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COMPARISON ANALYSIS OF CRANK SHAFT

KEYWORDS: Crankshaft, FEM, Analysis.

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ABSTRACT *The overall objective of this study was 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, forged steel, metal matrix composite, E glass epoxy, Kevlar 29 and carbon epoxy composite, from similar single cylinder four stroke engines. Finite element analysis was performed to obtain the variation of stress magnitude at critical locations. The dynamic analysis was done analytically and was verified by simulations in ANSYS. Results achieved from aforementioned analysis were used in optimization of the forged steel crankshaft. Geometry, material, and manufacturing processes were optimized considering different constraints, manufacturing feasibility, and cost. The optimization Process included geometry changes compatible with the current engine, fillet rolling, and the use of metal matrix composite and carbon epoxy composite, resulting in increased strength of the crankshaft, without changing connecting rod and/or engine block.

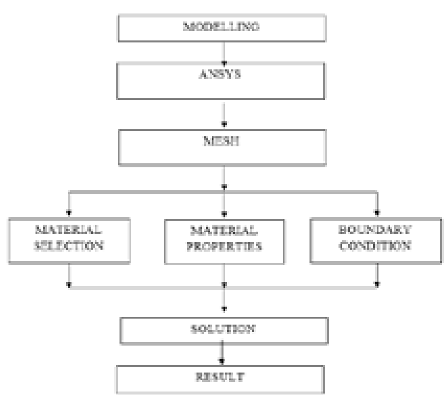
Introduction:
Crankshaft is one of the most important moving parts in internal combustion engine. Crankshaft is a large component with a complex geometry in the engine, which converts the reciprocating displacement of the piston to a rotary motion with a four link mechanism. Since the crankshaft experiences a large number of load cycles during its service life, fatigue performance and durability of this component has to be considered in the design process. Design developments have always been an important issue in the crankshaft production industry, in order to manufacture a less expensive component with the minimum weight possible and proper fatigue strength and other functional requirements. These improvements result in lighter and smaller engines with better fuel efficiency and higher power output. Crankshaft must be strong enough to take the downward force of the power stroke without excessive bending. So the reliability and life of the internal combustion engine depend on the strength of the crankshaft largely. And as the engine runs, the power impulses hit the crankshaft in one place and then another. This study is conduct on a single cylinder engine crank shaft. The modeling of single cylinder engine crank shaft is done by using PRO-E wildfire 5.0 software. The finite element analysis has been performed on crankshaft in order to optimize the weight and manufacturing cost. The material for crank shaft is forged steel EN9. Other alternate materials on which analysis has been done are Metal Matrix Composite (Ti-6al-4v+12% Tic), E glass epoxy, Kevlar 29 and carbon epoxy.

Materials and Methodology:
forged steel, metal matrix composite, E glass epoxy, Kevlar 29 and carbon epoxy composite are the five material which we used for this simulation. This five materials having different material properties. That material properties are given in the below table1.

Table 1 Material Properties

Properties	Forged Steel	Metal Matrix Composite (Ti-6al-4v+12% Tic)	Carbon Epoxy Composite	E Glass/ Epoxy	Kevlar 29
Density kg mm^-3	7.833e-006	4.43e-006	1.6e-006	24000 MPa	1.35e+5 MPa
Young's Modulus MPa	2.05e+005	1.14e+008	2.1e+005	0.3	0.36
Poisson's Ratio	0.3	0.342	0.3	1520 kg/m^3	1440 kg/m^3
Bulk Modulus MPa	1.708e+005	1.2e+008	1.75e+005	28991 MPa	150 GPa
Shear Modulus MPa	7.88e+004	4.2e+007	8.07e+004	50484 MPa	50 Pa

Transient dynamic analysis is a technique used to determine the dynamic response of a structure under the action of any general time-dependent loads. The time scale of the loading is such that the inertia or damping effects are considered to be important. These five materials having Transient Structural also. So the below steps to be followed in this Transient Structural analysis.



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The types of loading that can be applied in a static analysis include:

- Externally applied forces and pressures
- Steady-state inertial forces (such as gravity or rotational velocity)
- Imposed (nonzero) displacements
- Temperatures (for thermal strain)

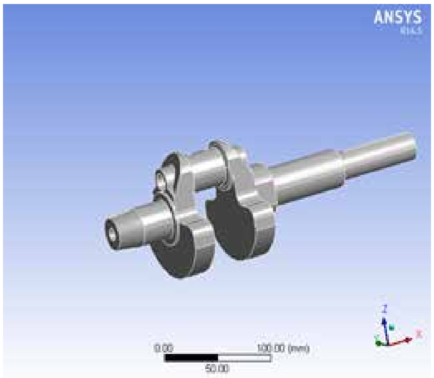

Fig 1: 3-D model of Crankshaft using Pro-E

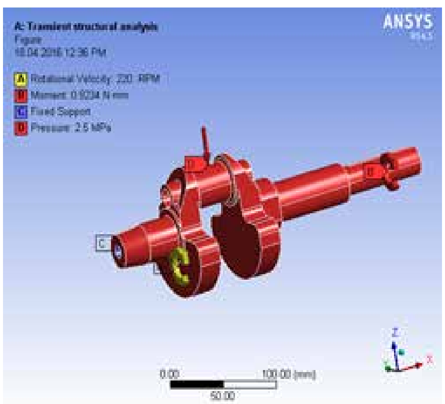

Fig 2: Input Values Applied On The Crank Shaft

Experimental Results and Discussion:
The below results are obtained from this analysis. In Transient dynamic analysis

of total deformation, equivalent stress, equivalent strain for forged steel, metal matrix composite, E glass epoxy, Kevlar 29 and carbon epoxy composite were found as follows.

Structural analysis of crank shaft
After the application of boundary conditions and force, the next step is to perform the structural analysis of crank shaft. In this structural analysis, we are mainly concern with the total deformation and the stresses acting on the crankshaft (von-mises stresses). When the force is

applied, the slight deformation takes place in the crank shaft 0.00859mm. The total deformation of crank shaft is shown in fig.3. The deformation in the crank shaft is not same throughout. The portion in red colour shows that the deformation at that region is maximum and the portion in blue colour shows that the deformation is minimum in that region. The stresses acting on the crank shaft is shown in fig.6. The maximum stresses acting on the crank shaft is indicated by the red colour. The maximum equivalent stress (von-Mises) is 18.396 MPa as shown below.

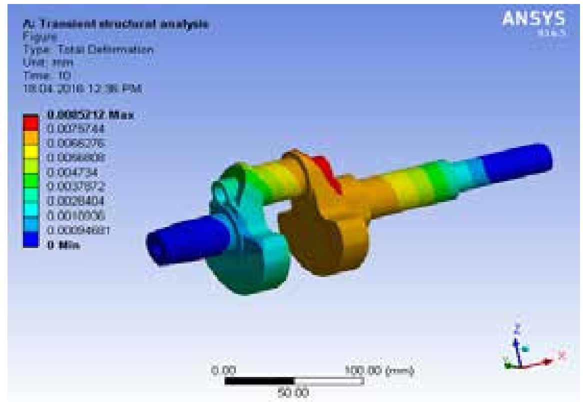

Fig 3: Structural Analysis of crank shaft (Total Deformation)

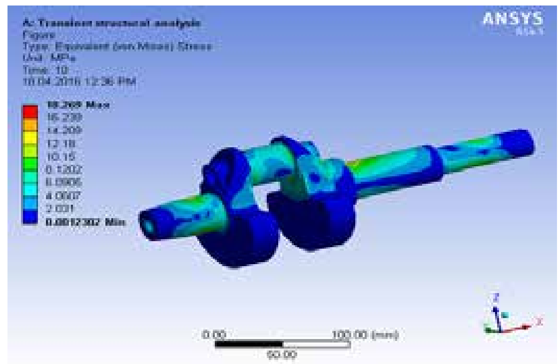

Fig 4: Structural Analysis of crank shaft (Equivalent Stress)

Fatigue Analysis of Crank Shaft
Fatigue failure is the failure occurs when the load is cyclic or repetitive. The fatigue analysis is important in the case of crank shaft. The fig.5.8 shows the fatigue analysis performed on the crank shaft. The figure below shows the probable life of the crank shaft. The red colour portion shows that the life of the crank shaft is minimum at that region and the blue colour portion shows that the fatigue life of the component is maximum at that region. The portion shown by the red colour shows that the fatigue life of the component is minimum and it is the portion where the chances of crack formation are maximum 4.599e-5(mm/mm).

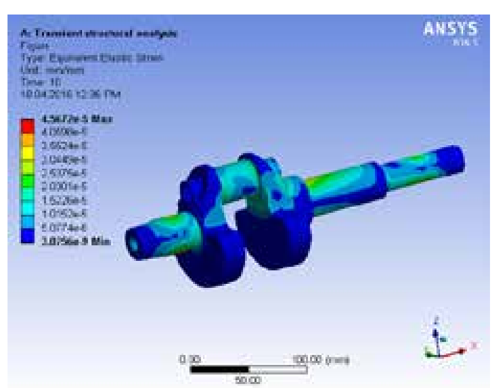

Fig 5: Fatigue Analysis of crank shaft (Equivalent Elastic Strain)

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2.Tabulation

Results For Coventional Material

	Forged steel	Metal Matrix Composite	E glass Epoxy	Kevlar 29 (Aramid Fiber)	Carbon Epoxy Composite
Total Deformation (mm)	0.07472	0.07067	0.0287	0.02548	0.00859
Equivalent Strain (mm/mm)	2.84e-4	2.584e-4	1.616e-4	1.363e-4	4.599e-5
Equivalent stress (MPa)	53.956	51.694	19.396	18.41	18.396

3.Tabulation for Weights For Steel And Composite Materials

CRANK SHAFT MATERIALS	WEIGHT (Kg)
Forged Steel	3.8228
Metal Matrix Composite	2.1635
E glass Epoxy	0.92727
Kevlar 29 (Aramid Fiber)	0.90277
Carbon Epoxy Composite	0.87846

CONCLUSION

Analysis Results From Testing The Crank Shaft Under Rotational Velocity And Moment Are Listed In The Table. Analysis Has Been Carried Out By Forged Steel (Existing Material) And Optimized Materials Like Metal Matrix Composite, E Glass Epoxy, Carbon Epoxy Composite And Kevlar 29 Fiber. The Results Such As Total Deformation, Equivalent Elastic Strain And Equivalent Stress For Each Material Are Determined. Comparing The Optimized Materials And The Conventional Material, Carbon Epoxy Composite Has The Low Values Of Total Deformation, Stress And Strain. And Also Weight Of The Crank Shaft Is Reduced By 77.02%. Hence It Is Concluded That Carbon Epoxy Composite Is Suitable For The Crank Shaft. The Project Carried Out By Us Will Make An Impressing Mark In The Field Of Automobile. While Carrying Out This Project We Are Able To Study About The 3dmodelling Software (Pro-E) And Study About The Analyzing Software (Ansys) To Develop Our Basic Knowledge To Know About The Industrial Design.

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