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EMBEDDED CAE TOOLS MAKE A COMPLEX DESIGN SIMPLER TO ANALYZE

An integrated CAD-CAE environment helps engineers perform linear, nonlinear, and dynamic analyses on a wretchedly complex mechanism

I am a CAE Specialist with ASC, a company that creates specialty vehicles. One of the products that we designed is a convertible header latch, which is a complex mechanism that secures the front bow of the top to the windshield frame structure. It has as many as 10 or 20 parts made of different materials that deform plastically differently.

These types of latches are challenging for virtual product development (VPD) software because of the many design issues and tradeoffs, including contact, joints, flexible bodies and multiple material properties. We had been using linear analysis, which helped us identify where an issue existed, but did not allow us to define the high nonlinear stress ranges the part experiences. We had determined an integrated CAD-CAE environment provided by embedded CAE tools was best suited for helping solve complex linear, nonlinear, and dynamic problems. In turn, these VPD tools allow validation of operational effort, load capacity and abuse testing. The VPD tools are part of ASC's strategy for migrating to Design-Analyze- »

Confirm processes and away from Design-Build-Test-Break processes.

During an earlier evaluation, we found Catia's V5 analysis tools to be robust, quick, and easy to use because the V5 generative design approach utilizes feature recognition. When features on a part are changed, it is automatically remeshed. By using V5 models and the generative approach the productivity gain more than made up for the time lost converting the V4 models.

In this analysis, we were tasked with ensuring the latch mechanism functions within customer-supplied requirements for operational effort, abuse and load capacity.

Step-By-Step Analysis

We first used a vertical force abuse analysis to determine if the handle would break when an opening (vertical) force of 600N was applied. The handle could bend but not break off. Beforehand, we ran a linear analysis to omit unnecessary parts and reduce nonlinear analysis computing time.

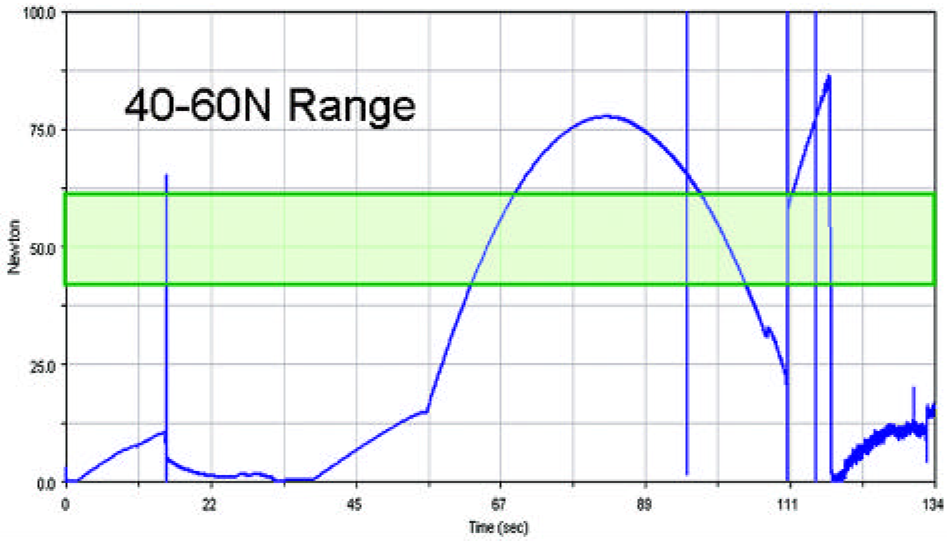
Initially, we meshed all the parts with Tetrahedron 4 (tet4's) linear solid elements, which are very stiff, to reduce computing time. The nonlinear analysis determined that all the high stress area hot spots were located in the handle, so we set it to tet10, a higher order element. The other parts were kept as tet4's.

We used a finer mesh in the critical stress areas using the local mesh feature, and we implemented local sag conditions around the area of contact and hot spots. Using localized refined meshing allows higher accuracy results in the critical areas identified during the linear analysis.

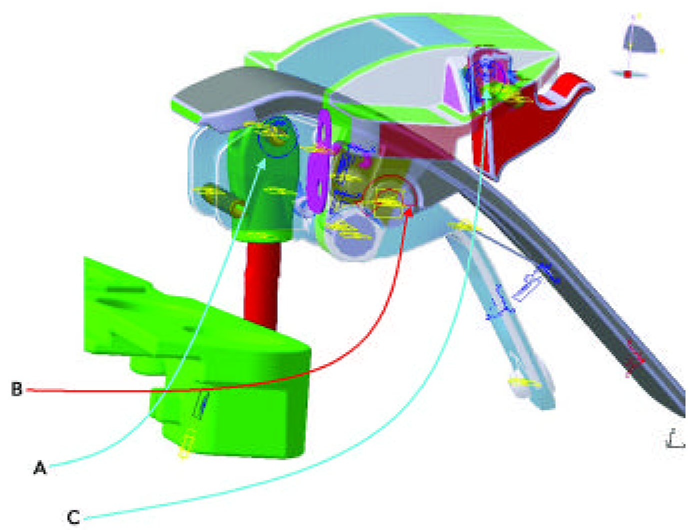
We defined different types of contact between bodies with SimDesigner Nonlinear. For example, when looking for tangency, contact or an impact, it allows two bodies to be constrained as "always glued together," "intermittent contact," or "never touch." The user can decide how the individual parts will interact, which makes the solver more efficient.

We then constrained the clamp mounting bracket and both handle-to-idler hinge pins. For bodies that do not collide and bodies contacting themselves, we set the contact to inactive. The bodies that did not need to rotate in relation to one another were set to glue. We set the bodies that could come in and out of contact with one another or would need to rotate relative to one another to touch. We then

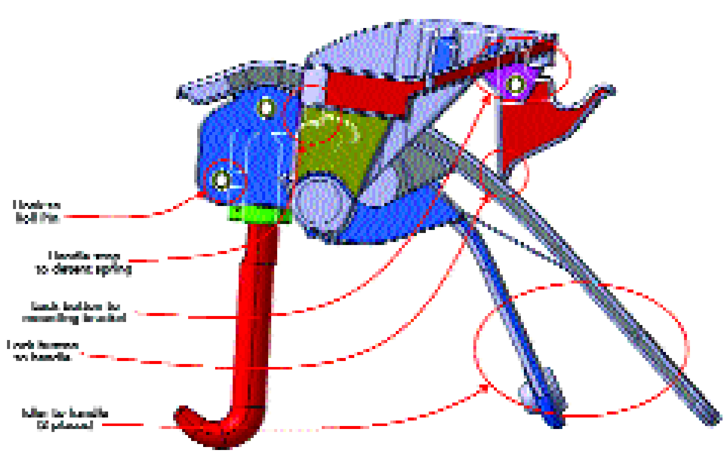
Force required to close latch mechanism



The force required to close the latch mechanism predicted that the specified range would be exceeded.



CATIA's DMU Kinematics tool was used to move the model to fully opened position, Sim-Designer Motion was used to build the model's motion constraints, including handle to the ground (A); and insert the torsional springs by hooking the clamp body to roll pin 1 (B) and the lock button to the long roll pin (C).



The parts eliminated did not reach yield strength and were not critical for maintaining the integrity of the mechanism, such as clamp_body, detent_spring, handle_spring, hook, receiver, rubber_stop, roll_pin_1 and roll_pin_2.

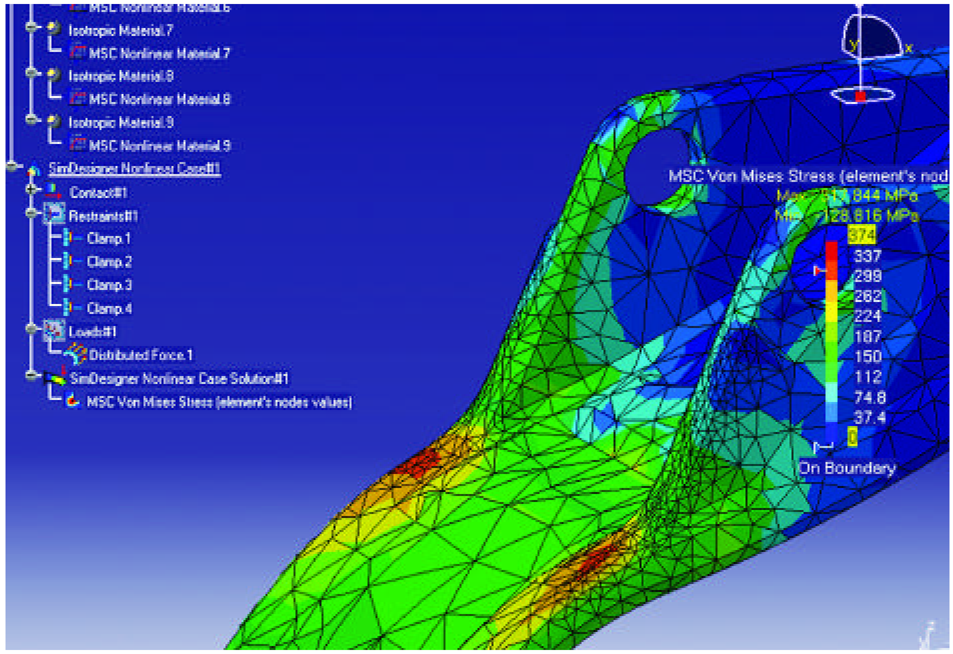
applied a 600N load in the vertical direction of the face near the end of the handle.

For the material properties, we used ZA8 zinc (the same material used in production parts) for all the components, except the 1010 steel connector pins. We did not validate the nonlinear material properties with physical testing, because we had a pretty good understanding of them. However any cold-working or heat treatment can lower or raise the yield and ultimate strength, dramatically affecting the nonlinear material curve, making this an important consideration.

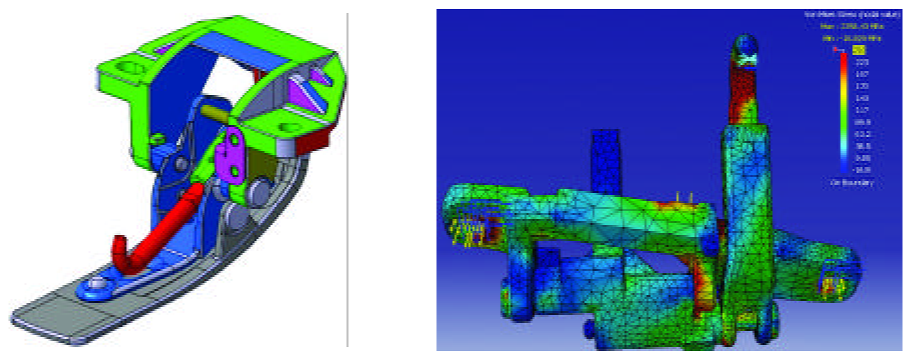
We set the contact bias at 90 percent, allowing the solver to converge faster because it doesn't have to reach the exact solution. Contact bias is a numerical method to help convergence in contact analysis using MSC.Marc, which is the solver in SimDesigner Nonlinear. For some applications, the contact bias helps improve stability in contact analysis. Coulomb friction was activated because friction affects material deformation or material flow on the contact boundary. This in turn is reflected in force and stress, etc. Additionally, friction generates heat which affects material properties in thermal-coupled analysis.

We fabricated the physical prototype out of ZA-12 which is not as strong as the ZA-8 production material. VPD tools enabled the use of ZA-8 production material properties, which with satisfactory correlation provided the performance data of production parts.

The handle design was simulated using ZA-12 and ZA-8 material properties. Additionally, a physical prototype was made with ZA-12 for correlation with



Latch handle abuse analysis in SimDesigner Nonlinear from modified design indicated the handle satisfied the vertical abuse specification.



Areas of high stress and failure found with SimDesigner Nonlinear analysis closely matched those identified during physical testing. The redesign determined no areas would fail, which also correlated with physical testing.

Table 1

Original Design Tests

Test	Material	Fail Load*
Physical Test	ZA12 (317MPa)	270N
Simulation	ZA12 (317MPa)	230N
Simulation	ZA-8 (374MPa)	370N

*Approximate

Table 2

Redesign Tests

Test	Material	Fail Load*
Physical Test	**ZA12 (317MPa)**	**780N**
Simulation	**ZA12 (317MPa)**	**600N**
Simulation	**ZA-8 (374MPa)**	**1,250N**

*Approximate

the simulations. The vertical abuse test of the initial design indicated the ultimate stress was exceeded in the handle using ZA-8 at approximately 60 percent load. The actual results are shown in table 1.

We modified the handle design and performed another simulation using ZA-12 and ZA-8 material properties. Additionally, a physical prototype was made with ZA-12 and tested for correlation. The actual results are shown in table 2.

The redesign using ZA-8 material properties provided an approximately 200 percent safety margin, which satisfied our customer's vertical abuse specification. Additionally, a simulation was run using the ZA-12 material properties, which indicated a failure at 600N. The physical test using the ZA-12 material determined failure would not occur until 130 percent of the load was achieved (approximately 780N). This was within 25 percent of the simulation results, which was within our correlation target—and voila, we confirmed the latch would function within the customer's requirements.

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ASC Toolkit

- Catia V4: http://rbi.ims.ca/4402-561
- Catia V5 and FEA/DMU Kinematics: http://rbi.ims.ca/4402-562
- MSC Software's SimDesigner and Motion and nonlinear tools: http://rbi.ims.ca/4402-563