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ANALYTICAL EVALUATION OF CRANK SHAFT UNDER CYCLIC LOADING USING FEM

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***ABSTRACT*:** The crankshaft is one of the critical components on the internal combustion engine. The dynamic analysis has been undergone in this paper under the condition of 4-stroke single cylinder diesel engine. The SOLIDWORKS software is used to create the 3D model of the single cylinder crankshaft. The Finite element analysis method had been carried out in this process to identify the various stress concentration and the critical point of the crankshaft. The preprocessing stage is done through SOLIDWORKS software and analyzing and post processing is done through ANSYS software. The dynamic analysis is done through the FEA method which results in the load iteration form applied on the crank pin bearing. The load is applied on the crankshaft based on the engine mounting condition and the stress concentration and the critical point has been found. The stress variation, Torsion and the bending load had been taken in consideration for this analysis. The relationship between the vibration and the frequency will be shown in the harmonic analysis of the crankshaft using this software.

***Index Terms*—** Crankshaft, 4-Stroke Single Cylinder Diesel Engine, SOLIDWORKS Software, FEA Method, Harmonic Analysis

I. INTRODUCTION

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. The crankshaft, connecting rod, and piston constitute a four bar slider-crank mechanism, which converts the sliding motion of the piston (slider in the mechanism) to a rotary motion. Since the rotation output is more practical and applicable for input to other devices, the concept design of an engine is that the output would be rotation. In addition, the linear displacement of an engine is not smooth, as the displacement is caused by the combustion of gas in the combustion chamber. Therefore, the displacement has

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sudden shocks and using this input for another device may cause damage to it. The concept of using crankshaft is to change these sudden displacements to a smooth rotary output, which is the input to many devices such as generators, pumps, and compressors. It should also be mentioned that the use of a flywheel helps in smoothing the shocks. the mounting of a crankshaft in an engine shows the P-V diagram during an engine cycle for a four stroke cycle engine, where Vdis the volume swept by the piston and Vbdc is the volume of the cylinder when the piston is at the bottom dead centre (BDC). Fig. 1 shows the Crank Shaft Architecture

Fig. 1 Crank Shaft Architecture

This paper explains the need for a comparative study of forged steel and ductile cast iron crankshafts, which are the most commonly, used manufacturing processes for an automotive crankshaft. In addition, it was desired to develop an optimized geometry, material, and manufacturing procedure which will reduce the weight of the forged steel component for fuel efficiency and reduce the manufacturing cost due to high volume production of this component. This research was performed on crankshafts from single cylinder engines. the failure of crank shaft due to the dynamic load and rotating system exerts repeated bending and shear stress due to torsion, which are common stresses acting on crankshaft and mostly responsible for crankshaft failure. Hence, fatigue strength and life assessment plays an important role in crankshaft development and its parts considering its safety and reliable operation [1]. The need of load history in the FEM analysis necessitates performing a detailed dynamic load analysis. Therefore, this paper consists of three major sections: (1) dynamic load analysis, (2) FEM and stress analysis, (3) optimization for weight and cost reduction. In this study a dynamic simulation was conducted on two crankshafts, cast iron 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 [2] the failure of crankshaft due to fatigue which are put into service in several applications. Crankshaft is important part in all types of engines employed in applications like aircraft, reciprocating compressor, marine engine, and vehicle engine as well as diesel generator. The failure of crankshaft is due to fatigue resulting into cracks on the surface of crankshaft and effect of residual stresses due to fillet rolling process. The motivation

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behind this paper is to study how fatigue phenomenon leads to the failure of the crankshaft. Christo Ananth et al. [3] proposed a principle in which another NN yield input control law was created for an under incited quad rotor UAV which uses the regular limitations of the under incited framework to create virtual control contributions to ensure the UAV tracks a craved direction. Utilizing the versatile back venturing method, every one of the six DOF are effectively followed utilizing just four control inputs while within the sight of un demonstrated flow and limited unsettling influences. Elements and speed vectors were thought to be inaccessible, along these lines a NN eyewitness was intended to recoup the limitless states. At that point, a novel NN virtual control structure which permitted the craved translational speeds to be controlled utilizing the pitch and the move of the UAV. At long last, a NN was used in the figuring of the real control inputs for the UAV dynamic framework. Utilizing Lyapunov systems, it was demonstrated that the estimation blunders of each NN, the spectator, Virtual controller, and the position, introduction, and speed following mistakes were all SGUUB while unwinding the partition Principle. 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. The dynamic analysis was done analytically and was verified by simulation in FEA [4]. A dynamic simulation was conducted on a crankshaft from a single cylinder four stroke engine. 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. The dynamic analysis was done analytically and was verified by simulation in ADAMS which resulted in the load spectrum applied to crank pin bearing [5].

The dynamic analysis resulted in the development of the load spectrum applied to the crankpin bearing. This load was then applied to the FE model and boundary conditions were applied according to the engine mounting conditions. Results obtained from the analysis were then used in optimization of the forged steel crankshaft. Geometry, material, and manufacturing processes were optimized using different geometric constraints, manufacturing feasibility, and cost. The first step in the optimization process was weight reduction of the component considering dynamic loading. This required the stress range under dynamic loading not to exceed the magnitude of the stress range in the original crankshaft. The optimization and weight reduction were considered in an interactive manner and evaluated by manufacturing feasibility and cost. The optimization

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process resulted in weight reduction, cost reduction and increased fatigue strength of the crankshaft [6]. Crankshaft is a large component having complex geometry that converts linear reciprocating displacement of the piston to a rotary motion. Since the crankshaft experiences a large number of load cycles during its service life, its fatigue performance and durability 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 minimum weight, proper fatigue strength, higher fatigue life and satisfying other functional requirements. The fatigue phenomenon is a damage process caused by the growing of cracks due to cyclic stress that generate and aggregate micro cracks which can cause sudden catastrophic failures [7].

Crankshaft is a mechanical component with a complex geometry which transforms reciprocating motion into rotary motion; hence crankshaft plays a key role in its functioning. The crankshaft is connected to the piston through the connecting rod. The journals of the crankshaft are supported on main bearings, housed in the crankcase. The design of the crankshaft and analysis study is the most important process for an effective engine design and engine performance improvement in the internal combustion engine [8]. The performance of any automobile largely depends on its size and working in dynamic conditions. The design of the crankshaft considers the dynamic loading and the optimization can lead to a shaft diameter satisfying the requirements of automobile specifications with cost and size effectiveness [9]. Finite Element Analysis of the forged steel crankshaft. In this present research work analysis is conducted on forged Micro Alloy Steel crankshaft. This crankshaft is used in new TATA Safari 2.2 L DICOR vehicle, which belongs to in line four cylinder crankshaft of four stroke diesel engine. But crankshaft is failed for various reasons. Therefore there is need for analysis of the crankshaft to find out the reasons of its failure using the FEA analysis. In this study a static analysis is conducted on this crankshaft, with single crankpin of crankshaft. Finite element analysis is performed to obtain the variation of stress magnitude at critical locations. With the help of maximum gas pressure at time of combustion, total load acting on the crankpin of the crankshaft is calculated. In this static analysis of crankshaft, loading and boundary condition depend upon the maximum gas pressure acting on the crankpin. For the FEA analysis of crankshaft we selected the different element length size for the meshing [10].

II. METHODOLOGY

SolidWorks (stylized as SOLIDWORKS) is a solid modeling computer-aided design (CAD) and computer-aided engineering (CAE) computer program that runs on Microsoft Windows. SolidWorks is published by

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Dassault Systems. According to the publisher, over two million engineers and designers at more than 165,000 companies were using SolidWorks as of 2013. Also according to the company, fiscal year 2011–12 revenue for SolidWorks totalled $483 millionA.

Modeling technology:

- A SolidWorks model consists of 3D solid geometry in a part or assembly document.
- Drawings are created from models, or by drafting views in a drawing document.
- Typically, you begin with a sketch, create a base feature, and then add more features to your model. (You can also begin with an imported surface or solid geometry.)
- You can refine your design by adding, editing, or reordering features.
- Associatively between parts, assemblies, and drawings assures that changes made to one document or view are automatically made to all other documents and views.
- You can generate drawings or assemblies at any time in the design process.
- With a Real View-compatible graphics card installed, you can display photo-realistic models and environments.
- Click Tools > Options on the main menu to display System Options and Document Properties.
- The Solid Works software saves your work for you with auto-recover. You can also choose to be reminded to save your work.

SOLIDWORKS Professional:

SOLIDWORKS Professional gives you all the power of SOLIDWORKS Standard with additional capabilities that increase productivity, ensure accuracy, and help you communicate your design information more effectively. SOLIDWORKS Professional includes libraries of standard parts and fasteners, tools to automatically estimate manufacturing costs and help convert imported geometry and utilities that search designs for errors. Realistically render your designs with Photo View 360 software and then share them with others using e Drawings Professional. SOLIDWORKS Professional also gives you integrated file management tools that securely store all project information and track all design changes Configuration of the Engine to which the crankshaft belongs is shown in Table 1

Table 1 Configuration of the Engine to which the crankshaft

PARAMETER	VALUE

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Crank Pin Radius	60 mm
Shaft Diameter	90 mm
Thickness of the Crank Web	50mm
Length of the crank Pin	197mm
Maximum pressure	35bar

III. DESIGNING RESULTS

TOP VIEW MODEL OF CRANK SHAFT

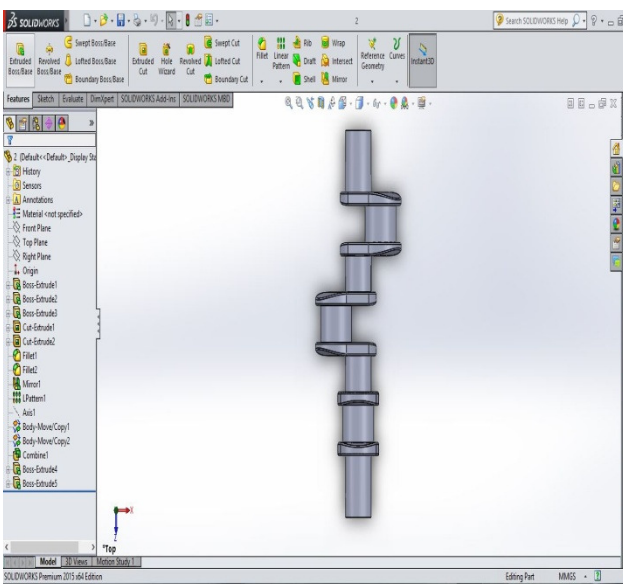

Fig 2 Top View Model of Crank Shaft

FRONT VIEW

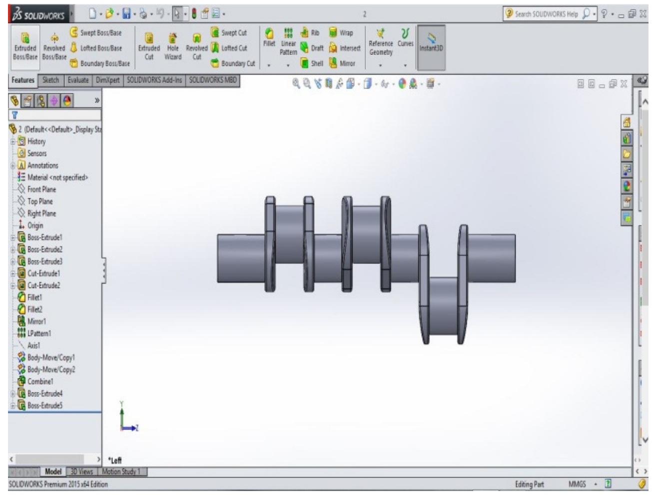

Fig 3 Front View

The major crankshaft material competitors currently used in industry are forged steel, and cast iron. Comparison of the performance of these materials with respect to static, cyclic, and impact loading are of great interest to the automotive industry. A comprehensive comparison of manufacturing processes with respect to mechanical properties, manufacturing aspects, and finished cost for crankshafts has been conducted performed on material alternatives for the automotive crankshaft based on manufacturing economics. Fig 2 and 3 shows the top and front view model of crank shaft.

3.3 RIGHT SIDE VIEW

Metal Forming fundamentals and applications carried on multi-cylinder crankshaft is considered to have a complex geometry, which necessitates proper work piece and die design according to material forge ability and friction to have the desired

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geometry .The main objective of forging process design is to ensure adequate flow of the metal in the dies so that the desired finish part geometry can be obtained without any external or internal defects. Metal flow is greatly influenced by part or dies geometry. Fig 5 shows the right side view model of crank shaft.

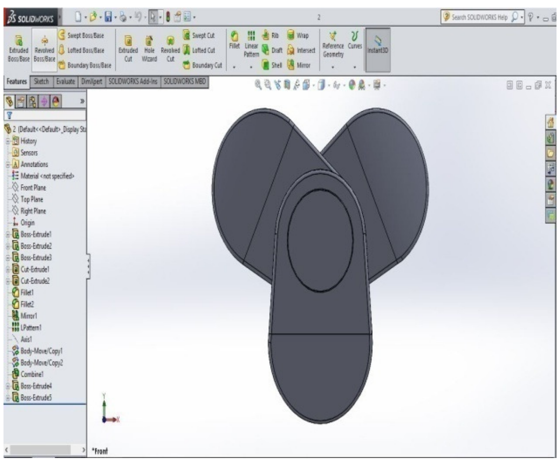

Fig. 5 Right Side View

D VIEWS (ISOMETRIC VIEW)

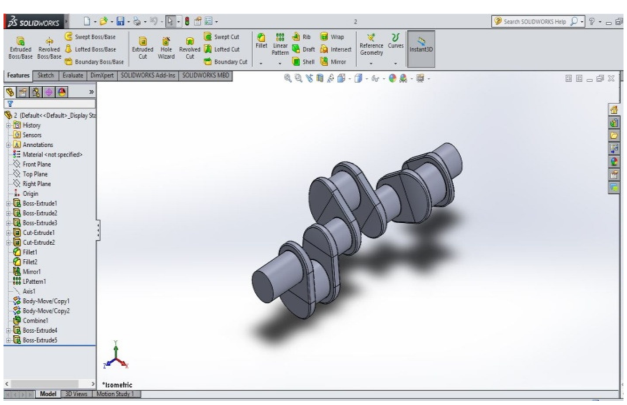

Fig. 4 D View (Isometric View)

The crankshaft is subjected to complex loading due to the motion of the connecting rod, which transforms two sources of loading, namely combustion and inertia, to the crankshaft. Optimization of the crankshaft requires a determination of an accurate assessment of the loading, which consists of bending and torsion. Dynamic loading analysis of the crankshaft results in more realistic stresses whereas static analysis provides results that may not reflect operating conditions. Fig 6 shows the 3D view model of crank shaft.

TOP SECTIONAL VIEW

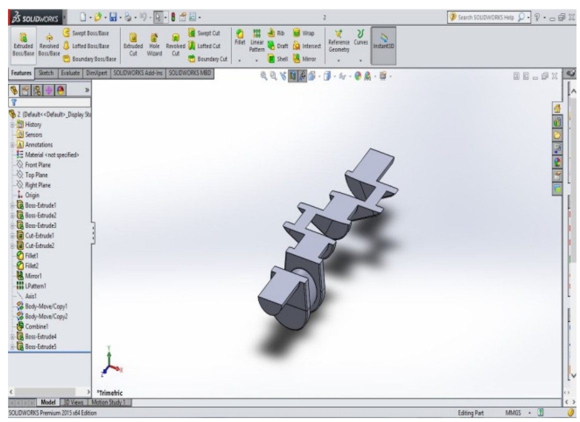

Fig. 6 Top Sectional View

Fig 6 and 3 shows the top sectional view model of crank shaft. Crankshaft showed that as the engine speed increases the maximum bending load decreases. Therefore, the critical loading case for this engine is at the minimum operating speed of 2000 rpm. This should not be misunderstood as to mean that the higher the engine rpm is the longer the service life because there are many other factors to consider in operation

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of the engine. The most important issue when the engine speed increases is wear and lubrication. As these issues were not considered in the dynamic load analysis study,

IV. CONCLUSION

This paper investigated weight reduction and the suitable better material for minimizing deflections in crankshaft. Load analysis was performed which comprised of the crankshaft, using analytical techniques and computer based mechanism simulation tools. FEA was then performed using the results from load analysis to gain insight on the structural behavior of the connecting rod and to determine the design loads for optimization. The following conclusions can be drawn from this study. Some researchers have considered composite structures in their study to analyze the strength and failure occurs in it. Various models have been developed by researchers using various theories and concepts to study the fatigue failure in crankshaft due to dynamic and static loading. The failure in the crankshafts has been initiated mostly from the crank pin-web fillet region by a fatigue mechanism. Shafts are made from the same material however one of them has undergo a surface hardening heat treatment and the other is used under the annealed conditions.

REFERENCES

[1] SuryakantRathod; ‘‘Evaluation of Fatigue Failure of Crankshaft Work on its Bearing and Crank Pin Analytically and Numerically - A Review’’ International Journal of Science and Research (IJSR) Index Copernicus Value (2013): 6.14 | Impact Factor (2013)

[2] Farzin H. Montazersadgh and Ali Fatemi; ‘‘Stress Analysis and Optimization of Crankshafts Subject to Dynamic Loading’’ Forging Industry Educational Research Foundation (FIERF) and American Iron and Steel Institute (AISI) 2007

[3] Christo Ananth,"A NOVEL NN OUTPUT FEEDBACK CONTROL LAW FOR QUAD ROTOR UAV",International Journal of Advanced Research in Innovative Discoveries in Engineering and Applications[IJARIDEA],Volume 2,Issue 1,February 2017,pp:18-26.

[4] Kanwar J. S. Gill , PaliRosha; ‘‘Durability Analysis Of Lightweight Crankshafts Design Using Geometrically Restricted Finite Element Simulation Techniques For CamlessEngines’’ISBN 978-93-5156-328-0 (ICARI-2014)

[5] Farzin H. Montazersadgh and Ali Fatemi; ‘‘Dynamic Load and Stress Analysis of a Crankshaft’’ (2007)

[6] Imran M Quraishi; ‘‘Stress Analysis And Optimization of Crankshaft Under Dynamic Loading’’

[7] Rahul Narayan Sapkal; ‘‘Evaluating Design of The Automotive Crankshaft for Fatigue Life Using

Finite Element Method'' International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974

[8] Mr. V. C. Shahane; ''A Review on Finite Element Analysis of the Crankshaft of Internal Combustion Engine'' (IRJET) e-ISSN: 2395 -0056 Volume: 03 Issue: 08 | Aug-2016,

[9] AmitSolanki, KetanTamboli, M.J.Zinjuwadia; ''Crankshaft Design and Optimization- A Review''

[10] Rajesh MallikarjunMadbhavi; ''FEA of the Forged Steel Crankshaft by Hypermesh'' Global Journal of Researches in Engineering Mechanical and Mechanics Engineering Volume 13 Issue 4 Version 1.0 Year 2013