DESIGN AND ANALYSIS OF CRANKSHAFT USING FORGED STEEL & COMPOSITE MATERIALS

Submitted in partial fulfillment of the requirements
Of the degree of

BACHELOR OF TECHNOLOGY
IN
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CERTIFICATE

This is to certify that the Research work titled **Design and Analysis of Crankshaft Using Forged steel & Composite Materials** that is being submitted by **Aatish kumar Chaudhary, Abhishek Mishra and Devendra Raj pandey** in partial fulfillment of the requirements for the award of **Bachelor of Technology**, is a record of bonafide work done under my guidance. The contents of this research work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

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This thesis/dissertation/project report entitled **Design and Analysis of Crankshaft Using Forged Steel & Composite Materials** by **Aatish kumar Chaudhary, Abhishek Mishra and Devendra Raj Pandey** is approved for the degree of bachelor of technology in mechanical engineering.

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It gives me immense pleasure to present the project report on Design And Analysis of Crankshaft Using Forged Steel & Composite Materials . It would not have been possible without the kind support of our teacher in charge , Mr. Jiyual Mustafa whose guidance and constant supervision the project report was brought to the present state . I would also like to express my gratitude towards my parents for their kind co-operation and encouragement which help me in the completion of the project report .

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ABSTRACT

Crankshaft is an important part of I.C. engine that converts the reciporacating motion of piston into rotatory motion through the connecting rod. Crankshaft is one of the critical components for the effective and precise working of the internal combustion engine**.** In this paper a dynamic simulation is conducted on a crankshaft from a single cylinder 4-stroke petrol engine. Three-dimension model of petrol engine crankshaft is created using SOLID WORKS software**.**. Finite element analysis is performed to obtain the variation of stress magnitude at critical locations of crankshaft. This load is applied to the FE model in ANSYS, and boundary conditions are applied according to the engine mounting conditions. The overall objective of this paper is to evaluate and compare the stress analysis and deformation in different loads of two competing manufacturing technologies for automotive crankshafts, namely Forged Steel and Composite Materials**.**

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List of abbreviations

FEA :- Finite Element Aanlysis

I.C :- Internal Combustion

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1

Introduction

1.1 Project background

Crankshaft is an important part of I.C. engine that converts the reciporacating motion of piston into rotatory motion through the connecting rod with a four link mechanism. Since the crankshaft encounters countless cycles amid its service life, fatigue performance and toughness of this part must be considered in the design procedure. Design improvements have dependably been an imperative issue in the crankshaft creation industry, so as to fabricate a more affordable component with the base weight conceivable and appropriate fatigue strength and other useful prerequisites. These enhancements result in lighter and smaller engine with better fuel efficiency and higher power output.

The crankshaft, sometimes casually abbreviated to crank, is the part of an engine which translates reciprocating linear piston motion into rotation. To convert the reciprocating motion into rotation, the crankshaft has “crank throws” or “crankpins”, additional bearing surfaces whose axis is offset from that of the crank, to which the “big ends” of the connecting rods from each cylinder attach .

Crankshaft converts the reciprocating motion of piston into rotatory motion through the connecting rod. It consists of three portions – crank web, crank pi and shaft.The big end of connecting rod is attached to the crank pin. The crank web connects the crank pin to shaft portion. The shaft portion rotates in the main bearing and transmits power to outside source through the belt drive, gear drive or chain drive.

1.2 TYPES OF CRANKSHAFT

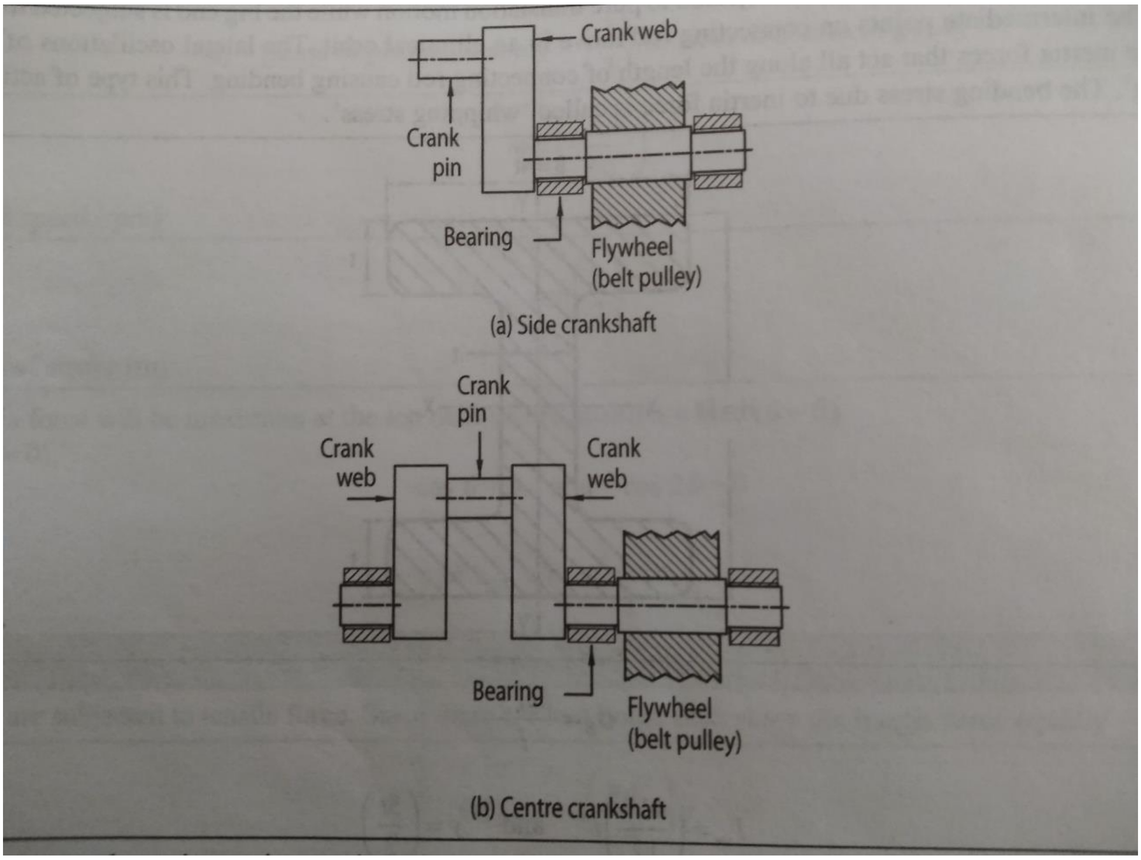
Crankshaft is an important part of I.C. engine that converts the reciporacating motion of piston into rotatory motion through the connecting rod with a four link mechanism.
There are two types of Crankshaft :-

1.2.1 Side Crankshaft

The side crankshaft is also called 'Over-hung' crankshaft. It has only one crank web and requires only two bearing for support. It is used in medium size engines and large size horizontal engines.

1.2.2 Centre Crankshaft

The centre carnkshaft has two webs and three bearing support. It is used I radial aircraft engines , stationary engines and marine engines. It is more popular in automotive engines.



Fig[1]: Types of Crankshaft

Crankshaft are also classified as single-throw and multi-throw crankshaft depending on the number of crank pins used in the assembly. Crankshaft used in Multi-cylinder engines have more than one crank pin. They are called multi-throw crankshaft.

1.3 FUNCTION OF CRANKSHAFT :

Crankshaft are the in charge of changing the linera or reciprocating motion into rational or rotatory motion. Crankshaft is exceptionally important to give a soother drive to the vast moters which have multi-cylinder.

While outwardly inspecting the crankshaft, you can discover the rod bearings are almost balanced or erratic. Here the balance of the shaft changes the responding movement (all over) of the piston in the rotating motion of the crankshaft.

Changes over the reciprocating displacement of the piston into a rotating movement with a four link mechanism. Since , revolution output is more down to earth and relevant for contribution to different gadgets, the idea outline of a engine is that the output would be turn. In addition, the direct removal of a engine is not smooth, as the uprooting is brought about by the burning of gas in the combustion chamber.

Hence, the removal has sudden shocks and utilizing this contribution for another gadget may make harm it.

1.3 Objective of the project

The overall objective of this paper is to evaluate and compare the stress analysis and deformation in different loads of two competing manufacturing technologies for automotive crankshafts, namely Forged Steel and Composite Materials and study to analyze the average von-misses stress and principle shear stress over the crankshaft using ANSYS Workbench software, the model creation can be created by well-known 3D modelling software SolidWorks.[1] ANSYS will be used as a tool for analysis and optimization of crankshaft. The crankshaft conducting static analysis of the crankshaft using modal analysis to find total deformation and frequency of the crankshaft. While converting the reciprocating motion into rotary motion by the crankshaft, it is subjected to various stresses and Forces. The study to be carried out to check the load carrying capacity of the crankshaft. Static analysis is conducted on the structural steel crankshaft.

For the evaluation and comparison between Forged Steel and Composite Materials Having different properties on the basis of stress analysis and deformation at the given load.

2

LITERATURE REVIEW

2.1 INTRODUCTION

A lot of crankshaft had been developed in the past to overcome the life of the crankshaft on the basic of different kinds of materials. Crankshaft is an important part of I.C. engine that converts the reciporacating motion of piston into rotatory motion through the connecting rod with a four link mechanism. Since the crankshaft encounters countless cycles amid its service life, fatigue performance and toughness of this part must be considered in the design procedure.

The overall objective of this paper is to evaluate and compare the stress analysis and deformation in different loads of two competing manufacturing technologies for automotive crankshafts, namely Forged Steel and Composite Materials**.**

2.2 REVIEWS

Some of the review of the researcher on this "Design and Analysis of Crankshaft Using Forged Steel & Composite Materials" ,topic are mentioned below :

M.Naveen Ram[1] the overall objective of this paper is to evaluate and compare the fatigue performance of two competing manufacturing technologies for automotive crankshafts, namely forged steel and composite material. In this study a dynamic simulation was conducted on crankshaft, matrix material and forged steel, from similar single cylinder four stroke engines. Finite element analysis was performed to obtain the variation of stress magnitude at critical locations. Geometry, material, and manufacturing processes were optimized considering different constraints, manufacturing feasibility, and cost

Mr. Randhavan [2] to design and finite element analysis of crankshaft of four cylinder diesel engine of heavy vehicle like truck. The FEA in ansys software by using three materials based on their composition viz. FG260 ,FG300 and Aluminium based composite materials. The parameter like von misses stress, deformation; maximum and minimum principal stress & strain were obtained from analysis software. The results of Finite element shows that the Aluminum based composite material is best material among all.

Shani dev[3] in this paper the modeling of single cylinder petrol engine crankshaft is created using auto-cad software. FEA is performed to obtain the variation of stress at critical location of the crankshaft using ansys software. The load applied to the FE model in SOLIDWORKS simulation boundary conditions are applied according to the engine mounting conditions. Stress variation over the engine cycle and the effect of torsion and bending load in the analysis are investigated. Von-misses stress is calculated using theoretically and SOLIDWORKS software.

Sai Bhargar[4] in this paper they describes designing and Analysis of connecting rod using Composite materials. In this drawing is drafted from the calculations. A parametric model of connecting rod is model using Catia software. Analysis is carried out by Using Ansys-Workbench 14.5 software. Analysis is carried out for the two different loading conditions i.e. first load is applied to big end(crank end) and in for second load is applied to small end(piston end) while the respective ends are held fixed. The best combination of parameters like Stress, deformation, weight reduction for Suzuki 150 cc of two wheeler were done using Static and dynamic analysis.

K. Pandiyan [5] this paper will give an overall guideline for the student and industry enginers for designing the crankshaft which can servethe longer durability life without any failures.

Satya Narayan Gupta [6] the overall objective of this paper was to evalute and compare the fatigue performance of two competing manufacturing technologies for aerospace crankshaft namily Forged steel and ductile cast iron. In this project dynamic stimulation four cylinder four stock engine.

M. Guru Bramhanand[7] in this paper a static simulation is led on crankshaft from a single cylinder 4-stock diesel engine. A three dimensional model of diesel engine crankshaft is made utilizing pro-E. FEA is performed to get the verity of stress magnitude of basic areas of crankshaft.

R. Suganthi Rekha[8] the overall objective of the paper is to evaluate and comparing the load and fatigue performance of two varying production technique for crankshaft used in automobiles. Static simulation and variation of stress is done in finite element analysis.

Ketan V.Karandikar[9] this paper aims at designing of I.C engine multi-cylinder crankshaft and camshaft using stander design procedures. Further Creo software is used to create 3Dmodal crankshaft and camshaft. After creating modals static structural analysis is performed for both of these using different materials boundary condition using Ansys software.

Mukund Hingne[10] in this paper presents the design connecting rod of internal combustion engine using the topology Optimization. In this paper one basic and three implement modal is proposed. The crankshaft modal 3D geometry is created by using Catia V5 and then it is imported in Ansys and check all the results in three different load cases.

3

PROBLEM DISCRIPTION

3.1 Problem description

In the present automotive market, the industries which manufacture automotive components always aim at manufacturing the components with the highest quality, excellent reliability and minimum possible cost. It is highlighted in many studies that engine related components are maximum prone to failure, followed by the drive train components. Owing to the intricate geometry and sudden changes in area in a crankshaft, it has high chances of accumulation of stresses, leading to failure. In addition, it is acted upon by bending and torsion loads since it is a rotating element. Similar is the case with a camshaft. Due to this, it is very complicated to determine the exact values of loads acting on the crankshaft and camshaft. The life of any component is mainly dependent on its design, material and manufacturing method.

3.1.1 Theoretical Analysis

A. Geometrical properties of the materials

1. Material Type: - Forged Steel

Designation: - 42CrMo4

Yield strength (MPa):- 680

Ultimate tensile strength (MPa):- 850

Elongation (%):-13

Poisson ratio:-0.3

Young’s Modulus:-210E3 MPA

Density:-7.9 g/cm3

2. Material Type: - Composite material

Designation:- Epoxy

Poisson ratio:- 0.34

Young's Modulus:-140

Density:-1.6

Yield strength (MPa):-1900

Applied Pressure = 100 Bar

Avg. Speed (N) = 1800 rpm,

so angular velocity $=\omega= 2\pi N/60 = 188$ rad/s

B. SPECIFICATION OF CRANKSHAFT

Physical parameters	Values
Crankpin diameter (mm)	50
Crankpin axial length (mm)	24
Diameter of shaft (mm)	32
Web thickness (mm	23
Web width (mm)	125

3.2 CALCULATION

Material : Forged Steel

calculation

Here,
capacity of engine=3785.1cc
No of cylinders= 4
Bore*stroke=97mm*128mm
Compression ratio=18:1
Maximum power=100hp
Maximum torque=475Nm
N=2300rpm
weight of flywheel=800N
Maximum gas pressure=2.5N/mm2

1. Design of crankshaft when the crank is at TDC of piston where maximum bending moment occurs

Let

D = piston diameter or cylinder bore in mm

Design reaction

Force acting on piston $Pp = \pi D2/4*Pmax$

$= \pi*(97)2/4*2.5$

$=18474.53N$

Assume that distance(b)between the bearing 1 and 2 is equal to twice the diameter of piston (D)

$b1=b2=194/2=97mm$

By symmetry$(R1)v=(R2)v=Pp/2=18474.53/2$

$=9237.27N$

Similarly it is assumed that

$c1= c2=c/2$

We know due to the weight of flywheel acting downward there will be two

Vertical reaction V2 and V3 at bearing 2 and 3 respectively such that

$(R2')v=(R3)V=W/2=600/2=300N$

And due to the resultant belt tension (P1+P2) acting horizontally then will

be two vertical reaction V2 and V3 at bearing 2 and 3 respectively,such that

$(R2')v=(R3')v=w/2=600/2=300N$

And due to the resultant belt tension (P1+P2) acting horizontaly then will be two horizontal reaction (R'2)h and (R'3)h respectively

Therefore $(R2')h=\{(P1+P2)/C\}*C1=\{(P1+P2)/C\}*C/2$

$=(P1+P2)/2$

$=1000/2$

$=500\ N$

Now the various parts of the Crankshaft are designed such as

a. **Design of Crank pin**

let dc = Diameter of Crankpin in mm

σb = Allowable bending stress for the crank pin = 75 N/mm2

Pb = allowable bending pressure at the crank pin = 10 N/mm2

We know that the bending moment at the centre of crankpin

(Mb)c = (R1)v * b1

= 9237.27*97

= 896.015*10^3 N-mm

From data book

(Mb)c=(πdc^3/32)= π*dc3/32*75

Dc^3=121689.7846

Therefore dc=49.55 or 50mm

Assumption:let (l/d) ratio of crank pin bearing is 1

(lc/dc)=1

lc=dc=50mm

Pb=Pp/dclc=18474.53/50*50=7.39Nmm^2

Therefore Pb<100Nmm^2

Design of left hand crank web

Let w=width of crank web(mm)

t=thickness of crank web (mm)

The empirical relationship are as follows (from V.B Bhandari)

t=0.7dc=0.7*50=35mm

w=1.14dc=1.14*50=57mm

The direct compressive stress is given by

σc = (R1)v/(w*t)

=9237.27/(35*57)

= 4.63 N/mm2

Compressive stress due to bending moment

σb = {6*(R1)v*[b1-l/2-t/2]}/w*t^2

= 21.19 n/mm2

Therefore Compressive stress $(\sigma c)t = \sigma c + \sigma b$

= 4.63 + 21.19

= 25.82 N/mm2

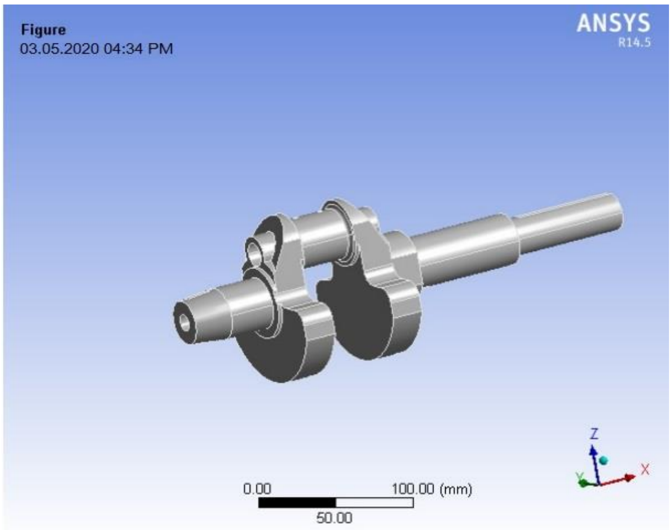
The total compressive stress is less than that of allowabe bending stress 75 N/mm2 and the design of crank web is safe .

3.3. ANSYS

ANSYS is the standard FEA teaching tool within the Mechanical Engineering Department at many universities and colleges. ANSYS is also used in Civil and Electrical Engineering

3.4 STATIC ANALYSIS

The design of crankshaft has been done in Solidworks and is save the part in ICGS file format. The file has been ex- ported in to ANSYS workbench simulation module. Forged steel has been used as material for crank shaft.



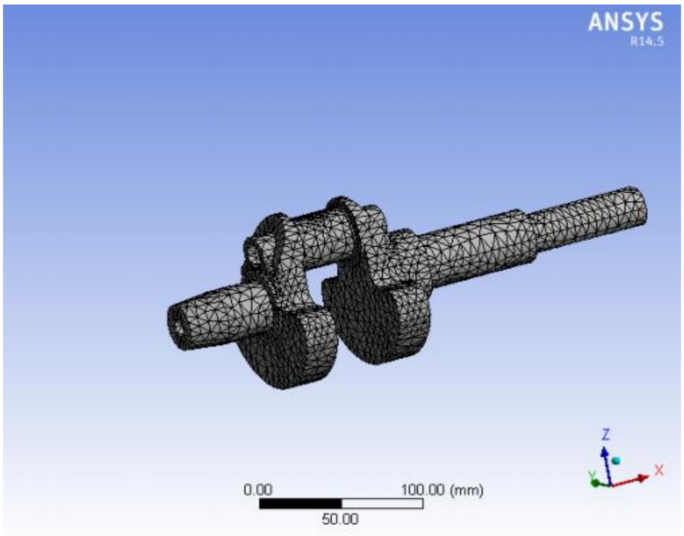
Fig[2]: Modal of Crankshaft in Solidworks

3.4.1 Meshing

Meshing is defined as the process of dividing the whole component into a number of elements so that whenever the load is applied on the component it distributes the load uniformly called as meshing.

For meshed the crank shaft tetrahedron element has been selected. The total number of nodes and the total number of elements are obtained as shown in figure.

- Meshing is nothing but discretization of continuous body into finite number of elements.
- It affects are different based on what type of analysis you are doing.
- If you are doing durability analysis then at critical regions more no of elements should be placed and no triangular elements are used.
- If you are doing crash analysis then flow of mesh is very important.



Fig[3]: Meshing of Crankshaft

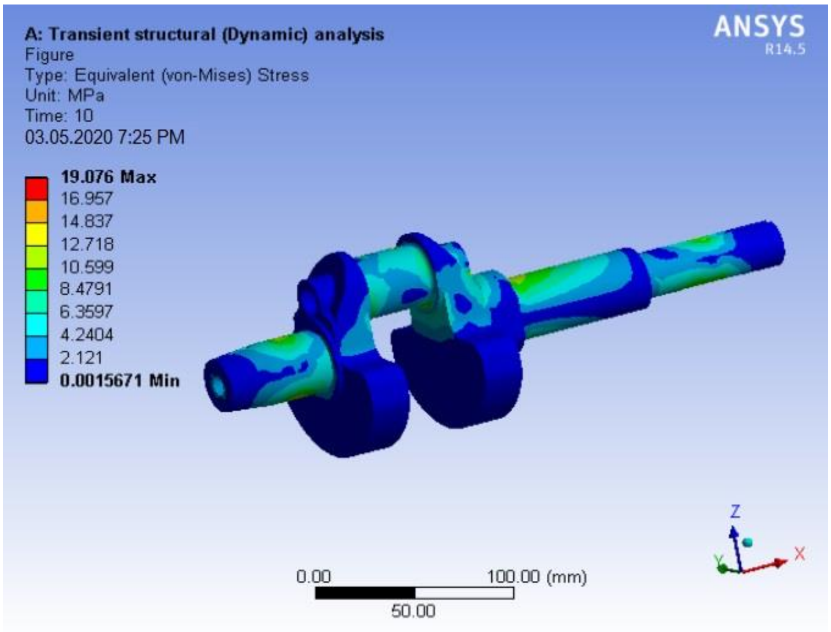
3.4.2 Boundary Condition :

The FE model created was subjected to static structural analysis after assigning suitable material properties and boundary conditions.

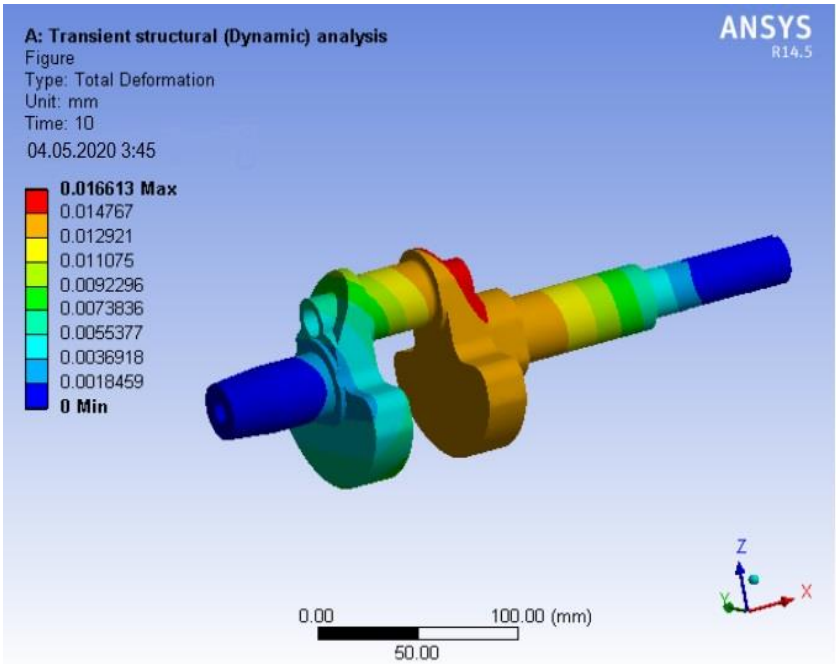
Boundary conditions (b.c.) are constraints necessary for the solution of a boundary value problem. A boundary value problem is a differential equation (or system of differential equations) to be solved in a domain on whose boundary a set of conditions

3.4.3 Fixed Support

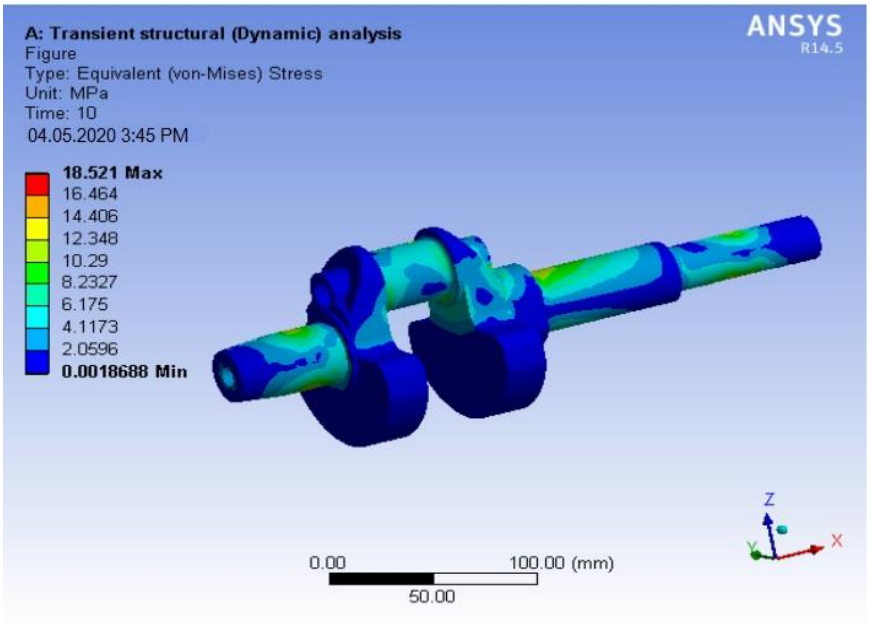
The crankshaft is fixed in both the end of shaft.To make a body or part or surface fixed so that it does not move when the load is applied to that body. It remains Rigid (stiff) without any deformation. ... In Ansys Workbench select the part, body or any face and assign Fixed support to it so that it remains Rigid.



Fig[4]: STRUCTURAL ANALYSIS, STRAIN FOR MATERIAL 1



Fig[5]: TOTAL DEFORMATION



Fig[6]: STRUCTURAL ANALYSIS, STRESS FOR MATERIAL NUMBER 2

TABLE 1. RESULT FOR CONVENTIONAL MATERIAL FORGED STEEL

	MIN	MAX
Total Deformation	0	0.16613
Equivalent elastic strain	7.644e-9	9.3e5
Equivalent Stress	1.567e-3	19.076

TABLE 2. RESULT FOR COMPOSITE MATERIAL

	MIN	MAX
Total Deformation	0	0.016298
Equivalent Elastic Strain	8.89e-9	8.82e-5
Equivalent Stress	1.868e-3	18.521

TABLE 3. WEIGHT OF FORGED STEEL AND COMPOSITE MATERIAL

Crank Shaft Material	Weight(kg)
Forged Steel	3.8228
Metal Matrix Composite	2.1635

3.5 RESULTS

We shows that due to different Chemical and physical properties of Forged Steel and Composite materials deformation and Fatigue analysis is different because Composite Materials deformed under less stress in comparison to Forged steel .

From the Table 2 , the deformation of Composite Materials due to the load applied on the crank pin is less in comparision of that Forged Steel.

So, we choose the Composite materials for the manufacture of the Crankshaft.

3.6 Conclusion:

Based on these analysis results, concepts have been developed which reduce the weight of the crankshaft to a possible extent, without affecting the performance of the engine. The 3D model of crankshaft system, obtained from SOLIDWORKS software is analyzed in ANSYS to assess the motion and loads acting on the crankshaft .

Topology optimization is help to optimize the performance of any machine. The crankshaft model 3D geometry is created by using SOLIDWORKS and then it is import in ANSYS and check all the result in two different material

- Diameter of crankpin=50mm
- Length of crankpin=24mm
- Diameter of the shaft=125mm
- Web thickness=23mm

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