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# A REVIEW ON OPTIMIZATION OF GATING SYSTEM IN METAL CASTING

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## ABSTRACT

In the modern period, there a requirement for casting units & foundry to deliver components with less rejection rate i.e. short lead time. The gating framework is assuming essential part in the field of quality. So optimization of gating framework in metal casting delivers the error free components. The principle motivation behind optimization of gating framework is expanding yield of cast items & overcome the defects like shrinkage, gas porosity, slag, inclusion, etc. Many researchers has been studied on optimization of gating system on the basis of Taguchi method, Numerical Simulation, Mold flow Software, Gradient Search Method, Genetic algorithm technique and so forth to diminish the defects. The target of this paper that improper design of gating framework and riser system result in internal shrinkage which is a major defect in cast product. So good design of gating system reduces defects and increase yield.

**KEYWORDS:** Metal Casting; Optimization of Gating Design; Optimization Technique; Casting Defects

## INTRODUCTION

Casting is a manufacturing procedure for making complex shapes of metal materials in large scale mass production. It is one of the essential procedure for quite a long while and one of critical process even today in the 21st century. Today, casting applications incorporate automotive parts, spacecraft components and numerous industrial & domestic components. The time has never defaced the significance of castings nor ever will, yet yes technology, has assumed a vital part in making Castings more flexible, faster, more precise, energy efficient and greener for the environment. There are two consecutive stages, filling process and solidification process in casting industry. In filling process, gating system is the passage in which it leads the molten metal poured from the ladle, into the mold cavity. A typical gating system comprises pouring basin, sprue and well, runner and Ingate as & risers.Risers serve a double function, they compensate for solidification shrinkage and heat source with the goal that they solidify last and promote directional solidification appeared in the figure 1. Its fundamental capacity is to guarantee, smooth, uniform and finish filling so that minimization of turbulence, air aspiration, sand erosion, and sand inclusions, shrinkage. Improper design of gating framework can lead to casting defects and influence the casting quality. So there is need of optimization to control the process parameters which lead to reduce the defects. The optimization technique is vital to improve the performance as per the industry norms. These performance members incorporate improving productivity and cost by minimizing rejections. In the interest to accomplish these improvements different process parameters, for example, runner and gate locations,

number of risers and gate shape, mould material and temperature of molten metal should have to be optimized by controlling them efficiently.

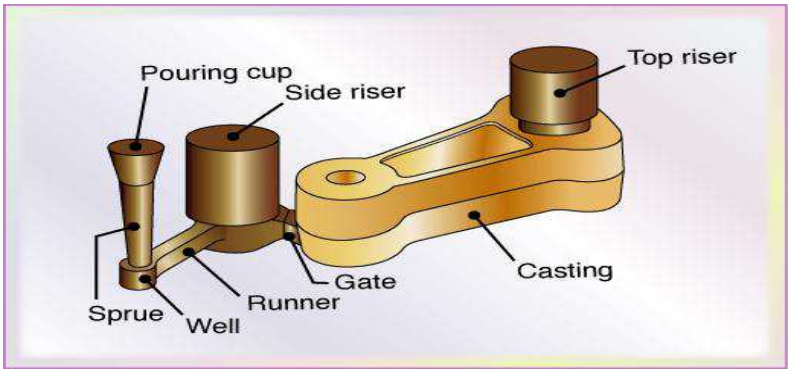


**Figure1: Parts of Typical Gating System**

## LITERATURE REVIEW

There is extensive literature of review about optimization of gating system in Casting Industry and they brought a various optimization technique used in casting to control defects and maximize the yielding of products. S.H. Wu, J.Y.H. Fuh, K.S. Lee proposed new technique has shown that Semi-automated parametric design of gating framework for die-casting die, the gating framework is very critical to die-casting dies, however designing the gating framework is an iterative procedure that can be very time consuming & costly. The point of this work is to developed automatic generation of the gating framework geometries by applying parametric design. Parametric design deals with variable dimension as control parameters & permits the designers to alter the existing design by changing the parameter values. This paper introduces a prototype parametric system for designing the gating framework of die-casting. The proposed system can reduce the geometry construction time of gating component significantly. It gives direction to the designer, the system first make trial design of gating framework near to the final designer, so that time modification & redesign is shortened **[1].** Carlos Esparza et al given his suggestion on optimal design of gating system by the gradient search method. A numerical optimization technique based on gradient-search is applied to obtain an optimal design of a typical gating system used for the gravity process to produce aluminum parts. This represents a novel application of coupling nonlinear optimization techniques with a foundry process simulator, and it is motivated by the fact that a scientifically guided search for better designs based on techniques that take into account the mathematical structure of the problem is preferred to commonly found trial-and-error approaches. The simulator applies the finite volume method and the VOF algorithm for CFD analysis. The direct gradient optimization algorithm, sequential quadratic programming (SQP), was used to solve both 2D and a 3D gating system design problem using two design variables. The results clearly show the effectiveness of the proposed approach for finding high quality castings when compared with current industry practices **[2].** B. Senthilkumar, S.G. Ponnambalam, N. Jawahar has used the DOE technique as a tool and Doe are used as a tool to optimize the affecting Variables. Doe is a series of ordering tests in which purposeful changes are made to input factors to recognize the corresponding change in the output response variables. DoE is a statistical technique used to concentrate on the impact of the result of multivariable at the same time. In this paper, they used most influencing factor, i.e. GATING SYETEM that affect the performance of casting. The feeding system can be designed and dimensioned once the optimal pouring temperature has been taken. Feeding from the gating system is adequate, if the casting modulus is less than 0.3cm.

However, it ought to be guaranteed that the ingate does not solidify off too soon and in this way obstructs he flow of feed metal from the pouring cup. If the modulus is larger than 0.3cm then it is recommended to use a feeder. So in this way, they concluded that if the optimal range of influencing factor has been employed, so it leads to reduction of pull-down effect to some extent. The number of castings approved and their particular rates of castings had improved from 86.22 to 96.17.So by controlling the 'PULL- DOWN DEFFECT', productivity was very much enhanced **[3].** Yazad N. Doctor, Dr. Bhushan T. Patil, Aditya M.Dareker suggested that in a global competitive environment, there is a requirement for the casting set ups and foundries to build up the parts in short lead time. Defect free castings with a minimum production cost have turned the need of this basic industry. Rejection of casting is caused due to defective components. These defects rely on various process parameters which need to be improved using various techniques as a part of optimization. They additionally brought the idea in the formation of front end integration for casting Industries in the form of engineering workshops to machine castings and finally offer the finished item ready for assembly and use. This was more a necessity and need. Thus, all major casting manufacturers have forward integrated into value add by creating castings and machining them to finish specifications themselves to ensure that the perfect end product reaches the customer and there is zero rejection**[4].** P.B.Lagdive, K.H.Inamdar investigated that Genetic algorithms are strong, effective optimization techniques inspired by the mechanism of evolution and natural genetics. It is extremely helpful for complex or loosely defined problems. Consequently, in GA problem fitness function for this problem will be minimization of the volume of the riser. It can often be done with proper consideration of riser size, shape, and location, and the nature of the connection between the riser and the casting. The Genetic algorithm code gives a number of options and optimized designs of riser sizes. These risers sizes fulfill all the technical requirements of the riser. He likewise considers in this if we need yield percentage so the volume of the riser should be minimum. Riser is designed using modulus method. With the help of GA, It can create code to be used to design cylindrical riser for each and every component. The Code will give number of alternative designs of the riser. The riser design by the Genetic Algorithm technique is more effective than modulus method. It gives 6.2% less volume than the modulus method for same riser modulus. One other another advantage of the Genetic Algorithm method over modulus method is that it gives number of alternative solutions. While modulus method gives only one particular solution **[5].** Sandeep.v. Chavan, Rajeev.K. Tavildar approached the optimization technique for casting defect analysis and he said that optimization using computer aided casting simulation technique plays vital role in manufacturing of metal parts and determining various casting defects. In pressure die casting, we require a quality die to prevent unfilled phenomena, weld lines, deflection and air traps and provide two overflows for filling thin section of existing parts. The gating framework is very critical to a die-casting die, however designing the gating system is an iterative process that can be very time-consuming and costly. In casting simulation the mould filling and solidification analysis is done to identify the hot spot sand hence defects like shrinkage porosities, hot tears, cracks, etc. A proper runner and gating system is very important to secure good quality die casting through providing a homogenous mould filling pattern. For analysis of defects like weld lines, air traps and shrinkage, computer aided casting simulation technique is the most efficient and accurate method. The quality and yield of the casting can be productively enhanced by computer assisted casting simulation technique in the shortest possible time and without doing the actual trials on the foundry shop floor [**6].** Ranjit Singh, Jatinder Madan recommended that runner and gating framework design is one of the important activities of die casting die design. These parameters are then optimized by conducting process flow simulations on a computer and dry runs die casting machine, which usually requires a no of iterations. So it results in an increase the manufacturing lead time and makes the die-casting, die design is a very tedious task. Subsequently, they felt that a system which reduce the iterations

and make the design process more productive and desirable. It is demonstrated that runner and gating system can design for die-casting,die based on the computer aided system. The system first generates the runner and gating system feature library based, in part, material and machine information. And this feature library for runner and gating system are helpful for die-casting engineer who does not have much familiar for design and CAD model of it with the use of this feature library, the system defines the design parameters of runner and gating systems and useful for die casting die having multiple gate. Likewise, less experienced engineers use this feature library and expert knowledge about the parameters of runner and gating system has been set up in this[**7].** Vivek S. Gondkar, K.H. Inamdar proposed new idea Optimization of Casting Process Parameters through Simulation. Casting simulation helps visualize mold filling and casting solidification; predict related defects like cold shut, shrinkage porosity and hot spots; and optimize the casting design to achieve the desired quality with high yield. Flow and solidification of molten metals are, in any case, a very complex phenomenon that is difficult to simulate correctly by conventional computational techniques, particularly when the part geometry is complicated. Simulation work has done on the component bracket chassis. Data regarding this component has acquired from one of the reputed foundry of C.I. Casting. After that, all the steps are carried out required for simulation in Auto CAST-X software. The methods, design involve cores, feeders and the gating system. They compare the old gating system of bracket chassis to the new gating system. Because they found hot spots like shrinkage porosity in the old gating system while simulation carried out on it. New feeding and gating system is developed to eliminate porosity defect and after that simulation of the new gating system is carried out. As a result of it, improved casting quality, reduction in rejection, lead time and cost and it lead to increase in efficiency and yield [**8].** Udhaya Chandran.R.M et al focused to minimize the casting defects such as, sand drop, sand blow holes, scabs, pinholes. Casting defects, consistently occurring on the casting components, it is due to some improper sand properties and improper gating system and labor's fault. But mostly occurring related to only insufficient of sand reinforcement. An optimization technique used for process parameters of green sand casting process. Taguchi method is a powerful problem solving in improving the quality of the product. The Taguchi approach is used to capture the effect of signal to noise ratio of the experiments based on the orthogonal array used due to optimum conditions are found. The improvement expected in minimizing the variation is 47.66%, which implies that reduction of casting defects of the present of 6.89% to 3.33% of the total casting product in the foundry. This also shows that by using Taguchi method (Figure 2) the factor levels when optimized will result in reduction of casting defects and expand the yield rate of the accepted casting without any additional cost [**9]**.

**DOE**: Senthil Kumar [8] has used the DOE technique as a tool and Doe are used as a tool to optimize the affecting Variables. Doe is a series of ordering tests in which purposeful changes are made to input factors to recognize the corresponding change in the output response variables. DoE is a statistical technique used to concentrate on the impact of the result of multivariable at the same time. In this paper, they used most influencing factor, i.e. GATING SYETEM that affect the performance of casting. The feeding system can be designed and dimensioned once the optimal pouring temperature has been taken. Feeding from the gating system is adequate, if the casting modulus is less than 0.3cm. However, it ought to be guaranteed that the ingate does not solidify off too soon and in this way obstructs he flow of feed metal from the pouring cup. If the modulus is larger than 0.3cm then it is recommended to use a feeder. So in this way, they concluded that if the optimal range of influencing factor has been employed, so it leads to reduction of pull-down effect to some extent. The number of castings approved and their particular rates of castings had improved from 86.22 to 96.17.So by controlling the 'PULL- DOWN DEFFECT', productivity was very much enhanced**.**

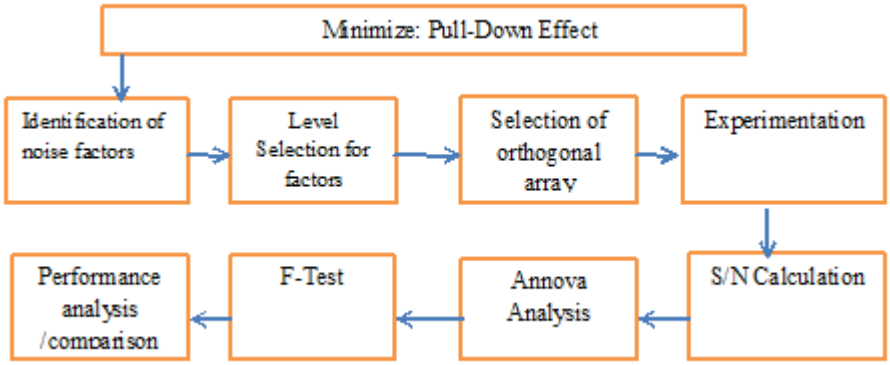


**Figure 2: Factor Optimization using Taguchi's Doe**

**Genetic algorithem: P.B.Lagdive et all he suggested that** Genetic algorithms are strong, effective optimization techniques inspired by the mechanism of evolution and natural genetics. It is extremely helpful for complex or loosely defined problems. Consequently, in GA problem fitness function for this problem will be minimization of the volume of the riser. It can often be done with proper consideration of riser size, shape, and location, and the nature of the connection between the riser and the casting. The Genetic algorithm code gives a number of options and optimized designs of riser sizes. These risers sizes fulfill all the technical requirements of the riser. He likewise considers in this if we need yield percentage so the volume of the riser should be minimum. Riser is designed using modulus method. With the help of GA, It can create code to be used to design cylindrical riser for each and every component. The Code will give number of alternative designs of the riser. The riser design by the Genetic Algorithm technique is more effective than modulus method. It gives 6.2% less volume than the modulus method for same riser modulus. One other another advantage of the Genetic Algorithm method over modulus method is that it gives number of alternative solutions. While modulus method gives only one particular solution.

**Casting Simulation Technology:** Rajeev.K.Tavilda et al recommended that optimization using computer aided casting simulation technique assumes crucial part in the manufacturing of metal parts and deciding various casting defects. In casting simulation the mould filling and solidification analysis are done to identify the hot spot, consequent defects like shrinkage porosities, hot tears, cracks, etc. The simulation programs depend on finite element analysis of 3D models of castings and include advanced feature for user interface, computation and display. The casting model (with feeders and gates) has to be created using a solid modeling system and imported into the simulation program. An appropriate runner and gating framework are essential to secure good quality die casting through providing a homogenous mould filling pattern. For analysis of defects like weld lines, air traps and shrinkage, computer aided casting simulation technique is the most productive and precise technique. The quality and yield of the casting can be productively enhanced by computer assisted casting simulation technique in the shortest possible time and without doing real trials on the foundry shop floor.

**Table 1: The Casting Simulation and Optimization Methodology is Detailed in Following Table**

| **Step1:Data Gathering** | **Part model, Material, Process Parameters, Method Design, Exiting Defects** |
|---|---|
| Step2: Methods Design | Parting line, Cores, Feeders, Gating System, Mold Cavity Layout |
| Step3: Simulation | Model Import, Mesh generation, Material and Process, Visualization |
| Step4:Optimization | Modify design, Simulation, Check quality |
| Step5:Project Closure | Methods report, Analysis report, Compare results, Archive project |

## CONCLUSIONS

In this paper, it dealt for obtaining a gating framework design of good quality. A proper runner and gating framework are essential to secure quality of casting. With the use of casting simulation technique design of the gating framework of casting defect has been measured. In this manner, the casting simulation technique has become an essential tool for casting defect troubleshooting and optimization method. It helps in enhancing product quality and upgrade the yielding of casting, reduced cost and spare time among other optimization technique. Throughout the years, numerous design standards or optimization method has been developed and employed in the casting industry, yet the simulation has wide application among the others. Since simulation is easy to use, fast and having reliable result. It also enable to minimize the value added time in casting development. In the long run, Casting Simulation is a single software program and having the ability to predict the internal defect of casting which helps to reduce the shop floor trials.

## REFERENCES

1. S.H. Wu, J.Y.H. Fuh, K.S. Lee, “Semi-automated parametric design of gating systems for die-casting die”, Computers & Industrial Engineering 53 (2007) 222–232, 15 June 2007
2. Carlos E. Esparza a, Martha P. Guerrero-Mata b, Roger Z. Rı´os-Mercado c, “Optimal design of gating systems by gradient search methods, Computational Materials Science 36 (2006) 457–467,16 may 2005
3. B. Senthilkumar, S.G. Ponnambalam, N. Jawahar, “Process factor optimization for controlling pull-down defects in iron castings” journal of materials processing technology 2 0 9 ( 2 0 0 9 ) 554–560,16 Feb, 2008
4. Yazad N. Doctor, Dr. Bhushan T. Patil, Aditya M. Darekar, “Review of Optimization Aspects for Casting Processes”, International Journal of Science and Research (IJSR), 2013
5. P.B.Lagdive, K.H. Inamdar, “Optimization of Riser in Casting Using Genetic Algorithm”, International Archive of Applied Sciences and Technology, IAAST; Vol 4 [2] June 2013: 21-26© 2013 Society of Education, India.
6. Sandeep.v. Chavan,Rajeev.K.Tavildar, “Casting Defect Analysis and Optimization Using Computer Aided Casting Simulation Technique”, International Journal of Innovative Research in Science, Engineering and Technology, Vol. 3, Issue 7, July 2014
7. Ranjit Singh,Jatinder Madan, “Computer Aided Runner & Gating system Design From Die-Casting Part Model” 5th International & 26th All India Manufacturing Technology, Design and Research Conference (AIMTDR 2014) December 12-14,2014, IITGuwahati, Assam, India.
8. Vivek S.Gondkar1, K.H.Inamdar “Optimization of Casting Process Parameters through Simulation”International Journal of Application or Innovation in Engineering & Management (IJAIEM),Vol 3,issue 6, June 2014.
9. Udhaya Chandran.R.M, “Optimization Of Process Parameters To Minimize The Casting Defects”, International Journal of Advances in Engineering Science and Technology..
10. Swapnil A. Ambekar1 Dr. S. B. Jaju, “A Review on Optimization of Gating System for Reducing Defect” International Journal of Engineering Research and General Science Volume 2, Issue 1, January 2014.