Identification of Casting Defects by Computer Simulation –A Review

Vipul M Vasava[1], Prof D.R.Joshi [2]
1. P.G.Student (CAD/CAM) 2.Assistant Professor
Sardar Vallabhbhai Patel Institute of Technology,Vasad.Gujarat-India

Abstract

Most common defect in steel castings is porosity, hotspot, blowholes.As a consequence the porosity formation is very closely studied phenomenon. The investigation described in this paper will examined the porosity formation in the casting component of Housing. In the current environment many casters still use the trial and error approach for process development. The capability to produce sound casting component of high quality of the same time reducing product costs & development times is the most highly challenge for the foundry today.

Computer aided modeling plays an important role for the foundry industry for the past several years. Not only with the new design components but also in the redesign of existing products.Simulation gives the observed porosity and it will give the possibility to reduce porosity by changing appropriate gating system, riser design & modification.

1. Introduction

Casting is a manufacturing process by which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting is a metal part formed by pouring molten metal into a sand mold or metal die. The mold or die is comprised of two halves that, when mated together, form a cavity into which the molten metal is poured. The mold or die from the external surface of the casting. If an internal cavity is required in the casting, a core is placed inside the mold cavity. In casting process, after the metal solidifies, the mold is broken, the cores removed and the part is readied for finishing operations. The sand is then remolded and used again. When a metal die is used, the two halves of the die are separated and the solidified casting is removed. The die is then reused.

As a combination of two of more elements is referred to as an alloy provided the final combination has metallic properties. Though the physical properties of an alloy do not differ much from its constituent elements, the engineering properties like shear strength and tensile strength can be completely different. There are many different types of alloys made in casting foundries and the most common alloy castings in India are as follows.

1. Alloys of Aluminum Includes Alnico, Duralumin, Zamak and Silumin.
2. Alloys of Bismuth Includes Woods metal, Fields Metal and Rose metal.
3. Alloys of Cobalt The most common alloys are Stellite, Vitallium, Ultimet and Talonite.
4. Alloys of Copper Includes Arsenical copper, brass, bronze, cunife, nickel silver, Nordic gold and manganin
5. Alloys of Gold the main alloys containing gold are Tumbaga, Electrum, White Gold and Rose Gold
6. Alloys of Iron Includes Pig Iron, Cast Iron, Wrought Iron and Anthracite Iron.
7. Other alloys include ferrous alloys like steel and lead alloys like solder.
8. Steel casting is better than all other alloy castings as they offer superior tensile and shear strength. This allows steel castings to be used in hydroelectric turbines, gears, valve bodies, mining machinery and railroad truck frames. The main benefits of alloy steel castings are:

This casting has a very high resistance to corrosion due to the presence of chromium, which prevent iron from combining with air and water and rusting. It also has the capability to reflect light as a result if which it appears bright. Steel casting is a specialized form of casting involving various types of steel. Steel castings are used when cast irons cannot deliver enough strength or shock resistance. Examples of items that are steel castings include: hydroelectric turbine wheels, forging presses, gears, railroad, truck, valve bodies, pump casings, mining machinery, marine equipment, turbocharger turbines and cylinder blocks.

2. Casting Process

Casting is a manufacturing process by which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify. The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process.

Casting is a metal part formed by pouring molten metal into a sand mold or metal die. The mold or die is comprised of two halves that, when mated together, form a cavity into which the molten metal is poured. The mold or die from the external surface of the casting. If an internal cavity is required in the casting, a core is placed inside the mold cavity.

In casting process, after the metal solidifies, the mold is broken, the cores removed and the part is readied for finishing operations. The sand is then remolded and used again. When a metal die is used, the two halves of the die are separated and the solidified casting is removed. The die is then reused. As a combination of two of more elements is referred to as an alloy provided the final combination has metallic properties. Though the physical properties of an alloy do not differ much from its constituent elements, the engineering properties like shear strength and tensile strength can be completely different.

3.Casting Porosity

Understanding the various porosity-type defects also helps in casting design. While some defects can be fixed by the manufacturing process, others can be fixed through design changes or a combination of both. By knowing the casting factors that are likely to contribute to the different defects, you can work with the casting supplier to avoid potential problems, relocate porosity-prone areas to nonstructural sections of the part and establish mutually acceptable levels of porosity present.

Porosity may be the most persistent phenomena in casting, and it is hard to be eliminated completely. Porosity is harmful to the ductility of the casting and its surface finish. Porosity in castings is due to bubbles being trapped during solidification. It may be caused by shrinkage, or gases, or both. There are many factors contribute to the development of porosity such as the entrapped air during filling, blowholes from unvented cores, dissolved gases from melting, etc. Because liquid metals have much greater solubility for gases than do solid metals, when a metal begins to solidify, the dissolved gases are expelled from the solution. It will cause microporisty or accumulate in regions of existing porosity.

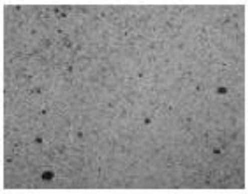

Figure 1 Example of porosity

Incomplete filling [2] is primarily caused by poor fluidity of molten metal, and manifests in the form of a cold shut or misrun. A cold shut occurs when two streams of molten metal coming from opposite directions meet, but don't fuse completely. A misrun occurs when the molten metal does not completely fill a section of the mould cavity. The presence of surface oxides and impurities on the advancing front of liquid metal aggravates such defects.

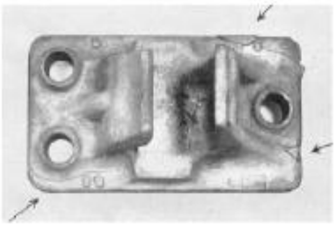

Figure 2 Cold-shut defect

Figure 3 Misrun defect

Sand holes can arise as result of defective pattern made and set of gate patterns, figure 4

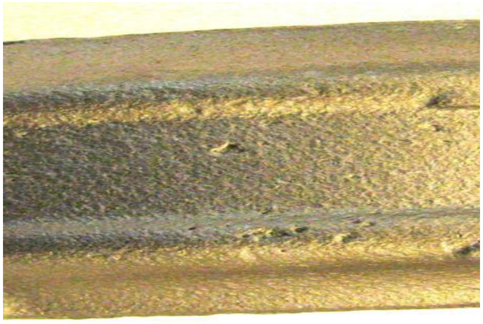

Figure 4. Sand holes of casting

Essential influence on the arisen of sand holes have a quality of molding sand. In order to decrease of sand holes quantity in castings it is necessary to apply of moulding sand with green strength. The local cluster of small voids is defined as porosity, fig. 4. This defect arises frequently as a result of gas separate from a solidification metal.

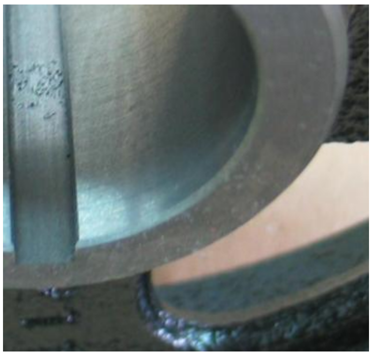

Figure 5 Porosity of casting

The porosity can arise also as a result of gas separate from a moulding sand. The mechanism of porosity formation is analogous to the blistering, because the causes of formation these defects are identical. The most frequently cause of blowholes formation is gas separating from a moulding sand, rarely gas separating from solidify metal, fig. 6

Figure 6 Blowhole of casting

The sand buckle is a build up which arise on the casting surface as a result of liquid metal penetration to the surface of sand mould. The small sand strength, high temperature liquid metal and long time of pouring are the factors conductive to the sand buckle formation. Moreover, long time of pouring causes that superheated liquid metal strongly heats the top surface of cavity niche. The shrinkage is defined as shallow and extensive hollow with smooth surface and oval outline, figure 7

Figure 7 Shrinkage porosity of casting

The shrinkage can arise only in place, which is not or is wrongly feeding by liquid metal. The wrongly feeding through riser can often cause formation of shrinkage in castings. The reason of shrinkages can be also wrong project of gating system or hot moulding sandThe mould shift is defined as part casting displacement with respect to oneself in parting plane of sand mould or core. Mould shift can be also caused by the constructional defects or wrong assembly of sand mould to pouring or attrition of moulding box pins.The casting quality is heavily dependent on the success of gating/riser system design.

3.Casting simulation

Today, most of the casting simulation packages in the market can handle solidification and fluid flow in the casting with satisfactory accuracy. Now, the foundry industry wants to focus on more advanced predictions such as stress and deformation, microstructure determination, as cast mechanical properties, micro porosity indication and core blowing defects.

Even though computer aided process simulation has been available for the past fifteen years, many investment casters still use the conventional trial and error approach for process development. In many foundries, new cast components are often put together in different departments working independently of each other. When a new customer's need is identified, the design group generates the part drawings. Then engineering department then identifies the mechanical stability and establishes guidelines for finalizing the design of the component. Finally, the foundry brings the component into production, conforming to the stringent specifications provided by the designers. Inevitably, the foundry man is always under tremendous to produce excellent castings within a tight schedule and budget. Unfortunately the traditional approach rarely allows the foundry man to participate in the design and engineering phases prior to the production stage. In recent years, thanks to advanced computer aided technologies and casting process modeling, the traditional approach is becoming a thing of the past. Process Simulation provides valuable information that facilitates participation by the foundry engineer early in the product development stage. This reduces the time between the concept stage and production stage in the life of a new component.

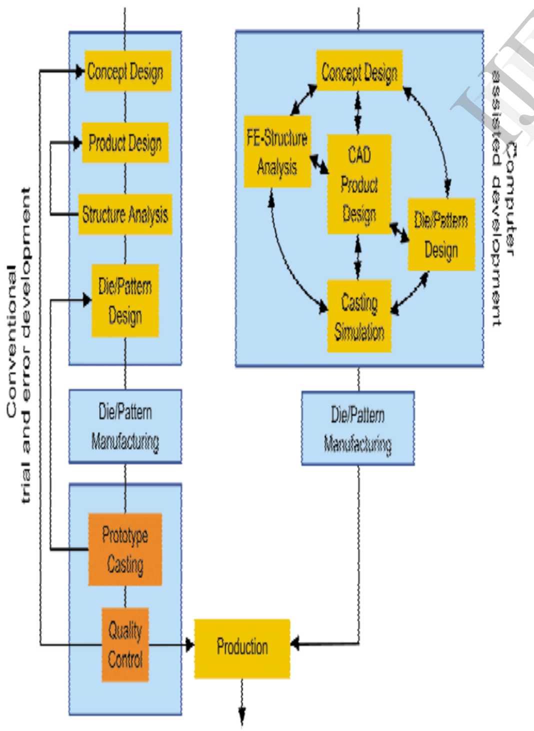

Figure 8 Trial and error developments versus Computer Assisted Development

In this paper case studies from the industry is analyzed for the casting process. In some cases, the original casting design produced poor quality castings, others had low yield.

Part: 1 Slide gate valve housing

In this case company has a problem in this casting component. This casting had a high rejection due to its shrinkage defect and sand fall. Rework cost of this product is very high Instead of redesigning the mould several times in trial and-error fashion, the gating and risering was redesigned with the assistance of computer modeling.

Figure 9 Housing defect

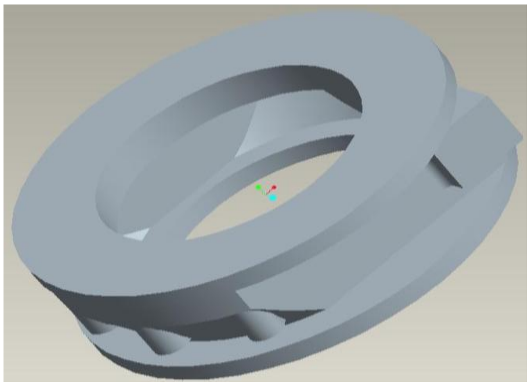

Figure 10 CAD model of housing

The 3D models of the casting created in ProE are shown in figure 10. The models are incorporated with gating systems as practiced in the foundry. The pressurized gating system is used so as to fill the cavity faster and get the maximum yield. It is used to avoid aspiration because straight sprue is provided and it also allows all the gates to flow full in multi gated system. The 3D model is converted to stl format.

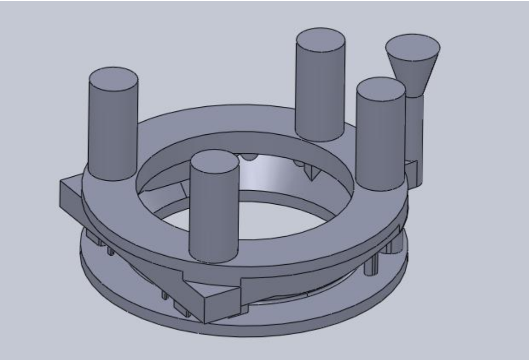

Figure 11 modeling steps with gating system

As shown in the figure 11 component of housing with modeling will be shown in figure. Then after based on that suggestion for the analysis will be carried out on Pro-CAST software. Input data for housing and material composition is shown in as under

Input data for housing

1	Pouring temperature	1620° C
2	Composition of casting	A 351 CF8 sand casting
3	Shrinkage	5.10%
4	Casting volume	8843390 mm^3
5	Surface area of castings	491507 mm^2
6	Mold box size	735 x 635 x 460 mm
7	Weight of casting	96 Kg
8	Core material	No-bake resin
9	Sand type	No-bake resin
10	Inspection test type	Visual and Radiography
11	Pouring time	21 secs
12	Ingate size	100 x 8 x 60 mm
13	Feed aids	Exothermic sleeves, chills
14	Density	7.86 gm/cc

Material composition of SS304

Material grade	Carbon %	Manganese %	Silicon %	Chromium %	Nickel %	Sulphur %	Phosphorus %
SS304	0.05	2	1	18-20	8-10	0.03	0.045

All this above information then added to the Pro-CAST software for find out the defects and give proper simulation for the above case study .which will be very helpful to the industry for better and accurate production.

CONCLUSION:-

Producing casting without defect is very difficult task, it require repetatitive effort. In this regard we have removed defects by using pro-e software. With the head of exiting set of knowledge, from company peoples with minimum efforts. It has been observed that company people are not much aware of pro-e software; there is need of interaction between industry and education.

Advanced casting simulation tools like *Procast*™ allow the foundry engineer to quickly bridge the gap between design and manufacturing. Optimization or improved efficiency during the manufacturing cycle leads to substantial time and cost savings. Computer analysis provides the means for verifying design ideas and viewing the effects of “what ifs” at minimal costs by avoiding time-consuming and expensive rework and retooling.

ACKNOWLEDGEMENTS:-
Author wish to thank Shree Vallabh alloy steel casting Ltd For allowing in the company.

REFERENCES:-

[1] IMPROVEMENT OF CASTING PROCESS CONTROL BY COMPUTER SIMULATIONAND EXPERIMENTAL OBSERVATIOND. Kakas1, L. Kovacevic1, T. Pal11. Faculty of Technical Sciences, University of Novi Sad, Serbia

[2] CASTING DEFECTS ANALYSIS BY THE PARETO METHOD B. Borowiecki*, O. Borowiecka, E. Szkodzińka Institute of Engineering Materials Science, West Pomeranian University of Technology,

Szczecin (Poland) al. Piastów 19, 70-310 Szczecin, Poland

[3] MINIMIZING POROSITY IN CAST JUNCTIONS Casting modeling helped to create general design guidelines to improve the manufacturability of junctions in metal castings. D. Joshi, SGS Institute of Technology and Science, Indore, India B. Ravi, Indian Institute of Technology, Bombay, India

[4] SHREE VALLABH ALLOY STEEL CASTING PVT.LTD Vitthal udhyog nagar,Anand.,India.

[5] IDENTIFICATION OF CRITICAL FACTORS AFFECTING SHRINKAGE POROSITYIN PERMANENT MOLD CASTING USING NUMERICAL SIMULATIONSBASED ON DESIGN OF EXPERIMENTS D.R. Gunasegarama,∗, D.J. Farnsworthb,1, T.T. Nguyena,2a CAST Cooperative Research Centre (CAST CRC) and CSIRO Materials Science and Engineering,Private Bag 33, Clayton, VIC 3169, Australiab Ford Motor Company of Australia Ltd., PO Box 14, Geelong, VIC 3220, Australia

[6] INVESTMENT CASTINGSIMULATION,Matthias Gäumann1 & Adi Sholapurwalla21) ,Calcom SA, Lausanne, Switzerland, www.calcom.ch.2) UES Software Inc., Annapolis MD, USA, www.ues-software.com