Renault employs ESI QuikCAST to Define Standards for Quality Castings

THE CHALLENGE

To define design rules for filling & feeding systems across different product lines to enhance competitiveness and achieve quality casting production.

THE STORY

Traditional methods in the past had produced poorly optimized layouts with lower yields. As Renault was making a huge investment for installing a new molding line at Fonderie de Bretagne (FDB), ESI QuikCAST was employed to quickly test different designs and understand the effects of these designs on the casting quality. QuikCAST was the chosen simulation route owing to its ability to provide designers an opportunity to try several preliminary designs on the computer, to arrive at an optimal design / process condition to reach the expected casting quality and competitiveness. A standard approach and tools were put in place to achieve quality castings across various system designs.

THE BENEFITS

- Enhance competitiveness in the market
- Reduction in development time & cost, cutting needless trials to optimize the pattern design & process parameters
- Improvement (or conservation) of quality level
- Know-how capitalization of filling and feeding systems designs

“After using ESI QuikCAST, not only were we able to increase our bottom line by saving on metal and creating more castings than before, but we also implemented a completely new system for casting that we now use routinely across various product lines within the company.”
- Laurent SOULAT, Cast iron design Referent, Renault, France

INTRODUCTION

Renault had an existing mold layout of a cast iron knuckle (RENAULT TRAFFIC Front Knuckle – Project Code:X82). This was a 6-cavities mold (Fig1), running in the production with some noticeable Shrinkage porosity problems (Fig2).

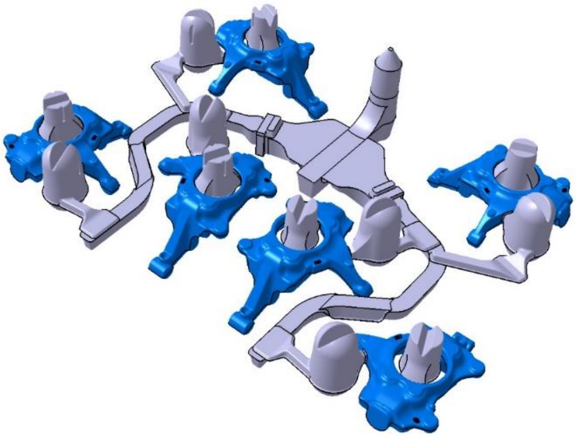


Fig1: 6-cavity mold layout derived from traditional approach

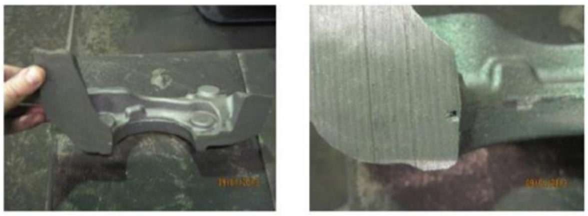


Fig2: Shrinkage Porosity noticed on the cut-sections of the shock absorber arm

Each knuckle weighed around 5.5kg and the total casting weight including the gating & feeding system was about 97kg. The current molding line was derived from several trials, and it was quite complex to go ahead with any improvements using this design. It was nevertheless very important to simulate this existing layout using ESI QuikCAST, and set-up a sufficient simulation model (right material properties & boundary conditions), to obtain in simulation the corresponding defects as observed on the shop floor. Once a sufficient correlation was obtained (Fig3), these set of parameters formed as a base for future work.

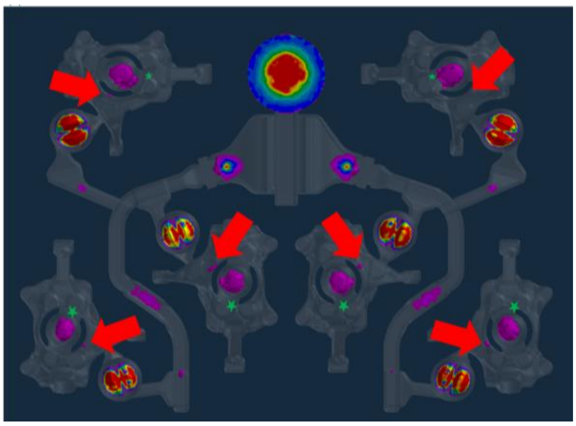


Fig3: Shrinkage Porosity correlation in ESI QuikCAST simulation

STANDARDIZED METHODOLOGY

As a part of the activity for this new molding line, it was decided to go through the simulation route from the early development stages. Thus, a methodology needed to be established to create standard mold layouts. As a first step towards this, the existing layout was abandoned and new approach was laid out, assuming as if the part was in an early development stage.

Determine the hotspots

A single casting simulation was first made. Here the casting has no filling / feeding system, and is assumed to solidify in the sand starting from a temperature around the pouring temperature. During this solidification, the natural thermal gradients of the casting are used to identify the solidifying liquid path and then identify the last solidifying regions in the casting. Fig 4 shows the thermal modulus of these last solidifying regions. These 2 regions need to be fed well while designing the feeders to avoid any last solidifying regions in the casting part, which could lead to shrinkage.

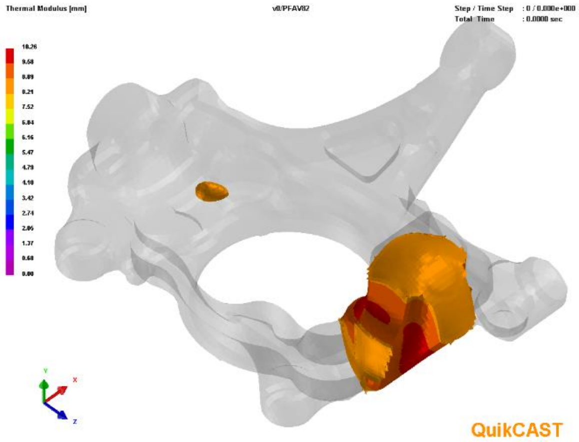
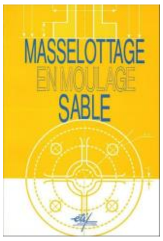


Fig4 : Thermal Modulus of the last solidifying regions in the knuckle.

Developing a feeding system



The CTIF feeding rules [cf: “Masselotage en moulage sable”- ETIF] were used to design the feeding system. To take advantage of virtual simulations, 6 different possible feeding systems suitable to feed these high thermal modulus regions were designed (Fig5). External feeder, internal feeder and a combination of external & internal feeders were proposed. The feeders were designed to have higher modulus than what was observed on the single casting following the CTIF rules of feeding.

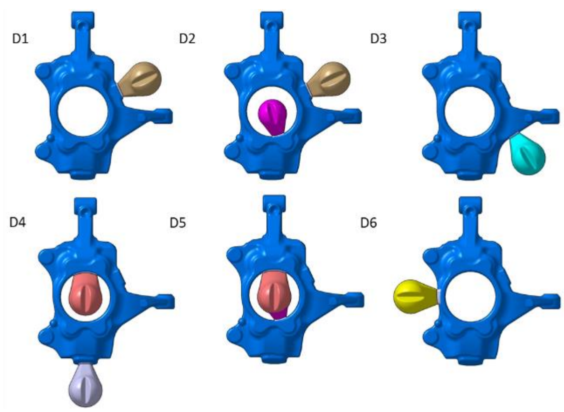


Fig5 : Proposed Feeders for Design Of Experiments

A thermal simulation including shrinkage calculation was performed on each of these proposed designs. The solidification cluster evolution, last solidifying regions / isolated liquid pockets which could lead to shrinkage in the part were analyzed. Design5 (D5) with an internal feeder connected to the knuckle arm from both sides, provided the best solidification pattern showing a feed path towards the feeders with no signs of shrinkage in the casting (Fig 6). D5 was the chosen design to go ahead with the filling system design.

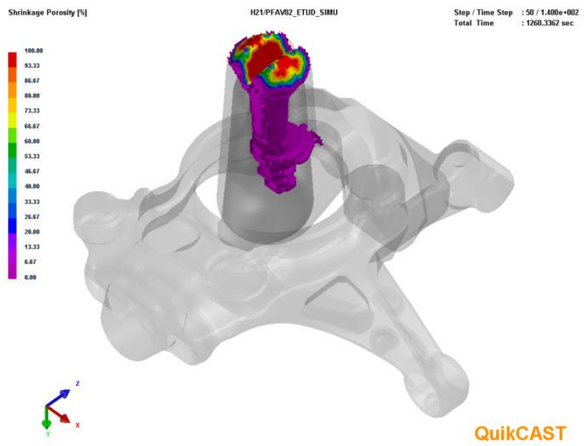


Fig6 : Design 5 shows the best feeder design , with no shrinkage in the casting part

Gate Positioning

With D5 as the chosen feeder, it was important now to identify the right gate positioning. Instead of designing a full cluster gating system, it was decided to first identify the right ingate positions. 4 different gating positions were proposed (Fig7).

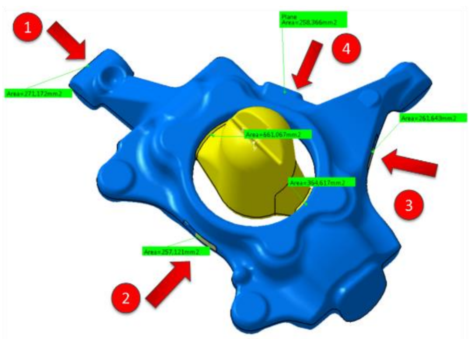


Fig7 : Proposed Gate Positions

Assuming the gates as inlets with average gate velocities, a filling coupled solidification simulation were performed with all these 4 gate positions. There was no noticeable difference in the filling behavior / fluid velocities between these 4 inlet positions. Apart from a slight increase (+ 0.4 mm) in the maximum modulus, found with these inlet simulations, there was also no soundness impact on solidification (see shrinkage porosity maps Fig 8).

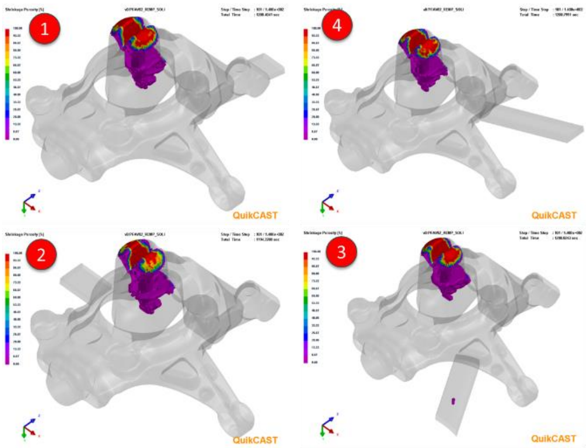


Fig8 : Shows identical shrinkage porosity maps with different gate positions

Developing the complete Mold Design

With CTIF rules [cf. “Le remplissage des empreintes de moules en sable”- ETIF] as the base of designing the filling system, the pattern was designed.

An 8-cavity molding layout (combined with D5 feeder and the gate position-4) was the outcome from the design engineers (Fig9).

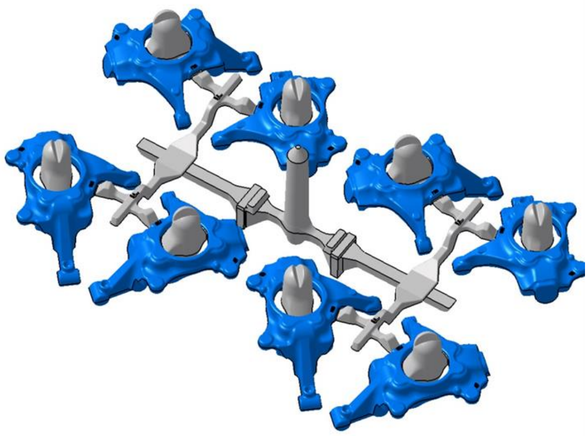


Fig 9: Shows the new 8 cavity molding layout

As opposed to the old design (Fig1), the new layout was designed in a more structured way, thanks to the step-by step methodology and the casting simulation software. Avoiding external feeders and opting for only internal feeders meant a possibility to have an uniform and symmetrical placement of the filling system. This helped in setting up the right process, as now each cavity had a possibility to fill almost identically and with similar filling time (<1s difference).
A full cluster validation simulation was performed on this molding layout. The filling simulation helped to check the filling behavior and the fluid velocities inside the mold. Slight modifications on the gate dimensions were suggested to reduce risk of sand erosions, slightly increasing the gate cross section. The solidification patterns were very healthy and yielded no shrinkage on the knuckle (Fig 10).

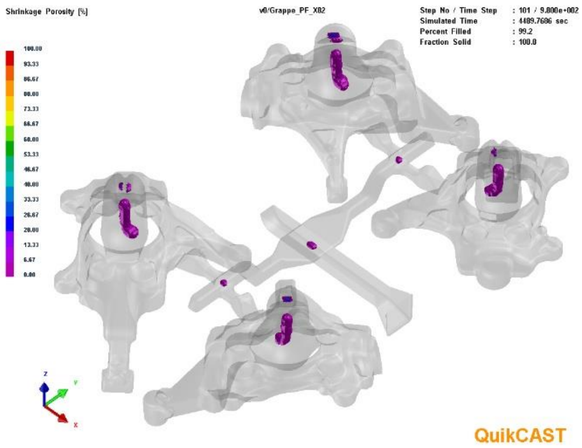


Fig 10: Shows the shrinkage porosity map on 4 of the 8 cavities of the new molding layout (symmetry considered during simulation)

SUMMARY & CONCLUSION

Spheroidal Grey Iron RENAULT TRAFFIC Front Knuckle was used as the first study to show the standardized methodology that Renault put in place to implement for its new molding line at Fonderie de Bretagne. The knuckle mold was improved from a 6-cavity 97kg to 8-cavity 82kg cluster weight. The new design also solved the shrinkage sensibility faced during previous production. As the yield improved, it saved 37% metal for every part produced, providing 2 additional parts per mold (approximatively +520 parts per hour). The cost savings with the new design was consequently substantial. This standardized methodology is used successfully across different product families.

ESI Group – Media Relations

Céline Gallerne

+33 1 41 73 58 46

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About Renault & Fonderie de Bretagne

A 100% subsidiary of the RENAULT Group, created in 1965 in Lorient, FDB produces rough and machined parts in spheroidal graphite cast iron. FDB manufactures safety parts: suspension arms and rocket doors for the chassis, exhaust manifolds and elbows for the engines, and differential boxes for the gearboxes. The annual tonnage is 27000 tons in 2015. FDB has 2 molding lines and a machine shop on 150 hectares including 40 hectares of buildings and employs 464 people (end of 2015).

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