Performance Enhancement of an All Terrain Vehicle using Altair HyperWorks®

Overview

BAJA SAE India 2017 challenges students to design and manufacture an All-Terrain Vehicle (ATV) and compete in a 4 hour long endurance race where the durability of the vehicle is tested. The competition is based on a series of dynamic events that include acceleration, suspension and traction, maneuverability, and the endurance race. The teams are also evaluated based on their performance in the static events including design review, cost analysis, and sales presentation.

Team Kraftwagen, an ATV racing division of Sinhgad College of Engineering aims to build an ATV with a design and build quality which would sustain a 4 hour long endurance race. To continually improve their vehicle design by optimizing the weight of components with stiffness as a constraint, the team applies the Altair HyperWorks computer-aided-engineering (CAE) suite of tools. Altair HyperMesh® is applied for finite element model generation, OptiStruct®, the finite element solver and optimization tool, for topological optimization in the transmission and wheel assemblies, and HyperView® for post-processing results.

About Team Kraftwagen

Team Kraftwagen has a 5-year history of dedication to designing and building an ATV. Founded in 2012, to date, the team has built 5 ATVs, the latest being Legacy V. There was 28.5% weight reduction in the chassis and 23.5% over-all weight reduction as compared to the previous ATV. Over the years, Team Kraftwagen could enhance the power-to-weight ratio and build a rugged buggy with the help of Altair HyperWorks. The first ATV, Legacy 1.0 weighed over 400 kg, while Legacy V, weighed just 148 kg and had an enhanced acceleration which allowed it to cover 150 feet from rest, in 5.4 seconds.

Challenge

A significant challenge for BAJA SAE India 2017 teams is to determine an optimal design solution while meeting design constraints related to weight and rulebook specifications. To enhance the car performance, the team focused on optimizing the vehicle components while maintaining their functionality and stiffness and having significant mass reduction to increase the power-to-weight ratio. Driver comfort and his isolation from the engine vibrations also possess a major challenge. Considering driver’s safety in crash, a whiplash scenario was simulated giving the acceleration pulse as input. To meet the objective of manufacturing an ATV, student team members not only had to consider concurrent development design goals, but they also had to meet demanding build deadlines.

Achievements in BAJA SAE India 2017

<table>
<thead>
<tr>
<th>Event</th>
<th>Achievements</th>
</tr>
</thead>
<tbody>
<tr>
<td>M-Baja: Legacy V</td>
<td>• 3rd in Endurance • 4th in Design Evaluation • 5th Overall</td>
</tr>
<tr>
<td>E-Baja: Enigma 1.0</td>
<td>• 1st in Cost Evaluation • 1st in Manuverability</td>
</tr>
<tr>
<td></td>
<td>• 1st in Endurance • 1st Overall</td>
</tr>
</tbody>
</table>
Solution

Team Kraftwagen applied the HyperWorks suite of computational tools to implement their simulation-driven design process. HyperMesh was applied to generate finite element models and Optistruct was employed to solve and optimize the design and to increase the power-to-weight ratio. HyperView was applied to view and comprehend the optimized structure.

More specifically, for the optimization of the hub, CAD geometry was initially imported into HyperMesh and a discretized model was created. After assigning material properties to the component, design and non-design regions were defined and topological optimization was carried out on the component Fig. 1(a). Loads and constraints were given as inputs and the displacement and stress distribution in the component were evaluated Fig. 1(b). After analyzing the results, the team designed the geometry which could be manufactured Fig. 1(c), and was subsequently evaluated using linear finite element analysis to ensure that all the design requirements were satisfied.

To ensure driver safety, the team performed frontal crash specified weights in the roll cage using RADIOSS® solver Block 140 format Fig 2(a) & 2(b). The result was given as an input while simulating Whiplash.

The team also performed Modal analysis Fig. 2(c) on HyperMesh, which was done for locating the tabs positions on the firewall of the ATV. A free-free run on the Altair Simulation tool helped the team locate the necessary tabs positions at different frequencies; this was done by studying the various mode shapes at different frequencies.

Benefits

The optimization procedure applied to the vehicle components resulted in a weight reduction of 23.5% from the previous vehicle increasing the power-to-weight ratio. The weight optimization carried out resulted in improved acceleration times of 19.4% over 150 feet which enhanced the dynamic performance of the vehicle. The total chassis weight reduction was 28.5% while maintaining the overall rigidity. Driver comfort could be enhanced by isolating him from engine vibrations. Realistic results of front crash gave an acceleration pulse which was used as an input to simulate whiplash injury. Acceleration pulse of 10g acting during the crash ensured that the rollcage is safe for the driver. Post processing of the result in MATLAB resulted in Whiplash that was safe for a 95th percentile Indian Male.