Renault Improves Yield and Produces Over 520 More Parts per Hour

THE CHALLENGE

Renault needed to define design rules for filling & feeding systems across different product lines, with the end goal of achieving quality casting production and enhancing their competitiveness.

THE STORY

Traditional methods in the past produced poorly optimized layouts with lower yields. As Renault was making a huge investment in installing a new molding line at Fonderie de Bretagne (FDB), their team employed ESI QuikCAST to test quickly 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, and to reach the expected casting quality and competitiveness. Renault then put in place a standard approach and tools to achieve quality castings across various system designs.

THE BENEFITS

- Enhance competitiveness in the market
- Reduce development time & cost, cutting needless trials to optimize the pattern design & process parameters
- Achieved an economy of 44 hours / year of production time and around 1300 tons / year of liquid alloy
- Improve overall quality level
- Capitalize on know-how of filling and feeding system designs

“After using ESI QuikCAST, not only were we able to improve 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

At Fonderie de Bretagne (FDB), in Western France, 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 production with some noticeable Shrinkage Porosity problems (Fig2).

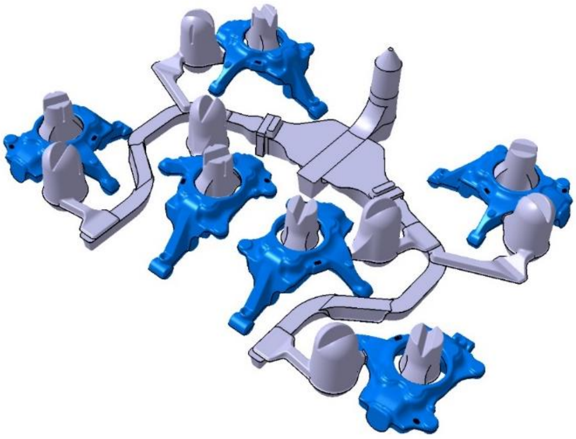


Fig1: 6-cavity mold layout derived from traditional approach

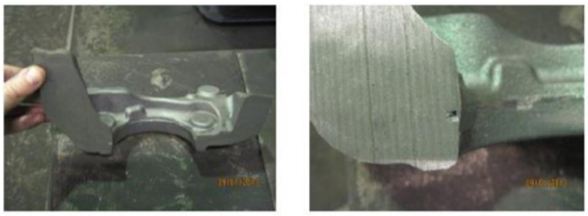


Fig2: Shrinkage Porosity noticed on the cut-sections of the shock absorber arm

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. Renault set up a simulation of this existing layout using ESI QuikCAST, defining the right material properties & boundary conditions, allowing them to obtain the same defects observed on the shop floor. Once they obtained a sufficient correlation (Fig3), these sets of parameters formed a base for future work.

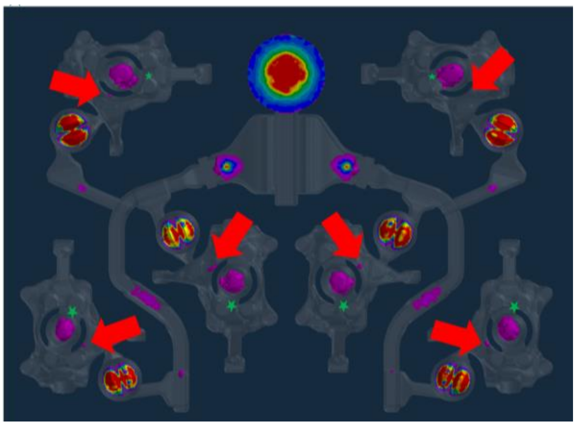


Fig3: Shrinkage Porosity correlation in ESI QuikCAST simulation

STANDARDIZED METHODOLOGY

Needing to set up a new molding line at FDB, Renault decided to go through the simulation route from the early development stages. Thus, they had to establish a methodology to create standard mold layouts. As a first step, they abandoned the existing layout and defined a new approach.

DETERMINE THE HOTSPOTS

The team first ran a single casting simulation. Here the casting had no filling / feeding system, and was assumed to solidify in the sand starting from a temperature around the pouring temperature. During this solidification, the natural thermal gradients of the casting were 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 needed to be fed well while designing the feeders to avoid any last solidifying regions in the casting part, which could lead to shrinkage.

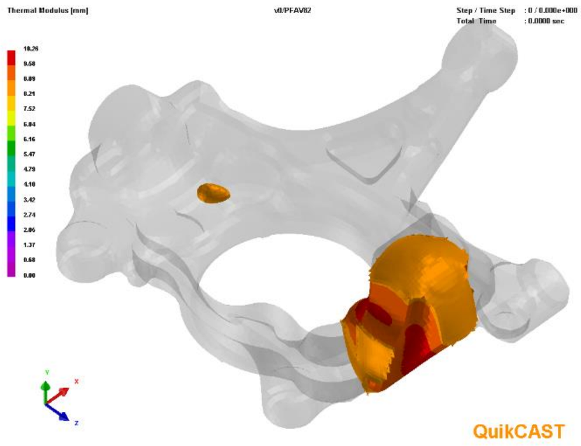
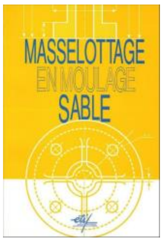


Fig4: Thermal Modulus of the last solidifying regions in the knuckle.

DEVELOPING A FEEDING SYSTEM



Renault used the CTIF feeding rules [cf: “Masselotage en moulage sable”- ETIF] to design the feeding system. In QuikCAST, they designed 6 different possible feeding systems suitable to feed these high thermal modulus regions (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.

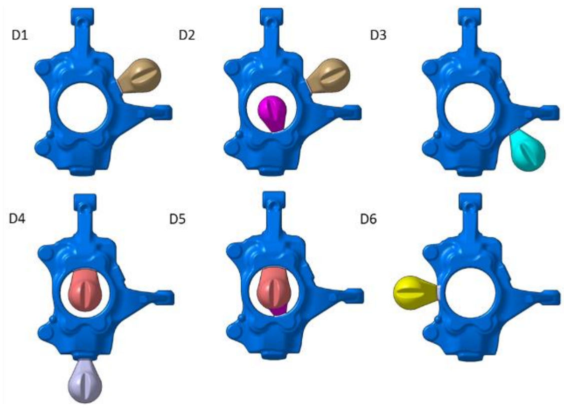


Fig5 : Proposed Feeders for Design Of Experiments

They performed a thermal simulation including shrinkage calculation on each of these proposed designs; followed by an analysis of the solidification cluster evolution, last solidifying regions /

isolated liquid pockets which could lead to shrinkage in the part. 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.

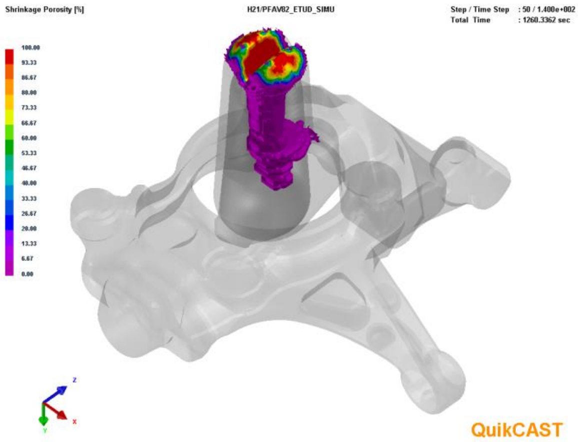


Fig6 : Design 5 shows the best feeder design , with no shrinkage in the casting part

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, Renault decided to first identify the right ingate positions. They came up with 4 different gating positions (Fig7).

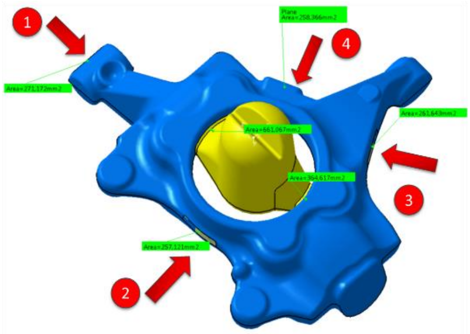


Fig7 : Proposed gate positions

Assuming the gates as inlets with average gate velocities, they conducted a filling coupled solidification simulation 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).

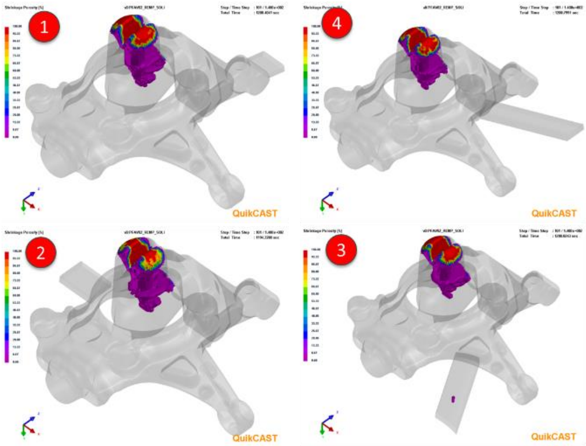


Fig8 : Shows identical shrinkage porosity maps with different gate positions

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, Renault designed the pattern.

Their design engineers arrived at an 8-cavity molding layout (combined with D5 feeder and the gate position-4) (Fig9).

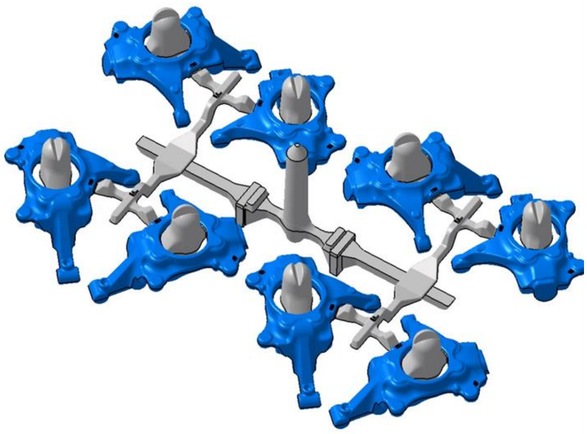


Fig 9: The new 8 cavity molding layout

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 a 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).

Renault performed a full cluster validation simulation on this molding layout. The filling simulation helped check the filling behavior and the fluid velocities inside the mold. They suggested slight modifications on the gate dimensions 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).

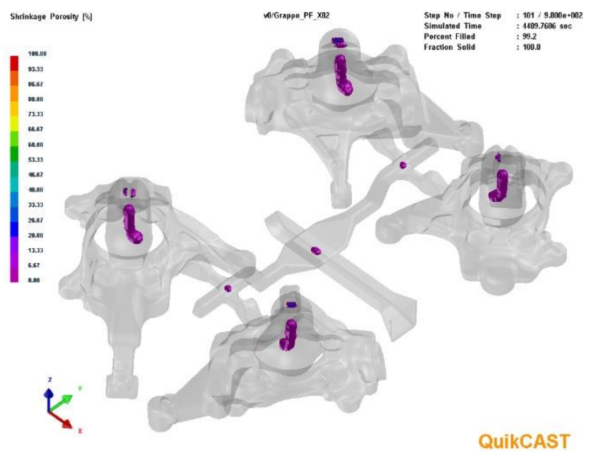


Fig 10: Shows the shrinkage porosity map on 4 of the 8 cavities of the new molding layout (symmetry considered during simulation)

SUMMARY & CONCLUSION

The 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 its new molding line at Fonderie de Bretagne. The knuckle mold was improved from a 6-cavity 97kg to lighter 8-cavity 82kg cluster weight. The new design also solved the shrinkage sensibility faced during previous production. As the yield improved, it saved 37% of 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. Renault now uses this standardized methodology successfully across various product lines.

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 tonnes 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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