DESIGN AND DYNAMIC ANALYSIS OF ROBUST CRANK SHAFT USING CATIA AND ANSYS WORKBENCH 14.0

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Abstract- Crankshaft is one amongst the crucial parts for the effective and precise operating of the interior combustion engine. it's a fancy form of pure mathematics. In Associate in Nursing absolute position of the crank because of tangential force, the crank arm is subjected to transversal shear bending and twisting, whereas because of radial part it's subjected to direct stress and bending. it's sophisticated to contemplate of these straining actions in many positions of the crank. Generally, the crank is intended for 2 positions; those are most twisting moment and maximum bending moment. This work is regarding evaluating and scrutiny the static structural analysis and modal analysis of crankshafts factory-made by 3 totally different materials viz. steel, Al 6063+5% Sic+5%Al2o3+5%Graphite (Particle strengthened Metal Matrix Composite) and High Strength Carbon Fiber. 3 dimensional model of shaft is made victimisation CREO three.0. Static simulation must be conducted on 3 totally different crankshafts from similar six cylinder four stroke engine. Finite part Analysis (FEA) is to be performed to get the variation of stress magnitude at crucial locations. The static analysis is completed and is verified by simulations in finite part analysis code ANSYS. Comparisons for the properties like equivalent stress and total deformation of crankshafts created of steel , Al 6063+5% sic+5%Al2o3+5%graphite , and high strength carbon fiber were determined and also the results were compared. Model theoretical calculations are performed for clear analysis. The output of result would offer an attainable recommendation for the event of engine style.

Key words: shaft, bending, structural analysis, CREO 3.0, ANSYS

I. Introduction

Crank shaft could be a massive element with a fancy pure mathematics within the engine, that converts the mutual displacement of a piston to a rotary motion with a four link mechanism. A shaft connected to crank could be a mechanical half able to perform a conversion between mutual motion and motility motion. in an exceedingly internal-combustion engine, it interprets mutual motion of the piston into motility motion; whereas in an exceedingly reciprocating mechanical device, it converts the motility motion into mutual motion. so as to try to to the conversion between 2 motions, the shaft has "crank throws" or "crankpins", further bearing surfaces whose axis is offset from that of the crank, to that the "big ends" of the connecting rods from every cylinder are being connected. it's usually connected to a regulator to cut back the pulsation characteristic of the four-stroke cycle, and typically a torsional or undulation damper[1] at the alternative finish, to scale back the torsional vibrations usually caused on the length of the shaft by the cylinders farthest from the output finish functioning on the torsional physical property of the metal This study was conducted on six cylinder engine of truck. Crankshaft experiences massive forces from gas combustion. This force is applied to the highest of the piston and since the rod connects the piston to the shaft, the force are going to be transmitted to the shaft. The magnitude of the force depends on several factors that carries with it crank radius, rod dimensions, weight of the rod, piston, piston rings, and pin. Combustion and inertia forces functioning on the shaft cause 2 varieties of loading on the crankshaft structure; balance load and bending load. There are several sources of failure within the engine. they might be categorised as in operation sources, mechanical sources, and repairing sources. One of the foremost common shaft failures is fatigue at the fillet areas thanks to bending load caused by the combustion. Even with a soft case as bearing contact surface, in an exceedingly crank shaft freed from internal flaws[2] one would still expect a bending or balance crevice to initiate at the pin surface, radius, or at the surface of associate degree oil hole. thanks to the shaft pure mathematics and engine mechanism, the shaft fillet experiences an oversized stress vary throughout its service life. supported the strain obligatory on the element throughout the operation, in operation temperatures and supposed operation, the fabric to be elect for this element ought to posses following characteristics. The materials are categorised into metal, copper and steel. Machining is yet one more method which might be accustomed manufacture crankshafts. Crankshafts is machined out of a billet, usually employing a bar of top quality vacuum re-melted steel. Machining method has following benefits Higher quality of steels, that can't be solid is used through machining method. No pricy tooling is needed for machining method. extraordinarily top quality crankshafts is factory-made. However, machining method conjointly has following disadvantages. it's a extremely pricy method because; it usually uses top quality material. Moreover, a major amount of fabric is additionally wasted throughout machining method. further heat treatments are needed to induce required material properties.

II.LITREATURE REVIEW

Singh et al., has steered optimum design parameters of the prevailing crankshaft by dynamic the look variables like journal diameter, crank pin diameter, filters and counterweights. Model of 4 cylinder ICE shaft was designed within the ANSYS worktable and Finite component Analysis was administrated beneath constant loading conditions. the most von-mises stress is 288.36 MPa and also the directional deformation is 1.113 mm

Mandeis et al., has sculpturesque crankshaft by victimization Pro-E package and conducted structural analysis by using ANSYS worktable. He has obtained von-mises stress and shear stress to be 523.44 MPa, 56.32

MPa that is nearer to theoretical 121.15 MPa and 96 MPa. He conjointly steered such helpful resources for improvement of the shaft.

Besnet et al., studied the pc aided Modeling and improvement of crankshaft and compare the fatigue performance of 2 competitive producing technologies for automotive crankshafts, particularly solid steel and gray forged iron. The 3 dimensional model of shaft were created by solid edge package and so foreign to ANSYS software. when a series of research he ended that the cast iron shaft is ready stand up to the static load, it's ended that there's no objection from strength purpose of read conjointly, within the method of commutation the forged iron shaft by solid crankshaft. we have a tendency to conjointly scale back solid shaft price by manufacturing the crankshaft in profusion.

Idris et al., has conducted dynamic simulations on a forged steel crankshaft from one cylinder four stroke engine. Finite component analysis was performed to get the variation of the strain magnitude at the essential locations. The dynamic analysis resulted within the development of the load spectrum applied to the crank pin bearing.

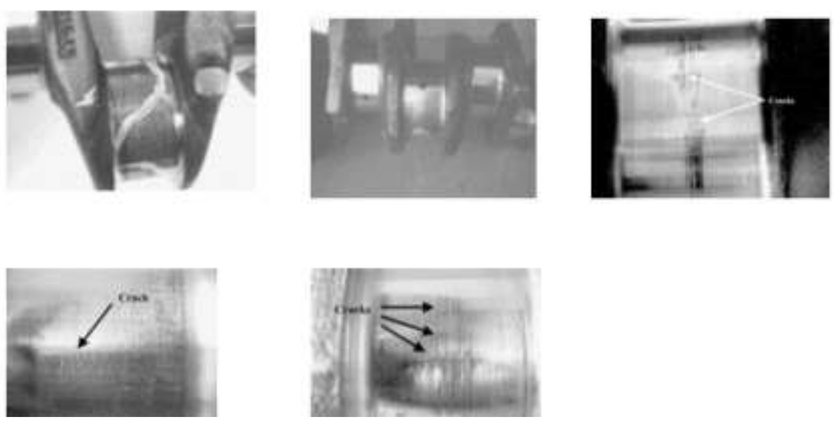


Figure Problem – Crank shaft

III ANALYTICAL PROCEDURE ON SIX CYLINDER FOUR STROKE ICE VICTIMIZATION CREO THREE.0 & ANSYS

The analysis was performed on six cylinder engine crank shaft of a significant vehicle. initially theoretical results of a steel material are valid with simulation results. second 2 materials were chosen for crank shaft one is Al6063 metal matrix composite. Al6063 matrix alloy consists of corundom carbide and plumbago. Another is high strength carbon fiber. Simulation results of each these materials are compared and best material is chosen primarily based upon the values of von-mises stress, shear stress and total deformation. A free vibration analysis is administrated on best material and a collection of natural frequencies are obtained. Thus, engine in operation speed shouldn't overlap with these natural frequencies.

3.1 Materials considered for research purpose

1.Structural steel

Steel exhibits advantageous physical characteristics that make it one of the most flexible technical resources in use

Table 1 Indicating properties of structural steel

Young's Modulus	**3*25^10 MPa**
Poisson ratio	**0.5**
Density	**8961 kg/m^3**
Shear Modulus	**41.9 GPa**
Tensile Strength	**892 MPa**
Shear Strength	**500 MPa**

2. Metal Metal Matrix composite:

In the gift analysis work, Al 6063 is chosen because the matrix alloy and also the reinforcements are corundom carbide and plumbago. Table illustrates the share compositions of the samples thought of for the analysis work with variable weight fraction.

Table 2 Indicating properties of Aluminium Metal Matrix composite

Particulars	Weight fraction with reinforcements
Al 6063+5% Sic+5%Al2o3+5%Graphite	250 gm of Al, 10%(15 gm) of SiC, 10%(25g) of Al2o3 and 10%(12 gm) of Graphite
Young's modulus	69832 Mpa
Poisson ratio	1.56
Shear modulus	39652 Mpa
density	3.58/cm

3.High Strength Carbon fiber.

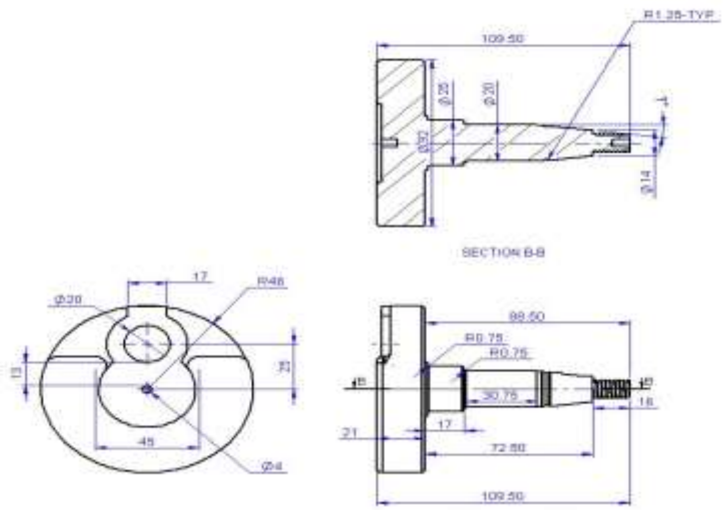
Table 3 indicating properties of High strength carbon fiber

Young's Modulus	**250 GPa**
Poisson ratio	**1.5**
Density	**2155 kg/m^3**
Shear Modulus	**1.9 Msi**
Tensile Strength	**98.36 N/mm^2**
Shear Strength	**860 a**

4. Methodology and Calculations

This module principally centered on pure mathematics generation used for finite component associate degreealysis and explains the simplifications that were created to get an economical atomic number 26 model. Mesh generation and its convergence are mentioned. victimization correct boundary conditions and kind of loading are necessary since they powerfully influence the results of the finite component analysis. characteristic acceptable boundary conditions and loading state of affairs also are mentioned. Finite component models of 3 elements were analyzed; the AL6063, high strength carbon fiber shaft and steel crank shaft. Since these 3 crankshafts are from completely different engines, loading used are completely different for each. This facilitates correct comparison of the elements made of 3 completely different producing materials.

4.1 Modeling of shaft victimization SOLIDWORKS



4.6 Result Analysis

V. DESIGN CALCULATIONS

Table 4 indicating dimensional parameters of crank shaft

Bore diameter	**264 mm**
Force on the piston	**236.23 KN**
Length of the connecting rod	**986mm**
Crank radius	**90 mm**
Tangential force on the crank shaft	**98.254 KN**
Radial force on the crankshaft	**345.32 KN**
Bending moment at the center of crank shaft	**9587.32 KN-mm**
Twisting moment at the crank pin	**4582.24 KN-mm**

Table 5 comparing different materials with the deformation, equivalent stress and shear stress

MATERIAL	TOTAL DEFORMATION(mm)	EQUIVALENT STRESS(MPa)	SHEAR STESS(MPa)
Structural steel	**0.785213**	**250.36**	**45.36**
Aluminium Metal matrix composite	**0.236874**	**250.36**	**45.98**
High Strength Carbon Fiber	**0.98452**	**365.24**	**45.78**

Dynamic analysis of six cylinder four stroke diesel engine*:*

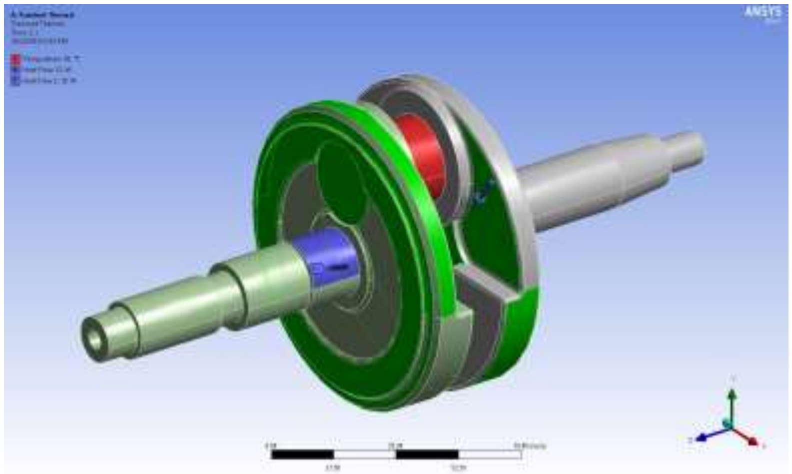


Figure 2 Boundary conditions

- **Free vibration analysis Material I: Structural steel**

Table 6 indicating Natural frequencies and the corresponding Mode displacement

Mode	Frequencies [Hz]	Type of mode
1	1	Rigid body displacement
2	1	Rigid body displacement
3	1	Rigid body displacement
4	1	Rigid body displacement
5	2.5971e-005	Rigid body displacement
6	3.5478e-005	Rigid body displacement
7	586.32	Bending
8	658.21	Bending
9	856.12	Bending + Torsion
10	986.58	Bending + Torsion

Material II: **AL 6063+Sic+Graphite+Al_2o_3**

Table 7 indicating Natural frequencies and the corresponding Mode displacement

Mode	Frequencies [Hz]	Type of mode
1	1	Rigid body displacement
2	1	Rigid body displacement
3	2.598e-005	Rigid body displacement
4	3.539e-005	Rigid body displacement
5	4.4986e-005	Rigid body displacement
6	4.098e-005	Rigid body displacement
7	235.69	Bending
8	365.24	Bending

9	895.21	Bending + Torsion
10	896.34	Bending + Torsion

Material III: High strength carbon fiber

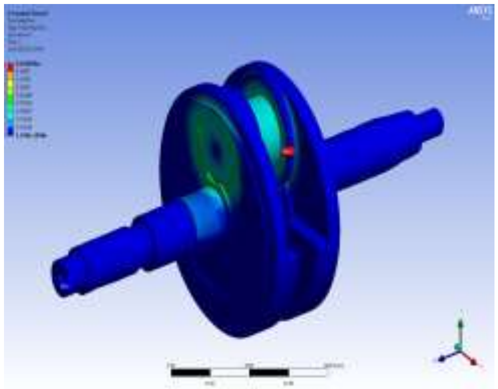


Figure 3 Dynamic analysis of High strength carbon fiber

Table 8 indicating Natural frequencies and corresponding mode positions

Mode	Frequencies [Hz]	Type of mode
1	1	Rigid body displacement
2	1	Rigid body displacement
3	1	Rigid body displacement
4	4.1402e-005	Rigid body displacement
5	5.2986e-005	Rigid body displacement
6	5.439e-005	Rigid body displacement
7	209.36	Bending
8	356.21	Bending
9	549.54	Bending + Torsion
10	613.64	Bending + Torsion

VI.CONCLUSION

1. style calculations of six cylinder four stroke ICE are calculated as per design standards of design of machine components and CREO model of crank shaft is completed and analysis victimization ANSYS worktable is carried with success

2. The deformation obtained in steel is zero.031032 metric linear unit that is a smaller amount when put next to metal metal matrix composite and high strength carbon fiber which has zero.08446 metric linear unit & zero.05568 metric linear unit severally

3. Equivalent Von- mises stress is a smaller amount for metal metal matrix composite is less when put next to steel and high strength carbon fiber

4. Shear stress is a smaller amount for metal metal matrix composite is less when put next to steel and high strength carbon fiber

5. At 3600 crank angle position the whole deformation is zero.0331 mm ,max von-mises stress is one hundred fifteen.32 MPa and soap shear stress is forty three.295 MPa is for steel

6. At 3600 crank angle position the whole deformation is zero.0902 mm ,max von-mises stress is 114.67 MPa and soap shear stress is forty three.01 MPa is for metal metal matrix composite

7. At 3600 crank angle position the whole deformation is zero.0593 mm ,max von-mises stress is 121.65 MPa and soap shear stress is forty five.83 MPa is for prime strength carbon fiber

8. At mode ten of 320.67 Hertz the mode of bending and torsion is obtained in steel.

9. At mode ten of 333.5 Hertz the mode of bending and torsion is obtained in metal metal matrix composite

10. At mode ten of 502.57 Hertz the mode of bending and torsion is obtained in high strength carbon fiber

REFERENCES

[1] Mendes, A. S., P. S. Meirelles, and D. E. Zampieri. "Analysis of torsional vibration in internal combustion engines: modelling and experimental validation." Proceedings of the Institution of Mechanical Engineers, Part K: Journal of Multi-body Dynamics 222.2 (2008): 155-178.

[2] Basnet, Ankit, et al. "Design And Analysis Of Solid Crank Shaft Using Catia And Ansys Workbench." International Journal Of Advanced Research İn Biology Engineering Science And Technology 2 (2016): 86-99.

[3] Shahane, V. C., and R. S. Pawar. "Optimization of the crankshaft using finite element analysis approach." Automotive and Engine Technology 2.1-4 (2017): 1-23.

[4] Pratik, Kakade, M. D. Pasarkar, and A. G. Thakur. "Static Analysis of Crankcase and Crankshaft of Single Cylinder Four Stroke Diesel Engine." Power 2600 (2015): 8HP.

[5] Karimaei, Hadiseh, and H. R. Chamani. "Effect of Crankshaft and Crankcase Material Stiffness on Load Distribution in Main Bearings." International Journal of Automotive and Mechanical Engineering 15.4 (2018): 5941-5956.

[6] Idris, Momin Muhammad Zia Muhammad, and H. Vinayak. "Optimization of crankshaft using strength analysis." International Journal of Engineering Reasearch and applications 3 (2013): 252-258.

[7] Singh, Pawan Kumar, et al. "Modelling of Crankshaft by Cad Tool and Finite Element Analysis Using Ansys Software." International Journal of Mechanical Engineering and Technology 7.4 (2016).

[8] Yingkui, Gu, and Zhou Zhibo. "Strength analysis of diesel engine crankshaft based on PRO/E and ANSYS." 2011 Third International Conference on Measuring Technology and Mechatronics Automation. Vol. 3. IEEE, 2011.