Casting Process Simulations - Smoothing the path to optimum casting geometry design

The design and manufacture of a metal component involves a multitude of decision points and will be influenced by considerations like structural performance, weight, lead time, cost, aesthetics, etc. It is understandable, therefore, that thoughts about how precisely that component is going to be manufactured are often left until the design is at a fairly advanced stage. This is often the case where there is pressure to get a manufactured product to market quickly.

The importance of close co-operation between the designer and the founder is crucial to the success of a project and the appreciation of this is likely to be enhanced if design engineers are more familiar with the plethora of casting and processing constraints that will need to be considered before a casting can proceed. The designer is unlikely to have acquired a thorough familiarity with the foundry techniques and casting parameters which are essential to produce high-quality castings. Foundry engineers, however, will be well aware of the limitations on the shapes that can be produced in the cast form which are imposed by the physical conditions that are necessary for the metal to solidify free of internal defects.

The Design Development Process

Before discussing how casting simulation software is able to smooth the path to effective casting geometry design, it is worth examining a typical casting design process to highlight the importance of co-operation at an early stage between designer and foundry. A typical experience based on an iterative design process might be as follows.

The product design engineer will design casting geometry based on the component's functional, mechanical and performance requirements. The design is then passed to the casting engineer at the foundry who also goes through an iterative process taking account of the geometry but working within the known constraints of the casting process, the requirements of the running system (which delivers molten metal to all parts of the casting) and allowing for shrinkage of the casting as it solidifies and cools. Issues identified during the design of the running system will often result in changes to the casting geometry. Further iterations of both the geometry and running system may be required during tool or mould fabrication and preparation for production. And even more changes may be needed to each element to meet production requirements or budget constraints.

Clearly, this process calls for very close co-operation between the design engineer and the production team at the foundry. With a complex casting, this process can lead to additional costs and delays in production schedules, particularly when iterations are left until late in the process. This can also result in sub-optimal design as safety factors are over allowed-for in an effort to speed up design completion, resulting in higher costs, less elegant product design and greater weight.

The closer the co-operation between the customer and foundry teams and the earlier this starts in the process the easier it is to avoid constant design refinement.

There are several ways of mitigating the risk to project schedules and budgets. At NovaCast, we work hard to ensure that, where possible, we fully understand the customer's needs and are involved in the design of the casting geometry so that we can provide input from a casting process perspective at the earliest opportunity. It is important to recognise that component geometry not only affects the load carrying functionality of the casting, but also the mould construction, mould filling and material solidification processes involved in producing the casting. These processes in turn affect cycle time, casting quality, and material properties such as yield strength, ultimate strength, and fatigue resistance.

Getting the initial design as close to the optimum as possible at an early stage reduces subsequent iterations. By advising on shape optimisation and running system design while the geometry is being finalised we also help the designer to consider the implications of design decisions on material choice and usage, process interactions and overall costs.

Much of the expertise that the foundry team add into this process was based on extensive experience and knowledge about the physical and thermal properties of various alloys and the way they interact with the moulds into which they were cast. Today, many foundries also have sophisticated computer modelling software and casting simulation systems. While these don't replace the need for skill and craftsmanship, they can considerably speed up the design development process by identifying potential issues and optimising geometry earlier.

Casting Process Simulation

Casting process simulation is used to develop comprehensive modelling of the intended production process to determine the size and shape of sprues, runners, gates, and risers. One of the main benefits of these systems is that they make it possible to quickly identify areas within the casting geometry that could give rise to process related defects (microporosity, tears, etc.).

Using these methodologies, the foundry process engineer can quickly adjust the running system design to evaluate how different design options might affect defect size and location so they can be controlled or eliminated. Using computer simulation early in the design process can greatly reduce the amount of guess work involved in specifying cost effective and functionally acceptable casting geometry.

Computer based casting process simulation also delivers consistency and predictability because it provides a scientific base for casting design. This makes it much easier for design engineers and process engineers within the foundry to work as a team, quickly producing the casting geometry and running system in a coordinated process. In practice, this makes it possible to properly evaluate the overall design before tools are cut and the design is irreversibly committed to hardware. When used properly, the result is a substantial reduction in design time and tooling iterations. As noted already, however, it is important to understand that the use of casting process simulation software is not a substitute for the early input of experienced tooling and foundry engineers. It is actually a tool that helps promote closer integration of the customer and foundry teams at an earlier stage.

Conclusion

While recognising that there will always be a clear differentiation between the roles of the customer's design engineer and the casting process engineer within the foundry, our experience has proven over the years that closer co-operation at an earlier stage delivers better outcomes for all. Innovations in computer software are speeding up the process considerably and removing many of the design iterations that have often plagued complex geometry design in the past.

About NovaCast

NovaCast has over 35 years of ferrous and non-ferrous metal casting experience extending into markets as diverse as transport, utilities, offshore and general engineering. The company's non-ferrous foundry, based in Melksham, England, is supported by a fully risk-managed supply chain that expends out to the Far East allowing NovaCast to provide a single source solution for precision cast and machined components. NovaCast has particular expertise in the production of pressure-tight valve and industrial pump components, complex non-ferrous castings and a wide range of precision castings for many engineering applications. Metals cast include alloys of Carbon and Stainless Steel, Copper, Aluminium, Nickel and many others with a full range of testing, machining, surface treatment and finishing options.