly challenged use, such as jet motors, may have more than 10 elements.

- Iron Alloys and Materials: There are several types of iron-containing alloys. Among the most prominent ones are carbon steels, alloy steels, stainless steels, instrument steels, cast iron and steel management.
- Carbon steels are stones, which are made from carbon as the principal alloy ingredient. The lowest cost of mild steel is the most popular. It is neither fragile nor ductile, has relatively low tensility and mallurgical. During carburizing the surface hardness can be raised. High carbon steels have a higher carbon content and are substantially more resistant to ductility.
- Steels are alloyed with other metals to increase their characteristics, steels (iron and carbon). Molybdenum, chromium and nickel are the most prevalent metals in low alloy steels for improving soldering ability, formability, wear resistance and corrosion resistance.

2. LITERATURE REVIEW

Farzin H Montazersadgh et al. [1] The proposed dynamic analysis, utilising the finite-element analysis techniques, studied the influence of torsional stress and the difference in stress magnitude at the critical region.

Amarjeet Singh et.al. [2] The major aim of this method was to do static analysis on a four-cylinder motor cranking shaft, analysed and optimised strength. The critically detected places were the knuckle of the crank arm and the far left handle after obtaining the stress findings.

Jian Meng et al. [3] Crankshaft model and crank throw revived and studied. The crankshaft distortion was largely a low frequency bending distortion. The connection between the primary bearing diary, paddle and cum cheeks had higher distortion.

GuYingkui et.al [4] Researched a 3D diesel engine crankshaft model displayed by the PRO/E programme. The greatest stress, which was placed mainly on a knuckle for the crank arm, the main log and the crank arm & rod journal connection, was detected using Ansys software.

Xiaorong et.al [5] The crankshaft assessment was done. The inspection, shell conditions, operating conditions and other sources of failure are discussed. The effects on tiredness, such as residual stress and ways for decreasing residual compressive stress on crankshafts, were analysed.

Guagliano et.al [6] The study used Finite Element Analysis to assess stress concentration on a marine diesel engine crankshaft. In this investigation of the numerical model, experimental data were validated. The FEA results were more accurate and acceptable compared to the experimental results.

Henry et.al [7] The stress was determined using the Finite element analysis approach for the fillet area of the crankshaft. The stress achieved was evaluated on a 1.9 litre turbo-charged diesel engine with the type of combustion chamber Richard. The testing results

Prakash et al [8] Studies on crankshaft stress and fatigue analysis utilising the classical technique and FEM method with Ansys. From this analysis, the findings showed that the exponents of strength and ductility have a strong impact on life.

3. MRTHODOLOGY

3.1 General

The study uses sketch and part design module for the CAD design of crankshaft in CATIA V5 software. CATIA is a three dimensional interactive application computer-assisted acronym. It is a leading 3D software in many industries, from aerospace, automotive and consumer items. Figure 3.1 shows the flow diagram for the research process.

And the FEA analysis is done by using software ANSYS 16.2 on the crankshaft to find out the stress, vibrations and deformation in the static condition of the crankshaft. The module tools which are used for this FEA analysis are Static structural analysis to find deformation and stress in the body and Modal analysis to find the frequencies caused by vibrations in the structured component. We are dividing this methodology into two parts

1. Design methodology.
2. Analysis methodology.

The main objectives in this project are as follows:

i. To model the crankshaft using SOLIDWORKS software
ii. To mesh the model of crankshaft using ANSYS 16.2 software
iii. Static analysis by using ANSYS WORKBENCH software

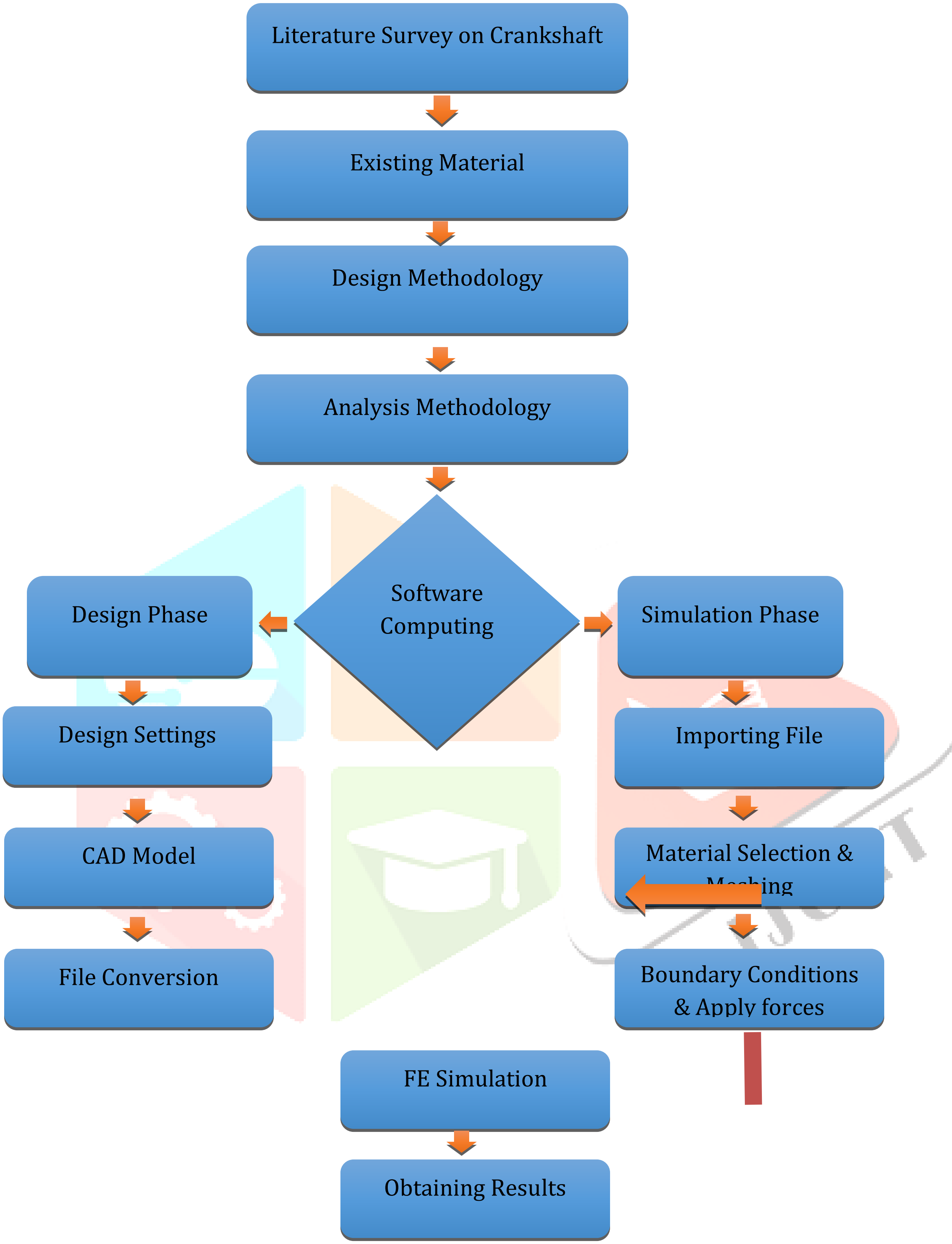


Fig 3.1 Research Methodology Flow chart

3.2 Design Methodology

As we discussed above the CAD model of crankshaft is designed in CATIA v5 using sketcher and part design module. This module can draw zero dimensions and weight surfaces and has applications in the fields of aerospace, automotive, ships and mould design. To draw these elements started by designing the crankshaft outer design. The tools used for this design are as follows:

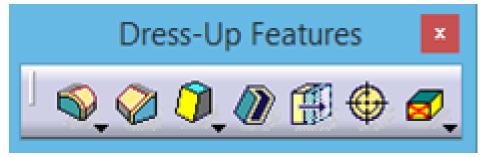
a) Sketch-Based Features.
b) Dress-Up Features.
c) Transformation Features.

3.2.1 Sketch Based Features

1. Pad
2. Pocket
3. Shaft
4. Groove
5. Rib
6. Slot etc....

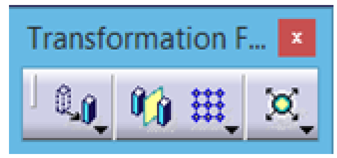
3.2.2 Dress up Features

1. Edge fillet
2. Chamfer
3. Draft
4. Shell



3.2.3 Transformation Features

1. Mirror
2. Symmetry
3. Patterns



3.3 Modelling of Crankshaft

The parameters used to design the crankshaft are as follows. All the dimensions displayed are taken in mm (millimeter). The two dimensional representation of the crankshaft and thickness formations are shown in the below images. The crankshaft modelling is carried out using the following software: CATIA V5:

Parameter	Value (mm)
Crank nose diameter	16
Main bearing journal	30
Counter weight angle	110^0
Counter weight length	130
Counter weight top diameter	66
Counter weight bottom diameter	150
Counter weight head height	37
Flywheel diameter	48.3737
Flywheel thickness	33
Web thickness	15
Distance between two webs	24
No of webs	4
Length of crankshaft	396.24
Length of shaft	60

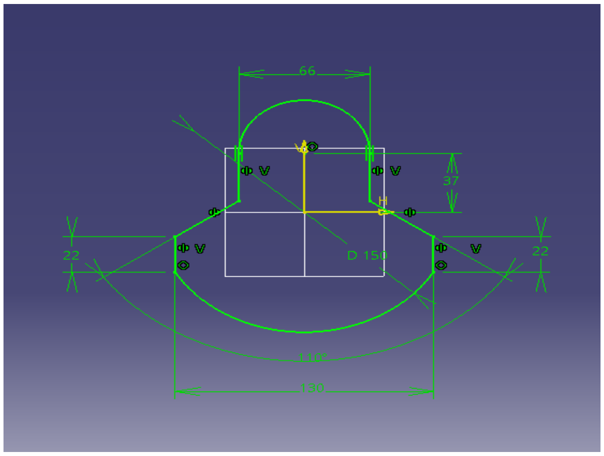


Fig 3.2 2D Sketch of the web

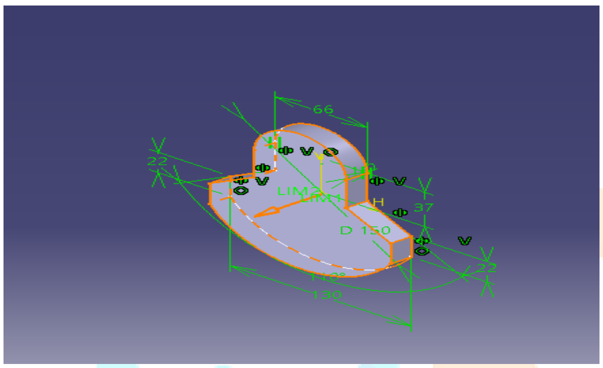


Fig 3.3 3D body of the web

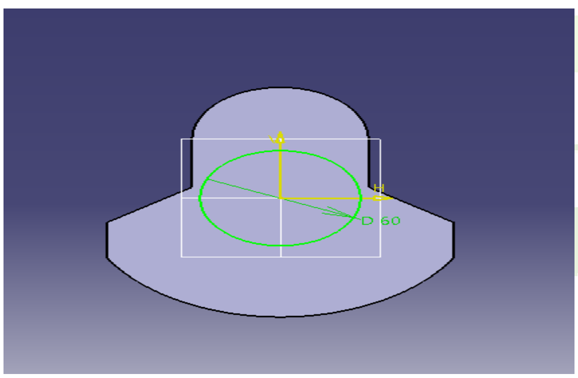


Fig 3.4 2D Sketch of the main journal placed at centre of web

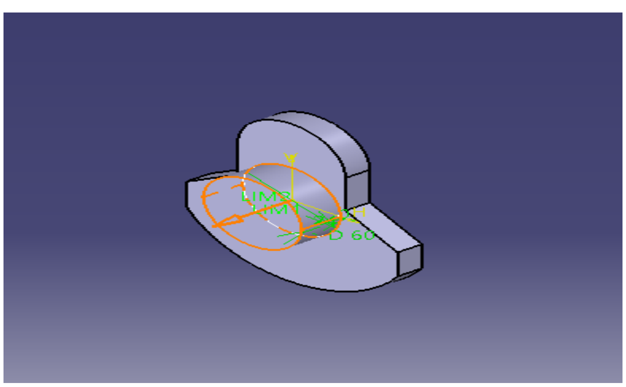


Fig 3.5 3D body of the main journal

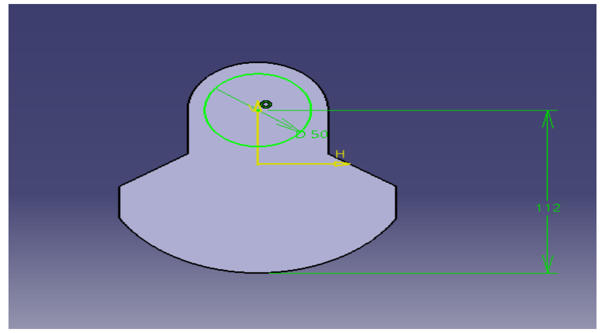


Fig 3.6 2D Sketch of the main journal placed at concentric of the web

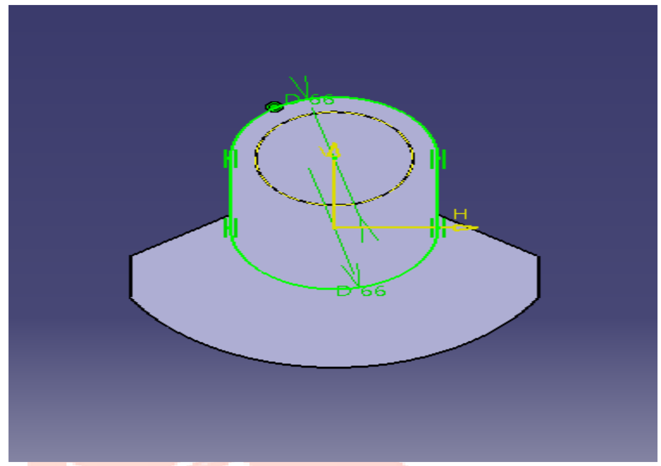


Fig 3.7 2D Sketch of the rounded web placed concentric to the top main journal

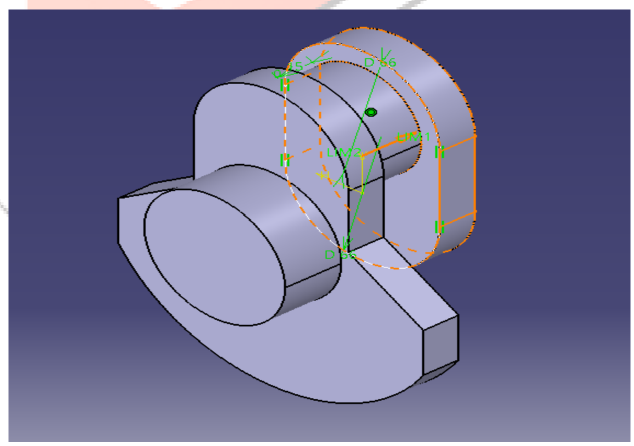


Fig 3.8 3D body of the rounded web with thickness of 15 mm

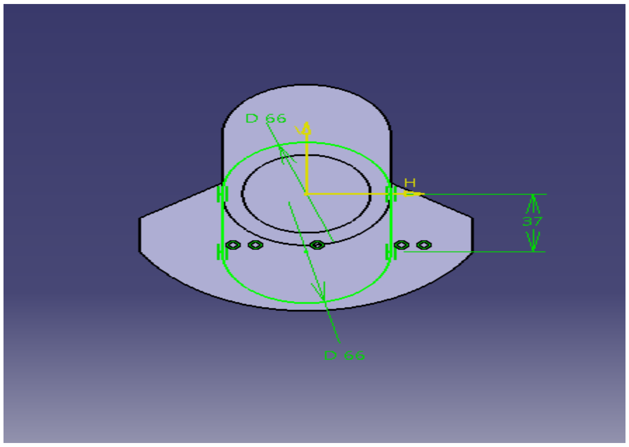


Fig 3.9 2D Sketch of the rounded web placed at the centre of the main journal

3.4 Analysis Methodology

We are using ANSYS Workbench 19.2 software for the analysis of the designed crankshaft. ANSYS workbench software works on Finite Element Method. ANSYS workbench is a common platform for solving engineering issues such as Static structural, Modal analysis etc. These tasks can be performed in Workbench by importing models from CAD systems.

3.5 Finite Element Analysis

The method of the finite-element is utilised for analysing a range of engineering issues in order to find approximate answers. It receives great attention in nearly every business because of its richness and versatility as an analysis tool. Today, we find it important to achieve approximation answers to the problem rather than accurate closed shape solution in ever more technical circumstances. There are many engineering problems that cannot achieve analytical mathematical answers. The finite element method is now a potent instrument to solve a large range of technical problems numerically.

It has been developed at the same time as the rising use of high-speed digital electronic computers and an increasing focus on numerical analysis techniques. This method started as a generalisation of the structural notion to certain issues of elastic continuum, which began with distinct equations. The principles in the field of engineering must be based on the structure offered for the behaviour needed. Evidence is necessary in the typical problem field, modelling methodologies, data transfer and integration, computer features of the Finite Element Method. The Finite Element Method considers that the solution area consists of several small interrelated regions known as finite elements.

4. RESULTS AND DISCUSSION

4.1 General

As we know we working on comparison between the materials aluminium 6061 and structural steel to design the wing for finding the behaviour of crankshaft under constant and rotational speeds, when these materials are used to construct the structure of the crankshaft. The following two types of the analysis were performed in ANSYS 16.2 Workbench.

1. Modal analysis on the crankshaft.
2. Structural analysis on the crankshaft

4.2 Geometry Parameters

Object Name	*Geometry*
State	Fully Defined
Definition	
Source	Crank Shaft New one.igs
Type	Iges
Length Unit	Meters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	

Length X	429. mm
Length Y	130. mm
Length Z	150. mm
Properties	
Volume	1.7776e+006 mm^3
Mass	13.954 kg
Nodes	180726
Elements	105301

4.3 Mesh Parameters

Object Name	*Mesh*
State	Solved
Display	
Display Style	Body Color
Defaults	
Physics Preference	Mechanical
Relevance	0
Sizing	
Use Advanced Size Function	Off
Relevance Center	Medium
Element Size	2.50 mm
Initial Size Seed	Active Assembly
Smoothing	Medium
Transition	Fast
Span Angle Center	Coarse
Minimum Edge Length	4.9358e-002 mm
Inflation	
Transition Ratio	0.272

Maximum Layers	5

4.4 Structural Steel Material Properties

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm

4.5 Modal analysis of the crankshaft – Structural Steel

In this modal analysis we foundsix modes of frequencies when the two root ends are fixed. The first mode is shown in the below figure.

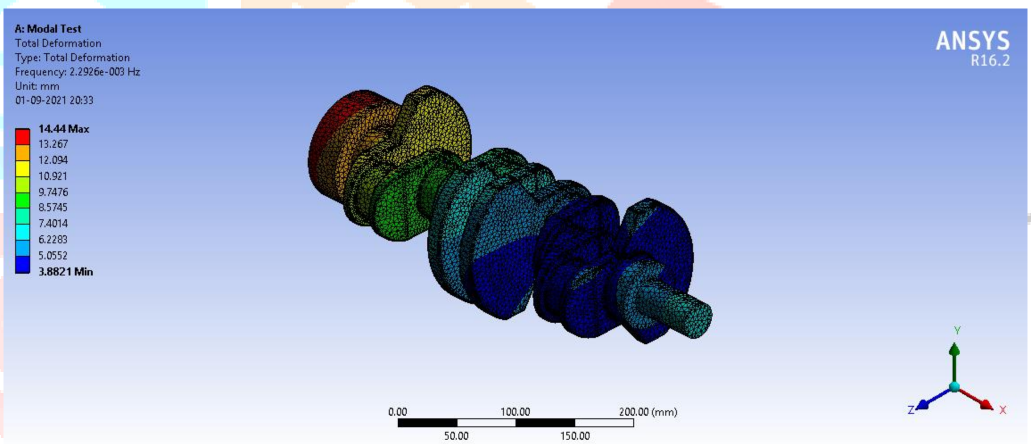


Fig 4.1 Mode Shape 1

Here as shown in the above figure, this analysis result is obtained through ANSYS Workbench 16.2. To obtain the mode shapes and natural frequencies, total deformation is selected. Where the maximum stress occurs at 14.44 mm and the average stress value is 3.8821 mm. This analysis is made on the crankshaft which is made of structural steel body. So finally, the natural frequency obtained at mode 1 is **2292.6** Hz.

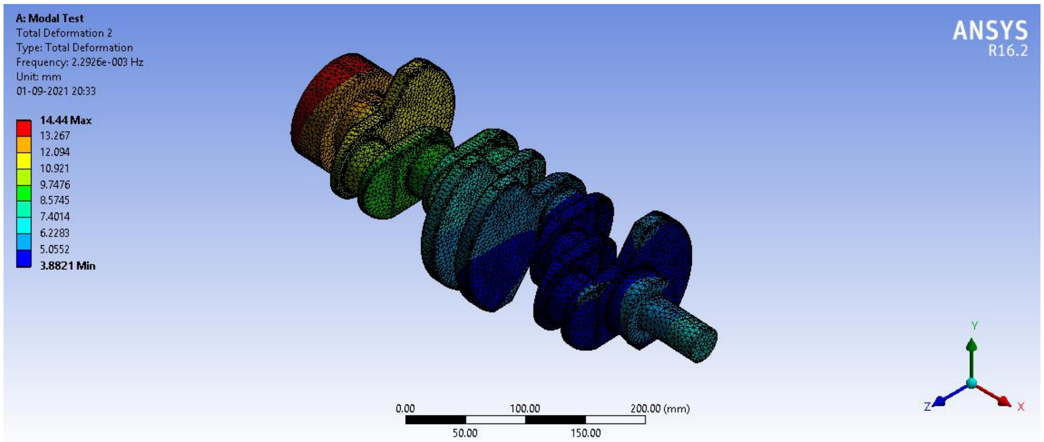


Fig 4.2 Mode Shape 2

Here as shown in the above figure, this analysis result is obtained through ANSYS Workbench 16.2. To obtain the mode shapes and natural frequencies, total deformation is selected. Where the maximum stress occurs at 14.44 mm and the average stress value is 3.8821 mm. This analysis is made on the crankshaft which is made of structural steel body. So finally, the natural frequency obtained at mode 2 is **2292.9** Hz.

CONCLUSION

After careful consideration and procedure followed through this project. As we discussed in the abstract, we designed the crankshaft in CATIA V5 and did the analysis on crankshaft in ANSYS 16.2 software and compared the results of the aluminum alloy with Structural steel material. While comparing the results we found that in 6 mode modal analysis the crankshaft with aluminum alloys exhibits the natural frequencies from 770.68 Hz to 2103.7 Hz. And for the crankshaft with structural steel varies the natural frequencies from 2292.6 Hz to 11991 Hz.

In the case of the total deformation the crankshaft with aluminum alloys is 0.13767 mm whereas the 0.13767 with structural steel, the maximum deformation is 0.04944 m. And in case of von- misses stress we found that the maximum stress of aluminum alloy give 151.62 MPa and for the structural steelcrankshaft bears the maximum stress of 152.08MPa.

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