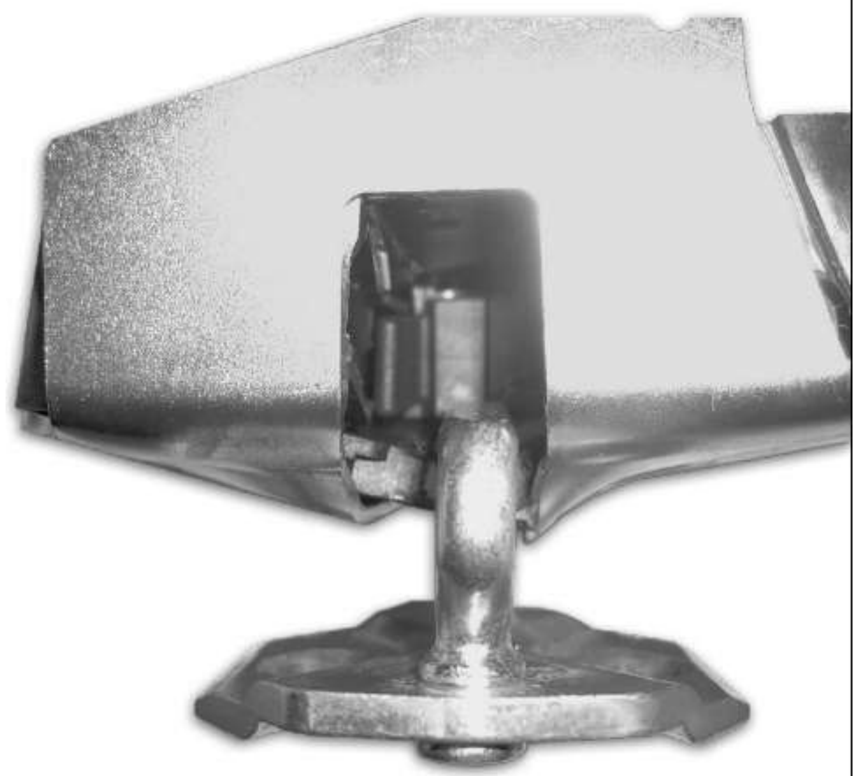
Kiekert Locks onto Car Door Safety with Realistic Simulation

Leading latch maker establishes virtual product validation process with help of Abaqus Finite Element Analysis



Keeping car doors securely fastened during automobile accidents is an important aspect of occupant safety. While airbags and seatbelts receive significant public attention, developing safe door latches is also a high priority for automotive manufacturers. Meeting pressing government safety standards and satisfying different OEM design specifications in a cost-effective, timely manner is a major challenge for automotive door latch suppliers.

German latch maker Kiekert, the world's most experienced manufacturer of automobile locking systems since 1857, produces 35 million door latches per year. Kiekert's customers, which include Daimler AG, Chrysler, VW-Group, BMW, PSA (Peugeot & Citroen), Renault, Ford-Group, and GM, also depend on their innovative technology for side-door latches, power sliding doors, remote operations, and liftgate-and trunk-lid actuators.

The critical components are those you can't see

The visible handle and lock cylinder of a car side door are connected to a complex inner system of cables, cams, levers, couplings, actuators, gears, pawls, and catches that is collectively known as a door latch system. When activated, the catch and pawl secure the door by clamping around the striker, a u-shaped piece of metal bolted to the vehicle's B-pillar (where the seatbelt is also fixed).

The side door latch enables a multitude of door functions, such as opening and closing from inside or out, locking and unlocking from inside or out, central-, child-proof-, remote-locking, and more. The entire system must continue to function for years at a wide range of temperatures, within specific noise and vibration limits, and also be strong enough to survive a crash. The integrity of the latch/striker connection is critical to that strength.

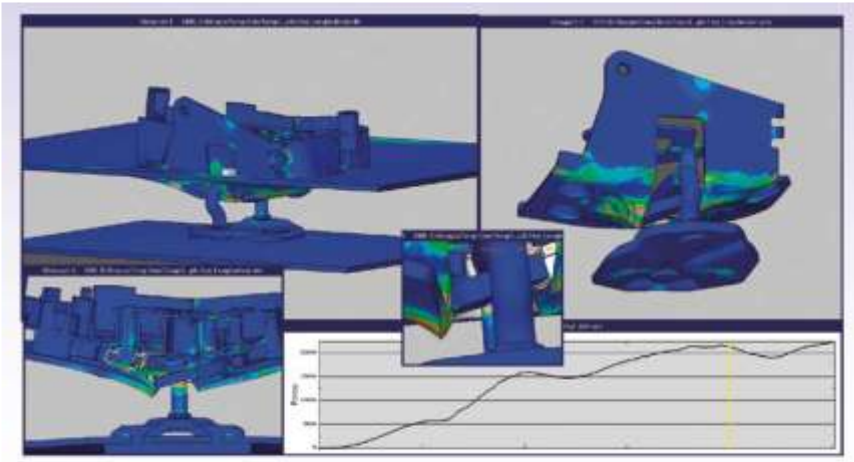
Governments and OEMs have different standards

"Strength testing of door latches is fundamental for us," says Thomas Waldmann, manager of the Technical Analysis and Simulation department at Kiekert. "Not only do we have to meet standards set by governments, but each car manufacturer has its own testing requirements as well."

Waldmann heads a global group that focuses on computer modeling of door-latch components with the primary emphasis on full virtual validation. The validation program (DSP&R, Design Simulation Planning and Report) was developed over many years and includes over 80 different simulations and calculations. "Kiekert's engineering tools provide a high-quality level of results," says Waldmann. "Our unique body of knowledge and our testing database ensure low project risks and the most efficient design process in the latch industry." Meeting global standards for strength testing (currently about 1.1 metric tons, or 11,000 Newtons, of force applied to the latch/striker connection from multiple directions) is relatively easy, he notes: the real work is passing the regulations from Kiekert's OEM customers. "Most customers' standards are about twice their government figures."

Quality, quickly

Kiekert begins with CAD models and runs them through a three-part process that includes finite element modeling, multibody dynamic simulations, and tolerancing—all of which must be done accurately in the least amount of time. Use of the virtual validation process has enabled Kiekert to significantly reduce the number of tests for product design validation, cutting their time to market for a new latch to less than 18 months.

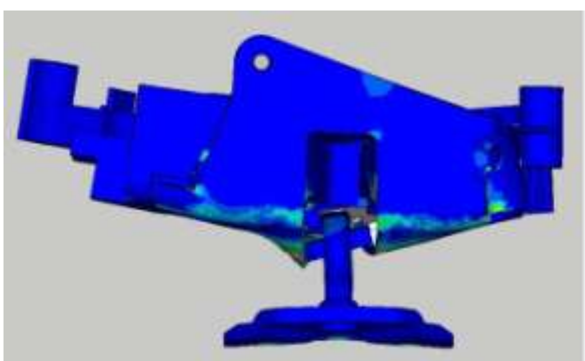


These images show different views of Abaqus finite element analysis of a Kiekert strength test in a longitudinal direction. The upper half of each figure is the latch with the test-plate (that simulates the door panel). The lower half of each figure is the striker on the test plate (simulating the B-Pillar). Left-upper figure shows the complete configuration. Right-upper figure shows only the latch and striker parts (without test rig). Left-lower figure is a cutting plane view through the catch. Small center inset image shows that the catch was pulled out. Graph at lower right indicates the reaction-force (in Newtons) reached during the test.

Abaqus unified FEA chosen for more complex analysis

The key to speeding up latch design and development at Kiekert has been Abaqus FEA software from SIMULIA. “Physical testing in a laboratory is slow and can’t realize the whole job,” says Waldmann. “We began our linear computer modeling of door latches with finite element calculations inside CATIA. Adding Abaqus enabled us to do more complex nonlinear simulation, which is what we need for accurate strength testing in three dimensions.”

Abaqus Unified FEA works well with Kiekert’s existing design software. “We can mesh complex parts in CATIA V4 and V5 and then export the meshes to Abaqus,” says Waldmann. “We use Abaqus for CATIA V5, in conjunction with Abaqus/Standard, Abaqus/Explicit, and Abaqus/CAE. We never have any problems getting what we want, because we have different ways to get our solutions.” Using the implicit and explicit solvers in Abaqus to solve the right type of problem is easy, Waldmann points out. “And modeling the nonlinearity of contact is something Abaqus does best.”



Postprocessing Abaqus FEA image of a Kiekert latch module after strength testing shows how the striker starts to pull out the catch through the mouth of the frame plate.

Choosing the elements for meshing the lock design is often task-dependent. Automatic meshing is a must in order to build models efficiently for Kiekert’s complex latch assemblies. By using tetrahedron elements, Kiekert can create a mesh in only half an hour—even though they need a little more CPU time for the job because they are modeling many small parts.

Waldmann’s group has a 16 CPU Cluster and primarily uses a Linux operating system. Most Abaqus jobs at Kiekert are run on 4 CPUs, providing substantial simulation throughput and efficiency. “We can run up to four jobs at once, usually overnight,” he says. They can also use UNIX platforms for calculation, or PCs with Microsoft Windows for Abaqus/CAE. An average job has between 700,000 and 1.5 million degrees of freedom.

Plastics versus steel and other design tradeoffs

Materials selection is important when modeling a virtual door latch. The first latches ever built were made entirely from steel and/or aluminum alloy. But today, multifunctional latches include plastic parts, even electrical motors, added for ease of function, noise reduction, or comfort.

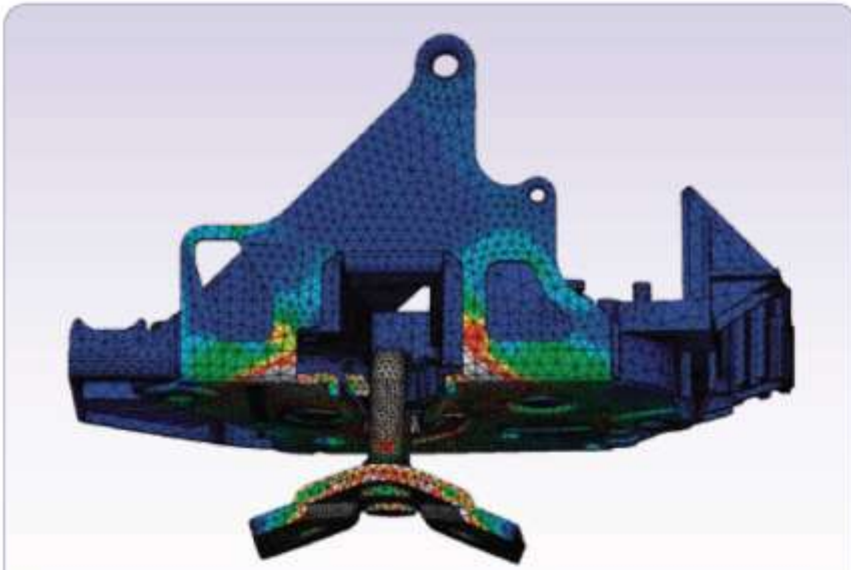
Kiekert has established a unique materials database over the years. "Accurate material data is the basis of exact simulation results," says Waldmann. "Kiekert has invested significant time and money in running scientific material tests to generate that data."

Using the Change Material function in Abaqus, Kiekert can evaluate plastics ranging from zero to 50 percent glass fiber content. But parts designed for safety must remain steel, Waldmann says, not only for strength but for fire resistance. "We have a long history working with different grades of steel with special heat-treatment capabilities. We search for the best balance between flexibility, strength, and abrasion. With the Change Material function, we can put a part through various stresses and see what works best. Sometimes we run the same job with the same geometry with five material variations."

Kiekert also uses FEA for evaluating temperature and noise/vibration, says Waldmann. "The parts of a latch, particularly the plastic ones, must continue to work between –40 and +85 degrees C (–40 to 185 degrees F). As for the noise testing department, they want more plastic to reduce noise whereas I want more steel for strength. We always need to satisfy both noise and safety considerations, but using Abaqus makes it easier to adjust your design and test the results."

Putting On the Pressure

When it comes to virtual strength testing, Waldmann's department comes down hard on their latch designs, loading 2–3 tons of virtual force (20,000N–30,000N) on the connection between latch and striker. All manufacturers require that strength tests are carried out along both longitudinal and transverse planes; sometimes vertical and/or transverse +45 degree rotation tests are included (rotational testing was a recent request from an OEM in the U.S.).



Abaqus 3-D FEA meshed model of car door striker/latch interaction under maximum force (up to 3 metric tonnes) at end of strength testing run. This test is on the latch in the primary position—when the door is completely closed. Strength tests on the secondary position (when the door is secured although not fully closed) are applied using lower forces. In this image the latch can be seen clamped through the loop of the U-shaped striker, holding fast despite deformation of catch, pawl, and B-pillar plate. Grey areas indicate highest strain.

FEA testing provides a safer way to evaluate latches than pulling apart real steel parts in a laboratory. "When we do virtual loading with FEA, we can make cutting planes during testing to look inside and see exactly what happened without the danger of steel shattering during physical testing," points out Waldmann. Using FEA, Kiekert engineers can also evaluate the sequence of events more incrementally, as stresses are applied to a latch, and observe internal structural changes that may not be reflected in the appearance of an actual latch at the end of reality testing.

Real Crash Data in the Future?

Since a latch is part of an entire door locking system, developing a theoretical forecast of complete latch system behavior during a crash will be the next step in increasing car door safety. "Kiekert has begun designing an integrated latch module in a holistic approach to optimize such door locking system behavior," says Waldmann.

For now, Waldmann's group has reached the point where FEA and other simulation tools they are using have enabled them to make the most realistic calculations in the latch industry. Such state-of-the-art simulation capabilities are one of the unique selling points that have made Kiekert the top latch supplier worldwide, according to Waldmann. "We spend a lot of time adjusting the geometry of our latches for the best result," says Waldmann. "The simulation department is an essential part of the Kiekert design process."

Postscript

Over 54,000 people a year in the U.S. are ejected from their vehicles during accidents, according to the National Highway Traffic Safety Administration. Although windows account for a majority of ejections, it is estimated that close to 7,500 people were thrown out of their car through an open door.

In an effort to reduce door-ejection statistics, the U.S., the European Union, Canada, and Japan have adopted the first global technical regulation (GTR) for motor vehicles to set minimum safety standards for door locks and retention components. Each country is aligning its domestic regulations with the world standard: voluntary compliance is in effect now in the U.S., becoming mandatory September, 2009, according to the National Highway Traffic Safety Administration. Most existing U.S. standards were established in the early 1970s.

For More Information

www.kiekert.de

www.simulia.com

www.edstechnologies.com

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