Topology Optimization and Casting: A Perfect Combination

Using topology optimization and structural simulation helps a casting company develop better products faster.

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Engineers usually need to ensure both functionality and zero defects during component production. This often can be achieved by simulating production processes and operating conditions in the virtual world. Development teams in the machine tool industry need not only to prove the mechanical strength of components but also to take into account rigidity and cost.

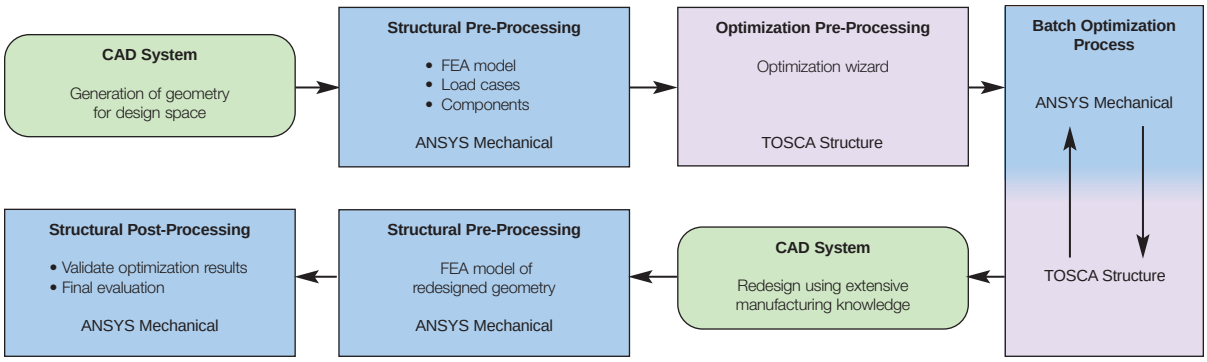
Heidenreich & Harbeck AG in Germany was established in 1927 as a foundry for cast iron components. Today, the company's range of capabilities has expanded to include modern machine tools for finishing large, quality castings that have high accuracy requirements. The company's in-house development department assists customers' designers and develops castings of complex machine structures according to customers' specifications.

The comprehensive software portfolio at Heidenreich & Harbeck contains several 3-D CAD tools, process simulation software for casting processes and numerical control (NC) machining, a sophisticated cost calculation tool based on 3-D CAD models, and project-planning software. In addition, Heidenreich & Harbeck uses ANSYS Professional software for the simulation of mechanical properties. To provide optimal design proposals to accelerate the development of large castings, the company obtained TOSCA® Structure software from German-based FE-DESIGN GmbH. This product interfaces with ANSYS Professional software.

In the past, the engineering team designed structural components with primary consideration to manufacturing restrictions. But structural analysis of these component designs often revealed weak points, especially for parts with a large number of load cases. Engineers then had to perform time-consuming iterations with alternating modifications of CAD design and structural analysis in order to fulfill customer requirements.

Currently, the Heidenreich & Harbeck development process starts with modeling the design space, which usually is easy to define. Engineers import the design space geometries into ANSYS Professional software and then generate meshes. Boundary and loading conditions are applied. Groups of volume elements that are required for optimization are defined in ANSYS Professional technology as components. The engineering team exports solver input files from the ANSYS Professional tool and imports them directly into TOSCA Structure software with the latter's user interface. Using this wizard-based technology, the optimization setup can be executed with a few mouse clicks by re-using group definitions from ANSYS Professional to

Topology optimization of support arm for paper unwinder
Courtesy Bielematik.



Scheme of topology optimization using TOSCA Structure based on solver from ANSYS

define the design area, frozen areas, evaluation areas for design responses, and areas for the application of manufacturing constraints. The optimization procedure is carried out in a batch process. TOSCA Structure software iteratively launches the ANSYS Professional solver for the analysis of the design space model and then launches the optimization module that evaluates results and changes material properties. Users who want to remain in the familiar ANSYS product environment may transfer the results produced by the TOSCA Structure product back to ANSYS Professional for post-processing using a file containing the material property values for the finalized optimization.

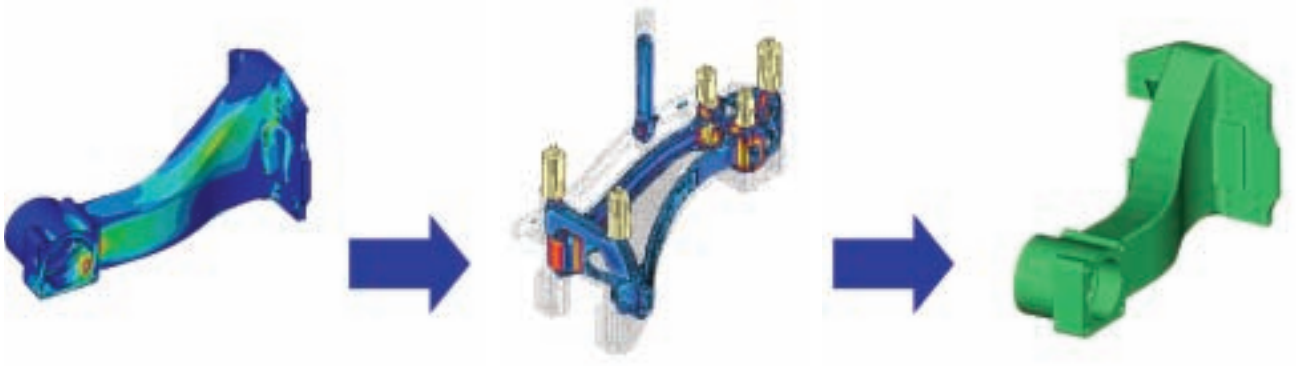
Heidenreich & Harbeck uses an optional module from FE-DESIGN called TOSCA Smooth to convert the optimization results into IGES or STL files containing isosurfaces and cutting splines based on the normalized material distribution.

For the design of castings, consideration of manufacturing constraints plays a very important role. It is essential to take into account demolding constraints for parts with low-cost restrictions. For a part that is loaded by an eccentric force leading to a torsional loading condition, a non-restricted optimization will generate a hollow section that would lead to high torsional rigidity. By applying a demolding constraint in the TOSCA Structure tool, the engineer can obtain a design proposal that is less rigid but has no undercuts and cavities and may, therefore, be manufactured without the use of cost-intensive cores in the sand mold. An automatic or user-defined parting plane may be specified. For the design of stiffening ribs, the casting constraints may be coupled with a wall thickness constraint.

A customer provided Heidenreich & Harbeck with the design space of a support arm for a large paper roll unwinder loaded with an eccentric force. The design with no casting restrictions led to a hollow profile without accessibility for fastening screws. A second optimization with casting restrictions resulted in a two-beam structure. The final design combined the benefits of both proposals (accessibility for screws along with hollow profile for cable and tube-laying, which the customer added to the specifications after he became aware of the first design proposal). Due to topology, optimization rigidity was increased by 25 percent, and weight was decreased 34 percent compared with the former two-piece design.

In another project involving a vertical lathe housing, the customer delivered two-dimensional sketches with the expectation of final pattern drawings within only three weeks. Using TOSCA Structure software, the rigidity requirements were fulfilled with minimal material consumption, and time-consuming design iterations were avoided. This reduced development lead time by approximately 50 percent. ■

Visit www.huhag.de and www.fe-design.de for further information.



ANSYS Professional simulation results, which are evaluated during the optimization process

Simulation of the casting process

Final component design