Design and Experimental Study on Yield Improvement in Gating System forTurbine Housing

1Prof. Yogini S. Jadhav, 2Roshni H. Bajgude, 3Prerana R. Gore, 4Priyanka P. Lonkar
1Assistant Professor, 2BE Mechanical, 3BE Mechanical, 4BE Mechanical
1Mechanical Department,
1Nutan Maharashtra Institute of Engineering and Technology, Talegaon Dabhade, Pune, India

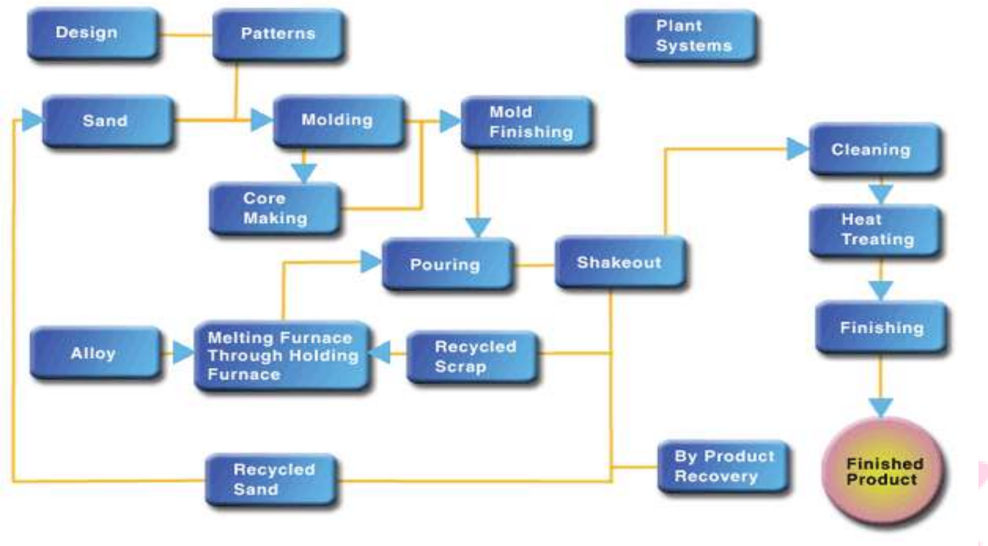
***Abstract*-Casting is a one of the economical manufacturing processes used in foundries. There are two important stages in casting, first is filling process and second is solidification process. Casting Yield is usually defined as the total weight of acceptable castings to the total bunch weight of the gating system which is expressed in percentage.The aim of the project is to optimize gating and risering systems of turbine housing component based on CAD and simulation technology with the goal of improving casting quality and increasing casting yield. Initially the match plate contains four moldcavities and each mold cavity contains single riser. In this project, we modified the design of the gating system in which the mold cavity contains only twocommon risers instead of four. Modeling of gating system is done in ProE software and the analysis is done in ProCAST Simulation Software and also Radiography test is performed to check whether the casting is defective or not.**

***Keywords:*Casting design; Optimization; Optimized casting design; Gating system; gating and riser design.**

I. INTRODUCTION

Casting is a manufacturing process in which a liquid material is usually poured into a mold, which contains a hollow cavity of the desired shape, and then allowed to solidify.[7] The solidified part is also known as a casting, which is ejected or broken out of the mold to complete the process. Casting is most often used for making complex shapes that would be otherwise difficult or uneconomical to make by other methods. The term gating system refers to all passage ways through which the molten metal passes to enter the mold cavity.The gating system is composed of: Pouring basin, Sprue, Runner, Gates, Risers.[6] Our component is Turbine Housing is encloses the turbine wheel. There are two main turbine housing types: axial and radial flow. Turbine housing size affects the ability of the turbine to transmit rpm to the compressor wheel. Casting Simulation simulates the real casting phenomenon using a computer program. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors/functions of the selected physical or abstract system or process. Thesimulation program is consists of set of mathematical equations. [5] Casting process simulation hasbecome an invaluable tool in the production of economical and high performance cast components.

$$\text{Yield Ratio} = \frac{\text{Total weight of casting component}}{\text{Total weight of gating system (bunch weight)}} \times 100$$



FigureNo. 1.1: Block diagram

II. MATERIALS AND METHODOLOGY

A. Materials

1. Cast iron (Material of match plate)
Properties:

- Composition and melting point- Crude from containing 2-4%
- Hardness- Hard, hardened by heating and sudden cooling
- Strength- Compressive strength 6.3-7.1 tonnes/sq cm

2. High Silicon Molybdenum Ferrite Ductile Iron (Material of casting)
Properties:

- Composition - range of 4-6% Silicon and/or .4-.2% Molybdenum.
- Hardness range of this SiMo is typically 200 – 230 BHN.
- High Silicon Molybdenum offers good thermal cycling performance and good resistance

Temperatures are in the range of 1200-1500ºF

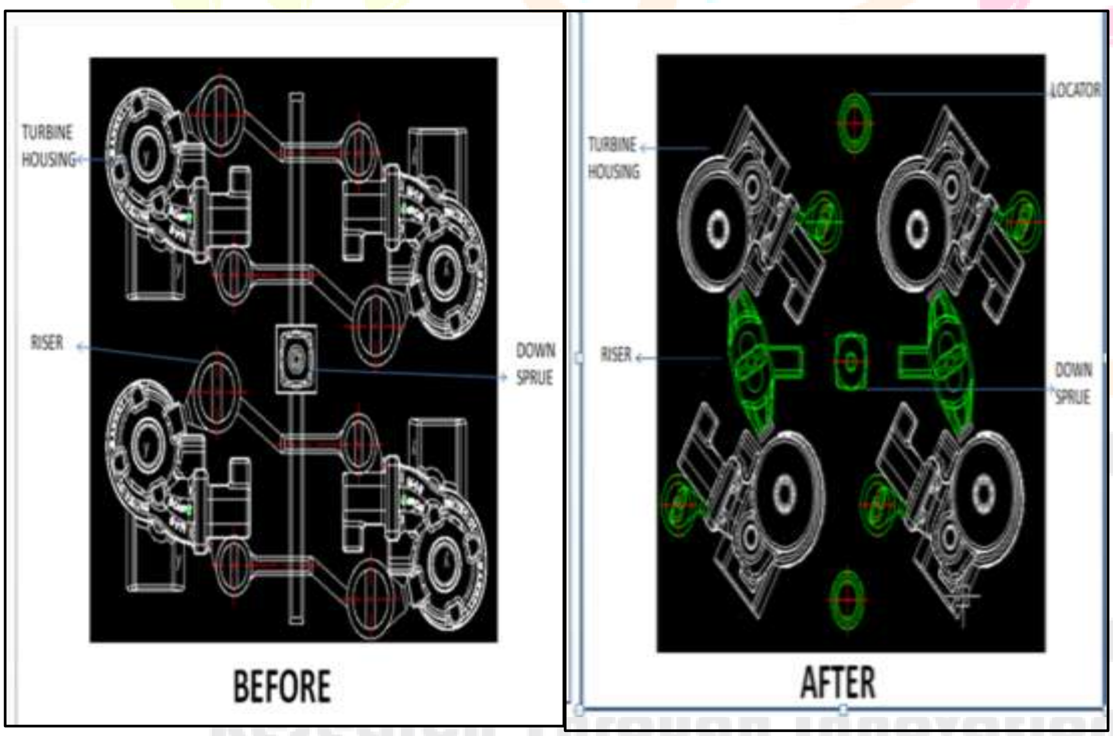
B. Methodology

We observed that each mold cavity consists of single riser, if we combine one riser for two mold cavities then the scrap rate will be reduced and yield will be improved.We discussed with our guide that if we combine one riser for two mold cavities instead of separate riser for four mold cavities in the gating system on match plate then what may be the chances of failure for feeding process or what defects may occur.Our main objective is to improve the yield ratio of the match plate. So, from 2D drawing sheet we have calculated the various parameters of existing gating system which consists of riser design, section modules, bunch weight and yield ratio.From existing gating system design calculation we obtained that the yield ratio is 35.89%.

From existing calculation we design new 2D drawing of gating system with our modifications and from standard dimension considerations we observed that the height of riser is increased then the feeding problem will not be occurred.Then modified drawing calculation showed that the yield ratio of the new match plate is increased to 42.26%.After the calculation or modification the 2D modeling design was made in AutoCAD software and then we designed the model of our modified match plate in ProE software. To analyze casting simulation process and to check fraction solidification, temperature and shrinkage porosity and proper feeding of metal flow in the gating system and weather the defects occurs or not, ProCAST Simulation software is used. So, the yield ratio is increased by making a common riser for two mold cavities (Turbine Housing) which is 6.37%.The simulation results showed that there were no major defects found and proper solidification was observed. From the above simulation results our modified design is sent for further casting and manufacturing process.After few weeks the casting process was completed and good casting productswere obtained. To check whether the casting is defective or not Radiography test is performed. From radiography test results casting product (turbine housing) is found to be defect free and acceptable.

III. MODELING STUDY

The objective of the present paper is to optimize gating/riser systems based on CAD and simulation technology with the goal of improving casting quality such as reducing incomplete filling area, decreasing large porosity and increasing yield. Therefore in this paper a case study on plate casting simulation technology based optimization framework is presented. Given a CAD model of part design and after its being converted to casting model, the objective is to evaluate casting design. Then runner and risers are presented parametrically. By varying each parameters, after analyzing simulation results, the original gating/riser system design will be optimized to improve casting quality. Theexisting match plate contains four mold cavities and each mold cavity consists of single riser and we modified the design of gating system by making common riser for two components. After the modification, new design of mold contains only two risers instead of four. The 2D modeling is done in Auto CAD. The 3D modeling of modified design of the mold is done in ProE.



FigureNo 3.1 : 2D modeling in AutoCAD

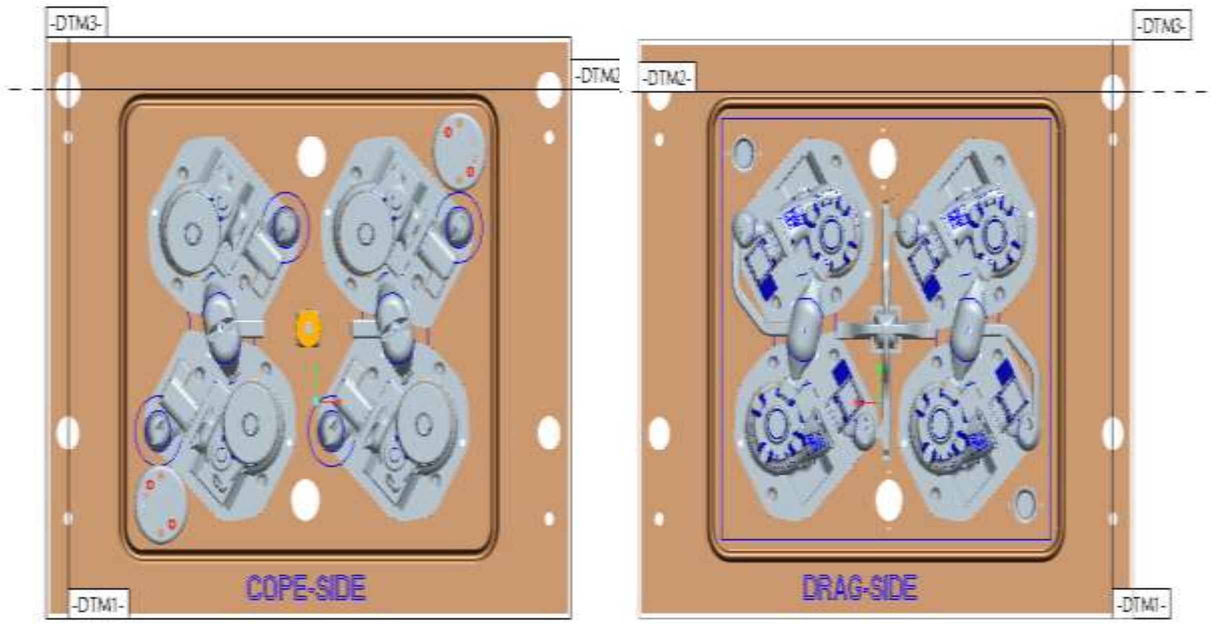


Figure No 3.2: 3D Modeling in ProE

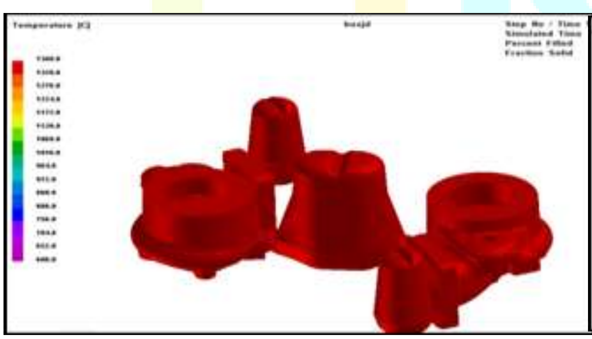
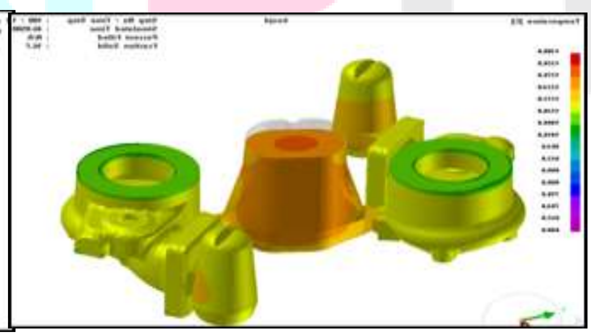
A. Casting Simulation Software

Analysis is done in Pro Cast Simulation Software.

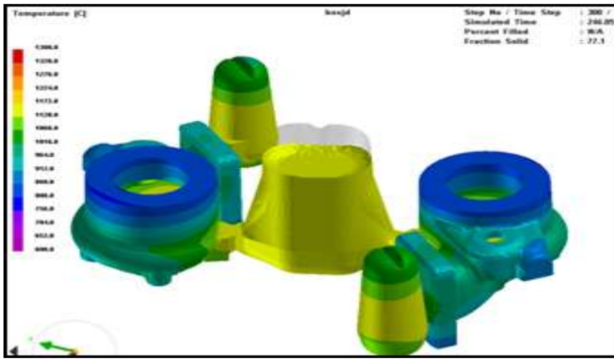
The key modules are called MeshCast, PreCast, ProCast and VisualCast.

- MeshCast – This module is used to create the geometry and finite element representation of the casting system.
- PreCast - This module is used to assign physical properties to all the materials involved as well as the boundary and initial conditions of the process.
- ProCast -This module is the computational engine that carries out the necessary mathematical calculations and produces computed values of metal velocity, temperature, fraction solidified.
- VisualCast -This module allows detailed examination of the computed results.

B. Thermal Simulation Results (Screenshots):

FigureNo. 3.4: Analysis of temperature at 1360°C Figure No.3.5: Temperature from 1172°C to 1056°C



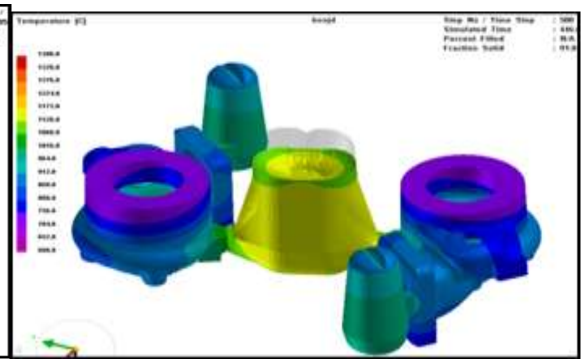
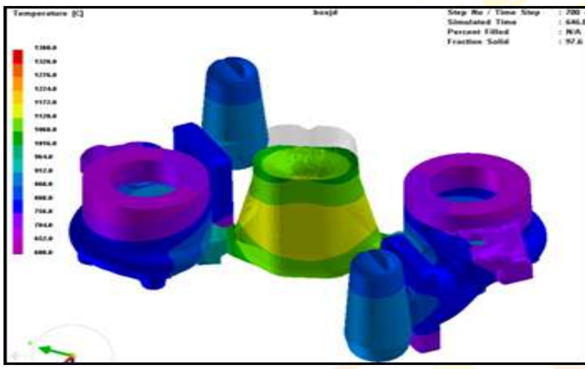


Figure No. 3.6: Temperature from 1120°C to 860°C **Figure No. 3.7: Temperature from 1016°C to 704°C**



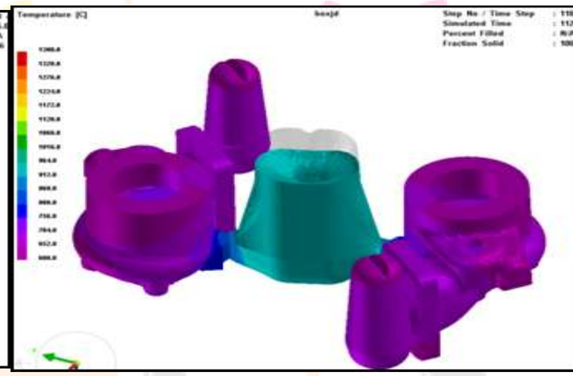
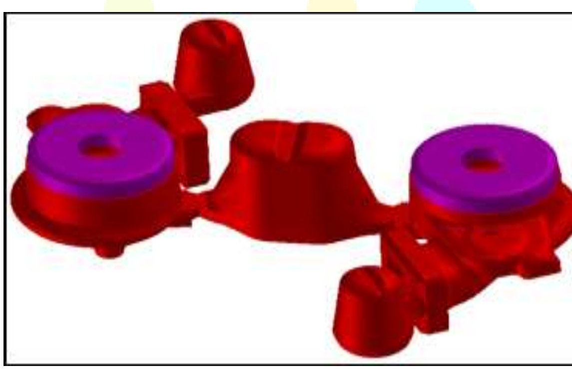


Figure No. 3.8: Temperature from 964°C to 652°C **Figure No.3.9: Temperature from912°C to 610°C**

In fig no.3.4 the temperature of molten metal is highest. As the solidification starts temperature goes on decreasing. In fig no. 3.9 the temperature is lowest and metal fully solidifies.

C. Fraction Solidification



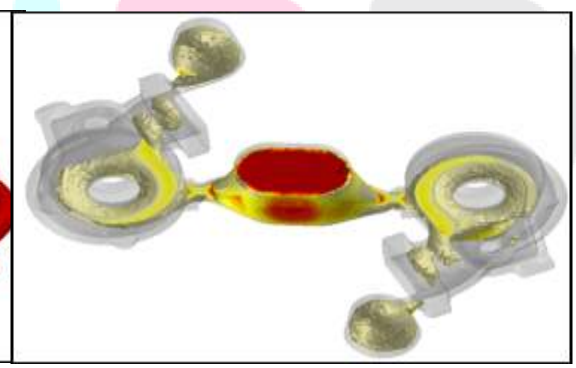
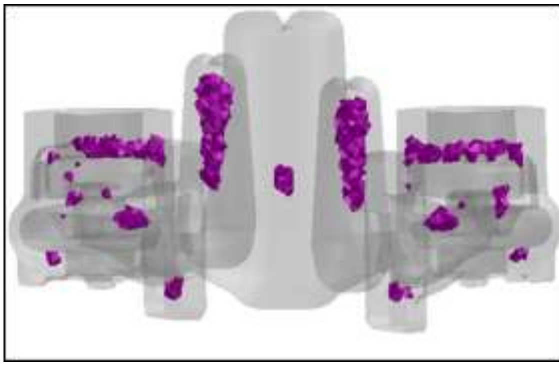


Figure No. 3.10: Initial stage of solidification **Figure No. 3.11: Intermediate stage of solidification**

D. Shrinkage Porosity



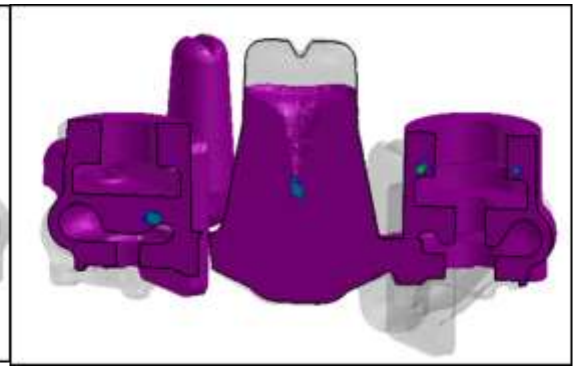
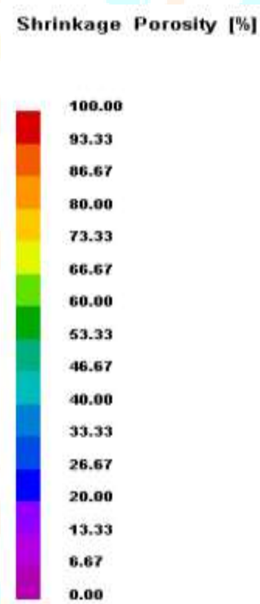


Figure No. 3.12: Cut section of gating system Figure No. 3.13: Blue color showing some minor voids



FigureNo. 3.14: Shrinkage Porosity Band(%)

IV. EXPERIMENTAL STUDY

From existing calculation we design new 2D drawing of gating system with our modifications and from standard dimension considerations we observed that the height of riser is increased then the feeding problem will not be occurred.From the above simulation results our modified design is sent for further casting and manufacturing process.

After few weeks the casting process was completed and good casting productswere obtained. To check whether the casting is defective or not Radiography test is performed. From radiography test results casting product (turbine housing) is found to be defect free and acceptable.

A. Calculations

Table No. 4.1: Calculations of Gating system

Sr. No	Comparison factor	Existing	Proposed
1	No. of riser	4	2
2	No. of cavities	4	4
3	Casting Weight	12.12 kg	12.12 kg
4	Choke Area	43.235 x 10^3 mm^2	38.670 x 10^3 mm^2
5	Riser Weight	8.24 kg	5.20 kg
6	Riser Height	75 mm	90 mm
7	Riser Diameter	45 mm	48 mm
8	Section Modulus	4 mm	4 mm
9	Bunch Weight	34.24 kg	28.675 kg
10	Yield Ratio	35.89 %	42.26 %

V. RESULTS

Table No. 5.1: Results

Sr.No	Comparison Factor	Existing	Proposed
1	Yield Ratio	35.89 %	42.26 %
2	Scrap	8 kg	4 kg
3	Riser Height	75 mm	90 mm
4	Riser Diameter	45 mm	48 mm
5	Riser Weight	8.24 kg(of 4 risers)	5.2 kg(of 2 risers)
6	Simulation Results	Defective	Defect-free
7	Radiography Results	Not-Acceptable	Acceptable

VI. CONCLUSIONS

- We have studied yield improvement in gating system for turbine housing by experimental and modeling study.
- Simulation results are taken and results showed that the casting and gating system is defect free.
- The yield ratio of the match plate is increased by 6.37%.
- Radiography results showed that casting is acceptable.
- With the use of optimization techniques, gating system of the casting is improved and increased the yield percentage of the match plate.

REFERENCES

[1] Dhruva Sadekar, G.R. Bharath Sai Kumar,"Yield Improvement of Castings using Computer Aided Simulation", Volume 3, Issue-31, 2014.

[2]Raghwendra Banchhor, S.K. Ganguly,"Optimization in green sand casting process for efficient, economical and quality casting graph", Vol. 5,Issue I , 2014.

[3] Utkarsh S. Khade and Suresh M. Sawant, "Gating Design Modification Using 3D CAD Modeling and Casting Simulation for Improving the Casting Yield", Volume 4, Number 7, 2014.

[4]Arunkumar P, Anand.S.Deshpande, Sangam Gunjati, "Analysis and Optimization of Investment Castings to Reduce Defects and Increase Yield" , Volume 3, Issue 1, 2015.

[5] Swaroop S. Magdum, Baliram R. Jadhav,"Design and Development of Casting by Simulation Technique for Yield Improvement in Foundry Industry", Volume 3 , Issue 6, 2015.

[6]Shashank V. Gulhane, A. D. Shirbhate, "Effects of Improved Gating System by Using Standard Gating Ratio", Volume22, Number 4, ISSN: 2231, 2015.

[7]Sandeep Singh, Lakhwinder Pal Singh & Gurudutt Sahni, “A review on optimization of gating system in metal casting”,Volume 4, Issue 3, 2016.

[8] Swapnil A. Ambekar Dr. S. B. Jaju, “A Review on Optimization of Gating System for Reducing Defect”, Volume 2, ISSN 2091-2730, 2016.