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A Review on Design, Simulation and Optimization of Feeder System for Reducing Casting Defects

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Abstract: This paper broadly review the available literature for various techniques to study ,analyse and predict investigation of Casting Defects with Simulation . Computer-aided casting design and simulation give much better and faster insight for optimizing the feeder and gating design of castings.
It was found that the defects like shrinkage cavity, porosity, and sink can be minimized by designing an appropriate feeding system to ensure directional solidification in the casting, leading to feeders . A different casting simulation software's available for Simulate and visualize the entire process of casting part , including pouring ,solidification and shrinkage formation .Controlling shrinkage porosity depends on understanding its sources and causes.Major improvements in product quality, component performance, and design reliabilitycan be achieved if shrinkage porosity in castings can be predicted, controlled or eliminated . Also A case study on feeder optimization is described in paper.
Keywords: Casting simulation , Feeding System, casting Defects ,casting softwares

I. INTRODUCTION

In recent years, computer simulation of casting solidification has gained much ground, owing to the constant and painstaking efforts of researchers to make such software tools more reliable and easier to use. A significant number of real-life case studies are also available in technical journals and proceedings of conferences related to casting.
Metal casting simulation is currently performed by Finite Element Method simulation software designed as a defect-prediction tool for the foundry engineer, in order to correct and/or improve his/her casting process, even before prototype trials are produced. The idea is to use information to analyze and predict results in a simple and effective manner to simulate different processes .(Ponginan, n.d.)

A. Casting Quality

There are numerous opportunities for things to go wrong in a casting operation, resulting in quality defects in the cast product

B. Casting Defects

Some defects are common to any and all casting processes.

1) Misruns, which are castings that solidify before completely filling the mold cavity.
2) Cold Shuts, which occur when two portions of the metal flow together but there is a lack of fusion between them due to premature freezing. Its causes are similar to those of a misrun.
3) Cold shots, which result from splattering during pouring, causing the formation of solid globules of metal that become entrapped in the casting. Pouring procedures and gating system designs that avoid splattering can prevent this defect
4) Shrinkage cavity is a depression in the surface or an internal void in the casting, caused by solidification shrinkage that restricts the amount of molten metal available in the last region to freeze. The problem can often be solved by proper riser design.
5) Microporosity consists of a network of small voids distributed throughout the casting caused by localized solidification shrinkage of the final molten metal in the dendritic structure. The defect is usually associated with alloys, because of the protracted manner in which freezing occurs in these metals.
6) Hot tearing, also called hot cracking, occurs when the casting is restrained from contraction by an unyielding mold during the final stages of solidification or early stages of cooling after solidification. (Groover, 2007)

II. LITERATURE REVIEW

The literature review is mainly focusing on design and optimization technique based on casting related defects and their research and outcomes.

Masoumi M.H.(Masoumi et al., 2005)suggested the effect of gating design on mold filling for light metal casting processes. The vali-dation results showed that the design and shape of the gate and the ratio of the gating system have a great influence on the pattern of mold filling.

Ravi and Joshi(Ravi & Joshi, 2007)worked on computer-aided casting design and simulation of feeder and gating design of castings using Auto-CAST software and they explain how it help in .

Ravi, B(Ravi, 2008)suggested ,Casting simulation helps to visualize mould filling, solidification and cooling, and also shows the location of internal defects such as shrinkage porosity, sandinclusions, and cold shuts. CAD/CAM/CAE used for remedy existing castings defects , and for improving new castings without shop-floor trials. 3D CAD model is the main input to a simulation program for casting. Main outputs of simulation programs include animated visualization of mould filling, casting solidification. Mould filling simulation helps in predicting the total filling time, mould erosion , incomplete filling (cold shuts and misruns), and air trap. Casting solidification simulation predict shrinkage porosity . Autor also notice simulation program can not improve method by it self ,its required experienced engineer. Casting simulation in foundary reduces the lead-time for the first good sample casting.

Feng Liuet(Liu, 2009),explained complex shapes of metal materials in mass production Casting exists many different defects such as porosity and incomplete filling.

Gating/riser system design is critical to improving casting quality. CAD and simulation technology was used to optimize gating/riser systems based on with the goal of improving casting quality such as reducing incomplete filling area, decreasing large porosity and increasing yield. CAD model Imported for casting simulation with adding runner and risers. After analyzing simulation results for engine block , the gating/riser system design is optimized to improve casting quality which decrease porosity around 18% while the yield increases 16%.

Sutaria(Sutaria, 2010) worked on a new idea where optimization of casting feeding is done with the help of feed-paths. The computation of feed-paths is done by the method known as vector element method (VEM).

M. Sutaria, B. Ravi(Sutaria et al., 2011)Author focused on defects like shrinkage cavity, porosity, centerline shrinkage, corner shrinkage and sink can be minimized by designing an appropriate feeding system to ensure directional solidification from thin to thick sections in the casting, leading to feeders . In a casting with different wall thicknesses, the direction of solidification is from thin tothicker to thickest sections. The feed paths are in the reverse direction, from thickest to thinnest sections, aligned along the maximum temperature gradient, which is in turn perpendicular to the local solidification front. The hot spot solidifies last, defect is distributed in the form of shrinkage porosity around the hot spot,feeder should be the last to solidify .

Auther study six industrial case studies, one for each feeding parameter, covering ferrous castings produced in sand molds as well as nonferrous castings produced in permanent molds.

Auto cast X developed in the EFoundry lab at IIT Bombay, based on Vector Method used for computer simulation of casting solidification for feeder evaluation and optimization . Most cases feeder size and location modified hot spot are shifted from parts side to feeder size for defect free casting. This was later verified by shop floor trials also yield increased marginally

ManjunathSwamy H M(ManjunathSwamy et al., 2012)Author has worked on casting of front axle housing front axle housing defects such as shrinkage and gas porosities . Optimization of the gating and risering system by using casting simulation software ADSTEFAN .Three types of gating system were examined through numerical simulation and an optimized design was chosen in which porosity decreased by 97% .

Hassan I..(Iqbal et al., 2012)Authorworks on the impeller shaped casting . For casting Simulation MAGMASOFT software used . After Simulation Feeding system ,Riser and gates modified and shown solidification and related defects.

HarshilBhattet(Bhatt et al., 2014) have commented that casting simulation can effectively overcome various difficulties like Shrinkage cavity, cold shuts, mis-run, porosity, and blow hole etc. in final product. Simulation could provide powerful tool for prediction of the process growth. Simulation of existing feeding system provides the location/s of the point/s where chances of defects are high. The information supplied by the simulation software can be used to modify the feeding system design. Feeding systems are modified and simulated unless satisfactory results are obtained. In this study, researchers have made an attempt to simulate various designs of feeding system which will give better output in order to obtain optimum design

C. M. Chaudhari(Choudhari et al., 2014)suggested that by optimization method cast-ing related defects can be improved. The proper location,size and design of gating and feeder system using simulation technology improved the shrinkage porosity and cracks in casting. Author work on numerical simulation using AutoCAST-X software and finally validation with experimental trial of cover

plate. Part made by sand casting suffered from shrinkage porosity defect and incomplete fill which cause premature failure . Gating system is modified to shifting hot spot toward feeder and placed toward last solidification region with AutoCAST-X software . His work simulation can be use in optimizing the feeder dimensions and identify and minimize Casting defects .

Y. V. Gore(Gore et al., n.d.)Author explained the effect of three parameters such as conductivity of sand, pouring temperature of molten metal and initial temperature of sand on the heat transfer during solidification of casting.

Himanshu Khandelwal ,Dr. B. Ravi(Khandelwal& Ravi, 2016) Authors worked on producing casting part propeller from rapid prototyping (3 d printing) method .

Cad model of propeller created and imported in Auto cast software for solidification analysis and Shrinkage porosity identification. .Pattern for part with gating system is manufactured in 3d printing using plastic material .

For experimental Mould fabricated with 3d printed Pattern which is coated With chemical resin, hardener and accelerator, after a material is poured . For inspection dimensional accuracy of final casting part of impeller scanned with software Colin 3D . The surface roughness of the cast impeller was inspected using ZETA 20 3D optical microscope .

Mark Jolly(Jolly, 2002)Author study how different foundry softwares like pro cast , Magma soft etc as most powerful tools used in foundry industry .Casting simulation software has rapidly increased although the proportion of foundries but no single piece of software completely satisfies the requirements of the foundry .Author also suggested Work on developing software for the prediction of microstructure and porosity is ongoing, and will become part of standard software packages in the near future .

Sachin L. NimbulkarRajendra, Dr. S. Dalu(Nimbulkar&Dalu, 2016)In this review, work is done on a wear plate. Existing feeding system is studied and imitation of new feeding system is done by using AutoCast software. During casting gates and riser were placed symmetrically and flow was uniform, gases were easily escaped to the atmosphere. By using this method superiority of casting has been improved.

Samir Chakravarti(Chakravarti et al., 2018) Author carried work on the calculation of temperatures at any point within the casting is performed by calculating the error function. Using FORTRAN software . The total solidification time is calculated and compared to benchmark solution .

Khan M.A. Sheikh A.K (Khan & Sheikh, 2018)Author reviewed on software Used in casting simulation. A number of software's are available for casting simulations among which author selected eight middle and high end software packages . Comparisons based on various features like casting process ,solution methods ,cast and mould materials ,defect prediction ,design and process optimization etc. Different Numerical solution methods used in casting simulations software .FDM (Finite difference method) used in MAGMA soft ,Solid CAST ,FLOW3D CAST softwares. FVM(Finite volume method) used in CastCAE and Nova Solid /Flow softwares and Vector Element Method (VEM) used in AutoCAST . FEM (Finite element method) used CAPCAST ,ProCAST, FLOW3D CAST softwares . Porocity ,cold shunt ,misrun ,shrinkage defects predicted by all these softwares .These softwares can Be use Foundries , Academic institutes, R And D .After comparison FLOW3D CAST, MAGMAsoft , ProCAST, Nova Solid /Flow, CAPCAST are considered as high end softwares where CastCAE, AutoCAST,SOLID cast are have limited features .

MojtabaJavahery(Javahery&Abbasi, 2019)In this paper, the sand casting process was evaluated using ProCAST simulating software and practical experience for manufacturing of the high chromium stainless steel outlet diaphragms used in iron ore ball mill. After simulation the different gating and feeding designs optimum feeder system selected .The simulation of solidification conclude four feeders are required to eliminate of the shrinkage porosities.

Pratesa(Pratesa et al., 2019) Author explain the casting design software Z-CAST used for failure Analysis of impeller which failed during services by impact load. The fracture occurred at the thin shroud area of the impeller and showed brittle exterior. Hardness test on impeller shows differences of hardness number between thin area (shrouds) and thick area at the impeller, resulted from microstructure differences. FEA simulation using Z-CAST confirms the development of microstructure differences which are largely affected by casting designs and solidification characteristics thin shroud area have a high possibility for under cooled graphite to form.

FEA solidification simulation conformed the result of Laboratories testing.

Atsushi Kishimoto(Kishimoto et al., 2019)In this paper Author investigated the physical property values for determining the simulation setting conditions, and validated with the physical property calculation software J-mat Pro for prevention of shrinkage defect .Comparison of the predicted shrinkage prediction result of the cast solidification simulation result and the actual result was carried out .

III. CASE STUDY

A. Casting simulation case study: Cast Iron Turbine casting ,e-foundry I.I.T.B.

A Cast Iron Turbine casting housing casting of overall size 170mm×150mm × 100 mm , weighting 3.2 kg , Side feeder have 35 mm bottom diameter and 60 mm height was production in leading foundry , suffered from frequent rejection from internal porosity After Solidification simulation analysis results shows feeder is slightly undersized and hot spot inside the casting which matches with shrinkage porosity found inexisting casting .

The feeder dimensions have revised 40 mm bottom diameter and 65 mm height and analyzed for hot spot .After solidification simulation in Autocast soft hot spot shifted in feeder side result in elimination of internal shrinkage .(*E-Foundry*, n.d.)

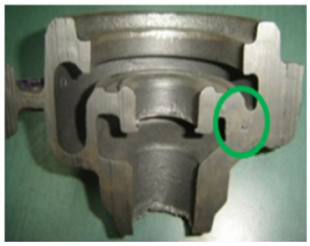

Fig1. Shrinkage Porocity in Actual Casting

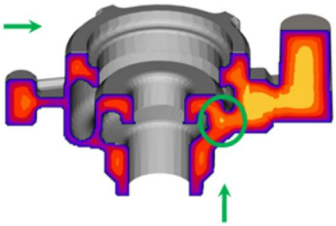

Fig2. Solidification Analysis hot spot in side Casting

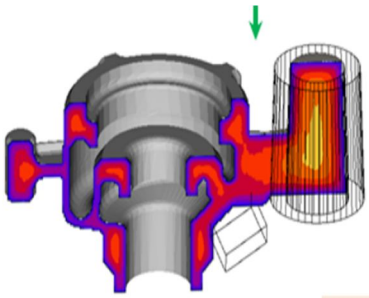

Fig. 3 Solidification Analysis hot spot transfer feeder side means Defect free casting

IV. CONCLUSION

By using casting simulation method, the percentage of rejection of casting due to gat-ing and feeding system related defects has been reduced

In this study, it was observed that solidification simulation enables and visualizes the progressive freezing from inside a casting to external environment and also identifies the last solidified regions, hot spots, metal flow rate, etc.

It is concluded that casting solidification simulation technology is used to eliminate defects like shrinkage, porosity and to locate the hot spot regions which helps to design the components effectively. Many researcher after solidification simulation and shop floor trial suggested if hot spot in casting should transferred in feeder side for defect free casting. Casting simulation can help to minimize casting defects and used for optimum feeder system design for defect free casting and avoids shop floor trials

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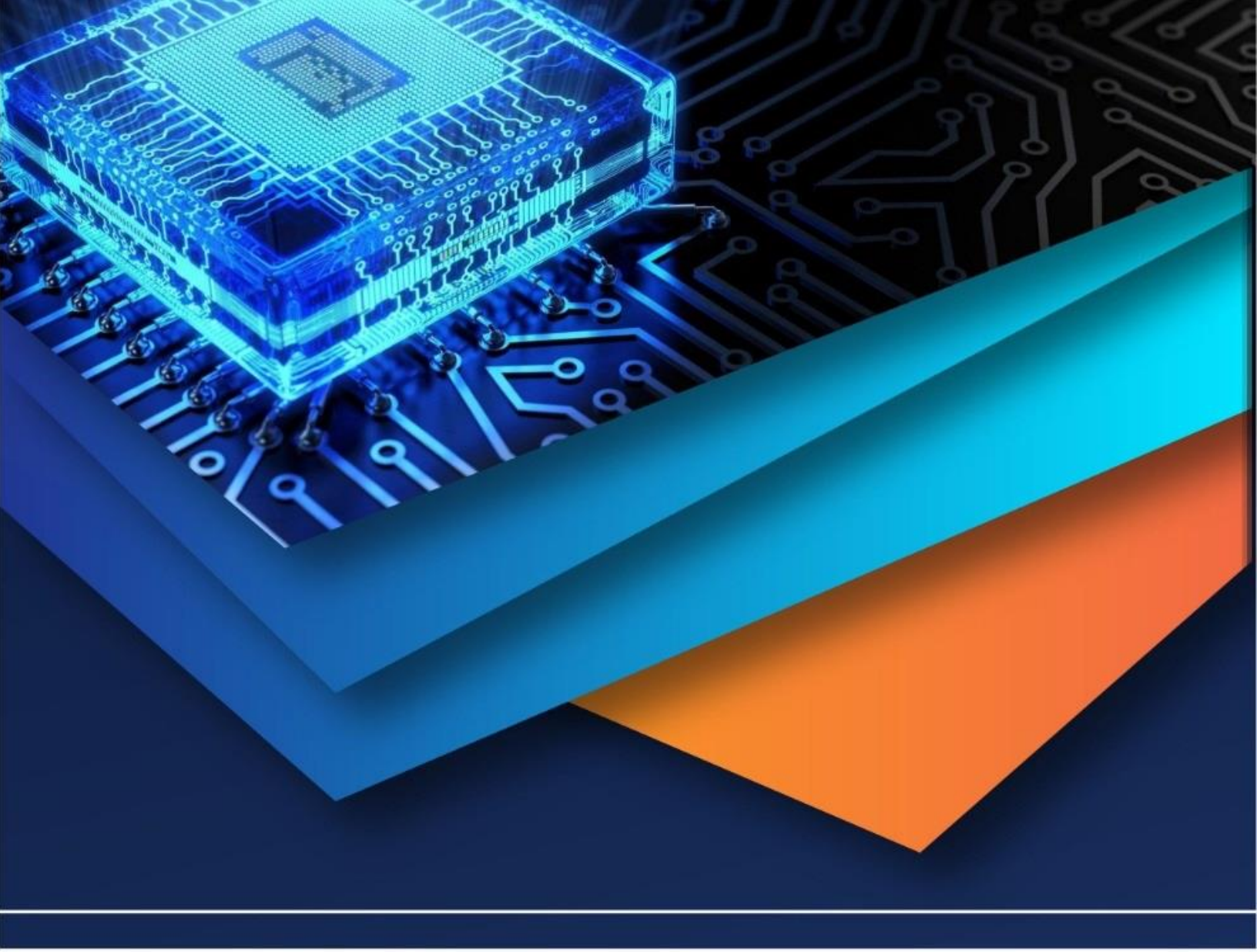

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