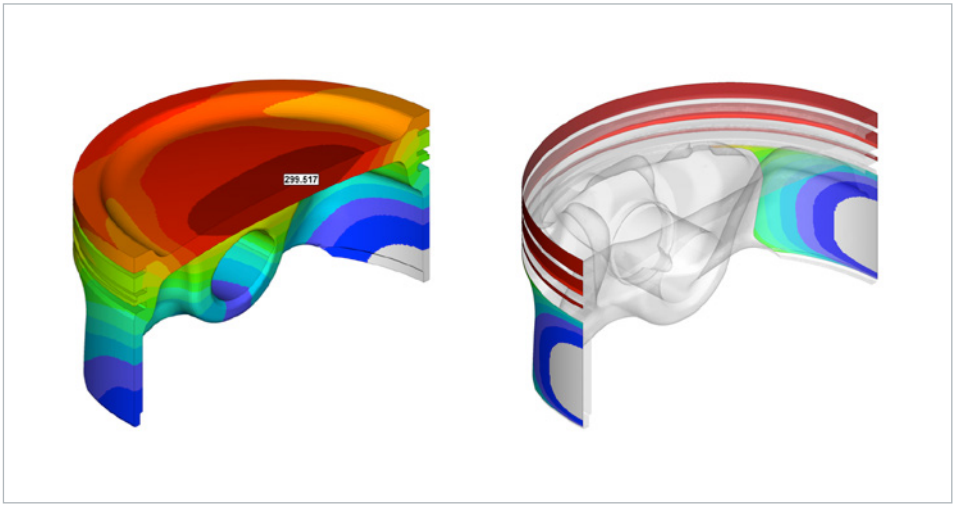
MAHLE Streamlines Simulation Reporting using Altair Solution



MAHLE

Driven by performance

Key Highlights

Industry
Automotive

Challenge
Make simulation results reporting consistent, more thorough, and simpler to perform

Altair Solution
Deployment of Altair's Automated Reporting Director

Benefits
- Reduction of non-value added work
- More engineering analysis, yielding better designs
- Consistency in customer reporting
- Improved collaboration

Customer Profile

MAHLE is a Tier 1 automotive systems supplier based in Stuttgart, Germany, with over 64,000 employees globally expected to generate sales of over $13 billion in 2014. The company maintains 10 different research and development (R&D) centers around the world, including locations in China, Japan, Brazil, England, India, and the United States. In North America, MAHLE generated sales of over $2.6 billion in 2013, boasting 29 locations and more than 10,000 employees. All of MAHLE's business units are represented in the region, Engine Systems and Components, Filtration and Engine Peripherals, as well as Thermal Management.

All light vehicle and truck OEMs with production operations in North America are supplied by MAHLE. The company serves the independent spare parts market though its Aftermarket business unit. In addition, MAHLE services motorsports customers in the region. A new MAHLE North American Headquarters opened in June 2013, housing MAHLE Industries, Inc.; MAHLE Aftermarket, Inc.; Engine Components USA, Inc.; and MAHLE Powertrain, LLC.

Scott Janowiak is a Senior Numerical Simulation Engineer at MAHLE who works mainly on pistons and connecting rods. He has been using Altair HyperWorks® for about five years. Altair has closely supported the team at MAHLE as members transitioned from other pre- and post-processing tools to HyperMesh® and HyperView®, pre- and post-processing tools contained within the HyperWorks computer-aided engineering (CAE) suite. When approached by Altair's product development division, Altair ProductDesign regarding other tools to help speed up the design process, a project was initiated to standardize the team's CAE analysis reporting.

Keywords: MAHLE, HyperWorks, HyperMesh, HyperView, Pistons, CAE

MAHLE Success Story

"All the simulation tools have really cut down the need for engine tests. We still should run a final test, but intermediate development testing can be eliminated with the use of simulation."

Scott Janowiak
Senior Numerical Simulation Engineer
MAHLE

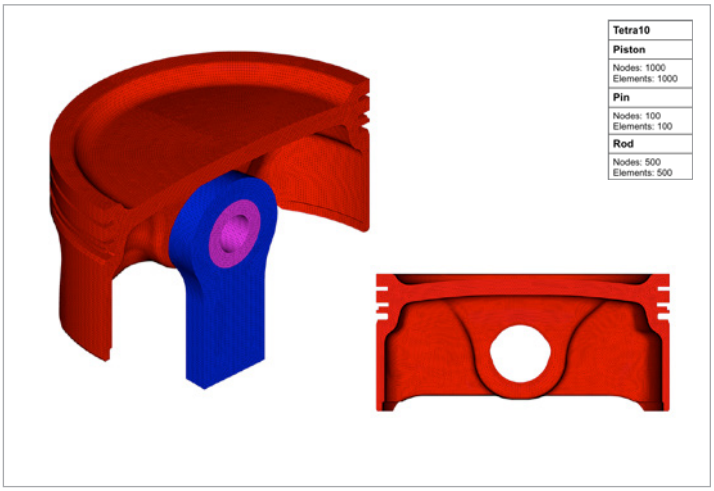
The Challenge:

Simulation is conducted for pistons, connecting rods, and pins, but pistons represent the volume of the group's work. The project sought to customize an automated reporting tool to accommodate the standard MAHLE piston process from start to finish, yielding an easily interpreted, standard report with lots of detail and flexibility. Six different engineers were at the time creating slightly different reports, which meant there were variations in how the simulation story was being told to customers.

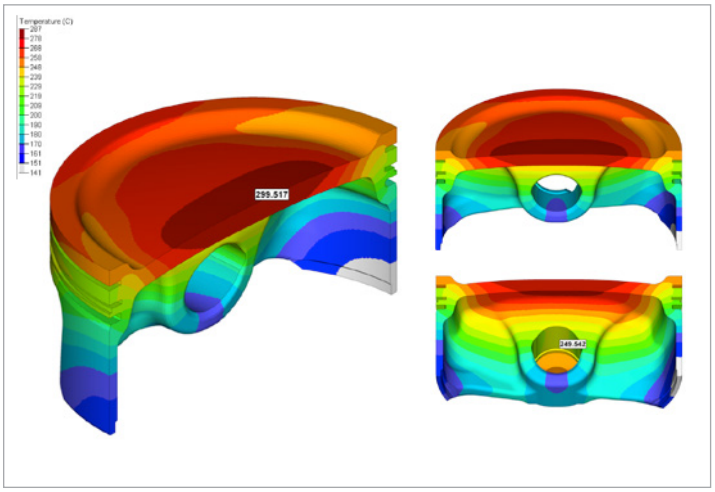
Pistons are very complex components; they must be designed to withstand very high temperatures from the combustion side. For example, newer engines running at speeds of 6000 to 7000 RPMs introduce a huge inertia load. Many different components, forces, and moving parts introduce many variables into the design process. The gas pressure force itself is large and only increasing, because engine manufacturers are trying to extract more power out of each piston, resulting in high loads for each part. Mechanical and thermal loading are all quite high for the new pistons; it is an intricate exercise to detail a piston and get it right. If the estimate were off by 10 degrees in the simulation, and the analysis indicated that performance is ok, a hotter temperature could cause a failure.

The main question to be answered by the simulation is whether the piston will survive the engine test. These are quite expensive. A pre-production piston needs to be tested before it is put into the engine to save physical testing costs and to enable more design iterations. Pre-production pistons require FEA analysis based on unknown load cases; the analyst does not know whether it will break or not. For example, if the test indicates low fatigue, something may be adjusted without running a lot of expensive engine tests. The whole point of the analysis is to enable the adjustment of the piston design so that it will ultimately survive the engine test.

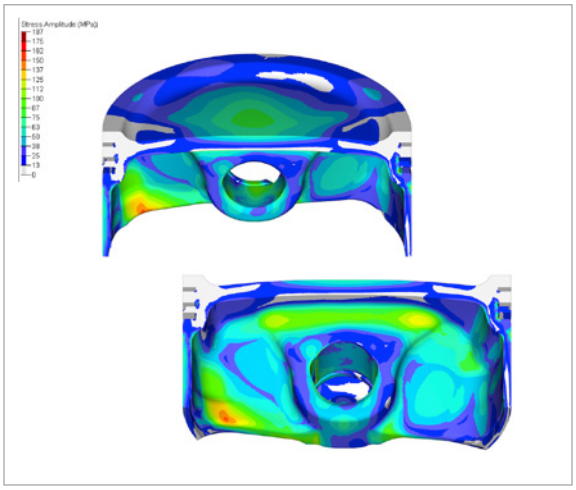
Lightweight pistons, high-efficiency engines, highly-loaded four-cylinder engines, more variability, and different materials all add to the complexity of the evaluation. Aluminum, steel, forged steel, and titanium all have different properties that must be understood and comprehended. MAHLE has a proprietary material database used just for this purpose.



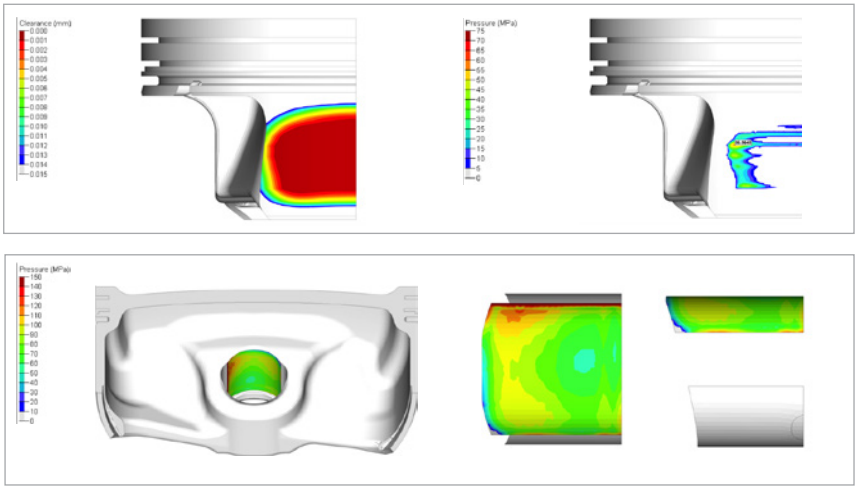
FEA Mesh of Piston, Pin and Conrod



Temperature Distribution



Stress Amplitude



Top image: Skirt Pressure (Right) Max Sideforce on ATS(Left)
Bottom image: Pinbore Pressure(Right) Max Gas Pressure(Left)

Many finite element analyses (FEAs) are performed annually at MAHLE. Once a design is past the proposal stage, there might be 20 to 30 iterations that occur. Several FEAs are done per piston. There are gas as well as diesel versions that must be tested, depending on the customer.

The Solution:

Altair ProductDesign's team suggested an implementation of Automated Reporting Director (ARD) to help MAHLE streamline reporting activity. ARD is a configurable and customizable reporting solution which is embedded in HyperView and loops over all defined groups and load cases, creating a single report page for each combination. ARD automates the detection of result maxima or hot spots, best view selection, creation of notes and legends, and highlights the most interesting results in an interactive tab. The tool is also flexible, allowing the analyst to step through each page before exporting it into PowerPoint or another desired format. Through an intuitive user interface, ARD allows the analyst to post-process results with given criteria, generate interactive overview result tables highlighting critical results, compare results between model iterations, and export results using preferred, customizable reporting templates.

The Results:

MAHLE's experience with Altair has been positive. According to Janowiak, having the freedom to adjust the process to meet his company's requirements is critical. A close collaboration has been forged between his team and Altair ProductDesign to create the automated reporting solution that improved MAHLE's day-to-day CAE workflow. While Altair developed the code, MAHLE described the current process and reporting requirements to ensure business alignment and an effective result.

Time saved is the main benefit of ARD; the team has cut down four to five hours of cropping and adjusting to 20 to 30 minutes for a big model. This reduction of time spent on non-engineering tasks enables CAE analysts to better utilize their time as engineers - yielding more analysis and better design, as opposed to time spent on more mundane tasks.

At this time, the entire team of CAE analysts at MAHLE's North American R&D center is using the same layout of the same report, with the same legend. This consistency benefits collaboration between engineers, as well as improves relations with customers, as there is less confusion evaluating the reports. The way the reporting is set up, MAHLE has control over the template, the view, and the parameters. Reactions from team members have been positive so far, and use of the tool has sparked interest from other simulation groups within the firm.

Before, users had to create a HyperView session, adjust all the pictures, snap a picture of each desired view, bring the visual assets into PowerPoint, crop and place, go back and create call-outs, and re-examine results to create notes for the report; this is now a push button operation. ARD automatically creates the layout for everything in HyperView, including 14 or 15 visual slides with standard views and designated load cases. It then enables the user to customize notes and views before export, producing a concise, suitably detailed report of the analysis results. Use of ARD has cut reporting time by several hours, freeing up engineers to do more analysis. HyperMesh and HyperView have been hailed for their ease of use, stability, and robustness, enabling more time to be spent on analysis as opposed to waiting or having the system crash.

Simulation has enabled pistons to be stronger, lighter, and cheaper. Reductions in material while meeting performance targets are possible through greater use of CAE. Simulation in general has cut down time to market, while use of ARD has increased engineering time utilization for the R&D team.

With respect to the future, Janowiak points out that capabilities are increasing every day. Using full models for analysis will become the norm. As processing speed and high-performance computing power and accessibility continue to increase, using bigger, more detailed models will no longer pose a problem. As to the use of the reporting tool, he is grateful that it has freed him from some of the more mundane daily tasks, enabling more engineering work, more investigations, and more studies of what will affect the design. This additional time gives Janowiak and other CAE analysts a head start as they strive to meet ever more elite performance criteria, and uncover issues that might otherwise have remained hidden.

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