Virtual Product Development Helps LEGO Engineers Stretch Their Own Creativity

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Customer:
The LEGO® Group, Denmark
www.lego.com

Software:
MSC.Marc®, MSC.Patran™, MSC.Nastran™

Summary:
The LEGO group used MSC.Software products in the development of plastic parts to identify problem areas. Different safety tests could be simulated with MSC.Nastran and MSC.Marc, such as a compression test with MSC.Marc nonlinear analysis, or drop tests including linear stress analysis with MSC.Nastran. Thanks to the simulation, LEGO engineers could try more solutions and fell confident in their improved designs. Using MSC.Software VPD tools, the LEGO Group has reduced overall cycle time from concept to finished part, and achieved significant savings in materials.

Since 1932, the LEGO Group has been making a reputation for delivering quality products and experiences that stimulate creativity in children around the world. Today, LEGO makes software, watches, and clothing, as well as operates LEGOLAND theme parks, but its core products are still the plastic bricks that made it famous. More than 1.4 million LEGO parts are produced every hour making up the 100 million LEGO sets produced annually. With this many parts, every part and every change, even small changes in material usage, have a tremendous impact on costs. To validate products before they go into production, maximizing safety, and minimizing time-to-market and costs, the LEGO product development team uses MSC.Marc, MSC. Patran and MSC.Nastran simulation software.

More than 300 engineers and managers develop new designs for the approximately 200 to 300 new parts designed each year. Since multiple parts are used in each product, the number of new products introduced every year is much less. While simulation with Finite Element Modeling (FEM) may seem a little heavy-handed for plastic injection molded products, when you're the leading manufacturer of products to stimulate creativity, imagination, fun, and learning, you have everybody's attention: customers and competitors. Maintaining state-of the-art product development tools is imperative.

Jesper Christensen, a LEGO Group CAE consultant, says, "The type of analyses that we do on plastic parts includes strength/stiffness, strength/thickness, and fatigue analysis. Of course, the goal is to ensure safety, especially for products for the zero- to five-year-old market, as well as reduce material usage where possible or change from one material to another. In the future, we will be coupling flow and structural analysis to get the ansiotropic material data and residual stresses that form the filling."

As its two-year simulation implementation program ends, LEGO Group is quickly achieving its goals, ensuring that safety and quality are the focus of new product development. At the same time, LEGO Group has reduced dependency on physical prototyping, eliminating costly changes to tooling as well as substantially reducing manufacturing costs, including material and service life of molds. Christensen explains, "When you make creative learning toys for children, whether they're one-month-old or 85 years young, there's a lot of responsibility and pressure to make sure the toys are designed for safety, which means they must be made right the first time."

MSC Software

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The FEM team at LEGO Group is responsible for virtual development of parts and tooling, beginning in the conceptual development phase. The objective is to focus on product safety, as well as reduce overall cycle time, increase functionality of toys, and make material/structural knowledge available to more people within the organization. Christensen explains, "FEM delivers the ability to see mechanical behavior at an earlier stage in the product development process. So, we are trying to keep our designs virtual for a longer time. By determining how a part will behave at an earlier stage, there are fewer changes made to tooling, so the costs associated with making a physical prototype and making changes to molds can be substantially cut. In fact, with a virtual prototype it's possible to make almost all the changes before the tooling is made. When you keep the product virtual, the costs involved in making changes are minimal."

With new software comes new processes, and in an organization the size of LEGO Group, change isn't always easy. Implementation requires a well-thoughtout plan that proves the concept as new software and processes are implemented. At LEGO Group, FEM was implemented as a three-phase process, including proof of concept, training, and production implementation. Christensen explains, "The FEM implementation process was divided into three phases. During the first phase, we benchmarked different FEM products, deciding on MSC.Marc, MSC.Patran, and MSC.Nastran because of their features, ease of use, and technical support. The second phase included training, and comparing simulation tests with known results to better understand how the software should be utilized. The third phase includes implementing structural calculations in the development phase and establishing a FEM team that is capable of avoiding structural problems in LEGO tools and parts." Currently, the LEGO simulation team includes five people: four dedicated to product development and one dedicated to mold design.

Christensen says, "The most fun is to optimize the plastic parts. For example, the designer may not be sure if there is a problem when he brings us a design. We use the software for development, even before the design has been done. We also use the software to find the problem areas and sometimes to define a concept."

Testing conducted at LEGO Group specifically for safety includes compression, torque, tensile, drop and plumb drop tests, as well as tests for sharp points and edges. A plumb drop test is a non-standard test in which a mass is dropped from a height of 12 inches several times onto a part that usually has welds. Examples of these tests include linear stress analysis on a tool part for the 2x4 LEGO brick, using MSC.Nastran, or, using MSC.Marc, contact analysis on the same part to define a more realistic boundary condition. MSC.Marc nonlinear analysis can also be utilized to simulate a compression test on the 1x16 LEGO TECHNIC element. On this same part, MSC.Marc can simulate a torque test or generate a force-displacement diagram for contact analysis.

One of many benefits LEGO Group has realized with FEM is improved design. Christensen says, "We're not afraid to try a new solution. With simulation, our designs have been more stable. Simulation provides an opportunity to try more solutions and have the confidence that when you have a very strict schedule, and you come up with a virtual solution, it will work when it is made."

With simulation, LEGO Group has reduced overall cycle time, from concept to finished part. In some instances, design time is either the same or maybe longer, but actual production time is reduced because there are fewer late changes. "If we are able to reduce the molding cycle time, the cost savings can be significant," Christensen says. "We are more secure with the injection mold that it won't break down, which can be a significant cost. At the moment, a mold has to run nonstop for 24 hours with only two maintenance sessions. By reducing the number of breakdowns we increase productivity, too."

A tangible benefit of simulation is understanding where the stresses are and where they are not. With this knowledge, an engineer can make what might seem to be a very insignificant change of mass. But the resulting material savings can be great, especially for high-volume parts. Christensen explains, "Some of LEGO Group's part runs are 30 million or more, so a three percent reduction in materials can save 1 million Kronas [about $125,000 USD]. This year we saved $625,000 USD per year in materials on just five parts. It's not unusual for us to see that kind of savings over four to five parts per year."

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