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Reduction of Shrinkage-Porosity Defects in Sand Casting Using Finite Element Analysis: A Review

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Abstract

Today production of casting is easy but market requirement is quality casting. Earlier casting is made with large no. of defects due to large no. of process parameter in casting process. Specially, to predict phase transformation is very critical. As the problem of automation in process, shortage of skill labour now a days; casting simulation requirement is high and it is identifies defects earlier without making actual casting. This process reduces time and cost. Many casting defects occur like; hot tears shrinkage-porosity etc. at the time of solidification of casting. Casting simulation software is very much helpful to get quality casting. This paper reviews the details of solidification of castings in foundries using computer simulation. In this review paper study is done to reduce shrinkage porosity defects in sand casting component.

Keywords: *Sand Casting, Shrinkage-Porosity, Casting Simulation*

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INTRODUCTION

This paper intends to study the sand casting process and how to reduce solidification defects of sand casting like shrinkage porosity using casting simulation technique. The main role of solidification of castings is metallurgical phase transformation. As compared to different countries, use of software in Indian foundries is very low, almost < 5%, which is very low, equated to German Foundries almost 90% and 75% in American foundries. However, day by day in India use of casting simulation is increasing.

Sand Casting Process

90% of casting is made by Sand Casting Process because it is used largely for both ferrous and nonferrous metals. Classification based on binders used:

(1) Inorganic (in green and dry sand moulds)
(2) Organic (in shell moulding)

It is a three steps process:

Step: 1 Pre-casting

- Sand Preparation
- Core making
- Moulding
- Mould assembly

Step: 2 Casting stage

- Furnace charging
- Melting
- Moulding
- Melt treatment
- Pouring into moulds

Step: 3 Post-Casting

- Shakeout
- Cleaning
- Fettling
- Shot blasting
- Inspection

Types of Defects in Sand Casting

Shrinkage Cavities

It is induced by liquid shrinkage occurring during the solidification of the casting. To Counterbalance, right feeding of liquid metal is needed (Figure 1).

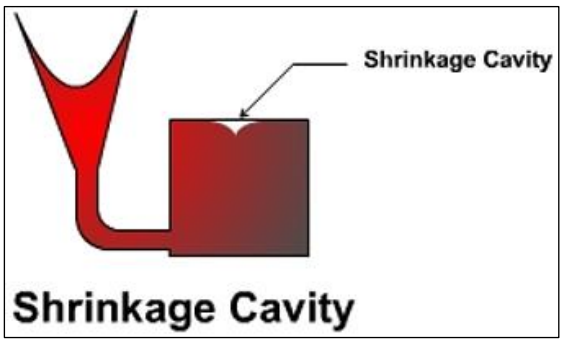

Fig. 1: *Shrinkage Cavity.*

Pin Hole Porosity

Molten metal absorbed gases so it's induced porosity. Practically all metals absorb hydrogen, nitrogen and oxygen. Molten metal takes up hydrogen from fuel, moisture in air and moulds (Figure 2).

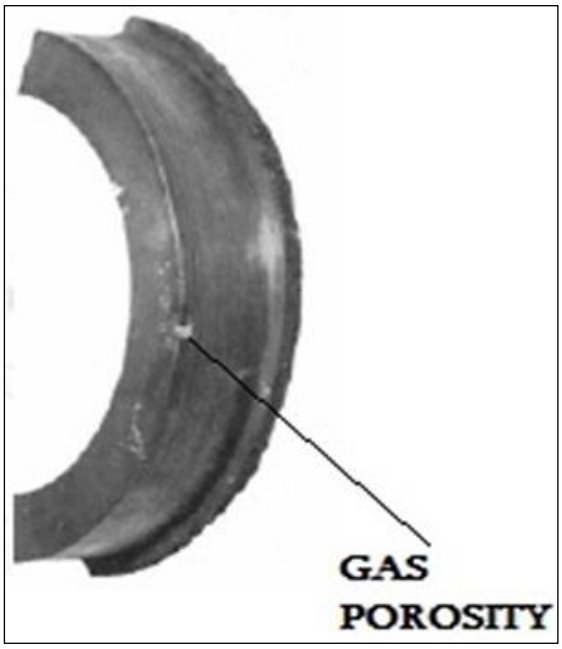

Fig. 2: *Pinhole Porosity.*

Porosity in Metal Casting

In casting, porosity is common problems which degrade the quality and decline the mechanical properties. Forgings, machined parts and fabrications are able with ingot cast feedstock and mechanical processing. There are two types of porosity:

Macro Porosity

Micro Porosity

Other defects also occur like misrun, blow holes, metal penetration etc.

PROBLEM IDENTIFICATION

Randal casting is leading mfg. of ductile and grey cast iron casting. Company facing various problems in casting; among them shrinkage-porosity defects in rear axle oil seal retainer are much more. Based on these defects, detailed literature review has been done in the present paper.

LITERAURE REVIEW

Ravi et al. expressed their views on simulation of casting. Casting simulation has become important tool to identify mould filling, solidification and location of shrinkage porosity etc. [1].

Feng Li optimizes the gate/riser system using CAD and simulation technology and improving casting quality [2].

Singh and Joshi, they identified attributes of the casting defects in jobbing foundry and to achieve desired quality they introduced a scientific approach comprising method design, process simulation, quality evaluation and cost estimation and this system is very easy and done on computer within one hour [3].

Rao et al. have worked on the simulation of the mould filling solidification of casting of green sand ductile iron casting [4]. They resolved that ProCAST is able to identify and resolve the defects like shrinkage, porosity etc.

Ravi described the steps of simulation process and how they can be applied to get best optimized result. Different projects have been taken to simulate them and get optimized result [5].

Bhedasgaonkar and Dabade combined the casting simulation techniques and DOE and analyse the defects which either related to sand or mathoding in green sand casting. They try to get optimal setting of moulding sand and mould related process parameters. For the experimental purpose Taguchi based L18 orthogonal array was used and analysis was done on Minitab software for analysis of mean (AOM), analysis of variance (ANOVA) plot [6]. Chudasama did analysis on different components and described that casting simulation reduces the defects [7]. They found that when riser height increased from 130 to

160, shrinkage porosity is increased but not in linear proportion. Another parameter that has major effect on shrinkage porosity is runner height. We have changed the runner height from 16 to 22, in between these optimum value for runner height is 18 with minimum shrinkage porosity 2.43% and reduces 30% casting rejection rate.

Sata worked on prediction of shrinkage defects by using various criteria functions. L shape casting is analysed by solidification simulation and compared with experimental result. They predicted that defects are approximately same as practical defects [8].

Piyush project covers the design improvement of gating design in sand casting; predict the internal defect such as shrinkage defect. Final product should confirm the design requirement without internal defects. They optimize the casting material by 0.5 kg [9].

According to Hussain et al. shrinkage defect may occurs at the last freezing point of casting in its thick section. Feeders are required to remove shrinkage porosity from casting. With the help of computer simulation on Ansys, hot spots have been identified and three feeders have been designed and optimization procedure has been developed for three feeders successfully. Three feeder optimization results from Ansys have been compared with traditional modulus approach. Feeder yield optimize 36.90% [10–12].
From this literature it has been studied that casting simulation is useful to reduce the casting defects.

CASTING SIMULATION

Thousands of new castings are developed every day in foundries all over the world. To improve the desired quality with high yield, most of the foundries depend on shop-floor trial and experienced person's knowledge. Without optimization methods, wastage of resources including material and energy are high. To reduce wastage and get good quality simulation is used. Casting simulation projects are two types:

(1) Quality or yield improvement of existing castings
(2) Rapid development of new castings

Simulation is a five stages process (Figure 3):

- Data gathering
- Methods design
- Numerical simulation
- Methods optimization
- Project closure

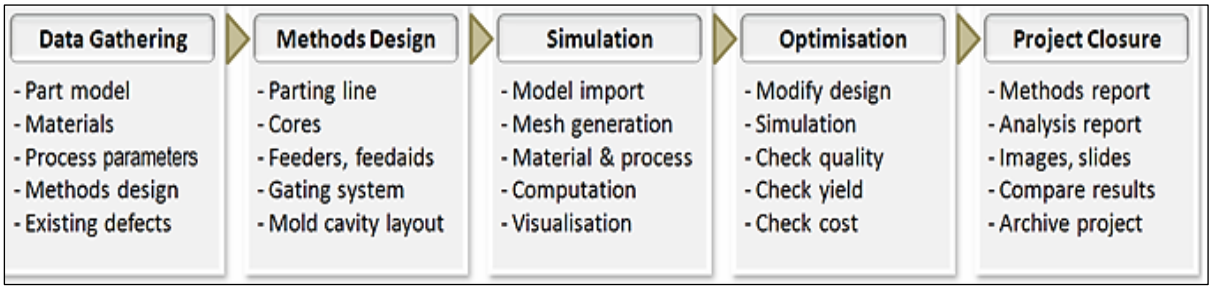

Fig. 3: *Major Stages in Casting Simulation and Optimization [5].*

The programmes employ different methods for casting simulation [5].

(i) F.E.M.(Finite Element Method) (ex. ProCAST, Ansys),
(ii) F.D.M.(Finite Difference Method) (ex. SolidCAST),
(iii) F.V.M.(Finite Volume Method) (ex. MAGMASoft),
(iv) V.E.M.(Vector Element Method) (ex. AutoCAST).

Each method has certain advantages and disadvantages. Among the last 40 years, there has been an extensive use of FEM technique in analysing physical phenomena in the field of solid, fluid mechanics, structural and solution of industrial problems. FEM have high capacity to study the process that other tools cannot. For the solidification analysis FEM is most helpful tool because it analyses all physical phenomena by elements. Each element is built by nodes (Figure 4).

CONCLUSION

Based on literature review it can be concluded that the shrinkage porosity defects can be reduced by using computer simulation technique FEM. Based on this theory software tools like Ansys and ProCAST software for simulation of sand casting process can be used and reduce the defects by analyzing new gating design.

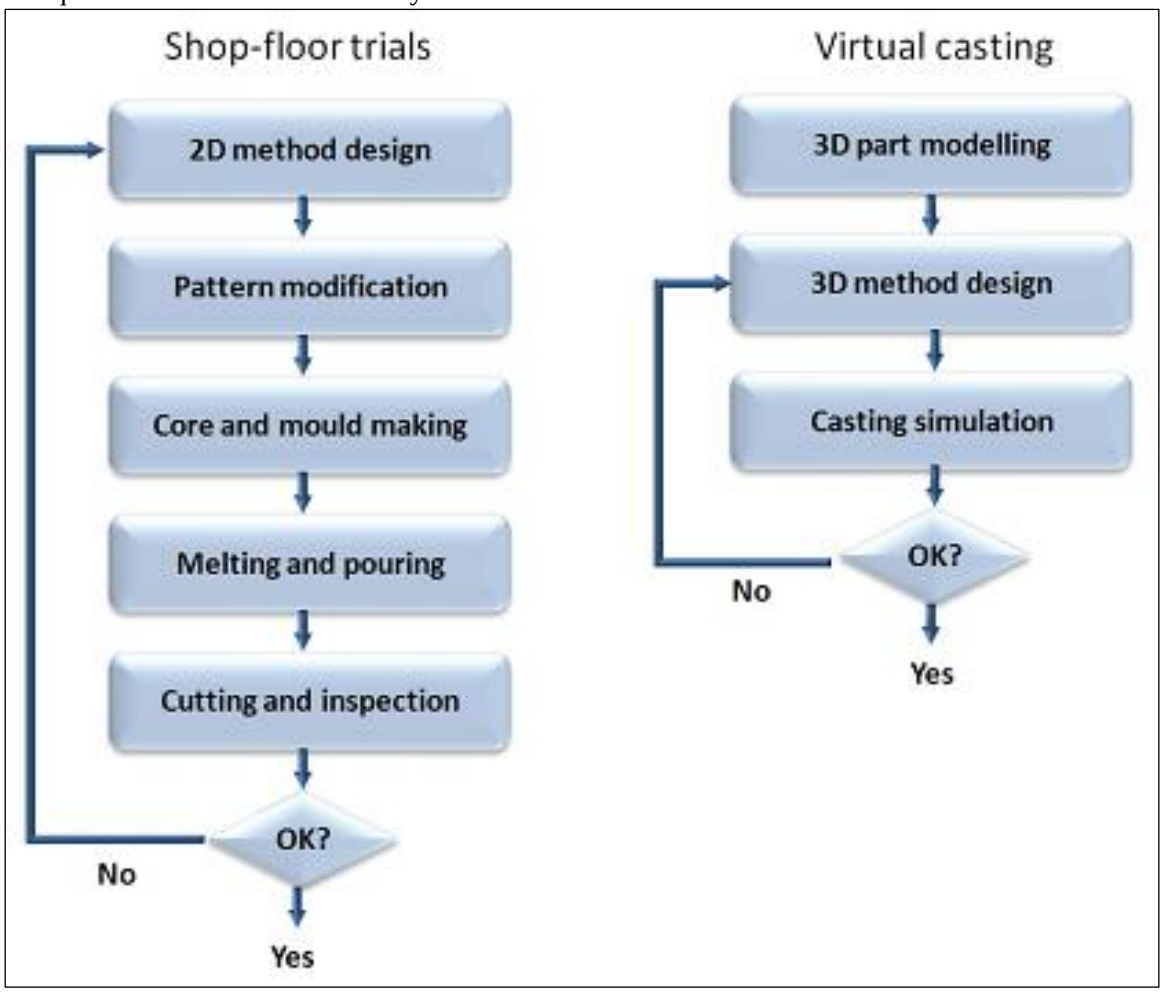

Fig. 4: *Equivalence of Manual and Computer-aided Method of Optimization [1].*

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