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Design & Analysis of Crankshaft by ForgedSteel & Composite Material

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Abstract: 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. A 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. The dynamic analysis is done using FEA Software called ANSYS. 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 material.

I. INTRODUCTION

Crankshaft is an extensive segment with a perplexing geometry in the engine, which changes over the reciprocating displacement of the piston into a rotating movement 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.

II. PROBLEM SPECIFICATION

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.

III. THEORETICAL ANALYSIS

A. Geometric Details Of Forged Steel

1) *Material Type:* Forged Steel
   a) Designation:-42Cr Mo4
   b) Yield strength (MPa):- 680
   c) Ultimate Tensile Strength(MPA):-850
   d) Elongation (%):-13
   e) Poisson ratio:-0.3
   f) Young's Modulus:-210E3 MPA
   g) Density:-7.9 g/cm3

2) *Material Type:* Composite Material
   a) Designation:- Epoxy
   b) Poisson ratio:- 0.3
   c) Young's Modulus:-140
   d) Density:-1.6
   e) Yield strength (MPa):-1900
   f) Applied Pressure = 100 Bar
   g) Avg. Speed (N) = 1800 rpm, so angular velocity = $\omega = 2\pi N/60 = 188$ rad/s

IV. SPECIFICATION OF CRANKSHAFT

Table 1

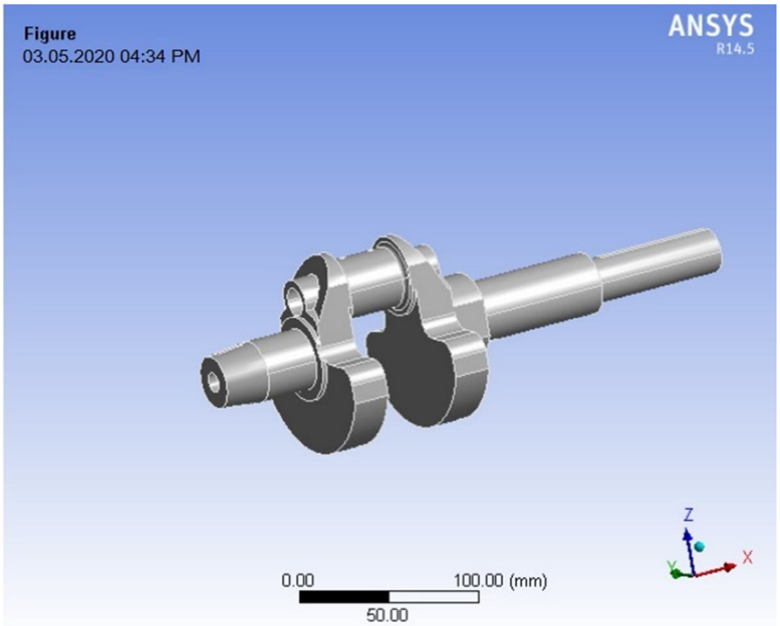
Physical parameters	Values
Crankpin diameter (mm)	50
Crankpin axial length (mm)	24
Diameter of shaft (mm)	32
Web thickness (mm	23
Web width (mm)	125

V. 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

VI. STATIC ANALYSIS

The design of crankshaft has been done in CATIA 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.



Crank Shaft In Ansys

VII. DESIGN CALCULATION FOR CRANK SHAFT

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

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A. 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= πD2/4*Pmax

= π*(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 horizontally 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

B. 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 is 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 *(σc) t= σc+σb*

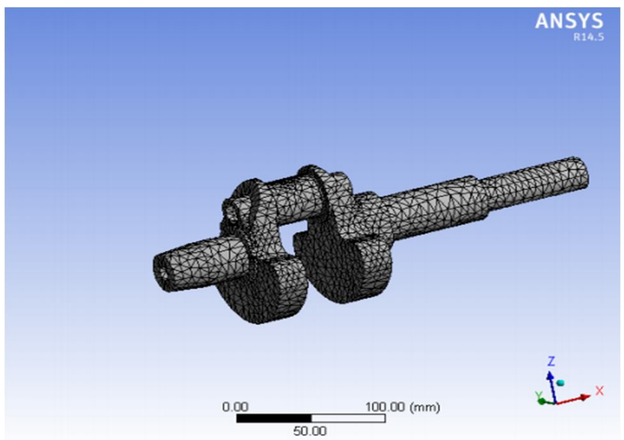
= 4.63 + 21.19

= 25.82 N/mm2

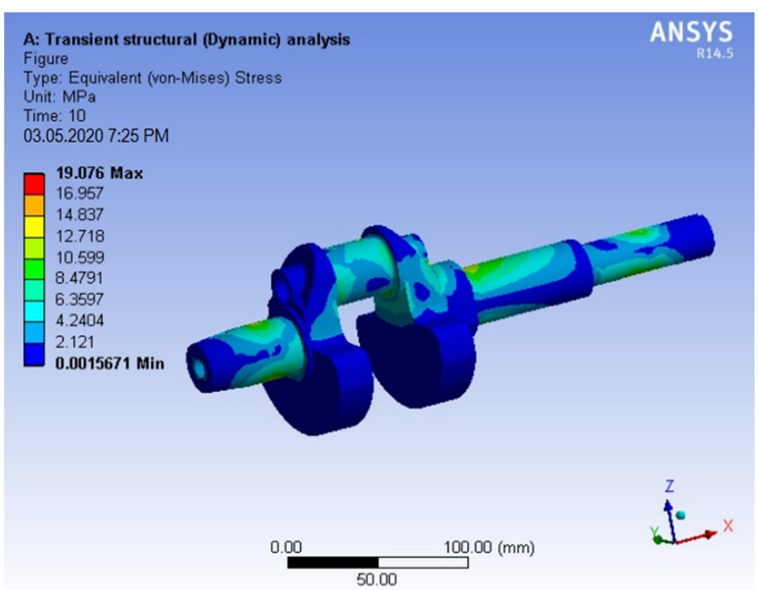
The total compressive stress is less than that of allowable bending stress 75 N/mm2 and the design of crank web is safe.

VIII. MESHING

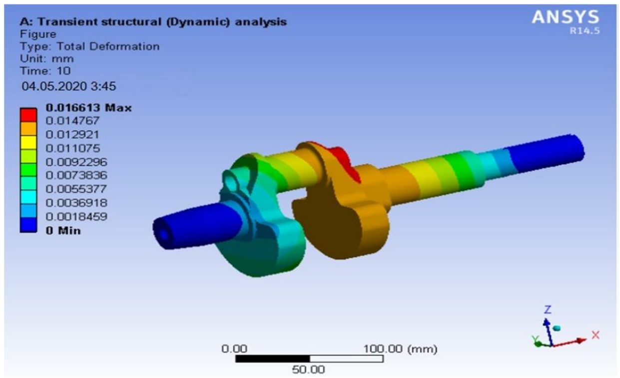
For meshed the crank shaft tetrahedron element has been selected. The total number of nodes and the total number of elements are obtained as shown in figure.



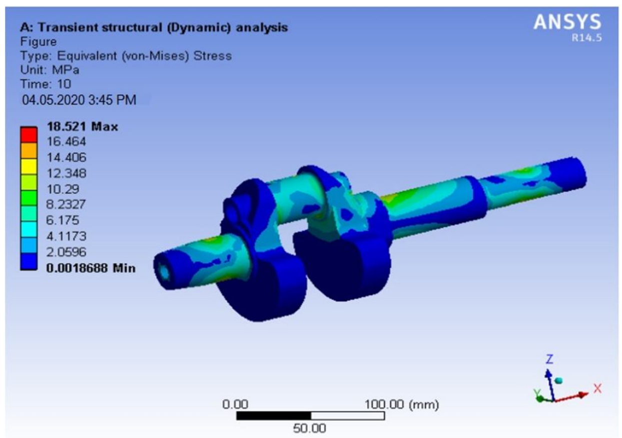
IX. RESULT FOR ANALYSIS OF CRANK SHAFT



Structural Analysis, Strain For Material 1



Total Deformation



Structural Analysis, Stress For Material Number 2

Table 2: 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-3: 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

X.RESULT

A. Diameter of crankpin=50mm
B. Length of crankpin=24mm
C. Diameter of the shaft=125mm
D. Web thickness=23mm

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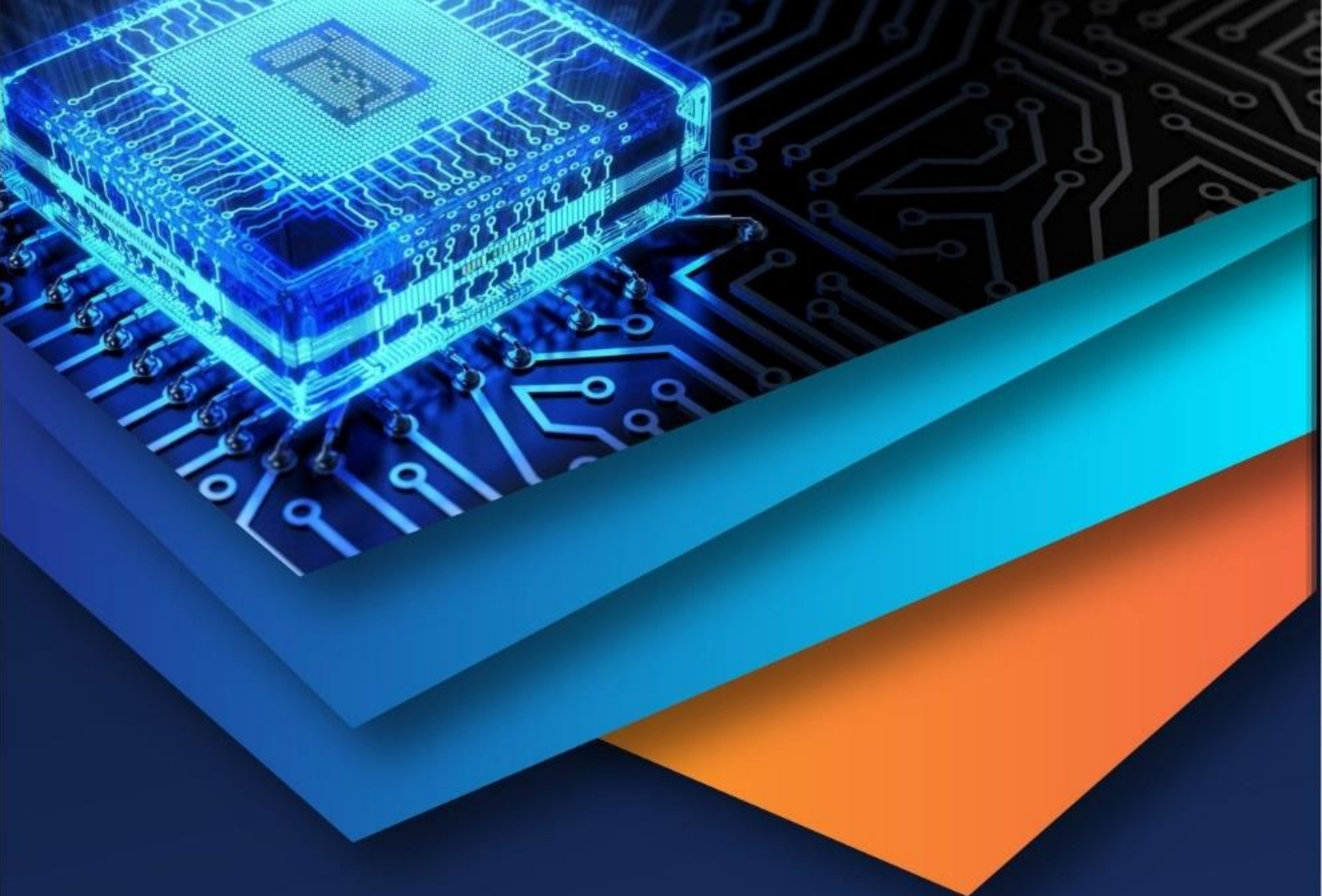

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