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Solid Modeling of 4-Cylinder Crank Shaft and its Frequency Analysis Using CATIA

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Abstract

Design and analysis of crank shaft is critical and requires accurate analysis involving all kinds of external influences on the component and needs to be optimized before it is sent to manufacturing. In this project work we have chosen to Design and Analyze 4-cylinder crank shaft using CATIA (v5) generative part structural analysis, which is mostly suitable for the components, related and subjected to loading and also requires frequency analysis. As Crank shaft is most often subjected to loads and requires critical frequency analysis and is modeled using CATIA and is also allowed to study the vibration characteristics of parts of the crank shaft to be assessed by calculating the natural frequencies and the associated mode shapes. In this work analyses is performed on volume parts, surface parts and wireframe geometries.

The analysis specifications, including loads, restraints, and material characteristics are applied directly to the design features. These specifications are then automatically incorporated into the underlying finite element model, where in Generative part Frequency Analysis automatically creates a finite element mesh and adapts a suitable mesh algorithm to ensure accurate results. In this "Virtual parts" allow items like forces, moments and restraints to be easily modeled without having to have a detailed geometric representation with ease. After subjecting the components to the external influences the deformed shape is plotted and the displacements scaled for better visual analysis. The displacements, stresses and local solution error will be visualized using contour plots, which are displayed on the unreformed or the deformed shape of the part allowing its behavior of complex parts to study the behavior of the complex features of the part. Later the required principal stresses are also plotted to know the loading effects and also characterized if the loading would cause yielding of the material and permanent deformation of the part.

Keywords:Cylinder,Crank shaft,CATIA.

1. Introduction

Crankshafts are common machine elements which transfer rotational movement into linear. Crankshaft design in modern internal combustion engines is driven by the desire for more power at higher efficiency rates and reduced weight. The demands on crankshaft material, therefore, are increasing, while the crankshafts themselves become smaller. The many different designs of crankshaft vary considerably, and even during mass production there can be subtle differences from one to another. To machine such a variety of cranks, SandvikCoromant has developed tool systems which are based on well designed and production tested components and inserts

Four cylinder crankshaft - Flange, Stub end and Main bearings are machined. Crankshaft is one of the most important moving parts in internal combustion engine . It must be strong enough to take the downward force of the power stroked without excessive bending. So the reliability and life of internal combustion engine depend on the strength of the crankshaft largely. And as the engine runs, the power inpulses hit the crankshaft in one place and then another. The torsional vibration appear when a power impuls hits a crankpin toward the front of the engine and the power stroke ends. If not controlled, it can break the cuankshaft. Srengthcaculation of crankshaft becomes a key factor to ensure the life of engine. Beam and space frame model were used to calculate the stress of crankshaft usually in the past. But the number of node is limited in these models. With the development of computer, more and more design of crankshaft has been utilized finite element method (FEM) to calculate the stress of crankshaft. The application of numerical simulation for the designing crankshaft helped engineers to efficiently improve the process development avoiding the cost and limitations of compiling a database of real world parts. Finite element analysis allows an inexpensive study of arbitrary combinations of input parameters including design

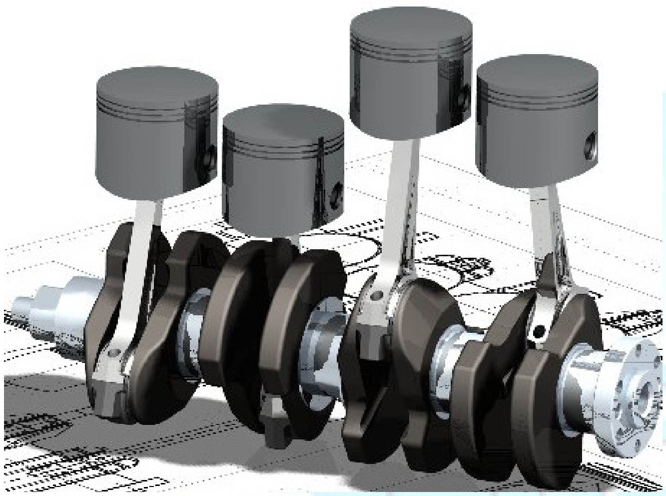

Fig 1 side view of crank shaft

2. Modeling and Analysis of Crank shaft

The main objective of this study to analyze the average von-mises stress and principle shear stress over the crankshaft using CATIA WORKBENCH software, the model creation can be created by well known 3D modeling software CATIA. CATIA will be used as a tool for analysis and optimization of crankshaft. The crankshaft conducting frequency analysis, fatigue life of the crankshaft and frequency analysis using modal analysis to find total deformation and frequency of the crankshaft.

While the converting the reciprocating motion into rotary motion by the crankshaft, it is subjected to vertical load and the vibrations. The study to be carried out to check the load carrying capacity of the crank shaft subjected to both vibration and rotation. Frequency simulation is conducted on the forged steel crankshaft, four cylinder four stroke engines. To calculate the load boundary condition in frequency simulation model, and other simulation inputs were taken from the engine specification.

Finite element modeling of any solid component consists of geometry generation, applying material properties, meshing the component, defining the boundary constraints, and applying the proper load type. These steps will lead to the stresses and displacements in the component. In his study, similar analysis procedures were performed for both forged steel and cast iron crankshafts.

Fig 2 design of crank shaft

The GPS workbench provides tools and functionalities to perform FEA in CATIA.

Frequency Analysis:

Allows you to compute a modal analysis of a restrained part. Additional mass can be applied Free Frequency Analysis: Allows we to compute a vibration case. wecan not apply restraintsAs we have seen in introduction there are 2 kinds of frequency analysis. we will see their specificities. Whatever the type of frequency analysis, we can not apply loads.

we have the possibility to start from scratch (New) or to use references for defining the restraints and masses. If we choose “Reference” it means we have previously defined in other cases and we just need to select them in the specification tree. we will see how to apply additional Mass in the following figs

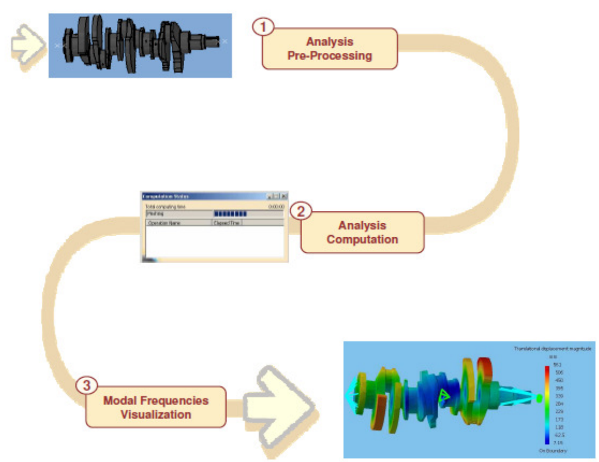

Fig 2 Frequency Analysis on a Crank Shaft

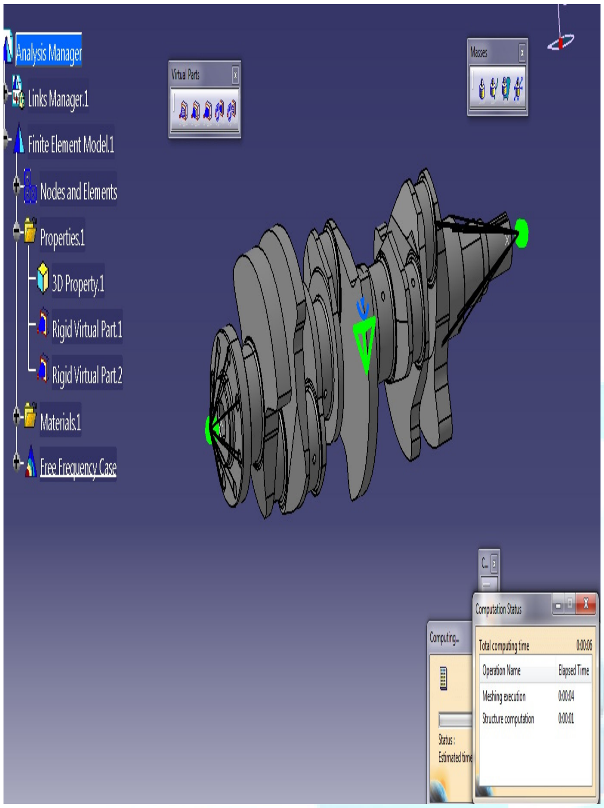

Fig 3 Vibration analysis of crank shaft

3. Results and discussions

In this paper, the crankshaft model was created by Catia(v5) software. Then, the model created by Catia software

S .no	Type of stress	Theoretical	FEA Analysis
1	Von-Misses (Stresses (N/mm2)	112.25	110.3
2	Von-Misses (Stresses (N/mm2)	50.15	59.89

• Above Results Shows that FEA Results Conformal matches with the theoretical calculation so we can say that FEA is a good tool to reduce time consuming theoretical Work. The maximum deformation appears at the center of crankpin neck surface. The maximum 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 stress area.

• The Value of Von-Misses Stresses that comes out from the analysis is far less than material yield stress so our design is safe and we should go for optimization to reduce the material and cost.

• After Performing frequency Analysis we Performed frequency analysis of the crankshaft which results shows more realistic whereas frequency analysis provides an overestimate results. Accurate stresses and deformation are critical input to fatigue analysis and optimization of the crankshaft.

Analysis Results. So we can Say that frequency of FEA is a good tool to reduce Costly experimental work.

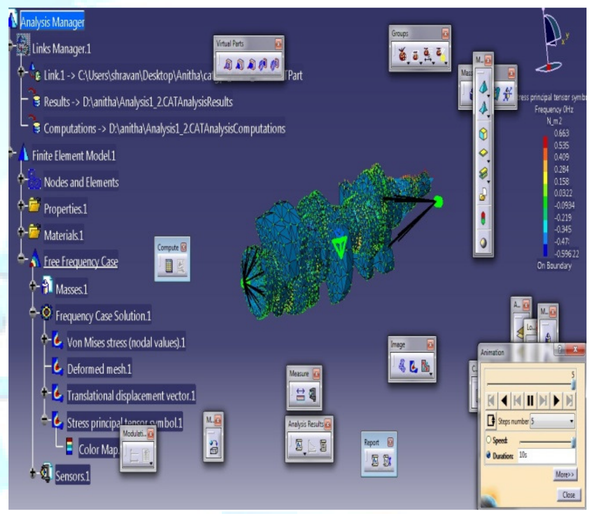

Fig 4 Model Meshing

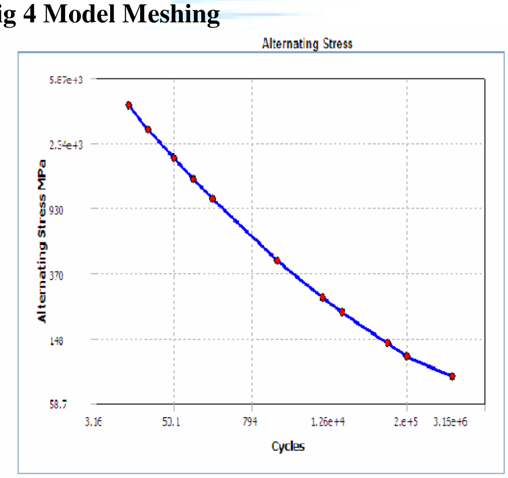

Fig 5 cycle Vs alternating stress

4 **Conclusion:**

Forged steel and a ductile cast iron crankshaft were chosen for this study, which belong to four cylinder four stroke water cooled gasoline engines. First, crankshafts were digitized using a CMM machine. Load analysis was performed based on Frequency analysis of the slider crank mechanism consisting of the crankshaft, connecting rod, and piston assembly, FEA model of each crankshaft was created and superposition of stresses from unit load analysis in the FEA, according to Frequency loading, resulted in stress history at different locations on the crankshaft geometry during an entire engine cycle.Material alternatives are other design variables that were considered in this study. Since automotive crankshafts are mostly manufactured from micro alloyed steels, this was considered as the alternative material. Micro alloyed steels have the main advantage of eliminating the time factor in the manufacturing process, which will reduce the cost of the final crankshaft. Inducing compressive residual stress at the fillets were investigated to improve the fatigue performance of the component. This improvement would allow additional changes in the geometry in order to reduce the weight of the final optimized crankshaft and physical testing of crankshaft will be done.

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