Case study

Commonization of critical structure to achieve value engineering with Adams

With the commonization of swing bearing component using Adams, THCM expects savings worth ≈ INR 15 million in addition to reduced validation time and engineering hours

Using Adams for product validation and development has also helped reduced the validation time and engineering hours drastically

Tata Hitachi Construction Machinery Company Pvt Ltd. (THCM) is an India-based joint venture between Tata Motors and Hitachi Construction Machinery of Japan. THCM's portfolio in the machine segments includes excavators, wheel loaders, backhoe loaders, soil compactors, transit mixers, dump trucks, mechanical cranes, motor-graders and reach stackers. THCM manufactures from three manufacturing bases in Jamshedpur, Dharwad and Kharagpur.

Due to the impact of the Covid-19 pandemic which began in 2020, companies across the board faced a reduction in sales volumes. To counter the impact, THCM was keen to innovate on the best products while being mindful of design costs by pursuing operational efficiencies and cost reductions.

Towards this end, THCM began an engineering commonization exercise for the design of swing bearing for two weightage classes of excavators - 14-tonne excavator and 13-tonne excavator HEX.

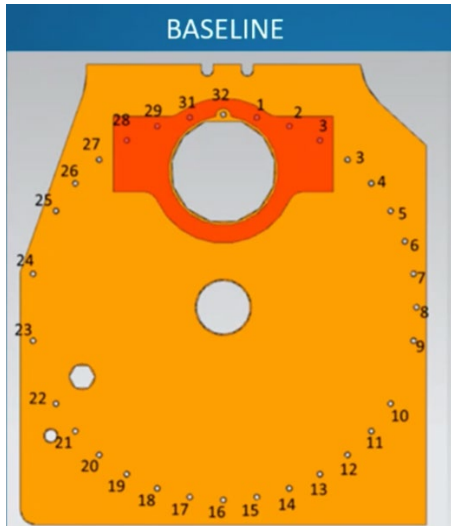
An excavator consists of a bucket, arm, boom and respective hydraulic cylinders as well as the upper structure and the under carriage. The team needed to study the coupling of the upper structure with the under carriage, which is done with a swing bearing - a roller bearing with an inner ring and outer ring, with bearings attached. Its purpose is to not only transfer load, but also allow rotational movement between the upper structure and the lower carriage.

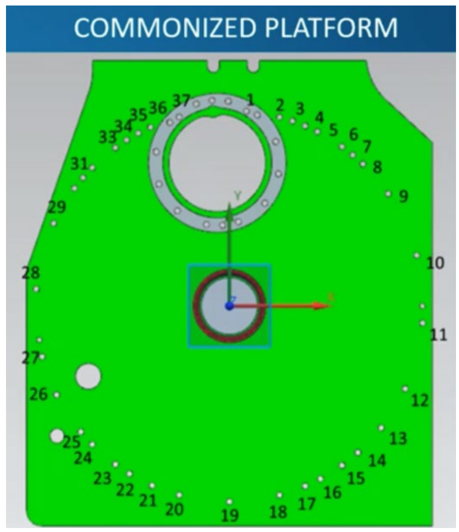
While design commonization of the swing bearing could help in reducing production costs, the traditional analysis method involved tedious calculations for several months before the team could provide any valuable design change inputs to the engineering department. The time constraints could be addressed by validating the design using Adams to simulate real-time loads subjected to the machine.

Multibody dynamics approach with Adams

Through a MBD (Multibody dynamics) approach using Adams, the modelling for both classes of excavators was done using various joints, bushings, and input motions and forces. Since model needed to be as accurate as possible to the real physics, a comprehensive Adams model was developed including all structures and components, and the inertia load. The cylinder rod end and pin joints were modelled using inline primitives. All other pin joints used revolute connectors. Swing bearing bolts were modelled using bushings, and contacts were assigned using track-ground and bucker-ground. Using a scripted simulation and force-motion combination, realistic behaviour was achieved.

Based on testing and field experiences, the team identified two loading operations that were needed to analyse the project. These were the swing-hit operation that generates transverse load on the machine and drop & catch, which generates longitudinal loads on the machine. These two operations generate most severe inertia loads on the swing bearing and consequently on the swing bolts, which hold the swing bearing.





Using in-house standards, the force vectors are displayed on the swing bolts in the swing-hit operation. Swing torque generated by the swing motor was applied as input. Together with the swing speed, the bucket was made to impact a solid block. The resulting de-acceleration of the machine generated enormous force and momentum on the swing bearing. In the drop & catch operation, an inertia force was applied on the machine. Interestingly, the team used motion as the input to actuate the boom cylinder. This was applied at the static position and then the arm was stretched to the maximum position and stopped there. This stopping or deceleration was done at the most extreme possible force. Then, the arm from the maximum position was dropped at full gravity force.

Testing against the baseline model

Before commencing on the commonization project, the team had conducted the base lining and benchmarks for a baseline design upon which to perform the commonization. The baseline CAD model was designed. The MBD model then drew information from field operations and testing information and generated the forces from it. These forces were sent to the Final Evaluation (FE) software to obtain the stress values compared with the actual test data. The comparison was made with the stress level because the stress data was available for all components. The approach was that if the stress values matched that of the ADAMs prepared load cases, the MBD model could be frozen. Else, changes were needed to the MBD model.

Once the baseline was prepared, the commonized geometry available with the MBD model and the stress values were compared with the baseline values. The design was then evaluated based on the stress criteria, which meant the stress value had to be lower or match the baseline values. If the criterion was fulfilled, the designs could be taken forward for parts development, proto testing and regular production. If not, they needed to go back to the commonized geometry and modify it with necessary changes.

While there were 32 bolts in the original design of the swing bearing, the new design had 37 bolts. Despite the overall increase in the number of bolts, the removal a 35 kg plate resulted in the design being cost efficient overall. The MBD model also allowed the spacing between the bolts to be different, such that the maximum force on each bolt decreased and each bolt took up the impact evenly to ensure optimal design.

Once suitable forces were obtained on the swing bolts, these were transferred to the FEA model of the mainframe. Comparing the stress results for the baseline and commonized platforms, it was clear that re-positioning the bolts for both the operations helped eliminate stress concentration in a particular region

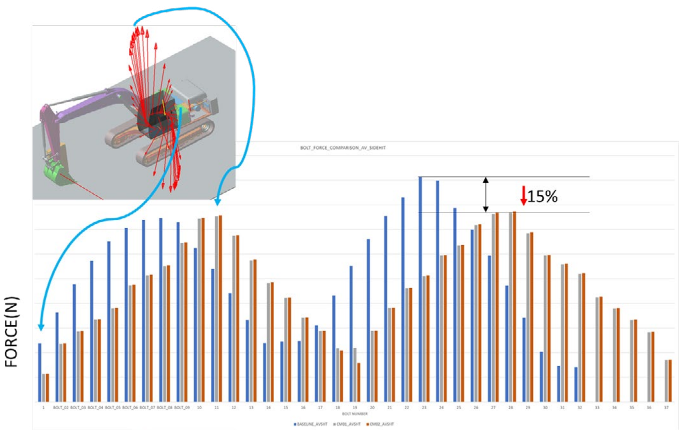
Significant cost and time savings

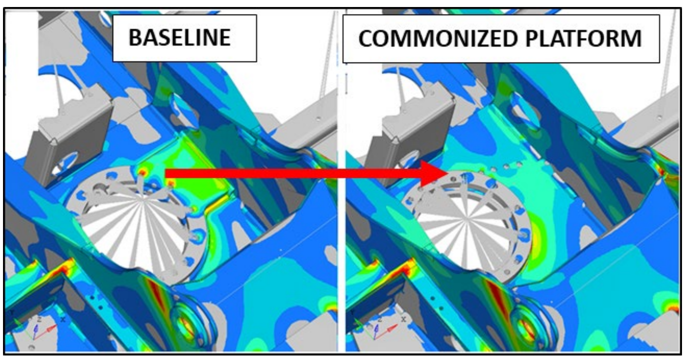
The commonization of the swing bearing component has had a huge business impact, with projected annual savings of nearly INR 15 million on annual product market demand.

Using Adams for product validation and development has also helped reduced the validation time and engineering hours drastically. While such projects would earlier take several months, they can now be done in a few weeks, further reducing the cost on resources and time.

Commonization helps in reducing manufacturing change over time by eliminating the use of new jigs and fixtures, so that the same process can be carried over to other machines.

Further, in the future, the company can use the commonization approach for other products as well. This could benefit the company and help it sustain itself in global markets by quickly performing proven virtual validation techniques without the need for extensive testing.





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