AUTOMOTIVE

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Driving for Durability

E-Z-GO produces utility vehicles that can be used to haul materials over rough terrain.

E-Z-GO engineers quickly and accurately design a reliable utility vehicle part that saves manufacturing costs.

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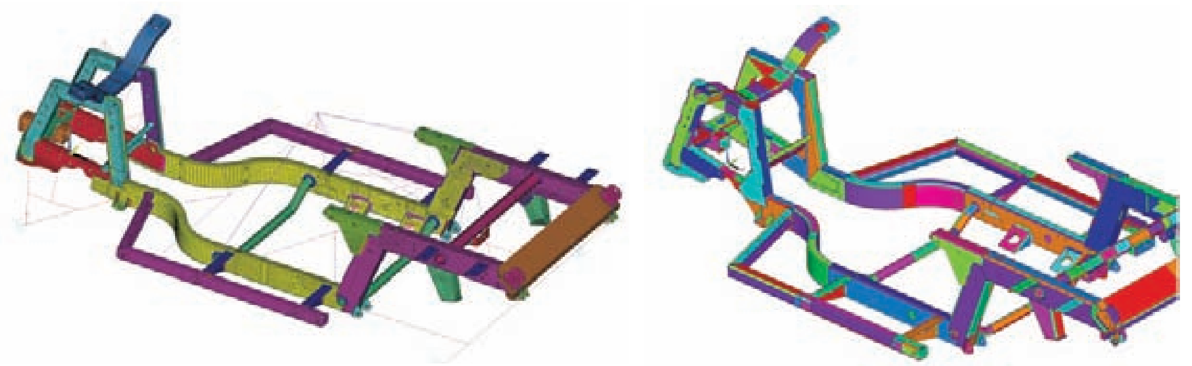
Designing rugged utility vehicles requires engineers to balance time and cost with durability. E-Z-GO, a Textron company located in the United States, develops durable, high-performance vehicles for a variety of off-road uses. In addition to being a leading manufacturer of golf carts, E-Z-GO produces turf maintenance vehicles, heavy-duty industrial material carriers, versatile personnel carriers and rugged trail utility vehicles.

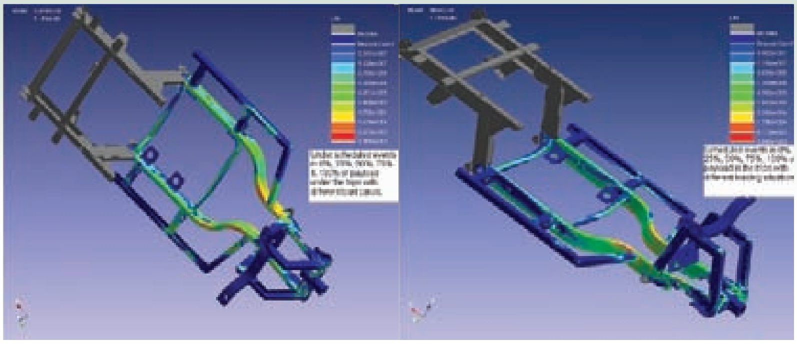
E-Z-GO engineers were given one week to redesign a utility vehicle frame to eliminate a bend that was causing manufacturing difficulties. The engineering team had a large amount of physical testing data available for the existing frame, which had been captured on the company's proving ground. This data consisted largely of time histories of loads measured at the spindle with accelerometers, and of stresses and strains measured at various points on the frame with strain gauges. Directly utilizing the load information would have required a very complex nonlinear model to incorporate the full dynamic behavior of the vehicle — one that might take four days to solve, and many simulation iterations to validate the model and evaluate different design alternatives.

The team used ANSYS Mechanical for this project because the software offers very powerful and flexible design optimization capabilities. Software from ANSYS makes it possible to optimize virtually any aspect of the design, including dimensions such as thickness, shape such as fillet radii, and placement of supports, load, natural frequency and material properties. For the utility vehicle application, the E-Z-GO engineering team took advantage of these capabilities to optimize the loads so as to achieve the desired stress level in the design.

The engineer assigned to the project selected six load cases from physical testing results, including static rolling, braking over bumper, wheeling in a pothole and cornering. He used the measured field-test data in one location near the redesign area to guide the optimization process. The stress in the X direction was most important from a fatigue standpoint,



The geometry of the original frame for the utility vehicle (left) and the geometry of the redesigned frame showing welds (right)



DesignLife (from HBM-nCode) simulation shows the frame life for scheduled events with different payloads for the original frame (left) and the new frame (right)

so this value was used as the design objective, while stresses in the Y and Z direction were used as state variables or constraints. The loads at the front and rear axle end were set as design variables. The engineer determined the best combination of input loads to match the field test data and then optimized the loading for the cases. To verify the accuracy of the load data, the simplified model then was run with the load data generated by the optimization to make sure that the stress levels in a second location on the frame matched the field-test data.

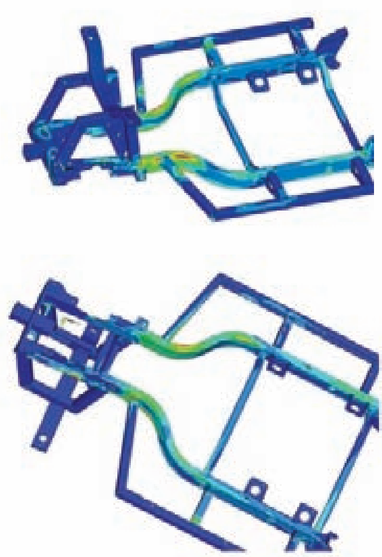
At this point, the simplified finite element analysis model behaved just like the real vehicle in terms of stress and strain on the frame, yet the analysis took only 30 minutes to run. The engineer modified the model to match the initial concept of the redesigned frame. Analysis indicated some weak areas, including the welding pattern, so the model was modified to strengthen the frame. He then evaluated the performance of the new design against each of the six load cases generated during the optimization process. The results showed that the maximum stress in the new frame was 5 percent to 10 percent lower than the current frame under each of the five payload situations.

The next step was verifying that the fatigue life of the new frame was better under the entire loading history. Engineers used DesignLife™ fatigue life estimation software from HBM-nCode to run the entire optimized load data against both the new and the old designs to get a complete picture of the frame durability. The fatigue life estimation predicted a longer life for the new design than for the old one.

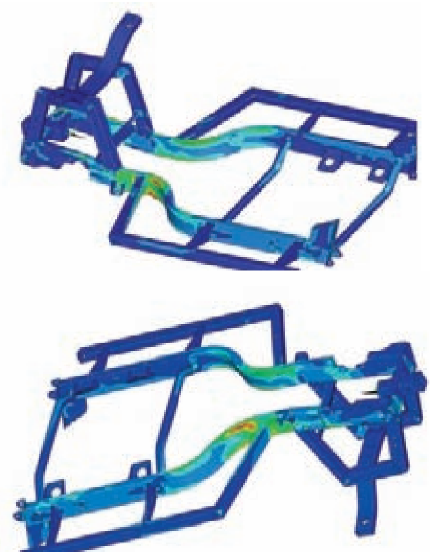
The final step in the design process was to run accelerated durability tests on the new frame to verify the fatigue life predictions and to demonstrate that the new design provides equal or better durability performance than the original frame. The optimized load data could be used as the loading environment for durability testing; however, E-Z-GO engineers needed to accelerate and simplify the test. They identified a simple step load that approximated the much more complicated time history data, which was acceptable because the goal of the test was to determine not the absolute durability performance but, rather, the relative performance of the two designs. The testing was completed in a relatively short time. It verified that the durability performance of the new design was better than that of the old design.

Based on the results of the finite element analysis, fatigue life estimation and durability testing, the new utility vehicle frame design was released for production. The new design demonstrated that its reliability and durability were at least equal to the previous design. This approach substantially reduced engineering costs and helped E-Z-GO get the new design into production faster. ■

HBM-nCode is now an ANSYS OEM supplier, which means that customers can efficiently access advanced fatigue capabilities within the CAD-integrated environment of ANSYS Workbench. The ANSYS nCode DesignLife product helps users answer the question "How long will it last?", helping to avoid iterative physical testing and speeding up the development process.



Original frame stress under a specific loading condition



New frame stress under the same loading conditions