International Journal of Scientific Engineering and Research (IJSER)
ISSN (Online): 2347-3878
Index Copernicus Value (2015): 62.86 | Impact Factor (2015): 3.791

A Review on Elimination of Defects in Gravity Die Cast Al-Alloy Casting Using Autocast Simulation

Sunil Umarane[1], Dr. D. N. Raut[2], Nimesh Dodiya[3]

[1]M. Tech. Student, Production Engineering, V.J.T.I., Mumbai-400019
[2]Professor, Production Engineering Department, V.J.T.I., Mumbai-400019
[3]Technical Director, Sonakshi Founders, Vasai, Mumbai-401208

Abstract: ***The paper deals with the elimination of defects in aluminum alloy casting produced by gravity die casting process. The main intention is to investigate the defects and improve quality of a gravity die cast component using Autocast simulation software. The defects in the component are identified to be solidification shrinkage, cracks, unfilled riser and incomplete mould cavity. The reasons of defects are analyzed as either improper selection of process parameter or improper design of gating and risering system. The Autocast software for casting simulation is helpful to visualize mould filling, solidification, cooling and to predict the location of internal defect in casting such as shrinkage porosity, sand inclusions and cold shuts. It can be used for troubleshooting existing casting and to develop new casting without shop floor trials. The die is modified accordingly with the simulation results and metal is poured into it. The casting produced are observed and found to have no defects.***

Keywords: Casting Defects, Simulation, Gravity die casting, Autocast-X1

1. Introduction

Casting is one of the most economical processes in manufacturing industry to produce metallic components. Metal casting is the process of producing metal component parts of desired shapes by pouring molten metal into mould and then allowing the metal to cool and solidify. Its applications include automotive parts, spacecrafts components and many industrial and domestic parts. The foundry engineer designs the gating and risering system for the casting. The time is spent in designing and redesigning the gating and riser system. It might take few days or up to several weeks, depending upon the complexity of the casting. Casting simulation process is developed from the methods which are useful to predict the defects and problems before the actual product of cast avoiding costly trail to prevent the defect. In the current scenario, the use of casting simulation software is increasing day by day in foundry industry and minimizing the shop floor trails to attain sound casting .The casting simulation technology has sufficiently matured and has become an essential tool for casting defect troubleshooting and method optimization.

1.1 Classification of casting defects

1) Filling related defects- Blow holes, sand inclusion, sand burning, cold shut, misrun
2) Shape related defects- Mismatch defects, distortion or wrap, flash defects
3) Thermal defects- Crack or tears, shrinkage, sink mark.
4) Defects by appearance - Metallic projection, cavities, discontinuities, incomplete casting, incorrect dimensions or shape and defective surface [7].

1.2 Inputs for the casting simulation process:

1) Thermo-physical properties (density, specific heat, and thermal conductivity of the cast metal as well as the mould material, as a function of temperature).
2) Boundary conditions (i.e. the metal mould heat transfer coefficient, for normal mould as well as feed aids including chills, insulation and exothermic materials).
3) Process parameters (such as pouring rate, time and temperature).

2. Literature Review

In their research work have taken a compressor Housing and performed casting simulation with the help of high end package. It is seen that designer can easily identify various defects of casting before actual production starts, this helps to reduce rework and finally produce good quality product in minimum time [1].

In their paper has optimized riser size of LM6 aluminum alloys by using conventional method and the computer aided casting simulation software. They have considered plate casting with different riser size to study solidification behavior of the alloy used [2].

The process of casting solidification is uncontrolled and complex in nature; hence simulation of such a process is needed in industries. The commonly observed defects like shrinkage cavity, porosity and sink can be reduced by designing an appropriate feeding system to obtain directional solidification in the casting which leading to feeders. Major parameters of the feeding system include the location of feeder, shape of feeder, size and feed aids of feeder [3].

The casting simulation technology has sufficiently matured and has become an essential tool for casting defect troubleshooting and method optimization. It enables quality assurance and high yield without shop floor trails and to reduce the lead time for the first good sample casting [5].

During the casting process, there is always a chance that the defects will occur. This paper gives the various types of defect and their causes and how to minimize this defect that is remedies of those particular defects [7].

The objective is to design the method system, optimize it with the help of simulation and minimize the cumulative total cost consumed in changing of machine set-up. The simulation model is prepared to assess the set-up cost of every possible combination of the orders. It is necessary to describe briefly the Computer Applications in Simulation of Metal Casting Process [10].

3. Casting Simulation

3.1 When is the simulation Necessary

Die Casting simulation should be used when it can be economically justified for at least one of the following reasons:

- **Quality Enhancement** by predicting and eliminating internal defects like porosity.
- **Yield Improvement** by reducing the volume of feeders and gating system per casting.
- **Rapid Development** of new casting by reducing the number of foundry trails.
- **Quality improvement** reduces the (avoidable) costs associated with producing defective castings, including their transport, and warranty or penalties.
- **Faster development** of castings through virtual trials eliminates the wastage of production resources, and improves the rate of conversion from enquiries to orders, giving foundries an opportunity to select higher value.

Casting simulation software can predict where and what defects might occur in a casting so the time and material used in the trail stage may be reduced. The casting simulation programs consider the thermo physical data of the alloys and suitable boundary conditions data as an input and helps in predicting the defects by observing temperature distribution or hot spot in the castings. Few casting simulation methods are mentioned below:[6]

1) Numerical Approach

A) Finite Element Method (FEM).
B) Finite Difference Method (FDM).

2) Geometrical Approach

A) K- Contour Method

3) Computer Wave Front Analysis.

A) Pour-out Method

B) Cubic spine Functions.

4) Mesh-less Analysis
5) Grid Based Simulation System

3.2 Steps involved in Autocast-X1 Simulation

1. Solid model a cast part and save it as a .STL file.
2. Browse and upload the casting model file.
3. Wait till the simulation results are displayed
4. Identify hot spots. Decide feeder size and location
5. Model the part with feeder and save as a .STL file.
6. Simulate again and check the location of hot spots.
7. If hot spot are not shifted inside feeders repeat 4-6.

3.3 Major stages in Casting Simulation and Optimization

Figure 1

4. Details About Casting Part

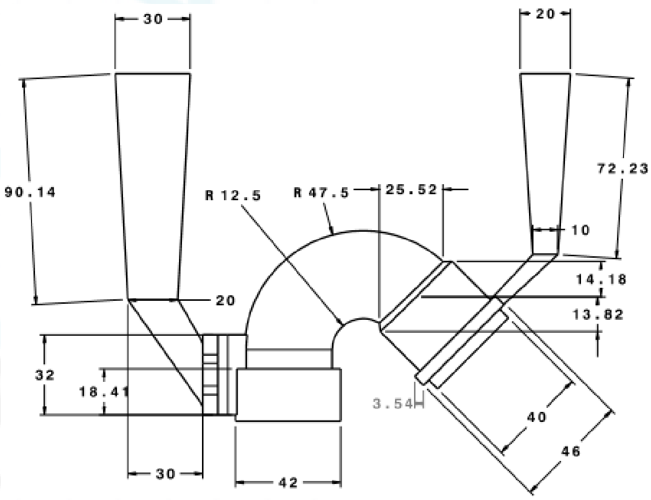

Figure 2: Dimenion of part

4.1Steps in gravity die castings

1) Melting of Aluminum
2) Degassing
3) Preheating of die
4) Coating of die
5) Clamping of die
6) Pouring of molten metal
7) Cooling and solidification
8) Cleaning and inspection

4.2 Dimensional details for casting part of die

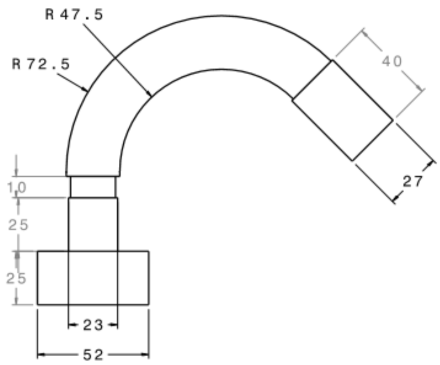

Figure 3: Dimensions of core

Figure 4: One part of the mould

Figure 5: Second part of the mould

4.3 Casting Materials

The chemical composition of LM6 (Al-si12) aluminium alloy is given in the table. Large quantities of sand and permanent mould casting are made from alloys such as LM6 and LM25. Aluminium –Silicon alloys have high fluidity because of the presence of relatively large volumes of the Al-Si eutectic. The advantages of Al-Si alloy castings are high resistance to corrosion, good weld ability and also silicon reduce the coefficient of thermal expansion virtually.

Material Type	Silicon %	Aluminium %
LM-6	10-13	85-86
LM-25	6-7	92-92.5

Figure 6: Defective casting part

Figure 7: Defective casting part

Figure 8: Defective casting part

5. Methodology

The actual production is difficult due to casting are associated with many defects. To produce good quality casting are essential to identify, understand the causes for the defects, find the remedies and work on it to eliminate them. Defect in the produced component are identified as solidification shrinkage, cracks, unfilled riser and incomplete mould cavity. Hence to eliminate these defects and produce quality castings, the experimental trails are to be performed either by varying the process parameter like pouring temperature , pouring time, alloy type and preheat temperature ;or by redesign the gating and risering system; or maybe both.

5.1 By changing process parameters

In this stage the casting are produced by changing the process parameter to check whether the defects are eliminated. The gravity die casting process parameters includes pouring temperature, Preheat temperature, Pouring time, Melt holding time, Degasification time, Die coat material, Pouring velocity and Die coat thickness.

Pouring temp varies from 650 to 800 degree Celsius. When we pour the Al-alloys then fluidity is completely dependent upon pouring temperature. The growth rate of fluidity above 735 degree Celsius is lower than between 695 to 735 degree Celsius. Preheating in the gravity die casting is done to remove the possibility of formation of temperature gradients. If we increase the preheat temp from the particular range then it may be affect die coating and may create defects like rough surface finish. So normally we preheat the mould up to 200 to 250 degree Celsius Pouring time was approximately 3-5 seconds based upon the shape and size of the casting. The gas used for the degasification is mostly argon and nitrogen which are inert gases. Degassing fluxes are added to remove hydrogen from the molten metal as well as to lift oxides and particles to top of the furnace so that they can be removed. Die coat in the gravity die casting in order to obtain smooth surface finish and to avoid direct exposure of mould to the molten metal in order to avoid direct chilling effect. The material used for die coating is generally calcium carbide and Silicone mixture and graphite. Sometimes sodium silicate + chalk powder is used as a die coat. Die coating in the casting –mould interface is the most important single factor to controlling heat transfer and, hence, it is the greatest influence on the solidification rate and development of microstructure.

5.2 By changing the gating and risering

Process parameter were varied in the 1st stage in order to minimize the defect but it was not that much successful as all the components produced are defective. Therefore in the 2nd stage gating and risering system is to be varied and simulated for elimination of defects.

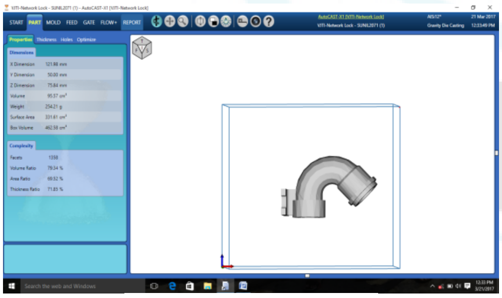

Figure 10: Casting part

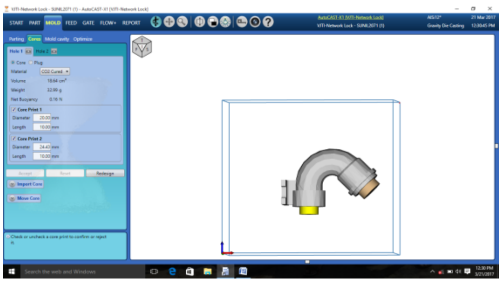

Figure 11: Casting part with core

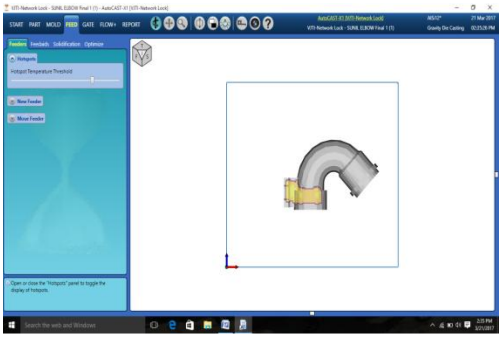

Figure 12: Hotspot region

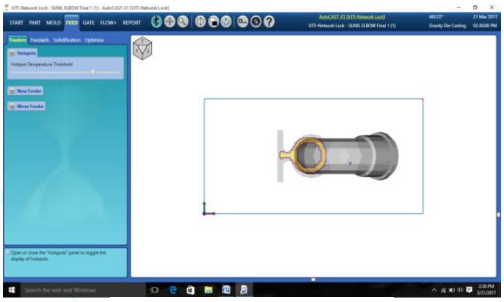

Figure 13: Hotspot region

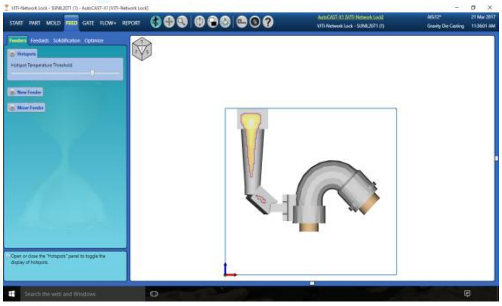

Figure 14: Hotspot with gating system

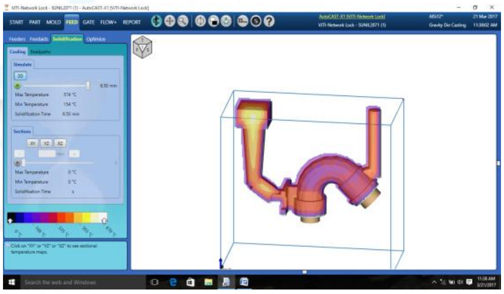

Figure 15: Flow Simulation

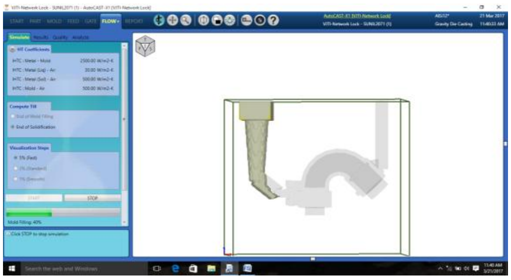

Figure 16: Mould simulation 40%

Figure 17: Mould simulation 80%

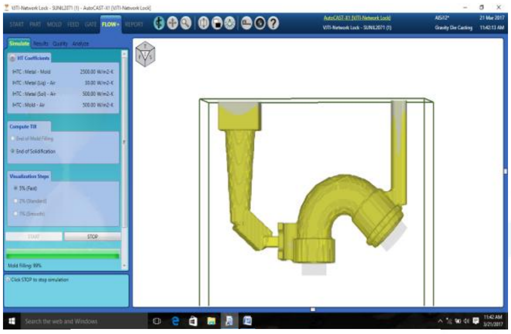

Figure 18: Mould simulation 95%

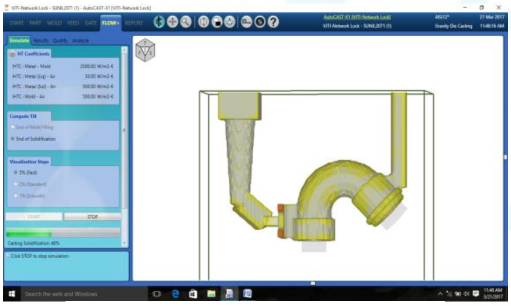

Figure 19: Casting simulation 40%

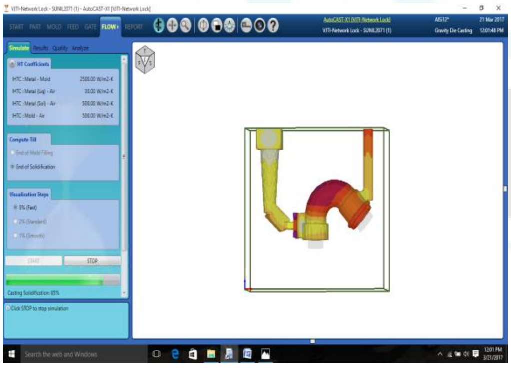

Figure 20: Casting simulation 80%

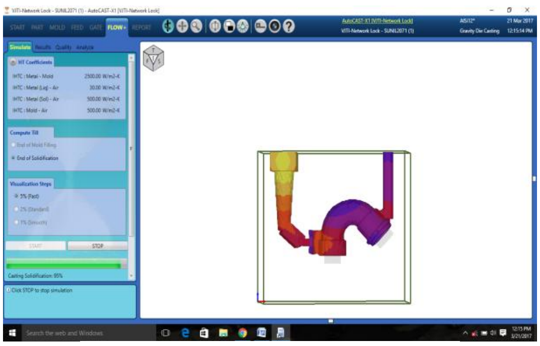

Figure 21: Casting simulation 95%

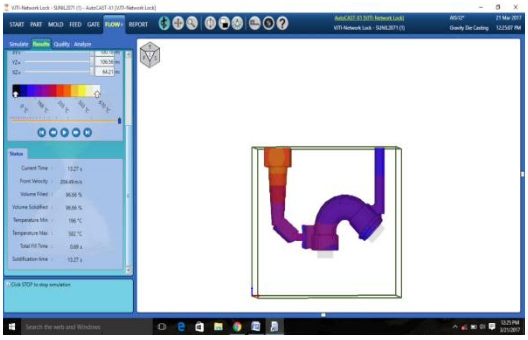

Figure 22: Simulation Results

5.3 Advantages of Casting Simulation

It has been reported that simulation studies can reduce casting defects, manufacturing costs and lead time by as much as 25%. Already, an estimated 1000 foundries (among 33,500 worldwide) are using simulation software to improve their performance and the number of simulation users is steadily increasing.

Some advantages of casting simulation by Autocast-X1 is given below:

1) Use of simulation on Autocast-X1 software, traditional gating system of component has changed into new gating system. Cost of new gating system is may be less as compared to traditional gating system.
2) Hot spots in the part suggest the proper location of feeder resulting in reduced defects.
3) Virtually we can minimize the defects like shrinkage porosity, blow holes, cold shuts, etc.
4) The time required is very less as compared to the conventional method of design of modeling. Visualization of mould filling phenomenon makes the process easy to understand to the user.
5) Hot spots were easily located where probable chance of occurrence of defect was more [8].

6. Conclusion

Casting simulation has become a powerful tool to predict the location of defects and eliminate them by visualizing mould filling, solidification and cooling. The use of simulation on AutoCAST-X software has caused traditional gating system of component to change into new gating system. Due to simulation on AutoCAST-X software, traditional gating system of elbow component has changed into new gating system. Cost of new gating system is less as compared to traditional gating system. Change in feeder location causes minimization of hot spots. The defects like solidification shrinkage, cracks, unfilled riser and incomplete mould cavity are completely eliminated from the casting. So zero defects casting has become a reality owing to computer aided design of casting, which it is possible produce casting right first time and every time. The time required is very less as compared to the conventional method of design of methoding.

Figure 23: Cast part after Simulation

Figure 24: Cast part after Simulation

Figure 25: Cast part after Simulation

References

[1] A.P. Wadekar, B.A. Ahire, "Die Casting Defect Analysis & Experimental Validation for Compressor Housing", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), ISSN(e) : 2278-1684, ISSN(p) : 2320–334X, PP : 55-61

[2] T. Nandi, R. Behara, S. Kayal, A. Chanda, G. Sutradhar, " Optimization of Riser size of Aluminium alloy castings by using conventional method and computer simulation technique", International Journal of Scientific and Engineering Research, Volume 2, Issue 11, November, 2011.

[3] C.M. Choudhari, B.E. Narkhede and S.K. Mahajan, "Casting Design and Simulation of Cover Plate using AutoCAST-X Software for Defect Minimization with Experimental Validation", ICMPC, 6, 2014, 786 – 797.

[4] B. Ravi, "Metal Casting: Computer-aided Design and Analysis", Prentice-Hall India, ISBN-81-203-2726-8, 4th print, 2007.

[5] B. Ravi, "Casting Simulation and Optimization: Benefits, Bottlenecks, and Best Practices", Technical Paper for Indian Foundry Journal, January - 2008, Special Issue

[6] S. Ferhathullah Hussainy "practical approach to eliminate defect in gravity die cast Al-alloy casting using simulation software" eISSN: 2319-1163| pISSN : 2321-7308

[7] Rajesh Rajkolhe and J.G. Khan, Defects, Causes and Their Remedies in Casting Process: A Review, International Journal of Research in Advent Technology, 2, 2014, 13121-13128

[8] Mahesh N. Jadhav and K.H. Enamdar," Review on casting simulation for defect rejection using Autocast" ISSN(o) 2454-9665,ISSN(p) 2454-0663.

[9] Vivek S. Gondkar and K.H. Enmdar "Optimization of Casting Process Parameters through Simulation" ISSN 2319 – 4847.

[10] B. Ravi and M. Srinivasan, Hot Spot Detection and Modulus Computation by Computer Graphics, 56th World Foundry Congress, 13, 1989, 19-23.

[11] Binu Bose V. and K.N. Anilkumar, Reducing rejection rate of castings using Simulation Model, International Journal of Innovative Research in Science, Engineering and Technology 2, 2013, 144149