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Numerical Optimization of Casting for Defects Analysis and Minimization: A Review

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ABSTRACT

Casting is old and important production process in manufacturing sector. Wherein mould cavities are formed by refractories material such as sand which is porus material. Casting process is molten or liquefied metal is pouring into the mould cavity, after solidification it takes the near net shape of the cavity. Foundry industries have major impact from poor quality and productivity because of a number of process parameter involved it. In casting process defect are due to wrong methoding of gating or improper location of riser and material properties.in this paper the casting defect of large size casting is identified by using simulation, shrinkage porosity mould filling mould solidification are forecast visualize and inspected in form of images. Simulation can be used for troubleshooting existing castings and to develop new castings without shop floor trials.

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

I. INTRODUCTION

Casting is a manufacturing process where a material is melted in furnace, heated to proper temperature and is then poured at proper temperature into a previously made cavity or mould, which contains it in the proper shape during solidification. Thus, in a single step, simple or complex critical design shapes can be made from any metal that can be melted. The main purpose of this process development is to improve the performance characteristics of the process which is related to customer needs and expectations. The optimized casting process can be achieved through taking number of iteration of simulation experimentation, which aim is to minimize and control variation of process parameters. [1]

Mild steel is one of the best materials in the view of best castability and better mechanical properties. Selection of charge material is the first step for producing mild steel casting, The ductile iron foundries productivity is related to mass production of castings for the automobile and other engineering sectors depends on the how many numbers of cavities per mold but denser packing of cavities, however, results in slower heat transfer from adjacent cavities, leading to delayed solidification, possible shrinkage defects, and lower mechanical properties [2]

1.1 CLASSIFICATION OF CASTING DEFECT

1) Pattern design and dimension related defect

Mismatch defects, distortion or wrap, flash defects.

2) Mould filling related defect

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

3) Thermal defect

Shrinkage porosity, sink mark, Crack or tears.

4) Defect by appearance

Metallic projection, cavities, discontinuities, incomplete casting, incorrect dimensions or shape and defective surface. [3]

II. LITERATURE REVIEW

Kumar et al. [4] studied that the 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.

Shinde et al. [5] 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 studied that there is no change in part 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.

Choudhari et al. [6] stated that the cast part solidification process 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.

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. [7].

Shamasunder [8] has studied that the steps which are involved in numerical optimization the possible sources of errors for defects and care to be taken during the casting simulation. According to him,the part designer needs to have full confidence in the casting simulation tool. This can come only by experience and usage of this technique to

minimize effect of various process parameters. With the advances in technology and proper care should be taken in modeling, it is possible to simulate the defects generated during virtual casting before the casting is produced practically. The objective of this technique is to design the gating system, optimize it with the help of simulation technique and minimize the cumulative total cost consumed in changing of machine set-up. It is necessary to describe briefly the Computer Applications in Simulation of Metal Casting Process [9, 10]

III. CASTING SIMULATION

Casting simulation technique mostly used in foundries and metal casting industries. Numerical optimization (Simulation) is the process of imitating a real phenomenon using a set of mathematical equations implemented in a computer program. Casting process simulation is now becoming a prime requirement and invaluable tool in the production of economical and high performance cast components.

Necessity of casting simulation

Casting simulation should be used when it can be economically justified for selecting at least one of the reasons given below:

- Improvement in the Quality by predicting and eliminating internal defects like porosity, blow holes, cracks, yield improvement and rapid development for new product.
- Rapid development: Numerical optimization of casting is virtual process so there are no wastages of material and other scrap. Casting through virtual trials eliminates the wastage of production resources, and gives opportunity to foundry to take high order.
- Yield improvement: With casting simulation technique, the casting process and methoding are optimized in short time. And also optimization of casting process there will be very lesser wastage of material thus it results in yield improvement, reduces the effective melting cost per casting, and increases the net production capacity.
- 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. [3,7]

3.1 Steps for Casting Simulation Formulation in Autocast

1. Create 3D solid model a cast part in cad software and save it as a .STL file.
2. Browse and upload the casting solid model file here.
3. After uploading wait till the simulation results are displayed.
4. Identify hot spots in cast part. Decide feeder size and location.
5. Modify the solid model the part with feeder and save as a .STL file.
6. Simulate again this modified model and check the location of hot spots.
7. Even though hot spots are not shifted inside feeders, repeat 4-6.

As we see the below Fig: 1.1 differences between actual ground floor process and virtual process by simulation:

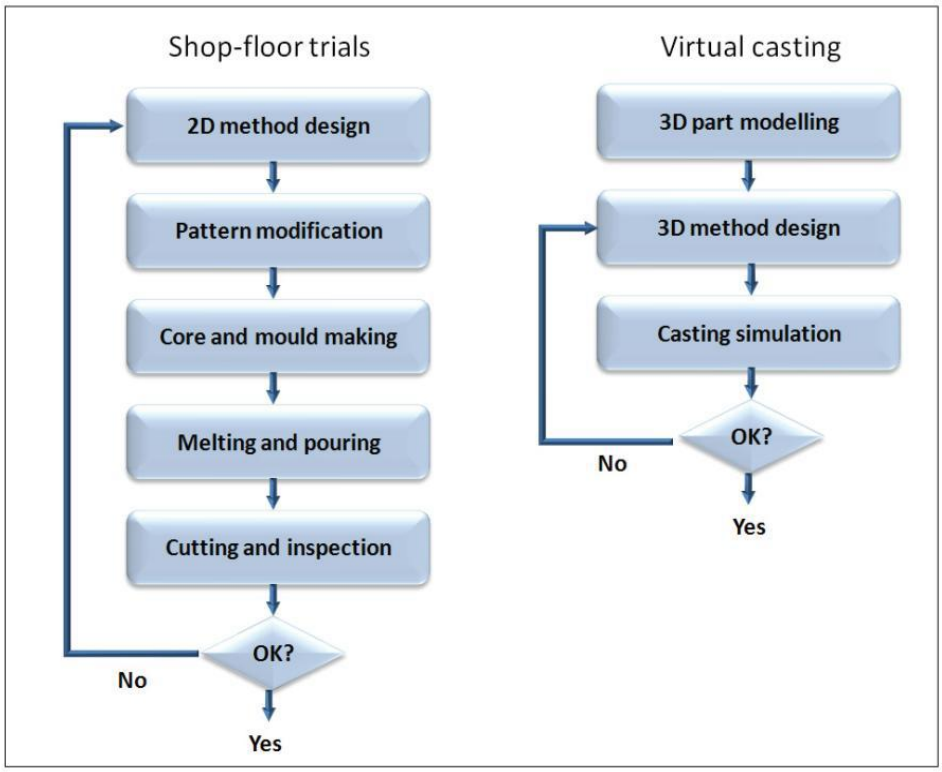

Fig.1 Actual and virtual casting process [1]

Numerical optimization is useful for both existing castings, and new product under development for the first time, by eliminating shop-floor trials. A small improvement in existing castings that are produced in higher quantity can lead performed significant roll to improvements in utilization of material, energy, equipment and labour resources. Simulation for large heavy castings is also critical under development, since their cost of trials or repair is prohibitive. In traditional method optimization the lengthy process was required actual casting performed number of time up to elimination of defect present in the part. This traditional process was time and resource consuming process and wastage of material, money and energy involved in it.

In virtual casting process of numerical optimization process involves the process of 3D part modeling, method design and casting simulation and if software is showing any defects then again modification was done and virtual trials were taken to optimize the results

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V. CONCLUSIONS

Numerical optimization (simulation technology) has played a sufficient role and has become an essential tool for casting defect analysis, troubleshooting and method optimization. Also, it is used for the production of reliable, economical and high accuracy cast component.

i. Utilization of simulation technology on AutoCAST software, existing or traditional gating system of component has modified into new gating system.
ii. Cost of new gating system is less as compared to traditional gating system as well as yield is more in new gating system.
iii. Hot spots in the cast part suggest the proper location of feeder resulting in reduced defects.
iv. We can minimize the defects virtually like shrinkage porosity, blow holes, cold shuts, etc.

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