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"DEFECTS MINIMIZATION IN CASTING THROUGH PROCESS IMPROVEMENT: A REVIEW"

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Abstract: Computer simulation of casting processes has advanced significantly within the last few years. The demand for precisely designed, cheap and perfectly made casts is constantly growing. Moreover, the competition in the market is rising every day. If the component's manufacturers want to keep their position on the market, they need to learn how to make use of modern simulation programs. Therefore, computer programs have been invented to enable designers to take control over liquid metal behavior and help to eliminate defective part, especially shrinkage porosity defects inside the casts. This paper shows a brief review of a casting Simulation Techniques presented by a different researchers.

Keywords: Casting defects, Casting Simulation, Process.

Introduction:-

Simulation is the process of imitating a real phenomenon using a set of mathematical equations implemented in a computer program. Metal casting, which has been compared to natural phenomena such as sea wave splashing and volcanic flow (Fig. 1), is subject to an almost infinite number of influences. Various simulation software's having Finite Element Method (FEM) or the Finite Difference Method (FDM) such as Inspire CAST, AUTO CAST, SOLID CAST, Pro CAST, Magma CAST etc. are used today. The Industry is following continuous improvement policy and efforts are being taken to improve the process and process parameters of various certified components. Therefore, computer programs have been invented to enable designers to take control over liquid metal behavior and help to eliminate defective part, especially shrinkage porosity defects inside the casts.

Dabade & Bhedasgaonkar (2013) In this paper the design of experiments and computer assisted casting simulation techniques are combined to analyze the sand related and methoding related defects in green sand casting. An attempt has been made to obtain the optimal settings of the moulding sand and mould related process parameters of green sand casting process of the selected ductile iron cast component. The green sand related process parameters considered are, moisture content, green compression strength, and permeability of moulding sand and mould hardness (in horizontal direction). In first part of this paper Taguchi based L18 orthogonal array was used for the experimental purpose and analysis was carried out using Minitab software for analysis of variance (ANOVA) and analysis of mean (AOM) plot. ANOVA results indicate that the selected process parameters significantly affect the casting defects and rejection percentage. In the second part, shrinkage porosity analysis is performed using casting simulation technique by introduction of a new gating system designed, solid model developed for four cavities mould. Number of iterations using casting simulation software was performed for mould filling and solidification analysis to reduce the level and intensities of shrinkage porosities in cast component. With new gating and feeding system design reduction in shrinkage porosity (about 15%) and improvement in yield (about 5%) is observed. [1]

Tiedje (2010) Ductile cast iron has been an important engineering material in the past 50 years. In that time, it has evolved from a complicated material that required the foundry metallurgist's highest skill and strict process control to being a commonly used material that can easily be produced with modern process technology. Yet, for the skilled metallurgist and foundry engineer, it is a material that can be engineered to meet extreme demands with regard to mechanical properties and geometrical complexity. It is therefore a material that has been in growing use since its discovery. And the results of the latest years of research indicate that ductile cast iron in the future will become a highly engineered material in which strict control of a range of alloy elements combined with intelligent design and highly advanced processing allows us to target properties to specific applications to a much higher degree than we have seen previously. It is the aim of the present paper to present ductile iron as a modern engineering material and present the many different possibilities that the material hides. Focus will be on the latest research in solidification and melt treatment. But for completeness and to illustrate how ductile iron's properties are optimized, the essentials of heat treatment are described too. It is the hope that researchers will find a comprehensive treatment of ductile cast iron metallurgy and that engineers and designers will be presented with the latest information on, and references to, the properties and possibilities in ductile cast iron. [2]

Ravi (2009) This paper show that, the location and extent of shrinkage porosity can be predicted by identifying regions of high temperature (hot spots) and low gradients (short feeding distance). The bottlenecks and non-value added time in casting development can be minimized by adopting CAD, intelligent methoding and simulation technologies. These have been developed, successfully demonstrated on industrial castings, and now being used in several organizations.

Several innovative algorithms, including VEM, geometric reasoning, and automatic solid modelling dramatically compressed the iteration time for methoding modification and simulation to less than one hour for even complex castings. Further, the simple and logical user interface greatly improved the learning curve for engineers, to just a few hours. As a result, even small foundries with little or no previous exposure to CAD/CAM software are able to effectively use the program to improve their casting quality, yield and productivity. It has also proven to be very useful for verifying the manufacturability of a casting and improving it by minor modifications to part geometry, before freezing the designIn future, it will be possible to offer automated methoding and simulation functionality over the Internet, enabling access to this technology to even SME foundries in remote areas.

This paper has presented an experimental and numerical analysis to relate the variation in ductility in ductile cast iron to casting defects and material microstructure. [3]

Ravi (2008) Casting simulation has become a powerful tool to visualize mould filling, solidification and cooling, and to predict the location of internal defects such as shrinkage porosity, sand inclusions, and cold shuts. It can be used for troubleshooting existing castings, and for developing new castings without shop-floor trials. This paper describes the benefits of casting simulation (both tangible and intangible), bottlenecks (technical and resource related), and some best practices to overcome the bottlenecks. These are based on an annual survey of computer applications in foundries carried out during 2001-2006, which received feedback from about 150 casting engineers, and detailed discussions involving visits to over 100 foundries. While new developments such as automatic optimization of method design are coming up, a national initiative must ensure that the technology is available to even small and medium foundries in remote areas. [4]

Aloe & Anton (2007) This paper show that, in order to better understand the shrinkage behavior of cast iron during solidification, a CAD model was developed to simulate the microstructure formation. The density change during solidification and the ambient temperature mechanical properties was calculated based on the microstructure. In ProCAST, a comprehensive micromodel has been developed to simulate microstructure formation of cast iron. The model can give accurate shrinkage prediction by taking into account density variation through microstructural information as well as the mechanical properties at ambient temperature such as yield strength, tensile strength, elongation and hardness. The predictions have been compared with experimental results and found to be in good agreement. [5]

Stefanescu (2005) In this paper, it was stated that the simulation software offers integrated simulation of the entire process (mould filling, solidification and cooling) using a micromodel casting. Ductile iron solidification is a complex process in which the mechanisms that occur during the mushy zone development have not yet been fully mastered. A proper understanding of solid fraction evolution, regarding graphite and austenite nucleation and growth, together with the corresponding contraction-expansion phenomena is of special interest in order to establish the most appropriate industrial procedure to manufacture sound castings and to avoid the formation of shrinkage defects. The model accounts for inoculation and growth condition of specific alloys. It predicts graphite morphology, carbide formation and microstructure length scale (eutectic grain size, type and average size of lamellae or number of models). The model predicts properties such as hardness, yield and tensile strength and fracture elongation. [6]

Huerta & Popovski (2005) In this paper, it has shown that samples were examined for chemistry, thermal analysis properties and microstructure evolution and the investigation shown that nodule numbers were highest immediately after inoculation. A series of treated ductile iron ladles were inoculated with various generic inoculants and at various addition rates. The ladles were held for up to 16 minutes after addition of inoculant and samples were extracted every two to five min. Samples were examined for chemistry, thermal analysis properties and microstructure evolution. The investigation has shown that there are significant metallurgical changes during holding of inoculated iron in a ladle. Time and temperature effects during holding are found to result in potential benefits to delayed pouring. The metal shows improved ATAS® (Adaptive Thermal Analysis System) thermal analysis graphite factors 1 and 2, reduced recalescence and better nodule count and nodularity as a function of hold time in the ladle. Colder pouring temperature in and of itself should cause microstructure that simulates a thin section with characteristic high nodule count and nodularity. The initial set of experiments was conducted over two days and similar experiment was done over a single day, four months later. [7]

Ecob (2005) This paper has reviewed the most common metallurgical defects in ductile iron production. As shrinkage is the most prevalent problem in most ductile foundries, then focus has been made on this. Systematic recording of defects, whether found in post casting inspection or even in post foundry operations is essential to identify the most common and the most costlyproblem areas. These can then be addressed in order of importance. The geometry of the casting was examined to determine whether the location of the defect is close to a sharp radius or a potential hot spot. At the same time, the sand in the region of the shrink was examined to look for any soft spots. [8]

Voracek (2001) In this paper the adaptive hierarchical model reflecting behavior of cast iron is designed and verified. The basic chemical composition and extra additives, various technological temperatures and delays are taken as input variables and metal structure shape, size and location of graphite nodules are stated.

This paper enable us to evaluate an industrial metallurgical process with respect to its parameters, such as many possible combination or various approaches to heat treatment and consequently to estimate mechanical properties of final product. Precise metallographic sample cut and analyzed visually. With the image corresponding to expected template, the behavior of metal is predicted. [9]

Naro(2000) This paper shows that, there are three major sources that may contribute to porosity formation in gray iron castings. These are: 1) high initial gas content of the melt originating from either the charge ingredients, melting practice or atmospheric humidity, 2) reaction of carbon and dissolved oxygen under certain melt conditions, and 3) mold-metal reactions between evolved mold and core gases at the solidifying casting surface.In addition, any combination of these three sources may have a cumulative effect on promoting porosity formation. However, the gases normally held responsible for subsurface porosity defects are nitrogen and hydrogen. Porosity formation was found to be very sensitive to core sand type.

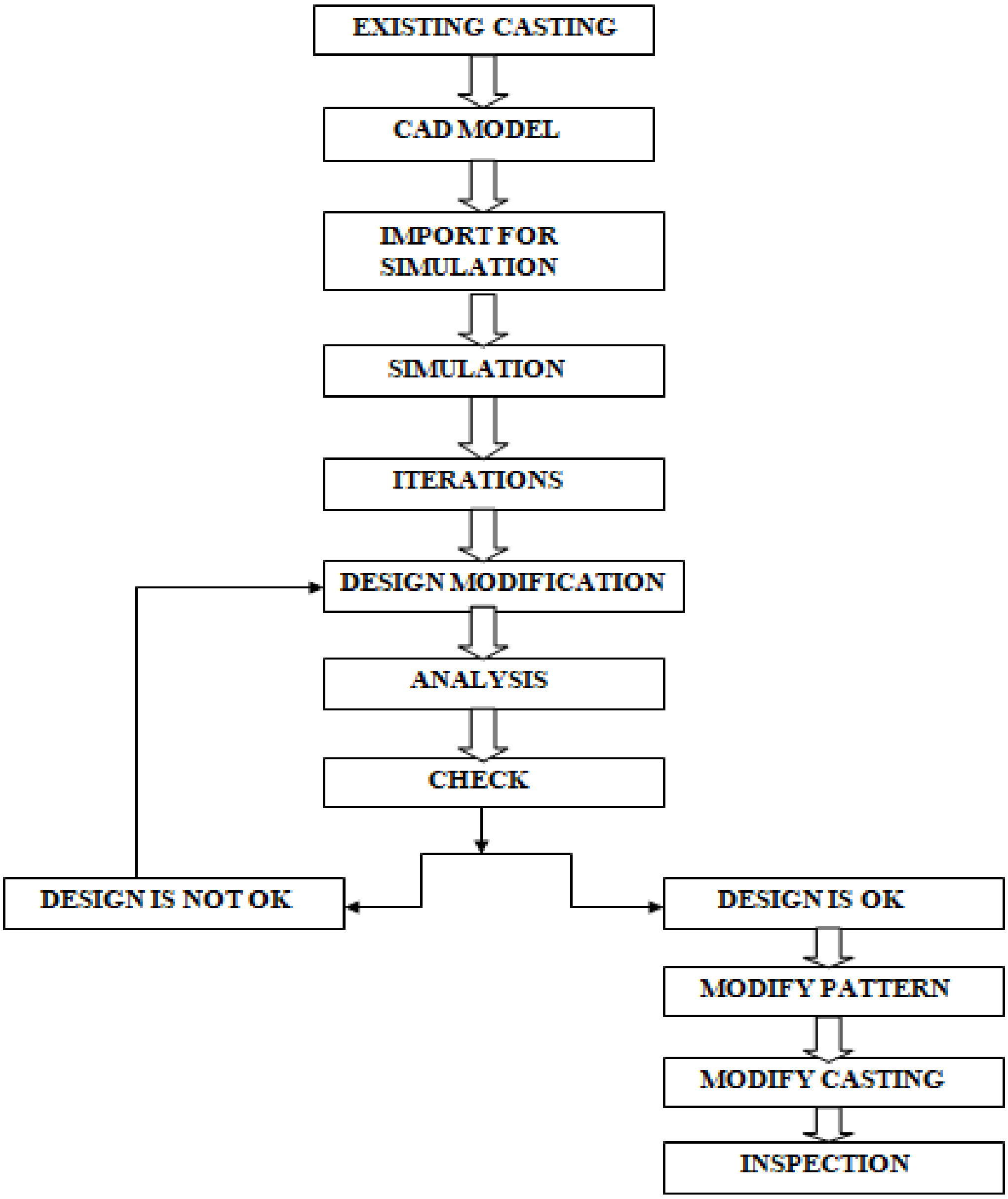
Lake sands were relatively insensitive to defect formation while high purity, round grained white silica sands were found to be very sensitive. Cast iron composition had an effect on porosity formation. Ductile iron was least susceptible to defect formation while low carbon equivalent irons were most susceptible. [10]

Ravi (2000) In this paper, the 3D CAD models of the part and die can be created using solid modeling programs (AutoCAD, CATIA, Cimatron, I-DEAS, Pro-Engineer, Solid Works, Unigraphics etc.).The 3D models can be transferred (through standard DXF, IGES, STEP and STL formats) and used for other activities, including stress analysis, cavity shape modeling, NC tool path generation, automated inspection (by comparing CMM data with original model) and process simulation. To ensure zero defect castings, it is necessary to correctly optimize the casting design (feeding and gating). This can be achieved by combining automated design, intelligent simulation and cast ability health-checks. [11]

The Purpose of this review is:-

1. To gain some insight about which domain is relevant in order to position the research.
2. To identify the existing work to form a theoretical base for understanding the concerned area.
3. To review current work in the selected area to understand of the progression of that work in future.

The properties of casting determine the quality of the final product. In particular shrinkage or porosity and cold shut are undesirable. It appears that one half to three quarters of scrap castings are lost because of these defects.



Flow Chart 1.Process for modeling and simulation for analysis and prediction of defects

Conclusion:-

Simulation of Casting is done to produce reliable, cost-effective and high accuracy cast component. Also, it is indirectly to increase the casting yield and diminish the shop floor experimental time. Withsupportof casting simulation techniques design optimization can be easily achieve. Casting simulation supports to predict the defects and their locations in an exact manner.

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