

Dynamic Load and Stress Analysis of a Crankshaft

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ABSTRACT

In this study 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. This load was applied to the FE model in ABAQUS, 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 from FE analysis were verified by strain gages attached to several locations on the crankshaft. Results achieved from aforementioned analysis can be used in fatigue life calculation and optimization of this component.

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 mechanism. This study was conducted on a single cylinder four stroke cycle engine.

Rotation output of an engine is a practical and applicable input to other devices since the linear displacement of an engine is not a smooth output as the displacement is caused by the combustion of gas in the combustion chamber. A crankshaft changes these sudden displacements to a smooth rotary output which is the input to many devices such as generators, pumps, compressors.

A detailed procedure of obtaining stresses in the fillet area of a crankshaft was introduced by Henry et al. [1],

in which FEM and BEM (Boundary Element Method) were used. Obtained stresses were verified by experimental results on a 1.9 liter turbocharged diesel engine with Ricardo type combustion chamber configuration. The crankshaft durability assessment tool used in this study was developed by RENAULT. The software used took into account torsional vibrations and internal centrifugal loads. Fatigue life predictions were made using the multiaxial Dang Van criterion. The procedure developed is such it that could be used for conceptual design and geometry optimization of crankshaft.

Guagliano et al. [2] conducted a study on a marine diesel engine crankshaft, in which two different FE models were investigated. Due to memory limitations in meshing a three dimensional model was difficult and costly. Therefore, they used a bi-dimensional model to obtain the stress concentration factor which resulted in an accuracy of less than 6.9 percent error for a centered load and 8.6 percent error for an eccentric load. This numerical model was satisfactory since it was very fast and had good agreement with experimental results.

Payer et al. [3] developed a two-step technique to perform nonlinear transient analysis of crankshafts combining a beam-mass model and a solid element model. Using FEA, two major steps were used to calculate the transient stress behavior of the crankshaft: the first step calculated time dependent deformations by a step-by-step integration using the newmark-beta-method. Using a rotating beam-mass-model of the crankshaft, a time dependent nonlinear oil film model and a model of the main bearing wall structure, the mass, damping and stiffness matrices were built at each time step and the equation system was solved by an iterative method. In the second step those transient deformations were enforced to a solid-element-model of the crankshaft to determine its time dependent stress behavior. The major advantage of using the two steps was reduction of CPU time for calculations. This is because the number of degrees of freedom for performing step one was low and therefore enabled an efficient solution. Furthermore, the stiffness matrix of the

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