Optimization of Two Wheeler Connecting Rod – Through Multi-Body FEA

Ravi Anandan
Lead Engineer
Hinduja Tech Limited
SKCL "Triton Square" 7th Floor
Unit No.C3 to C7,TVK Industrial
Estate,Guindy,Chennai-32,TN
Ravianandan.m@hindujatech.com

Sivadas B
Engineer
Hinduja Tech Limited
SKCL "Triton Square" 7th Floor
Unit No.C3 to C7,TVK Industrial
Estate,Guindy,Chennai-32,TN
Sivadas.balakrishnan@hindujatech.com

Abbreviations:

Keywords: *Connecting rod, Optimization, Multi body dynamics, Optistruct, Motion Solve*

Abstract

Over the decade, thanks to the growing economic strength of the Indian Middle Class, the two wheeler market segment has seen significant growth rates compared to other segments in the automotive Industry. In a fast growing market the onslaught of companies fighting for market share has lead two wheeler –OEM`s to emphasis on optimized Designs with better functionality ,reduced product cycle time and cost.

In this paper we have discussed the methodology based on which a two wheeler Connecting rod was optimized. A small reduction in weight even in terms of grams would have a significant effect on the efficiency and overall performance of the vehicle. In this process we started off by simulating the dynamic forces acting on the con-rod by building a Multi –body dynamics model using Motion View. The Multi-Body Simulation model helped us to capture the real time loading as per duty cycle and compute real time stresses and strains for fatigue life calculation. The Multi-body Simulation model build in motion view and solved in Motion Solve had a clear edge over rigid boundary conditions simulated in static and transient FEA codes. To optimize the design of the con-rod, necessary design changes in the geometry were made with the help of Optistruct solver to arrive at the best design.

Introduction

The automobile engine connecting rod is a high volume production critical component. From the viewpoint of functionality, connecting rods must have the highest possible Stiffness at the lowest weight. The major stress induced in the connecting rod is a combination of axial and bending stresses in operation. The axial stresses are produced due to cylinder gas pressure (compressive only) and the inertia force arising in account of reciprocating action (both tensile as well as compressive), where as bending stresses are caused due to the centrifugal effects. A MBD model simulating the above stated real time loading was built in Motion View. The appropriate loading Conditions were applied by means of the theta loading Curve by the use of Spline-3D in Motion View. A MBD Model of the crank train was built to determine the output force acting on the Connecting rod. The output from the MBD was used in optistruct to determine the maximum stresses developed in the connecting rod. The output representing the effects of gas loads acting on the connecting rod were used in optistruct to determine the stress acting on the connecting rod and iterations were carried out to optimize the design.

Process Methodology

The model was imported as a Step File in Motion View. The geometry was checked for CAD irregularities followed by appropriate assignment of Units and naming. The MBD model was built by appropriate assignments of joints at different interfaces in the body; the features in motion view helped us built a model that simulated real time conditions.

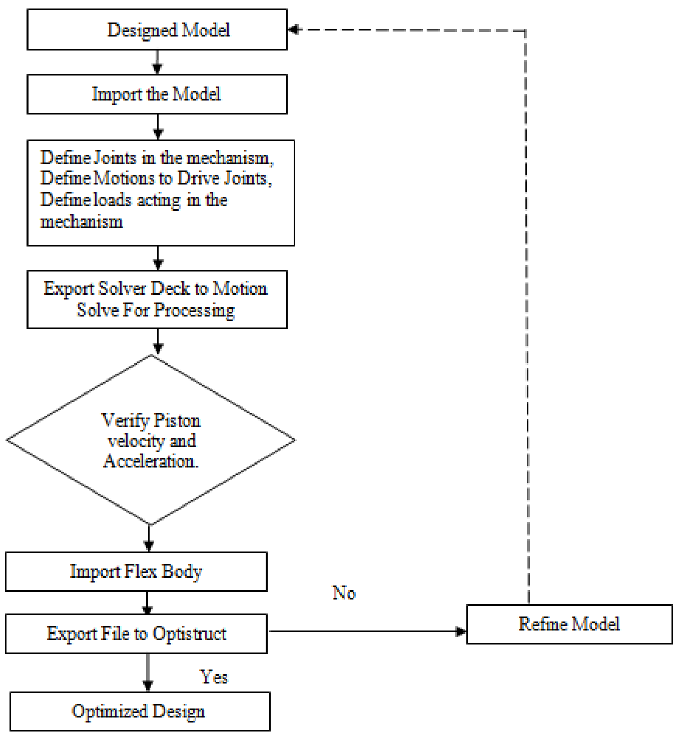


Figure 1: Process Methodology

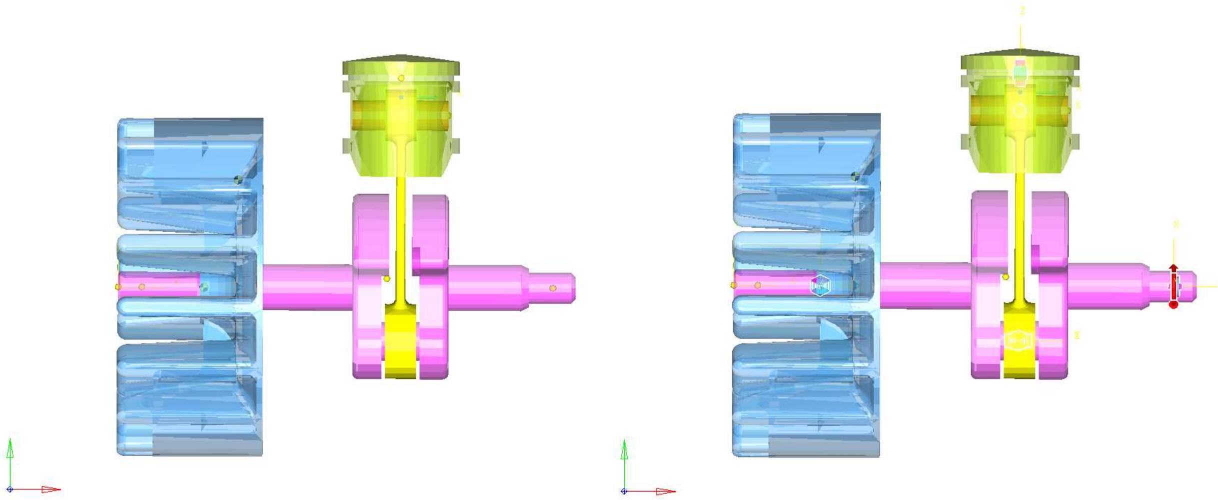


Figure 1: Imported Step Model, Applied Joints Using Motion View

Table I

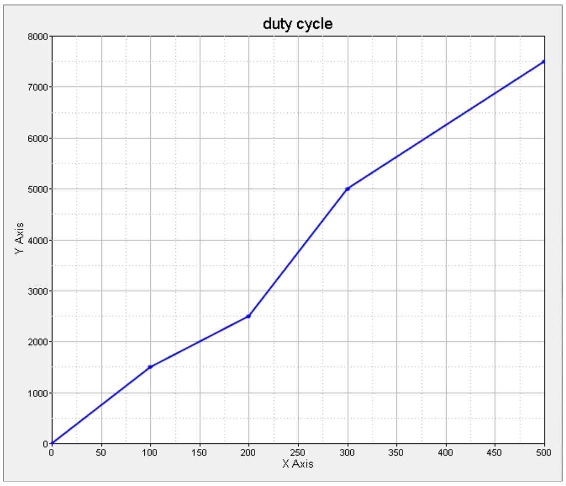
APPLIED JOINTS

S. No.	*Body 1*	*Body 2*	*Joint*
1.	*Connecting Rod*	*Crank Shaft*	*Ball Joint*
2.	*Piston*	*Connecting Rod*	*Cylindrical Joint*
3.	*Flywheel*	*Crank Shaft*	*Fixed Joint*
4.	*Crank Shaft*	*Ground Body*	*Revolute Joint*
5.	*Piston*	*Piston Pin*	*Fixed Joint*
6.	*Piston*	*Ground Body*	*Translational Joint*

The rotation of the crank shaft was simulated with a motion about the revolute joint. The motion was specified in terms of linear values. The solver deck was processed and results were viewed at regular intervals in hyper view to validate the motion of the joints. A mesh model of the Connecting rod was separately prepared in hyper mesh to extract the mode shapes. The mode shapes at different time steps were viewed using hyper view. To prepare the flex body the mode shapes were mapped to the MBD model. The deck of the prepared model was processed using Motion Solve to determine the outer force at different joints

The duty cycle and the corresponding P- theta Curve based on test data were imported into the model by means of the Curve and 3d- Spline.

The plots from hyper view provided a better perspective of the resulting force acting on the connecting rod. The forces acting on the connecting rod were applied in optistruct to determine the stresses. Optistruct gave a better understanding of the design and topology optimization was carried out for further improvement.



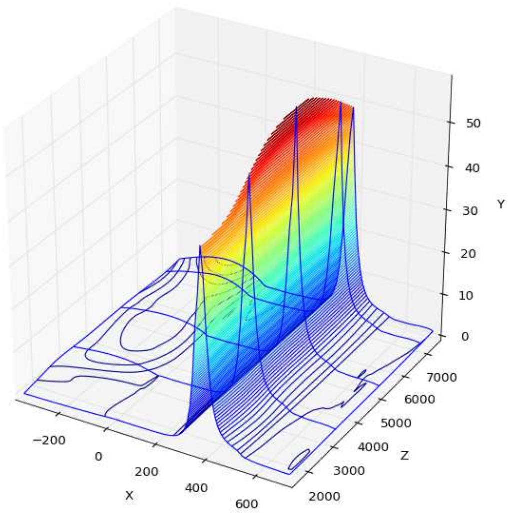


Figure 3: Duty Cycle and P-Theta Curve

Results & Discussions

The software's were really helpful to arrive at an Optimal Design, based on the results from Optistruct, materials at various portions were removed to reduce weight and fillets were added to the design.

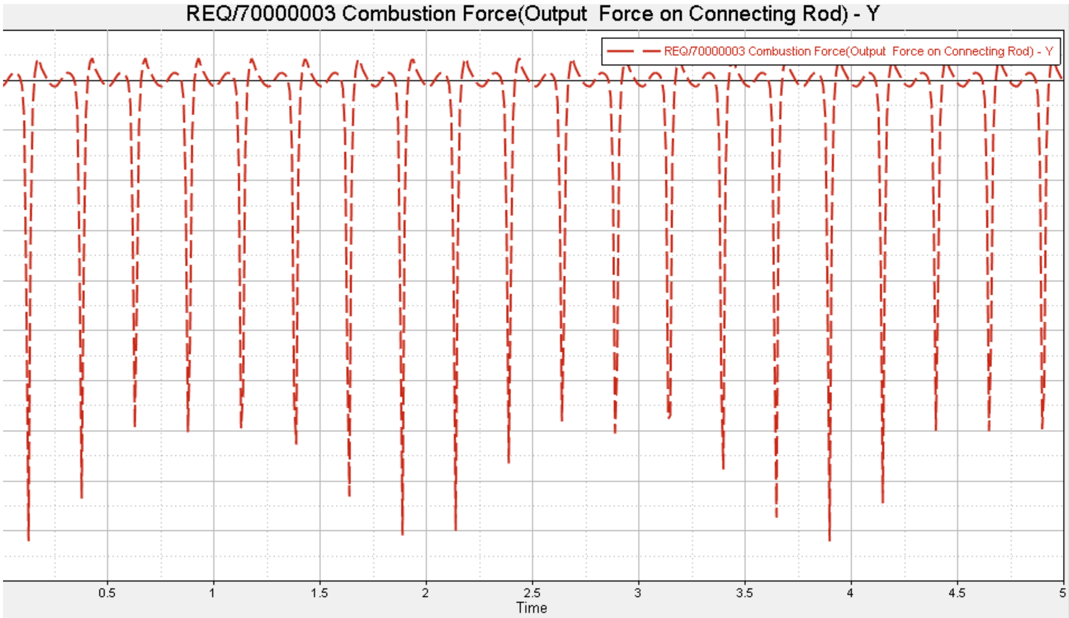


Figure 4: Force on the Connecting Rod

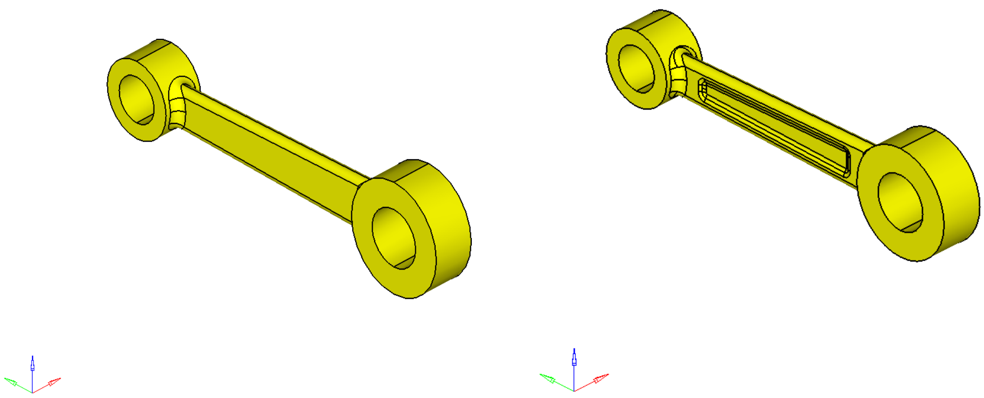


Figure 4: Original and Optimized Model of Connecting Rod

Benefits Summary

MBD with Flex body combines transient and optimization in a single thereby significantly reducing process time.

Challenges

Modules that enable the user to calculate the thermodynamic force on the piston would be of immense help. Default inbuilt templates representing Crank train assembly would ease the process further.

Future Plans

The hydrodynamic effects on the Connecting rod with respect to oil film thickness in the bearing and effects of Bolt preloads are to be considered.

Conclusions

The approach through a Multi body FEA with the help of hyper mesh, Hyper view, Motion View, Motion Solve, Hyper graph and Optistruct enabled us to optimize the design with better functionality and reduced overall development time.

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