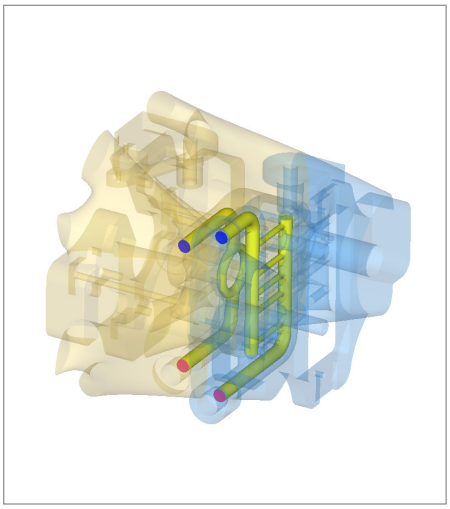
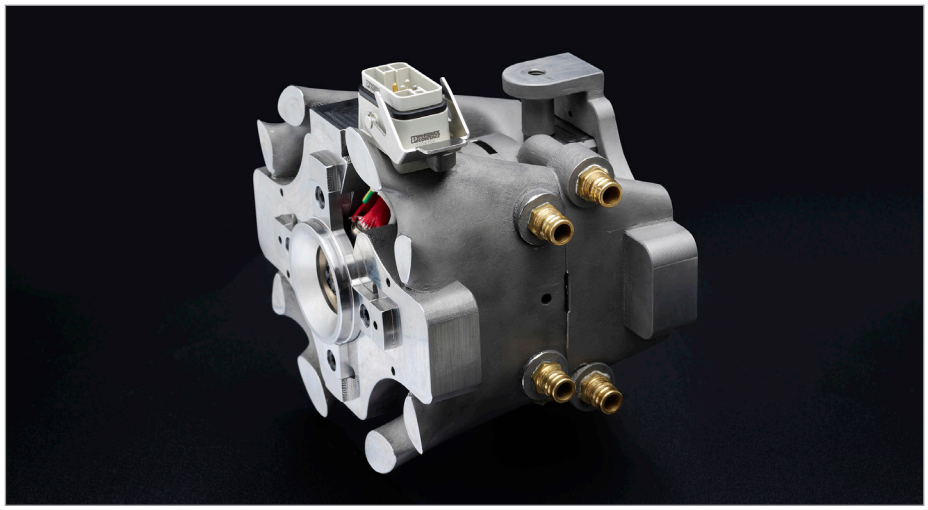
More Efficient and Economic Injection Mold Tools thanks to Topology Optimization, CFD Simulation and 3D Printing





PROTIQ
A Phoenix Contact Company

Key Highlights

Industry
General machinery and toolmaking

Challenge
Increase productivity through more efficient injection mold tools

Altair Solution
Development of optimized tools using simulation, optimization and additive manufacturing (model setup with HyperMesh, topology optimization and FE-analysis with OptiStruct, CFD-Analysis with AcuSolve, refinement with solidThinking Evolve).

Benefits
- Increased productivity due to shorter production cycles
- Weight reduction of 75%
- Shortened development time
- Reduced production costs (25%)

Toolmaking is usually characterized by cost-intensive, custom-made, single-unit production. Lately European and American manufacturers have experienced increased pricing pressure, caused by growing competition from Asian countries.

These competitors increasingly dominate the market, at least for standard tools. As a result, the European and American tooling industry has turned to innovative and high-quality solutions, offering its customers higher productivity and dramatically lower costs per part compared to standard solutions.

One of the most important parameters for higher productivity is the cycle time, which can be optimized through conformal tempering. In addition to reduced cycle time this optimization results in a reduced thermal deformation, leading to improved part quality. The shorter the cycle time, the greater the number of components that can be manufactured within the same period, significantly increasing the facility's overall productivity and economic viability.

Injection Molds from the 3D Printer

To create innovative tools, the industry increasingly relies on new manufacturing methods such as 3D printing (or additive manufacturing). The usual restrictions of additive manufacturing, such as limited part quantities, are not a major factor in single part production. Furthermore, the design freedom in 3D printing is virtually unlimited. When leveraging simulation and numerical optimization to consider structural, thermal, and manufacturing aspects for the design of an injection mold, highly efficient tools can be produced in a short time. Phoenix Contact started to evaluate these methods in 2009, initially using a polyjet printer and later adopting laser-sintering (plastic) and laser melting

Keywords: Optimization, additive manufacturing

Protiq Success Story

"We use OptiStruct, an Altair software solution, for topology optimization. With this solution we were able to build injection molds which weigh only 25 percent of the original part. This means we saved 75 percent of weight on each tool. In addition, the new tool was faster than all tools we built so far. We significantly reduced the cycle time by including conformal tempering and also the lead time to create the tools was reduced by 25 percent."

Ralf Gärtner
Unit Leader at Phoenix Contact and Managing Director at Protiq GmbH.

(metal) solutions. The company's business unit, Rapid Solutions, delivered fast toolmaking solutions and prototypes. Thanks to additive manufacturing and related short machine setup times, product ideas coming directly from the CAD system could often be realized within the next day and delivered to the customer right away.

This approach turned out to be very successful, and strong demands for these solutions led to the purchase of new facilities. At the end of 2016, the business unit Rapid Solutions was spun off into a separate enterprise within Phoenix Contact, named PROTIQ GmbH.

One-click Order for Additively Manufactured Parts

PROTIQ soon realized the high demand for individual tools made of different materials and decided to offer its solutions globally. Via the PROTIQ-platform (www.protiq.com) customers are able to upload their digital 3D data, calculate the price online, and have the final component delivered in no time.

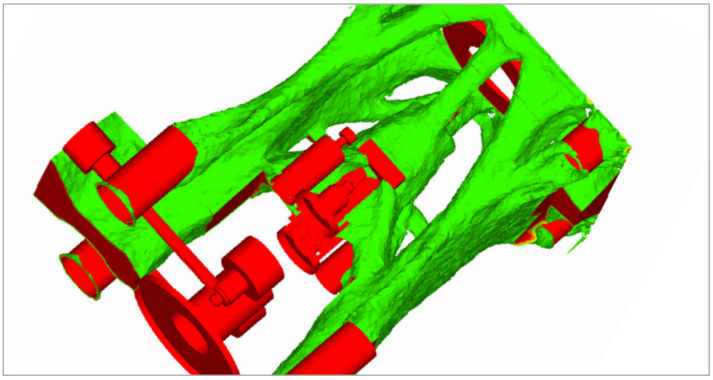
However, the company offers more than just the production of 3D printed parts. To fully benefit from the advantages of additive manufacturing, PROTIQ also leverages topology optimization and simulation to design the tools. Based on load case descriptions and other boundary conditions, such as desired internal channels, engineers are able to determine the optimal structure of the component prior to production. This approach ensures that only the necessary amount of material is used. The final part is much lighter than previously possible, leading to lower production costs as well as improved handling of the injection mold in operation.

"We use OptiStruct, an Altair software solution, for topology optimization", said Ralf Gärtner, Unit Leader at Phoenix, Contact and Managing Director of PROTIQ GmbH. "With this solution we were able to build injection molds which weigh only 25 percent of the original part. This means we saved 75 percent of weight on each tool."

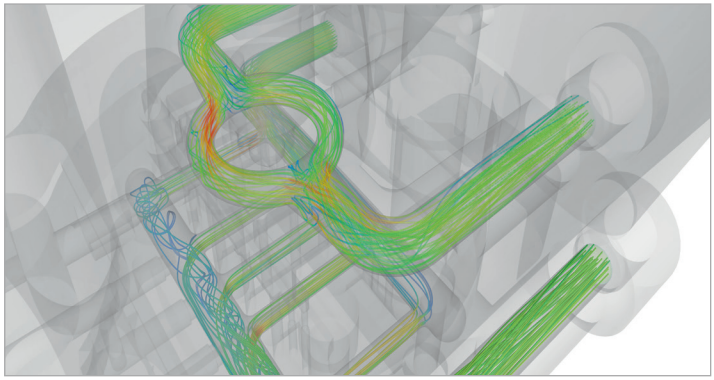
"In addition, the new tool was faster than all tools we built so far," Gärtner continued. "We significantly reduced the cycle time by including conformal tempering and also the lead time to create the tools was reduced by 25 percent. This was mainly due to the 3D printing process which allowed us to integrate many functions within the tool, easing and speeding up the formally manual assembly process."

The Pilot Project – Optimizing an Injection Mold

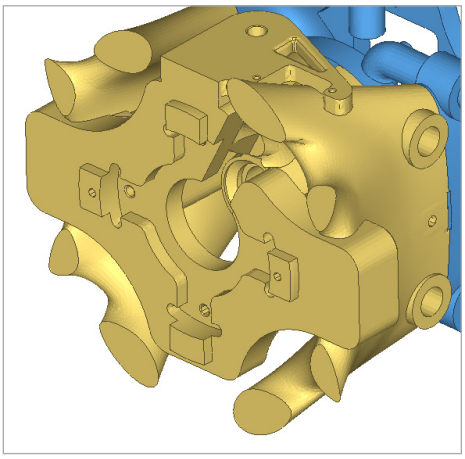
To realize the first project, PROTIQ turned to Altair's consulting unit ProductDesign. The Altair ProductDesign team supported PROTIQ during the entire simulation process and contributed to the development of the first prototype.



Topology optimization using HyperWorks. In compliance to the loadpaths material is only added where needed to reach the required stiffness and strength goals.

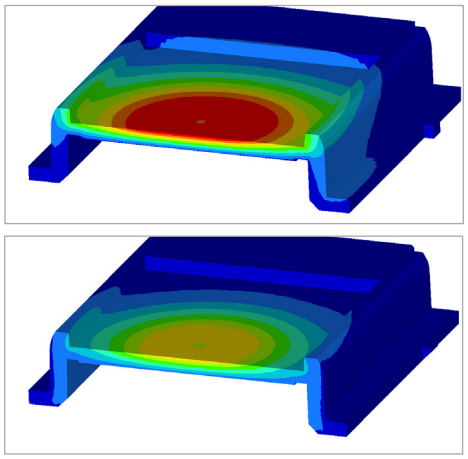


A conformal tempering reduces the thermal deformation, leading to better component quality while cycle times are shortened.



The refined geometry of the component servers as the input for the 3D printing.

EOS 3D printing machine for selective laser sintering.



Comparison of the temperature distribution before (above) and after (below) the optimization

In the first step, PROTIQ handed the geometry of the available design space over to Altair ProductDesign. Following that, load cases and boundary conditions were defined in close consultation between the teams of both companies. Based on these requirements, Altair's engineers created the optimization model in HyperMesh®, the integrated pre-processor of Altair's HyperWorks® suite. Subsequently, the model was used to conduct a topology optimization with OptiStruct®, Altair's FE solver and optimization tool. The optimization result was refined and prepared for 3D printing with solidThinking Evolve®.

To validate the optimization result, the engineers used OptiStruct again and conducted additional FE analyses of the optimized structure. In parallel, Altair ProductDesign also simulated the tempering of the injection mold with AcuSolve®, the CFD tool of the software suite. By doing this they were able to determine the cooling behavior of the product to be manufactured as well the needed cycle time.

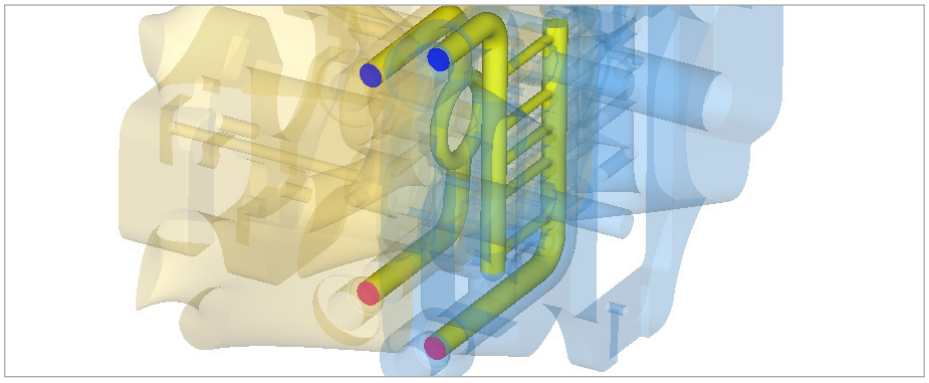
Lighter, Better, Faster!

The result of the work was an injection mold which was 75 percent lighter than the original tool created a couple of years ago with traditional methods. Conformal tempering was integrated into the 3D printing process which led to a dramatically reduced cycle time.

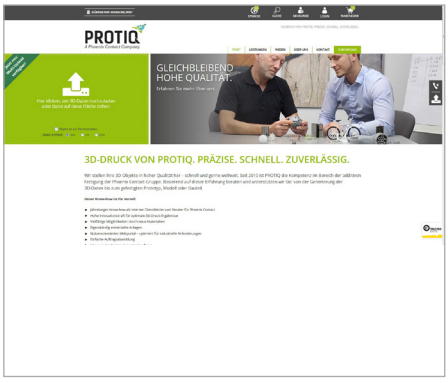
The lead time for the manufacturing of the injection mold was also reduced by 25 percent since the engineers were able to integrate functions already in the 3D printing process. This reduced the final manual assembly time of the tool further.

Thanks to shorter manufacturing lead time, production costs of the injection mold were also significantly lower.

Based on these results, PROTIQ adopted the Altair HyperWorks suite for their in-house development team and now offers all required services from one source, via the PROTIQ-platform.



Cooling channels can be directly created within the additive manufacturing process.



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Altair is focused on the development and broad application of simulation technology to synthesize and optimize designs, processes and decisions for improved business performance. Privately held and headquartered in Troy, Michigan, USA the company operates globally to serve customers in a diverse range of industries including automotive, aerospace, defense, meteorology, architecture and construction, energy, electronics, and consumer goods.

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HyperWorks is the most comprehensive open-architecture simulation platform, offering technologies to design and optimize high performance, efficient and innovative products. HyperWorks includes modeling, analysis and optimization for structures, fluids, multi-body dynamics, electromagnetics and antenna placement, model-based development, and multiphysics. Users have full access to a wide suite of design, engineering, visualization, and data management solutions from Altair and its technology partners.

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