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Review Paper on Simulation Based Casting

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ABSTRACT: Casting simulation technique widely used in foundries and metal casting industries. Casting simulation simulates the real casting phenomenon and gives a virtual casting process as molten metal flow in mould cavity with respect to time and direction. It shows the virtual process of casting like mould filling, solidification and cooling and also predict the location of internal defects. With the help of casting simulation, casting process method and designs optimization is possible. Casting simulation is used in the production of reliable, economical and high accuracy cast component. Although casting simulation becomes important tool, simulation cannot correct itself existing casting process or design. So for the application of casting simulation experienced and knowledge person required. Reliability of casting component can be improved with the help of casting simulation software. In this review paper, the casting simulation, its importance, types of casting simulation software, application and case study on feeder optimization is described.

KEYWORDS: casting simulation, reliability, method and design, optimization.

I. INTRODUCTION

Casting simulation:

Simulation simulates the real casting phenomenon using a computer program. The simulation program is consists of set of mathematical equations [1]. Casting process simulation has become an invaluable tool in the production of economical and high performance cast components. Its application by experienced and knowledgeable operators leads to reduced castings defects, casting yield improvement, and reduced trial and error iteration in development of a casting's optimization. Increasingly casting simulation is being used as a collaborative tool between component designers and casting producers to reduce lead times, to develop casting friendly component designs, and to produce better castings.

Need of casting simulation:

Casting simulation should be used when it can be economically justified for quality enhancement by predicting and eliminating internal defects like porosity, yield improvement and rapid development [2].

- Quality improvement: Improvement in quality improves the reliability of casting and reduces the excess cost of defective casting and other resources cost. The quality improvement can be obtained from simulation.
- Yield improvement: With simulation technique, the casting process and method are optimized in short time. And also the casting process is optimized there will be very lesser wastage thus it results in yield improvement, reduces the effective melting cost per casting, and increases the net production capacity.
- Rapid development: Simulation of casting is virtual process so there is no scrap material and other wastages. Casting through virtual trials eliminates the wastage of production resources, and gives opportunity to foundry to take high order.

Types of casting simulation software's:

The most useful casting simulation programs available in India are AUTOCAST, MAGMA, ProCAST, and SolidCAST. Some of these are available on hire for monthly and annually.

Programs employ different methods for casting simulation [2] are as:

- Finite Element Method (example- ProCAST),
- Finite Difference Method (example- SolidCAST),

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- Finite Volume Method (example- MAGMA),
- Vector Element Method (example- AutoCAST).

II. STAGES IN CASTING SIMULATION FORMULATION

There are five distinct stages in casting simulation projects, as data gathering, methods design, numerical simulation, method optimization, and project conclusion [2].

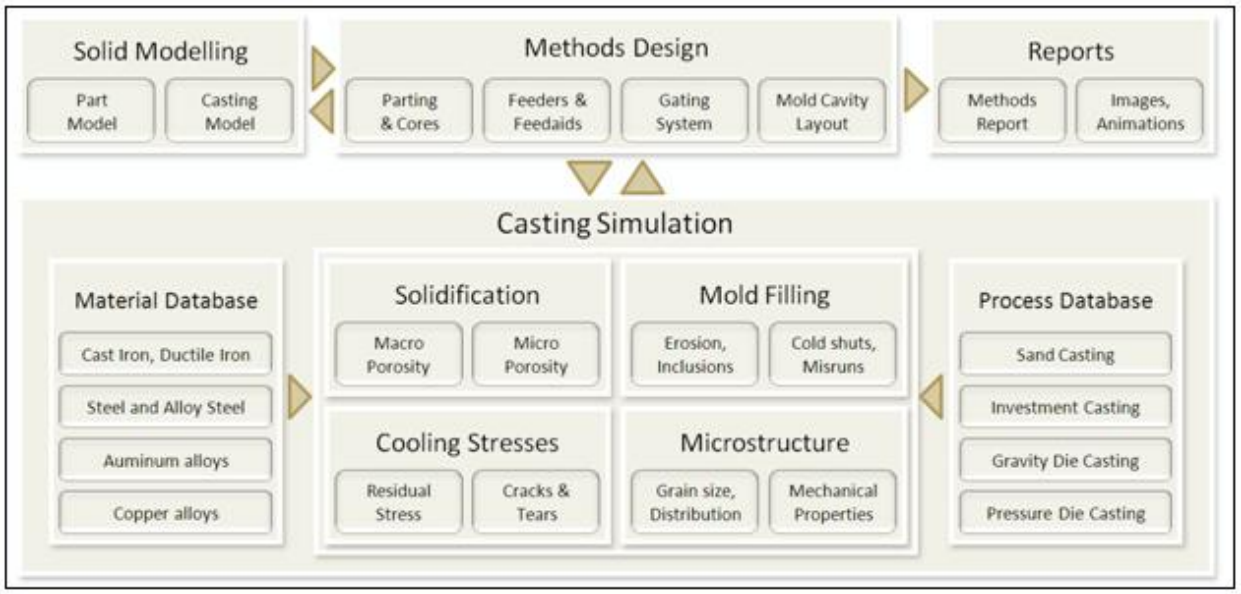

Fig.1 Flow chart of simulation formulation [2]

1. Data gathering:

This is most important stage, correct and complete data will lead to accurate simulation and conclusion. The problem must be defined first and also define the need and type of simulation. There two types of aim of projects which are as

- Quality or yield improvement
- Rapid development of new casting design

Inputs required for simulation:

- CAD model of casting should be in 3D of cast part,
- Cast metal properties as thermal conductivity, specific heat, shrinkage, viscosity, etc
- Method design data including details about mould parting, cores, feeders, gating system, cavity and feed aids.

2. Methods design and modelling:

In this stage, the methods design is solid modelled to convert the as cast model into a 3D model of the mould containing part cavities as well as feeders, gating channels, cores and feed aids.

3. Numerical simulation:

In this stage some critical input are required as, first is correct mesh generation which cover the entire model. The second is the various boundary conditions like heat transfer coefficient. The simulation run depends on functional module as:

- Solidification only
- Mould filling only
- Coupled filling and solidification
- Solidification, cooling and stress

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4. Method optimization:

This stage involves improving the methods design to eliminate defects and improve yield. The simulation results defect observed and then simulation methods design (feeders, gating, and runner etc) is modified again and then casting simulation run again. In this way method design optimized.

5. Project closure:

After finalizing the methods design, all relevant results need to be properly documented and archived. This includes the methods report, analysis report and result. All input and output data stored. A separate post processing module converts the data into colour coded values for visualization of result.

Comparison between actual ground floor process and virtual process by simulation:

Casting simulation is useful for both existing castings, and those under development for the first time, by eliminating shop-floor trials (Fig.2).

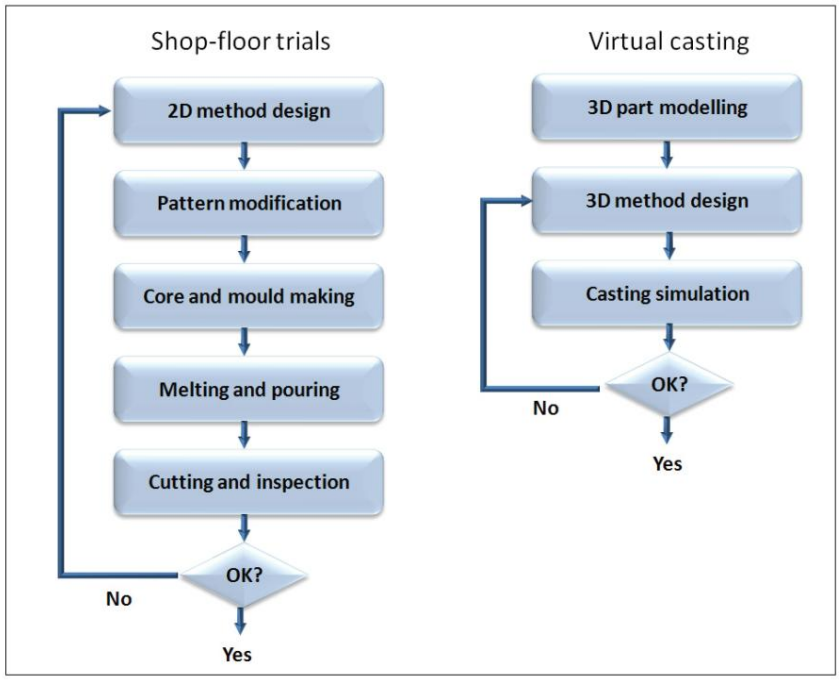

Fig.2 Actual and virtual casting process [1]

Even minor improvements in existing castings that are produced in large numbers, can lead to significant improvements in utilization of material, energy, equipment and labour resources. Simulation is also critical for large heavy castings under development, since their cost of trials or repair is prohibitive.

Application casting simulation:

- Casting process and design optimization
- Troubleshooting of existing casting design and process
- Reliability improvement of casting
- Rapid, economical and high performance casting

III. CASE STUDY EXAMPLE

The example of case study for the application of casting simulation presented here to optimize the casting feeding system design. The casting is of the block part 140×80×80 mm as shown in figure-03 with cast iron. A cylindrical-

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shape riser is assumed. The shrinkage within the casting should be less and the riser volume is to be minimized; this is the objective function.

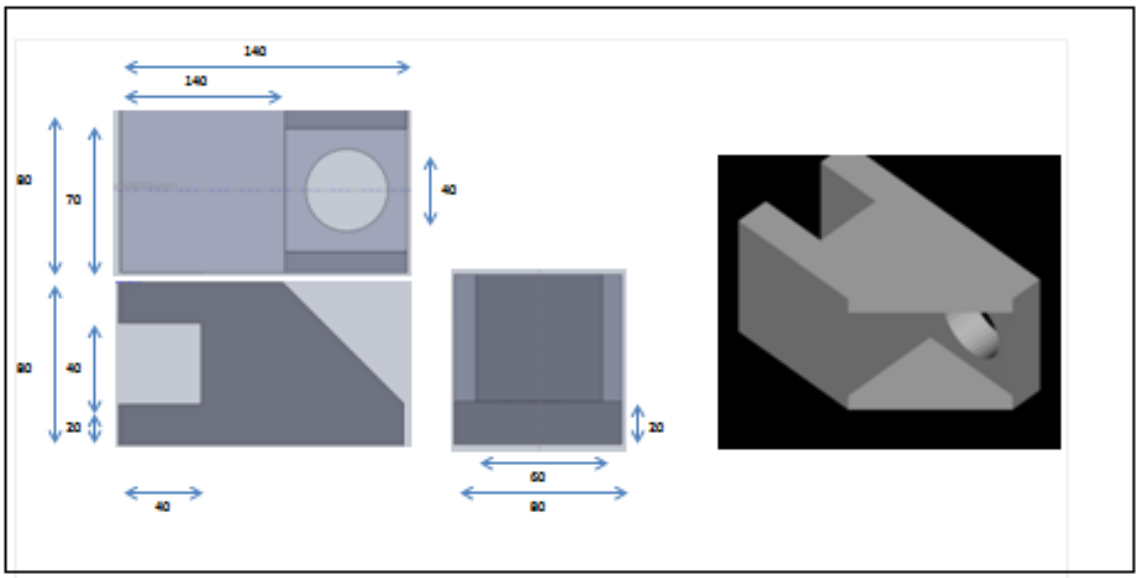

Fig.3 Casting part model

Hence the casting yield is to be maximized while keeping the shrinkage in the casting to a low level. The two design variables to be optimized are the radius '*R*' and height '*H*' of the riser.

Simulation without feeder:

The simulation of sand casting of part model with cast iron material is performed. The 3D model is imported in simulation software, and the virtual casting done with molten cast iron material. As there is no feeder hottest region formed in the virtual casting. A sample-based optimization method is used; the sensitivities of the riser volume to the radius and height are not needed by the software.

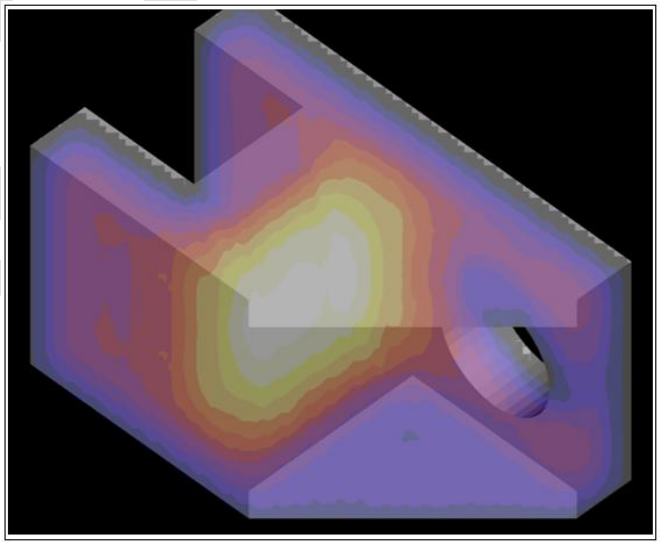

Fig.04 Simulation without feeder

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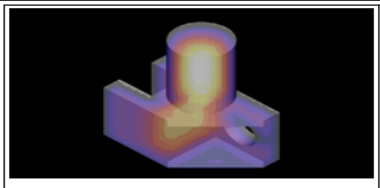
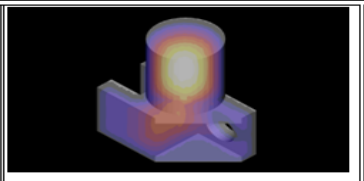
The typical practice cases were run first to determine the shortest riser height that satisfies the margin of safety condition. Once *R* and *H* for the typical practice case were found, those dimensions were used as the starting point for the feeder system optimization process with simulation.

Casting simulation with feeder:

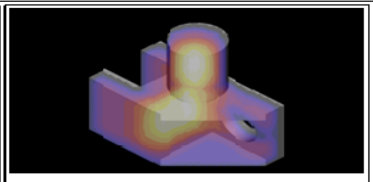
The value search ranges for *D* and *H* were defined in the software as 75 mm, 112 mm respectively. Also another range of D and H are taken. The casting simulation is performed with the three designed values of feeder. The resulting feeder dimensions, feeder volumes, shrinkage predicted and casting yield are given for each feeding system design method



Feeder D = 62 mm
Feeder H = 93 mm
Neck D = 49 mm
Neck H = 10 mm



Feeder D = 75 mm
Feeder H = 112 mm
Neck D = 60 mm
Neck H = 10 mm



Feeder D = 50 mm
Feeder H = 100 mm
Neck D = 40 mm
Neck H = 10 mm

	Designed Feeder	Larger Feeder	Smaller Feeder
Quality	Small shrinkage	No shrinkage	Major shrinkage
Yield	62%	48%	70%
Remark	Unacceptable	Acceptable	Suitable with sleeve

Fig.5 Comparison between the simulations with different dimensions of feeder

Simulation performed with the designed value of feeder i.e. diameter D= 62 mm, and height H= 93 mm. It shows the small shrinkage and yield will 62%. Thus the casting is unacceptable due to shrinkage. With another dimensions of feeder D=75mm and H=112mm, simulation performed. It gives better result as there were no shrinkage, yield is 48% and the casting is acceptable. Hence with the casting simulation, optimization of feeding system is possible.

IV. CONCLUSIONS

Casting simulation is used for the production of reliable, economical and high accuracy cast component. Also it is used to increase the casting yield and reduce the shop floor trial time. With casting simulation technique, casting method and design optimization is possible. Casting simulation helps to predict the defects and their locations. With casting simulation technique, the Feed ability of casting process can be analysis and optimized.

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