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A REVIEW ON CASTING SIMULATION FOR DEFECTS REDUCTION USING AUTOCAST

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ABSTRACT:

Foundries represent an important sector of the manufacturing industry. Foundry industries in developing countries have major problem of quality and productivity because of involvement of number of process parameters in casting process which are difficult to control. Though the process is completely controlled, defects in casting are observed and hence casting process is identified as process of uncertainty which challenges explanation about the cause of casting defects. AutoCAST software for casting simulation is helpful to visualize mould filling, solidification, cooling and to predict the location of internal defects in casting such as shrinkage porosity, sand inclusions and cold shuts. It can be used for troubleshooting existing castings and to develop new castings without shop floor trials.

Keywords: Casting defects, Methodology, Simulation, and Quality.

1. INTRODUCTION

The metal casting is one of the basic manufacturing processes. It has been a traditional manufacturing process from several centuries and even today in the 21st century. Its applications include automotive parts, spacecraft components and many of the industrial and domestic parts. The principle of casting process involves creating a hollow shape of the metallic component to be made in which liquefied metal is poured into previously prepared mould cavity and allowed to solidify. The purpose of process development is to improve the performance characteristics of the process related to customer needs and expectations. The optimized casting process can be achieved through experimentation, which aim is to minimise and control variation of process parameters. Subsequently, decisions must be made concerning which parameter affects the performance of the process. By properly adjusting the process parameters, the variations of the process are reduced thereby the losses can be minimized. A process of casting carries risk of failure occurrence at the process of finished product. Hence to obtain defect free parts necessary action should be taken while manufacturing of cast product [1, 2].

Casting simulation may be an agonizing experience for beginners. The software may not accept the user inputs, other data may not be comprehensible or available, the computer may get hang and take long time to produce the results which may not match shop floor trials. Even regular users experience such problems. A poor

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knowledge of solidification physics and inadequate training in simulation technology becomes barrier in successful utilization of simulation technology. A good knowledge in casting simulation can remove all these difficulties [3].

The process of casting solidification is uncontrollable and complex in nature; hence simulation of such a process is needed in industries. The commonly observed defects like shrinkage cavity, porosity and sink can be reduced by designing an appropriate feeding system to obtain directional solidification in the casting which leading to feeders. Major parameters of a feeding system include the location of feeder, shape of feeder, size and feed aids of feeder [4].

Gating system is the cavity passage from where molten metal is poured from a ladle into the mould cavity. A gating system consists of pouring basin, sprue, well, runners and ingates. The main function of the gating is to obtain smooth, uniform and complete filling, which will leads to minimize turbulence of metal, air aspiration, sand erosion of mould wall and slag inclusions. Poor design of gating system causes the undesired casting defects. The gating design should provide appropriate rate of molten metal flow to the correct locations to completely fill the mould cavity. In fig.1.1 B. ravi has suggested simulation and optimisation methodology which include five step procedure as [2, 5, 6].

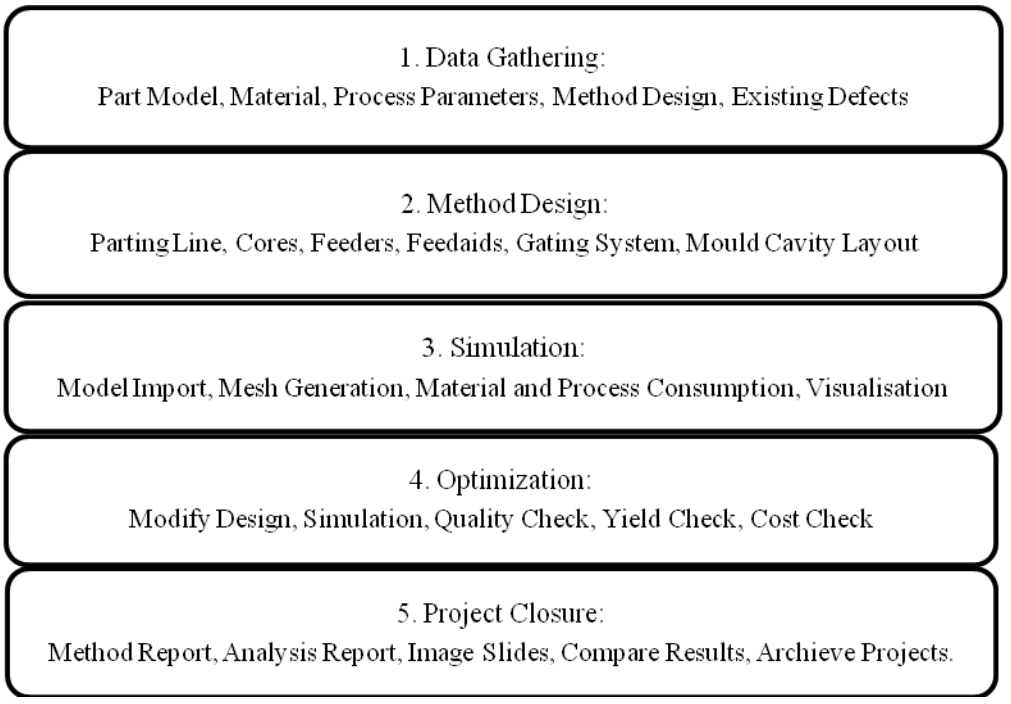

Fig. 1.1: Casting Simulation optimisation methodology.

1.1 Classification of casting defect:

1. Filling related defect

    Blow holes, Sand Inclusion, Sand Burning, Cold shut, Misrun.

2. Shape related defect

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Mismatch defects, distortion or wrap, flash defects.

3. Thermal defect

Crack or tears, shrinkage, sink mark.

4. Defect by appearance

Metallic projection, cavities, discontinuities, incomplete casting, incorrect dimensions or shape and defective surface [2].

II LITERATURE REVIEW

Choudhari et al. [4] stated that the process of casting solidification is complex in nature and the simulation of such process is required in industry before it is actually undertaken. The defects like shrinkage cavity, porosity and cold shuts can be reduced by designing an appropriate feeding system to ensure directional solidification in the casting, leading to feeders.

Kumar et al. analysed that study on various sand casting parameters which affect the casting qualities. The following parameters affect the quality Moisture, Green strength, Pouring temperature, etc. all these parameters affect the casting defects and also show the optimal settings of each parameter to reduce the casting defects and improve the quality of castings at low cost [7].

Shinde et al. [8] have suggested a methodology to optimize mould yield by selecting the correct combination of the mould box size and the number of cavities based on solidification time and mould temperature. Simulation studies have been performed by modeling solid and hollow cube casting with different values of cavity wall gap and finding the minimum value of the gap. He observed that there is no change in casting solidification time beyond minimum value of gap. Then double cavity moulds were prepared with different values of cavity-cavity gap and simulated to find the minimum value of gap.

The use of a simulation model helps to study real life systems which are imaginary. In particular, one is interested in quantifying the performance of a system under observation for various values of its input parameters. Such observed measures of performance can be very useful in the managerial decision process. The cost concerns of the metal casting company targets on the extra time and energy spent in replacing the setup configurations in the manufacturing system. The need for changing the machine set-up is due to the various customer orders that vary in material type, make and dimension [2, 9]. The objective is to design the methoding system, optimize it with the help of simulation and minimize the cumulative total cost consumed in changing of machine set-up. The simulation model is prepared to assess the set-up cost of every possible combination of the orders. It is necessary to describe briefly the Computer Applications in Simulation of Metal Casting Process [10, 11].

III CASTING SIMULATION PROGRAMS

The casting simulation should be used when it can be economically justified for at least one of the following reasons:

1. Quality enhancement by predicting and eliminating internal defects like porosity.

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2. Yield improvement by reducing the volume of feeders and gating channels for casting.
3. Rapid development of an existing or new casting by reducing the number of foundry trials. The corresponding cost benefits can be estimated.
4. Quality improvement reduces the costs associated with producing defective castings, including their transport and warranty.
5. Yield improvement reduces the effective melting cost per casting, and increases the net production capacity of the foundry (without adding melting or moulding units).
6. Faster development of castings through virtual trials eliminates the wastage of production resources, and improves the rate of conversion from enquiries to orders, giving foundries an opportunity to select higher value orders.

There are different types of users associated with casting simulation which are shown in fig. 3.1.

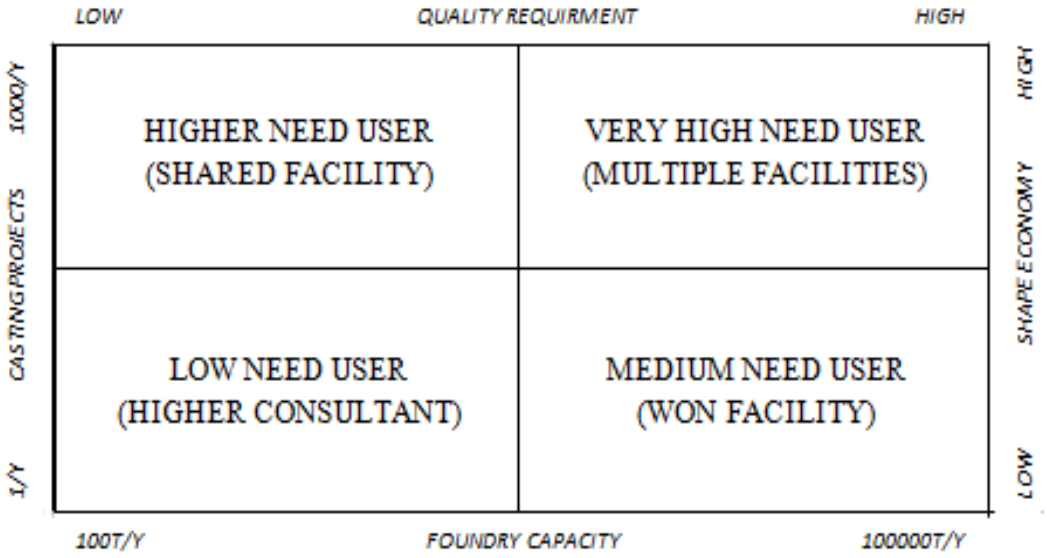

Fig. 3.1: Types of Casting Simulation Users Based on Various Factors [11, 12].

3.1 Steps involved in AutoCAST simulation

1. Solid model a cast part and save it as a .STL file.
2. Browse and upload the casting model file here.
3. Wait till the simulation results are displayed.
4. Identify hot spots. Decide feeder size and location.
5. Model the part with feeder and save as a .STL file.
6. Simulate again and check the location of hot spots.
7. If hot spots are not shifted inside feeders, repeat 4-6.

3.2 The casting simulation software is used for analysing

i. Filling of mould cavity

ii. Steps and direction of solidification Casting

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iii. Internal stress and distortion in casting

iv. Microstructure and mechanical properties of materials

The simulation programs are based on 3D models of castings and involve sophisticated functions for user interface, computation and display [9, 13].

3.3 The following advantages we gained by using AutoCAST software for the design of methoding for casting.

i. The time required for simulation is very less as compared to the traditional trials of method optimization.

ii. Improved quality and/or yield:

iii. Reduced shop-floor trials:

iv. Value addition:

v. Knowledge management:

[13, 14].

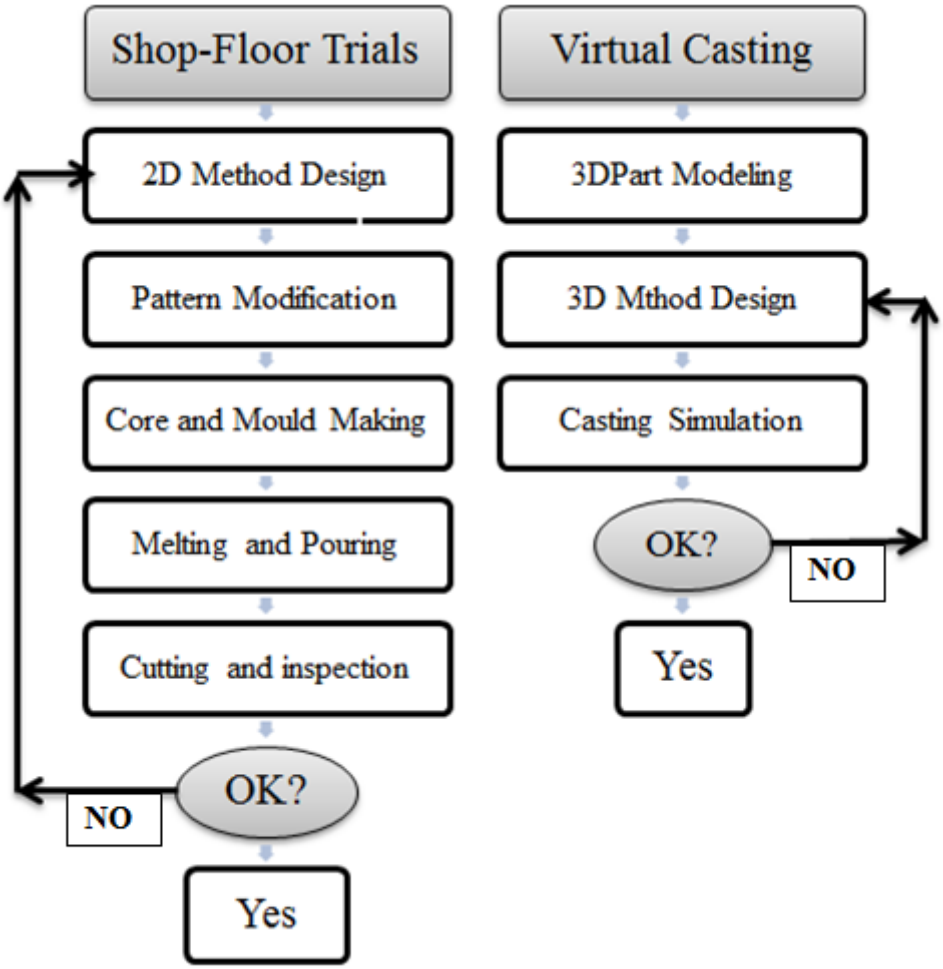

Fig. 3.2: Comparison of manual and computer-aided method optimization.

The comparison between manual and computer aided optimization is shown in fig. 3.2. In traditional method optimization the lengthy process was required first it is required to design the 2D method design of model of

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part then pattern modification and then core and mould making, melting and pouring, solidification, cutting and inspection this process was required to done and at last if any defects present then again the whole procedure was required to done. This traditional process was time and resource consuming process this has been reduced in virtual casting process of simulation. In virtual casting process involves the process of 3D part modelling, method design and casting simulation and if software is showing any defects then again modification was done and virtual trials taken to optimize the results [15].

IV CONCLUSIONS

Computer simulation modeling is a well-established technology but further progress was hampered by the primitive state of technology and the expense of building and running the models.

i. Use of simulation on AutoCAST software, traditional gating system of component has changed into new gating system. Cost of new gating system is less as compared to traditional gating system.
ii. Hot spots in the part suggest the proper location of feeder resulting in reduced defects.
iii. Virtually we can minimise the defects like shrinkage porosity, blow holes, cold shuts, etc.
iv. The time required is very less as compared to the conventional method of design of modeling. Visualization of mould filling phenomenon makes the process easy to understand to the user.

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