Simulation Enables 98% First Time Throughput for Complex New Parts

A foundry, supplying exhaust gas recirculation (EGR) valve castings to a major automobile supplier, began experiencing problems and that automotive supplier urgently needed to find an alternative source. Epcor Foundry, in Cincinnati, Ohio, was awarded the business. Epcor's challenge was to get the new part up and running quickly while avoiding the quality problems that the previous supplier had faced.

Epcor used ESI Group's QuikCAST casting simulation software to evaluate the initial mold design. They were able to identify several areas where the simulation showed porosity would be a problem. Engineers ran a series of alternative mold solutions while adding risers to feed molten metal to compensate for shrinkage in critical areas of the mold. "We constructed a design that the simulation said would work nearly perfectly," said Mike Maratta, Plant Manager for Epcor Foundry. "The result was 98% first time throughput for the initial parts, much better than you would expect to see on a complex part like this prior to simulations."

Epcor Foundry specializes in producing green sand aluminum castings for the automotive, heavy truck, automotive aftermarket, fueling, bulk handling, pump and air movement industries. In addition to castings, the company provides turnkey solutions including foundry tooling, heat treatment, machining, polishing, and painting services. The company's equipment includes a DISA Match130 (20 X 24 flask) and a Sinto FBO III (20 X 24 flask) automatic molding machines. Epcor's parent company, Seilkop Industries Inc., operates a number of businesses centered on sand casting, CNC pattern making, progressive stamping dies, Blanchard grinding, and roll repair.

Traditional mold design process

In the past, Epcor patternmakers designed molds for aluminum castings based on their experience. The molds were validated after a series of trials on the production machines. A problem with this approach was that the design rarely came out right the first time so several rounds of costly modifications and retesting were usually required to achieve the desired product. In the case of the EGR valve, besides adding to the cost of the program, it would simply not have been possible to meet the customer's aggressive delivery requirements using the traditional approach.

Epcor has been using the new approach that involves using simulation to evaluate the initial mold design. From there, they can test alternative solutions virtually, rather than on production machinery followed up by tooling adjustments. Epcor looked at several different casting simulation software packages before deciding on QuikCAST which simulates the filling and solidification of the casting. QuikCAST is affordable, easy to use and also offers an upgrade path to a more powerful, high end program. Air back pressure, filters, mold roughness, thermal exchanges, die coatings and gravity are all accounted for to accurately simulate standard casting processes, ranging from gravity sand casting to high and low pressure die casting. QuikCAST features a unique thermodynamic material database calculator that allows users to enter the chemical composition of the alloy. From that, they are able to obtain the temperature dependent properties required to accurately simulate the casting process of the foundry's exact alloy. "We tried QuikCAST on a few trial parts and found that it was able to accurately simulate our molding results," Maratta said.

Simulating initial mold design

Paul Kiefer, Senior Design Engineer for Hitech Shapes and Designs (a sister company to Epcor foundries) performed the simulation of the EGR valve casting process. He began by converting the

CAD model of the EGR valve provided by the customer to an STL file and importing it into the QuikCAST software. He then created the initial design of the mold using the software's user interface. The software then automatically produced a block-structured mesh. Kiefer defined the process parameters along with material properties, fluid and thermal conditions. The software then produced output that enabled Epcor to visualize the mold filling, solidification process and view the resulting part.

"When I simulated the initial mold design, it was obvious that porosity was going to be a challenging issue," Kiefer said. "Viewing the simulation results, I was able to determine that in several key areas the aluminum was solidifying early in the cooling process, creating isolated pockets of liquid metal that could not be fed as they solidified. Most metals are less dense as a liquid than as a solid so castings shrink upon cooling. As these pockets solidified, it would not be possible to replace the volume lost to shrinkage and the result would be porosity that would create leak paths and potentially cause the part to fail. The porosity would have been detected in physical testing and additional process trials, with a very real possibility that the automobile manufacturer's line would have to be shut down due to lack of parts."

Addressing porosity with risers

Once the baseline simulation model was set-up, the next step was to begin making changes to the simulation model in an effort to eliminate porosity. Kiefer considered several different approaches to addressing the problem including, opening up the gate to the part, changing the part orientation or adding risers. Kiefer felt that most promising approach was to add risers, which consist of reservoirs built into the mold that feed metal to the casting as it solidifies. Therefore, shrinkage occurs in the riser and not the casting. Risers must be carefully designed to work effectively. The riser must cool after the section of the part that it feeds. The mold must also be designed so that the area of the casting connected to the riser must be the last to solidify.

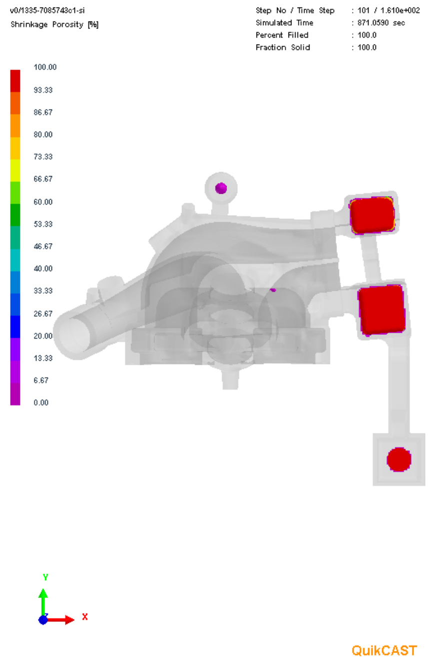
Guided by the simulation results, Kiefer added risers, one at a time, to the areas where it showed shrinkage would be a problem. Each time he modified the mold design, he reran the simulation to validate the riser design and evaluate the shrinkage of the area serviced by the riser. The new simulations showed that as the isolated areas in the mold shrank, they drew metal from the risers which avoided the formation of porosity. After running three additional iterations, the simulation showed that the problems had been solved and that the mold would consistently produce good parts. Epcor showed the simulation to the customer which helped build confidence in the new mold design.

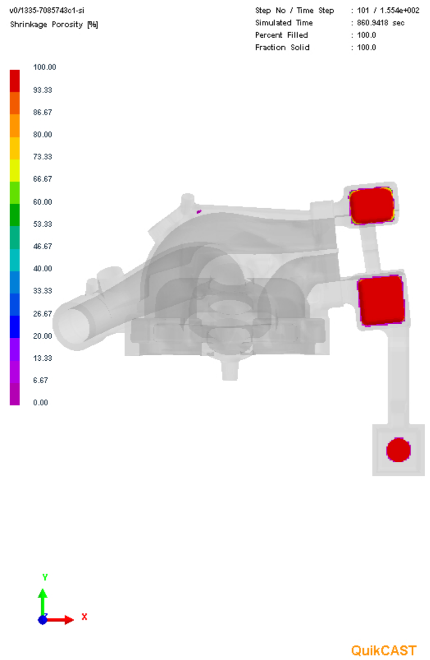
Getting the mold design right the first time

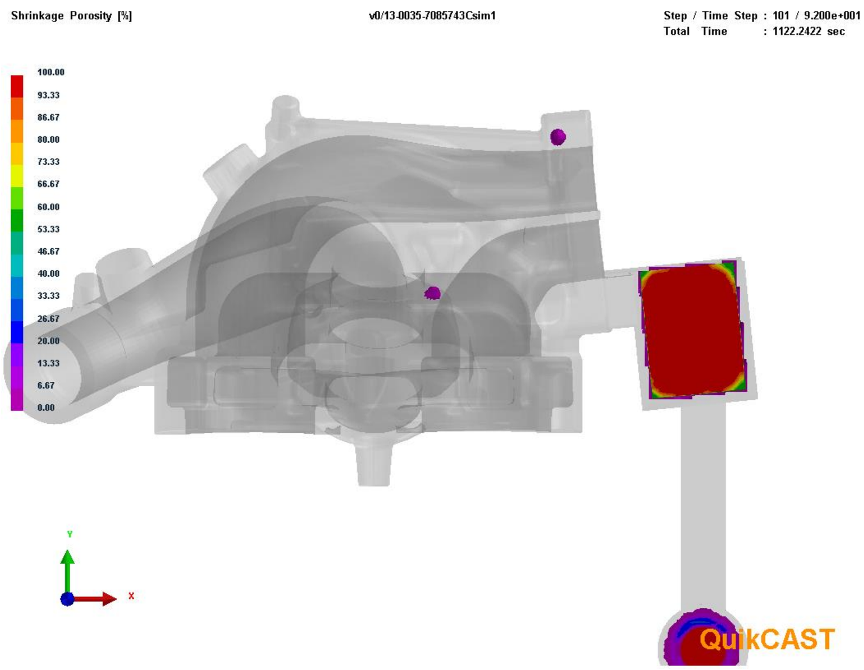
Epcor then went ahead and built the mold design as it was constructed during the simulation process. Once the design was frozen, the company cut the tooling for the core boxes and patterns and ran a few sample parts. The mold produced good parts that exceeded the customer's requirements from the beginning. Most important, porosity was never an issue during production. "Our customer was very pleased that we were able to get the new casting up and running so quickly," Maratta said. "This helped avoid downtime for our customer, and the OEM, which could have occurred if there had been significant delays during the process. The startup time and throughput levels were where they need to be at the start of a program for a complex casting with tight quality requirements. The customer was very happy with our ability to launch such a complex part without any issues."

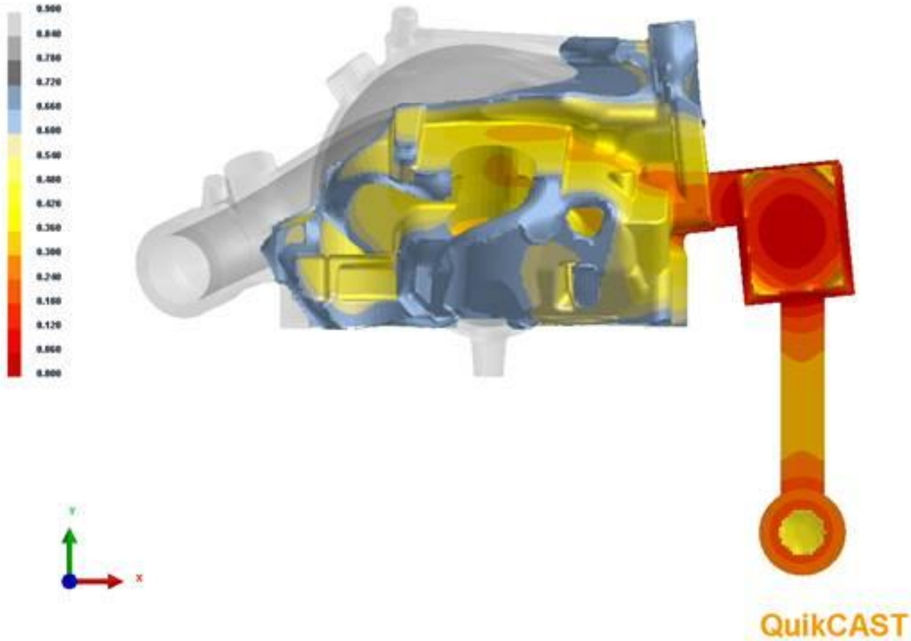
"The trial and error approach to mold design involves high costs for building and testing gating designs," Maratta concluded. "Yet it is often impossible using this method to identify the root cause of a quality problem. Computer simulation provides a more effective approach because it makes it possible to look inside the mold and view the filling process one step at a time. It becomes possible to clearly understand the cause of quality problems and often points the way to corrective actions that can solve these problems. Simulation makes it possible to evaluate alternative mold designs in a fraction of the time and cost. The end result is that Epcor can bring new parts into production in less time, at a lower cost and with higher levels of quality which helps improve our competitive position."

IMAGES & CAPTIONS:









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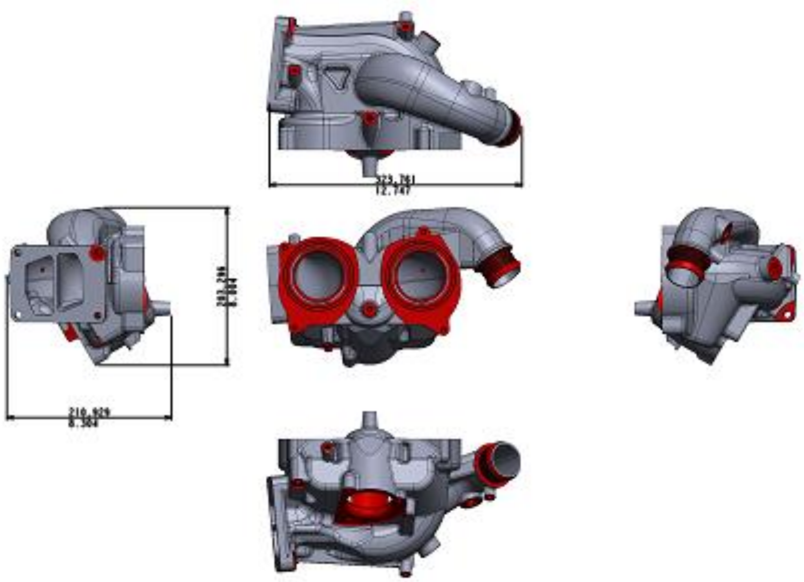

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