
TRIUMPH

Simulating Structural Motorcycle Components

The case of a single-sided-swing-arm developed through the collaboration of SCF and EnginSoft

The client, a major European motorcycle manufacturer engaged SCF Battistini to design and produce a single-sided swing arm for one of their motorcycle models. SCF recognized that this was a perfect project where **engineering simulation** would be beneficial in reducing time-to-market and general costs. So they teamed up with EnginSoft, known experts in engineering simulation, for the simulation part of the project. Their choice of partner was based on the professionalism, experience and efficiency that EnginSoft exhibited in previous projects.

A **four step analysis** was carried out. Starting from the mathematical model that had been defined we engaged in the following steps:

1. A preliminary simulation of the solidification process (for which only one 3D model of the mold was used). This was created in order to deduce the parameters to be used as guidelines for the design of the gating and feeding system;

2. A steady state simulation where the temperature and velocity of the filling phase were monitored (in this step all of the model parts were needed so it was necessary to have already designed the runner and feeding system, the different parts of the mold and the cooling system); the filling and solidification processes were simulated in a steady state condition using the gating system and mold parts which were designed taking into account the considerations deduced from the simulations described in step 1.

3. A further simulation was carried out with further modifications that took into consideration the results obtained in Step 2.

4. The results obtained from testing an actual physical prototype were analyzed. A comparison was then made between these results and those of the simulation carried out.

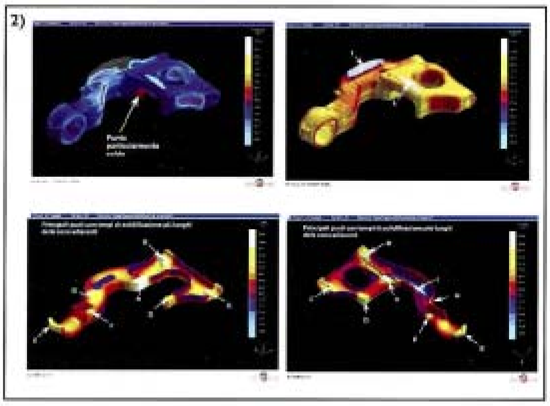
Definition of the model

The mathematical model, which was co-developed with the client, to be fed to the simulation software was "frozen" based on the results of these 4 steps. The completion of this phase made substantial use of SCF's knowhow on gravity casting, resulting in final casting tools whose performance met, as closely as possible, with the requirements of the client.

Step 1: The Preliminary Simulation

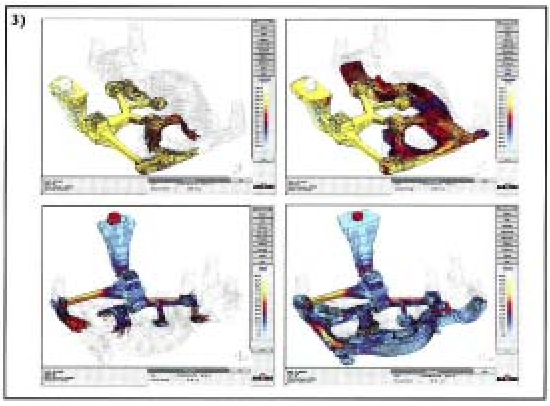
This first step verified the behavior as a result of the temperature distribution during the

solidification phase. The results provided the information needed to evaluate any massive zone and the computation of the corresponding thermal modules. As illustrated in figure 2, the simulation highlighted several critical zones. This information was taken into account during the design of the gating system with respect to the position and sections of the runners and of the other mold features.



Step 2: The Second Simulation

The second step specifically dealt with the filling and solidification process in a steady state. We

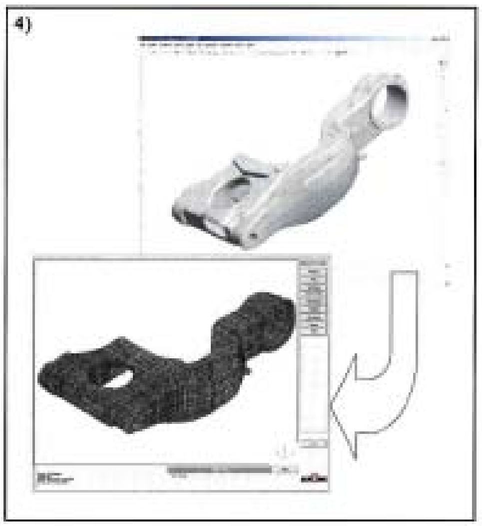


simulated the filling processes in terms of temperature and velocity as illustrated in Figure 3 and obtained information regarding:

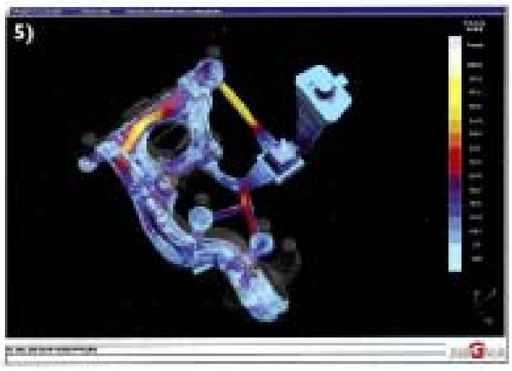
- the potential presence of cold shots and problems related to the complete filling of the cavity (cinematic analysis of the filling phase);
- the effects of turbulence and entrapped air (cinematic analysis of the filling phase);
- the time taken to solidify (thermal analysis).

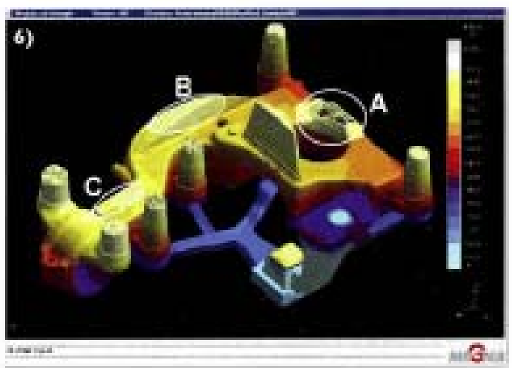
This information was used to modify the geometry and process parameters to improve the final cast quality. Specifically we:

- added more vents in the critical areas to avoid the entrapped gas;
- modified the geometry of the taps ;



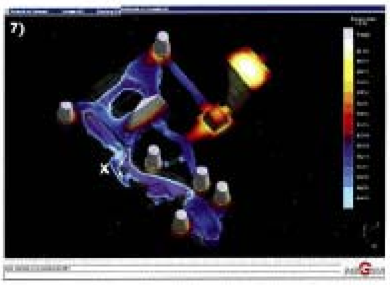
- modified the feeder necks in order to facilitate the feeding path;
- modified the cooling system of the central insert;
- modified the feeder necks of the little hubs in order to enlarge the gate section;
- widened the connected section between the massive zone, under the triangular support, and the top feeder;
- added a plate that interrupts the unloading in the horizontal sheet inside the central trunk of the fork.

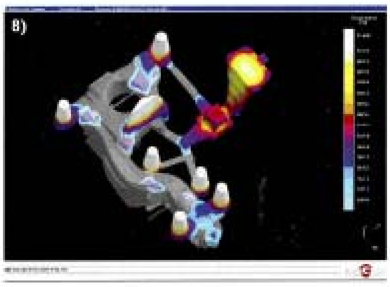




Step 3: Simulation after corrections

The new modifications caused changes to the geometry of the part and to the way the mold is filled. In comparison with the previous analysis a general improvement of the critical areas established in the first simulation was observed.
In particular, the stud at the base of the sprue did not display the same filling problems that were noted in the first analysis.



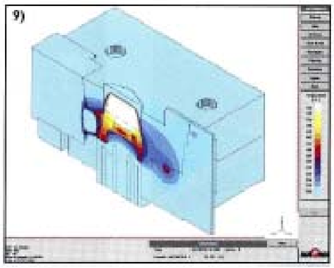


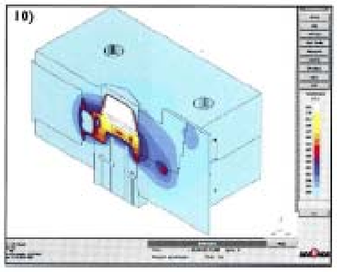
Figures 7 and 8 illustrate the solidification sequence with a temperature scale fixed between that of the solidus (542 °C) and that of the liquidus (613 °C).
The changes made to improve the solidification process resulted in a general improvement of the final quality of the overall gravity casting. A comparison of the temperature distribution in the mold was used to verify the effect of the changes made.
The following images show the temperature distribution on the mold, using the same angle and scale, illustrating the changes introduced by the modified cooling circuit in the insert as expected in the third simulation.

Step 4: Producing the Mold

As with every virtual simulation study, the time came to put what we learnt from the virtualization into practice. We combined all the data that resulted from the virtually engineered mold with our technical know-how to produce a physical mold.

The resulting mold was then put through the first casting. Several quality assurance personnel were involved at this stage in order to verify various aspects of the mold including its movement and its metallurgic behavior. This was an important step in the project as we were finally able to compare the results that were obtained through virtual simulation with those carried out on the actual mold produced.
We first verified the critical areas that resulted





from the steady state simulation and compared the results with those that we were expecting, and found the two sets of results consistent with each other.
Specifically:

- the changes made to the critical massive zones following the first analysis and the areas affected by the cooling circuit that was introduced now satisfied the client's requirements;

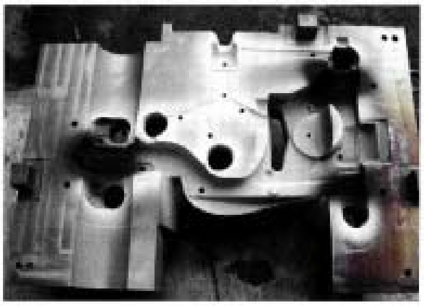
- the casting results were esthetically pleasing; the esthetics had benefited from the study of air entrapment which led to the introduction of vents and of the filling velocity.

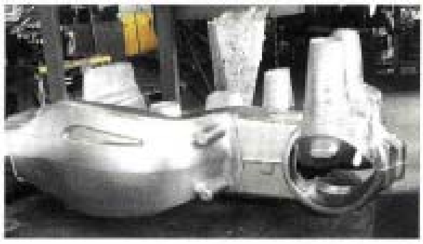
This analysis allowed us to avoid air entrapment and the presence of oxides. The production proceeded in a smooth, linear fashion without any notable problems. The figure below underlines the great aesthetical results obtained in the casting phase. This reduced the costs of designing an esthetically pleasing part and as a consequence reduced the time to market of the finished product.

In addition to guaranteeing the metallurgical results expected, the placement of feeders and ingates facilitated the next phase of the project which was to prepare a layout for mass production.

Based on the production results and on the specific results obtained from the analysis of the first casts produced, we concluded that thanks to the engineering-simulation we carried out we had achieved:

- time savings both in the co-design of the model and in the study of the tools used;
- the possibility to ask the client to make dimensional modifications;
- a cost reduction in mold production thanks to the need for fewer physical prototypes and fewer interruptions to the actual production cycle;
- time and cost benefits thanks to the reduced time-to-market of the finished product.





SCF Battistini

SCF Battistini was founded in 1965. Its experience in modeling and production of molds is still an important part of what it does. The company has made the specialization in gravity casting the major force behind its growth. SFC Battistini has developed strong specialized skills spread across the areas of Engineering, Equipment and Foundry allowing the company to manage the whole process from planning through to the final product, offering their clients the advantage of working with a single, qualified partner.