A Review on Design and Vibration Analysis of a Crank shaft by FEA and Experimental Approach

[1]Shruthi Mahendrakar, [2]Dr P R Kulkarni

[1]Research Scholar, [2]Head of the Department
Mechanical Engineering Department,
Walchand Institute of Technology, Solapur, India

***Abstract*: A Design and optimization of crankshaft weight is the key point for manufacturing and maintain the weight of crankshaft with higher rigidity under vibrating working conditions. Several attempts for optimization of crankshaft has been carried out by many researchers considering the static, dynamic, life and crack parameters to run the component for safer working conditions. The main objective of this paper is to focus on to study the various methods preferred for designing and optimizing the crankshaft for safer working under various boundary conditions by various researchers.**

***Keywords*: Crank shaft, stress, deformation**

1. Introduction

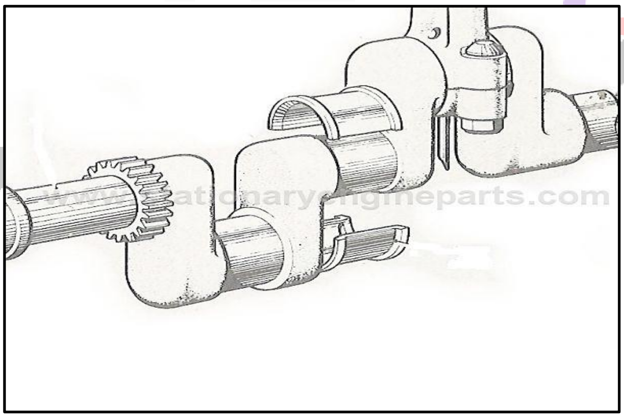
Crankshaft is used to transfer reciprocating motion/power from piston to gear/clutch in desired velocity/torque ratios with high efficiency. However any crankshaft defect occurring deteriorate the performance of the engine.

Crankshafts are basically used in rotating device like engines or generators. They transmit heavy loads of the flywheels and internal gaseous pressure of the engines at a very high rate. So, if any fault arises in the crankshaft, it must be alarmed & noticed by the operator or driver timely, to avoid the mass damage or catastrophe. Timely detection of fault/defect is very important in order to keep the entire system halt

The crankshaft consists of the shaft parts which revolve in the main bearings, the crankpins to which the big ends of the connecting rod are connected, the crank arms or webs (also called cheeks) which connect the crankpins and the shaft parts. The crankshaft, depending upon the position of crank, may be divided into the following two types :

1. Side crankshaft or overhung crankshaft

2. Centre crankshaft



Importance

Crank shaft is a critical component in power loom system if it undergoes breakage the entire system will stop therefore it is important to design.

There is need from Dhayafule textiles to check the physical phenomenon of the crank shaft under given working conditions

2. Literature survey

Much research work has been done in the field of vibration analysis of crank shaft. The literature review of some papers gives more information about their contribution in design and vibration analysis of crank shaft

Shin-Yong Chen, et al [1] in their research paper "Dynamic Analysis Of a Rotating Composite Shaft" One of the key factors in designing a motor built-in high speed spindle is to assemble the motor rotor and shaft by means of hot-fit. Presented in this paper is a study of the influence of a hot-fit rotor on the local stiffness of the hollow shaft. Dynamic analyses of the rotor-hollow shaft assembly using contact elements are conducted. The normal contact stress state between the rotor and the hollow shaft is obtained through the use of contact elements with friction effects included. The normal contact stress, considered as the pr-stress between the rotor and the hollow shaft, is then adopted for subsequent modal analyses. In this study, the modal analysis results are verified by a modal testing experiment

C. Azoury et al [2] presented a report on the experimental and analytical modal analysis of a crankshaft. The effective material and geometrical properties are measured, and the dynamic behavior is investigated through impact testing. The three-dimensional finite element models are constructed and an analytical modal analysis is then performed to generate natural frequencies and mode shapes in the three-orthogonal directions. The finite element model agrees well with the experimental tests and can serve as a baseline model of the crankshaft.

R. J. Deshbhratar, et al [3] analyzed 4- cylinder crankshaft and model of the crankshaft were created by using Pro/E Software and then imported to ANSYS software. The maximum deformation appears at the centre of crankshaft surface. The maximum stress appears at the fillets between the crankshaft journal and crank cheeks, and near the central point. The edge of main journal is high stress area. The crankshaft deformation was mainly bending deformation under the lower frequency. And the maximum deformation was located at the link between main bearing journal and crankpin and crank cheeks. So this area prone to appear the bending fatigue crack.

Abhishek choubey, and et al [4] have analyzed crankshaft model and 3-dimentional model of the crankshaft were created by SOLID WORKS Software and imported to ANSYS software. The crankshaft maximum deformation appears at the centre of crankpin neck surface. The maximum stress appears at the fillets between the crankshaft journals and crank cheeks and near the central point journal. The edge of main journal is high stress area.

Rinkle garg et al. [5] analyzed crankshaft model and crank throw were created by using Pro/E Software and then imported to ANSYS software. The result shows that the improvement in the strength of the crankshaft as the maximum limits of stress, total deformation, and the strain is reduced. The weight of the crankshaft is reduced .There by, reduces the inertia force. As the weight of the crankshaft is decreased this will decrease the cost of the crankshaft and increase the I.C engine performance.

Sanjay B Chikalthankar et al [6] investigated stresses developed in crankshaft under dynamic loading. In this study a dynamic simulation was conducted on crankshaft, Finite element analysis was performed to obtain the variation of stress magnitude at critical locations. The pressure-volume diagram was used to calculate the load boundary condition in dynamic simulation model, and other simulation inputs were taken from the engine specification chart. This load was then applied to the FE model, and boundary conditions were applied according to the engine mounting conditions. The analysis was done for different engine speeds and as a result critical engine speed and critical region on the crankshaft were obtained. Stress variation over the engine cycle and the effect of torsional load in the analysis were investigated. Results obtained from the analysis are very useful in optimization of the crankshaft.

Sagar R Dharmadhikari, et al [7] made modest attempt to review the optimization of Genetic Algorithm and ANSYS in their research report "Design and Analysis of Composite Drive Shaft using ANSYS and Genetic Algorithm**"**. Drive shaft is the main component of drive system of an automobile. Conventional steel is substituted by composite material which has high specific strength and stiffness. The finite element analysis is used in this work to predict the deformation of shaft. Natural frequency using Bernoulli – Euler and Timoshenko beam theories was compared. The frequency calculated by Bernoulli – Euler theory is high because it neglects the effect of rotary inertia & transverse shear. Hence the single piece High Strength Carbon / Epoxy composite drive shaft has been proposed to design to replace the two piece conventional steel drive shaft of an automobile.

K.Thriveni et al [8] made an attempt this paper to study the Static analysis on a crankshaft from a single cylinder 4-stroke I.C Engine. The model of the crankshaft is created using CATIA-V5 Software. Finite element analysis (FEA) is performed to obtain the variation of stress at critical locations of the crank shaft using the ANSYS software and applying the boundary conditions. Then the results are drawn Von-Mises stress induced in the crankshaft is 15.83Mpa and shear stress is induced in the crankshaft is 8.271Mpa. The Theoretical results are obtained. Von-Mises stress is 19.6Mpa, shear stress is 9.28Mpa. The validation of model is done by comparing with the Theoretical result. FEA results of Von-misses stress and shear stress are within the limits. Further it can be extended for the different materials and dynamic analysis, optimization of crank shaft.

Ashwani Kumar Singh et al [9] conducted statics analysis on a nickel chrome steel and structural steel crank shafts from a single cylinder four stroke engine. Finite elements analysis was performed to obtain the variation of stress magnitude at critical locations. Three dimensional model of crankshaft was created in Pro/E software .The load was then applied to the FE model and boundary condition where applied as per the mounting conditions of the engine in the ANSYS Workbench

Abhishek Sharma et al [10] in the present research work vibration analyses have been focused to detect crankshaft fault at the early stage, followed by the literature review of the shaft and the experimental methodologies. A simulation for the study of crankshaft is carried out by acquiring its fault signal and its fast Fourier transform is plotted to show the characteristics frequencies and its harmonics. A comparison of simulated data is also made to validate the experiment based condition monitoring.

Momin Muhammad Zia Muhammad Idris et al [11] this paper presents results of strength analysis done on crankshaft of a single cylinder two stroke petrol engine, using PRO/E and ANSYS software. The three dimensional model of crankshaft was developed in PRO/E and imported to ANSYS for strength analysis. This work includes, in analysis, torsion stress which is generally ignored. A calculation method is used to validate the model. The paper also proposes a design modification in the crankshaft to reduce its mass. The analysis of modified design is also done.

Neepa M. Patel 1, G.M. Karkar conducted kinematic and dynamic analysis to design high speed Beat-up mechanism shuttle loom, which is third primary operation of shuttle loom. Basically beat-up mechanism is the reciprocating motion of the reed which is used to push every weft thread to the fabric fell, because the only drawback of shuttle loom is its low speed, current shuttle looms are running at 120 ppm(pick per minute), and due to this its productivity is less

The table below gives the information about the methodology and parameters used by various researchers

S. No.	Researcher	Year	Methodology	Investigating Parameter
1	Shin-Yong Chen, Chieh Kung, Jung-Chun Hsu et al	2011	FEM, Experimental	Natural frequency
2	C. AZOURY et al	2012	FEM, Experimental	Modal Frequency
3	R. J. Deshbhratar, and Y.R Suple et al	2012	FEM	Deformation, Von-Misses Stresses
4	Abhishek choubey, and Jamin Brahmbhatt et al	2012	Analytical, Experimental	Deformation, Von-Misses Stresses
5	Rinkle Garg, Sunil Baghla	2012	FEM	Deformation, Stresses
6	Sanjay B Chikalthankar et al	2013	FEM	Deformation, Von-Misses Stresses
7	Sagar R Dharmadhikari, et al	2013	Analytical, FEM	Reduction in weight
8	K.Thriveni Dr.B.JayaChandraiah et al	2013	Analytical, FEM	Deformation, Stresses
9	Momin Muhammad Zia Muhammad Idris et al	2013	Analytical, FEM	stress concentration
10	Ashwani Kumar Singh et al	2014	FEM	Deformation, Stresses
11	Abhishek Sharma et al	2014	Experimental	Modal analysis
12	Neepa M. Patel 1, G.M. Karkar	2014	Analytical	kinematic and dynamic analysis

2.1 literature gap

Review of literature [1-12] suggested that many authors have reported determination of stress, deflection and modal frequencies of the crank shaft for different boundary conditions and some researchers have worked on the calculation of critical points in the crank shaft, still there exists to redesign and modify the geometry of the crank shaft to optimize the weight of the crank shaft and check the physical properties under given condition for safer work.

2.2 Problem identification

Crank shaft of Power loom system in textile machinery is a critical component which transmits the power from motor to machinery at a required speed and controls the complete operation. If crank shaft of the system fails then entire process will stop hence it is important to design the power loom system for continues operation. There is need from industry Dhayafule Textiles for the vibration analysis of the crank shaft of a power loom.

2.3 Objectives

This work comprises the following objectives for safe design of existing power loom system.

- To Select a critical component i.e. crank shaft of power loom system.
- To Model the existing crank shaft of power loom system then numerical analysis will be carried out in FEA
- To carry out Experimentation using FFT analyzer.
- To Compare the experimental and numerical results.
- To modify the component for optimization by changing the geometry then the analysis will be carried out.

3 Conclusions

From the above review it has been observed that the experimental, and numerical analysis is carried out to check the stress, deflection and modal frequencies. The maximum deformation that appears is mainly at the centre of crankpin neck surface. The maxi-mum stress appears at the fillets between the crankshaft journal and crank cheeks and near the central point journal. The edge of main journal is high stresses area, some researchers has measured the life of the crank shaft for safer conditions and also optimization of the crank shaft is carried out used in engine applications to reduce the material and cost. The decrease in the crank shaft weight reduces the inertia force

References

Ashwini Kumar Singh, Praveen Kumar Singh, Akash KumarTripathi, Ajeet Yadav, Shyam Bihari lal FEA of the crankshafts Design by using Ansys workbench For nickel chrome steel and structural steel International Journal of Scientific & Engineering Research, Volume 5, Issue 4, April-2014 1249 ISSN 2229-5518

Abhishek Sharma, Vikas Sharma, Ram Bihari Sharma A simulation of vibration analysis of crankshaft International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 International Conference On Emerging Trends in Mechanical and Electrical Engineering (ICETMEE- 13th-14th March 2014)

Sanjay B Chikalthankar, V M Nandedkar, Surender Kumar Kaundal Finite Element Analysis Approach for Stress Analysis of Crankshaft under Dynamic Loading International Journal of scientific & Engineering Research, Volume 4, Issue 2, Feb-2013 1 ISSN 2229-5518

Sagar R Dharmadhikari, Sachin G Mahakalkar, Jayant P Giri, Nilesh D Khutafale "Design and Analysis of Composite Drive Shaft using ANSYS and Genetic Algorithm" A Critical Review International Journal of Modern Engineering Research (IJMER) www.ijmer.com Vol.3, Issue.1, Jan-Feb. 2013 pp-490-496 ISSN: 2249-6645

K. Thriveni1 Dr.B.JayaChandraiah Modeling and Analysis of the Crankshaft Using Ansys Software International Journal of Computational Engineering Research||Vol, 03||Issue, 5

Momin Muhammad Zia, Muhammad Idris, Crankshaft Strength Analysis Using Finite Element Method International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 3, Issue 1, January -February 2013, pp.1694-1698

Jaimin Brahmbhatt1, Prof. Abhishek choubey Design and Analysis of Crankshaft gfor single Cylinder 4-Stroke Deisel Engine, International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974

Rinkle Garg, 2 Sunil Baghla, Finite Element Analysis and Optimization of Crankshaft Design International Journal of Engineering and Management Research, Vol.-2, Issue-6, December 2012 ISSN No.: 2250-0758

R. J. Deshbhratar, Y. R. Suple Analysis & Optimization of Crankshaft Using Fem international Journal of Modern Engineering Research (IJMER) www.ijmer.com Vol. 2, Issue. 5, Sep.-Oct. 2012 pp-3086-3088 ISSN: 2249-6645

C. Azouri, A. Kallassy, B. Combes, I. Moukarze, R. Boudet, Experimental and Analytical Modal Analysis of a Crankshaft IOSR Journal of Engineering Apr. 2012, Vol. 2(4) pp: 674-684

Shin-Yong Chen1, Chieh Kung2, Jung-Chun Hsu3 Dynamic Anaalysis of a rotary Hollow Shaft with Hot-Fit Part Using Contact Elements With Friction. Transactions of the Canadian Society for Mechanical Engineering, Vol. 35, No. 3, 2011