Use Casting Simulation to Optimize Product Design, Quality and Material Strength in the Production of Castings

By Hakan Fransson from NovaCast Systems

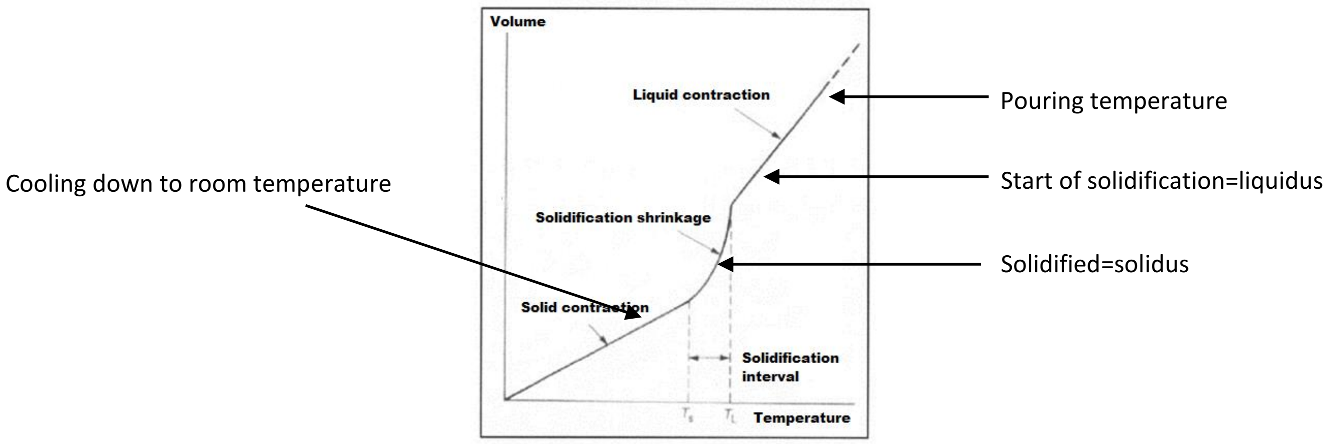
Casting is a complex method with many variables that can influence the quality and life of castings, as well as the resulting strength of the material. Yours truly has now been working in the foundry industry for 25 years and much has obviously happened during this time but the basic causes of casting defects still remain. However, the possibilities of using computer software both for designing and calculating the casting process constitute one of the major differences during these 25 years. Developments leading to presenting practically everything in 3D now have excluded the uncertainty of interpreting 2D drawings. In fact, many times in the past pattern makers were the ones who created the final design, especially with regard to for example radii, which could not be made based on drawings only were made more ”artistically”. Areas that previously involved guess work can now be calculated using casting process simulation. Casting process simulation became more widespread during the 1990’s but foundries did not start implementing it more generally until the past 10 – 12 years. The programs were not as reliable then as they are now. Programs of today give good results and clearly show what the casting will look like if made according to a specified method.

Optimal casting production

Unfortunately most castings are still being developed without prior investigation at an early stage as to whether they can indeed be cast or what problems might arise. This means that most details are not suitable for casting or at least not to the extent that is desired. When should the first casting process simulation be made? Of course as soon as an appropriate design has been established. There will be no good solution even if a detail is optimal with regard to design and material strength, but cannot be cast. A cheaper and better component can eventually be found if simulation is applied at the prototype stage. If you do not wish to commit to any foundry that can do this, you can purchase your own simulation software or purchase the service from an independent company. Otherwise, continuing on the old path will entail higher production costs, worse material strength and of course higher quality costs. Even if the foundry deals with many problems, it is easy to understand that quality costs will burden the end user depending on problems that arise in the casting process.

Why are there casting defects related to solidification?

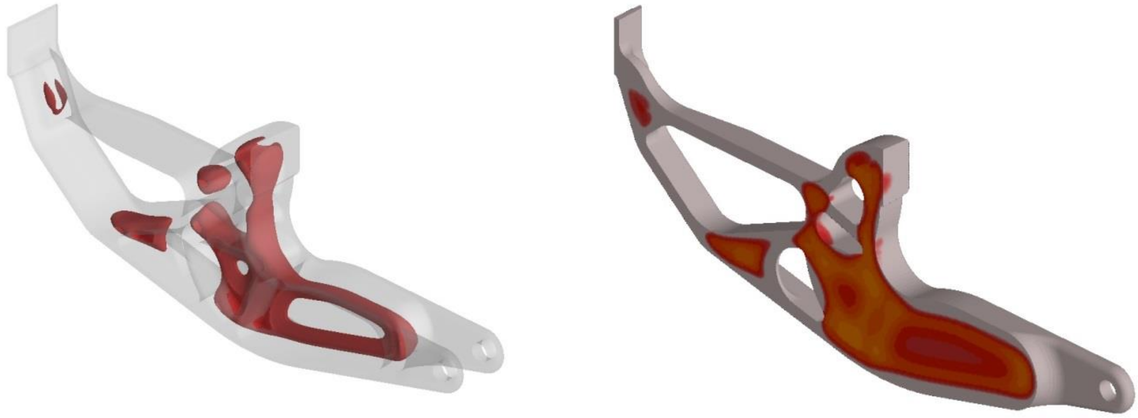
Basically, this is because volume decreases and density increases from casting temperature to room temperature, which means that if for example you fill 100 % only 93 % will come out. The missing 7 % is gone due to liquid contraction, changes in dimensions and shrinkages.



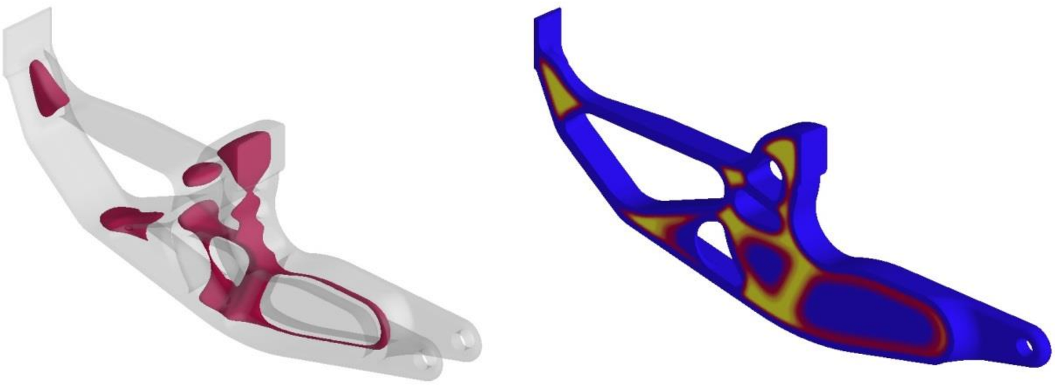
Why should design engineers use casting process simulation?

1. **Can the detail be filled** – Do a mold filling simulation with a minimal gating system to see if the melt can fill the whole cavity or to check if for example the walls are too thin. Other mold materials/casting methods can also be tested to compare how much better the result can be.

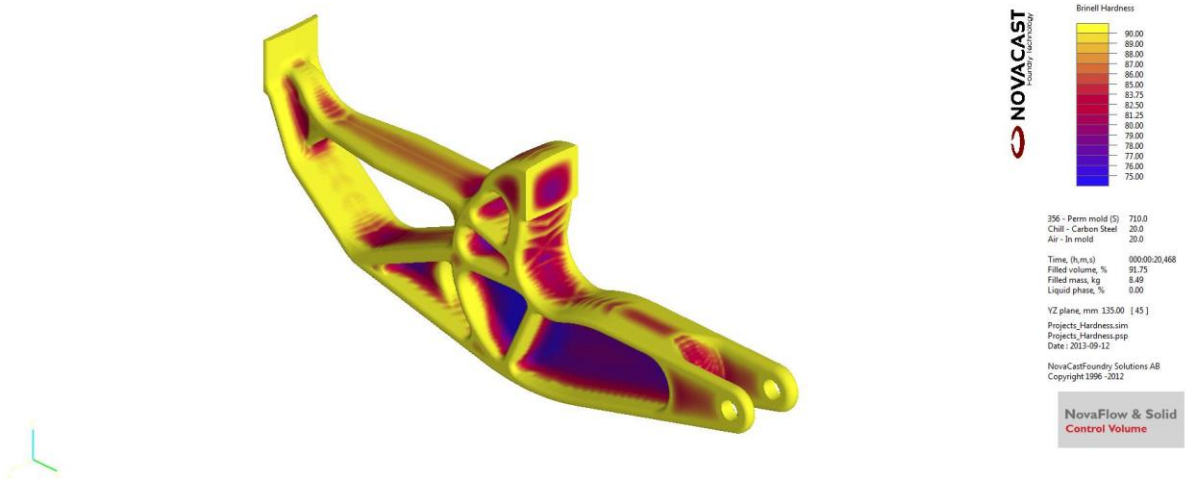
2. **Investigate how the detail solidifies and where "Hot spots" occur –** Running a solidification simulation can visualize where the casting detail solidifies last, which is where hot spots can occur.



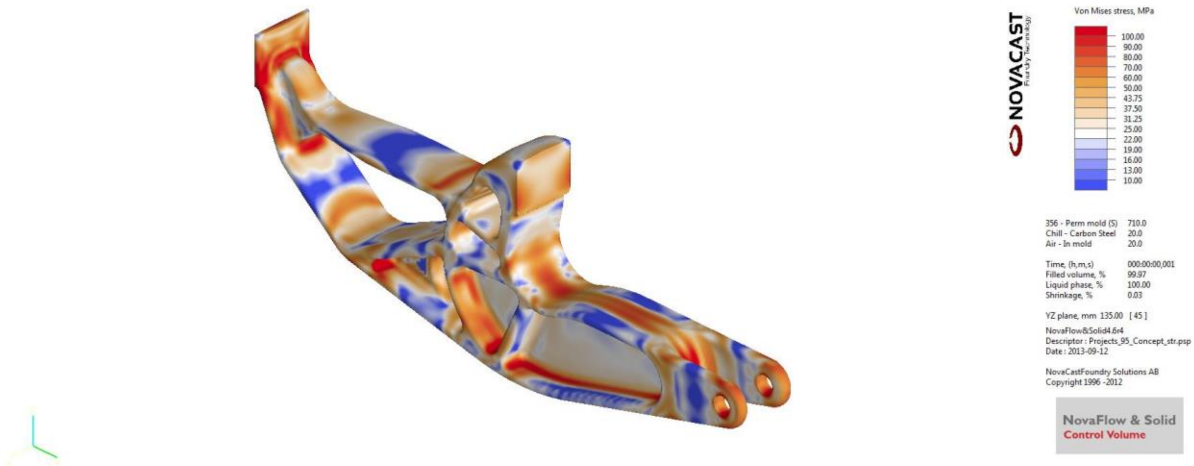
3. **Investigate where defects related to solidification can appear** – The size of these defects is also very interesting because most times it is impossible to achieve a sound casting, but it is desirable to achieve defect-free areas and as small defects as possible in the remaining areas of the casting. Defects can be exported from the simulation software as 3D models for use as input data e.g. in further calculations.



4. **Calculate material strength/hardness** – I assume that it is well-known that material strength in all materials depends on wall thickness but the decisive factor is solidification velocity. Solidification time can be observed and material strength and hardness can be calculated to compare how they are influenced by different methods.



5. **Residual stresses –** Most simulation packages allow calculating residual stresses, which uses the simulated thermal data to establish how the detail mold changes, what measurements are obtained, areas with risk for cracks and of course residual stresses. Residual stresses can be exported for further calculations to for example Simlab or other FEM based load calculation software. Furthermore, the deformed detail can be exported to better understand what will happen after casting and how to compensate in order to obtain a correct detail.



Conclusion

The bottom line is that the more consideration is given to producing a detail in the beginning, the better the resulting casting will be. Do not hesitate to make use of analyses if you do not have access to the software or the expertise because it pays to put in a lot of work at one end of the process to be able to profit at the other end.

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