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MODELING EVALUATION AND OPTIMIZATION OF RISER DESIGN IN SAND CASTING PROCESS

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***Abstract*— Casting is the significance of heat transfer by a substance during change of phase evolution. Most of the casting design consists of gating and riser system. It has a direct influence on the quality of casting. During the solidification process, the casting defects like shrinkage, porosity and hot tears are affect the final product. To avoid and eliminate these defects by standard casting riser and gating system design is essential. As per chvorinov's rule, the volume of riser should be greater than mould cavity. In this work, 3D model of riser is designed by using Creo software and ANSYS are used to analysis and optimize the framework. The first step is to evaluate castability of the design and the model of part design is converted into a casting model. Parametric representation of the riser is to be carried out and various parameters are to be changed to generate Creo models in ANSYS. The optimization of parameters is to be carried out by varying the riser design parameters to improve the casting quality in sand casting process. The actual riser design can be defined by optimization techniques and the important parameters like height and diameters of riser can be analyzed and proposed to sand casting process.**

Keywords— riser, optimisation and green sand.

I.INTRODUCTION

Casting is one of the manufacturing process for making more complex shapes of metal materials for mass production. There are two major consecutive stages,

1. filling process and
2.solidification process, in casting production.

At first the filling process is carried out in which the gating system composed of pouring cup, runner, sprue, sprue well and ingate is designed to lead the liquid metal filling process. Riser system is mostly used to compensate the shrinkage caused due to casting solidification. Casting process design is vital for enhancing production quality and efficiency. It is not preventable that many different defects occur in casting process, such as large porosity and incomplete filling etc. Finally, how to overcome this and improve the casting quality becomes important. Casting quality is majorly dependent on the success of riser system design, which is conducted mainly relied on technician's experience. Hence there is a demand for the development of a computer-aided casting process design tool with CAD, simulation, and optimization functions to ensure the highest possible quality of casting. The purpose of the research presented in this work is to optimize riser systems based on CAD and simulation technology with the ultimate motive of improving the casting quality such as reducing the unfilled area, decreasing large porosity and increasing yield. In this work, the optimization framework of CAD and simulation technology is presented. Given a CAD model of part design and after it is converted in to casting model, the priority is to evaluate castability of the casting design. Then the risers are parametrically presented. By changing each parameter, all CAD models will be obtained. After analyzing the simulation results, the original riser system design will be optimized to improve the quality of casting. In this work, an engine block is used to determine the effectiveness of the optimization method. Compared to the initial design, the optimized casting assembly may help in decreasing the porosity around 18% while the yield increases by 16%.

II.LITERATURE REVIEW

- A.Mohideen Abdul Kadhir Badhusha, M.Kannan, and S.K Mohammed Raffiq, [1] The riser is designed for an optimal diameter to reduce the defects in the aluminium castings, through simulation by Solidcast software.
- N.Yazad, T.Bhushan and M.Aditya, [2] It is optimized to simulate the casting process by various software. The simulated results are used to predict the defects, optimize the factors and take corrective actions to reduce the defects.
- L.H.Suarez Lisca and N.I.Coello Machado, [3] It is determined that the shape of the casting will affect the size of the riser necessary to meet its feed requirements for the obvious reason that the longer time the casting takes to solidify, the longer the riser should maintain a reservoir of liquid metal. The different methods have been used to calculate the riser size (shape factor method, geometric method, the modulus method).

  In this research, it has been determined that the riser geometry by different methods for the piece type wheel and the simulation is used to determine which of the methods is more efficient.

- K.Manikanda Prasath, [4] An optimized design will provide a minimum volume of riser system but warranting the quality of the casting. Genetic algorithm has been used to optimize the riser system design.
- Utkarsh Khade and Suresh Sawant, [5] An optimized casting of brake disc is analysed and studied to solve the issue of lower casting yield. Then the risers for brake disc are redesigned based on feeding rules, conventional method and casting simulation. The different models of risers are first made, then 3D CAD model of casting with these altered risers are simulated to analyse the effectiveness of modified risers. On analysing, the most suitable design is selected so that it will give the good sound quality of casting with the higher casting yield, profit and high productivity.
- Raghwendra Banchhor and S.K. Ganguly, [6] It states that the effects of riser design, moulding sand, oxidation and deformation of casting during heat treatment etc., on the economical manufacture of quality castings. It gives the optimal process parameter setting will significantly improve the mould yield, output ratio of metal, shorten manufacturing period, save energy and resource, reduce pollution, and improve the competitiveness of enterprises.
- Swapnil A. Ambekar and S. B. Jaju, [7] The optimized casting which is produced by foundry with internal shrinkage as a major defect was analysed and identified that the riser system was not properly designed. The designed riser system reduced defect and increase yield. Finally, a reasonable riser system was obtained by analysis of simulation results.
- C. M. Choudhari, B. E. Narkhede and S. K. Mahajan, [8] Optimum design of a riser is obtained by simulation. This paper attempts to study heat flow within the casting, and from the casting to the mould, and finally obtains the temperature history of all points inside the casting. ANSYS software is used to obtain the last solidifying region in the casting process by performing Transient Thermal Analysis.
- Ishwar P Keswani, [9] To optimize the sand casting process parameters of the castings manufactured in iron foundry by increasing the signal to noise ratio and reducing the noise factors using Taguchi method.
- T.Nandi, R.Behera, S.kayal, A.Chanda, G.Sutradhar, [10] Computer simulation provides the position and extent of interior defects, ensuring casting right as first time and every time. In the present study, plate castings are considered to investigate the solidification behaviour of Aluminium Alloy (LM6) with various sizes of risers. It is expected that this project will be of immense importance equally to the academicians as well as to the industrial engineers.

III.EXPERIMENTAL DETAIL

A. Pattern Making

Initially the experimental analysis is to prepare a wooden pattern with different allowances for shrinkage, draft etc. Next step is to made a wooden pattern for pouring basin, sprue and sprue base well, ingate, runners and as per the design dimensions for aluminium alloy casting.

B. Mould Box Preparation

Green sand used for casting. Green sand in the sense not green in colour but which is in wet state even when the metal poured in the mould. Green sand is a mixture of silica (80%), bentonite (11%), water (4%), inert sludge (5%). It also acts a binder and holds the sand firmly when pattern is withdrawn from the mould box. The mould box or flask consists of two parts. The upper part is called cope(Fig.1) their standard dimensions are 300mm × 300mm × 150mm and the lower part is called drag(Fig.2) their standard dimensions are 300mm × 300mm × 100mm respectively. Riser(Fig.3) is the reservoir which is built into a metal casting mold to prevent cavities due to shrinkage.

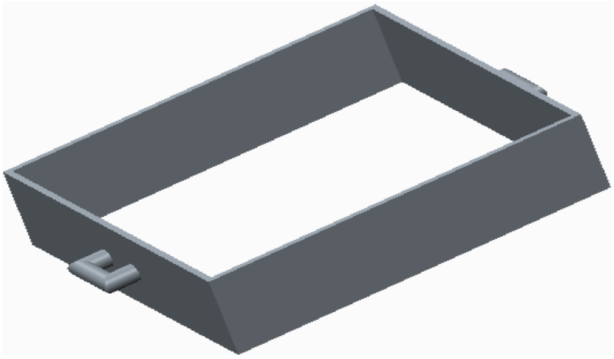


Fig.1 Cope

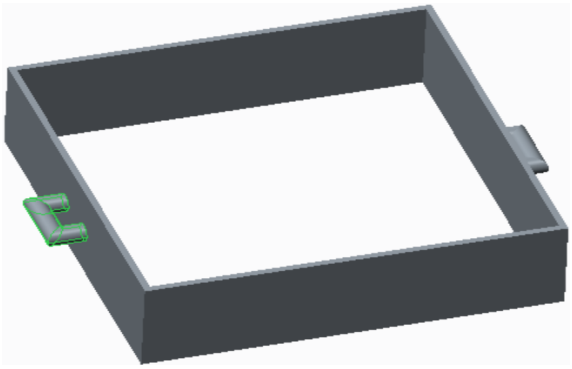


Fig.2 Drag

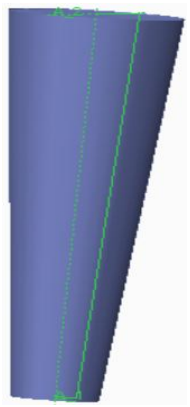


Fig.3 Riser

TABLE.I *Geometry of riser with various parameter*

S.no	D1 (mm)	D2 (mm)	H (mm)	V (mm)	Remarks
1	40	42	49	65000	Fair
2	32	40	63	64000	Good
3	38	40	54	64920	Fair
4	30	38	70	64000	Good
5	36	38	60	64880	Fair
6	28	36	79	64000	Good
7	34	36	67	64760	Fair
8	26	34	90	64000	Good
9	32	34	76	64630	Fair
10	30	32	85	64545	Fair
11	28	30	98	64490	Fair
12	26	28	112	64370	Fair
13	24	26	131	64230	Fair

Where D1 - Minor diameter of the riser
D2 - Major diameter of the riser
H - Height of the riser
V - Volume of the riser

IV.RESULT AND DISCUSSION

A. Analysis of riser design by using ANSYS software:

- Finite difference method (FDM)
- Finite element method (FEM)
- Boundary element method (BEM)

Finite difference method is the traditional mathematical technique used to generate the solidification simulation by discretizing the casting and mold arrangement into minimum equal elements. For an element, the small distance in the *X*-direction is taken as 'Delta *X*' and the opposite distance in the *Y*-direction is taken as 'Delta *Y*'. Besides, it is very useful to write heat equations for the nodes of elements based on the mode of transient conditions. By using finite element method different kinds of mesh elements are generated by time-temperature distribution and particle distribution also analyzed by the help of ANSYS software. Now a days, boundary element method is implemented to get exact value outputs and this is considered as latest technique by engineering technologists. From this work, the best geometry parameters of the riser is displayed in the table I. it is selected best four geometry parameters of the riser is analyzed by ANSYS as shown in fig 4 to 7respectively.

Fig.4-The riser parameters D1-32mm, D2-40mm and H-63mm

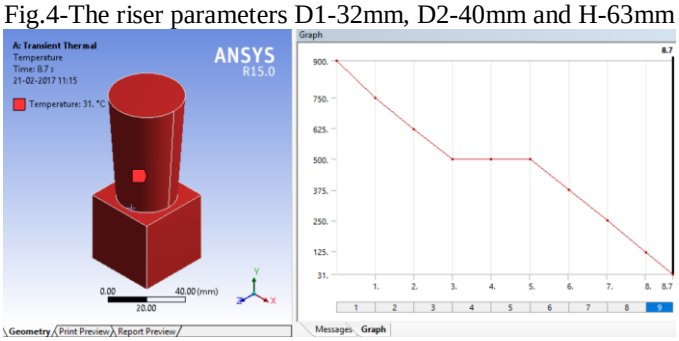


Fig.5-The riser parameters D1-30mm, D2-38mm and H-70mm

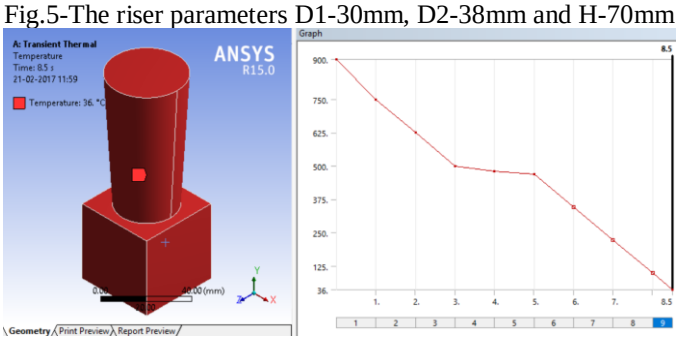


Fig.6-The riser parameters D1-28mm, D2-36mm and H-79mm

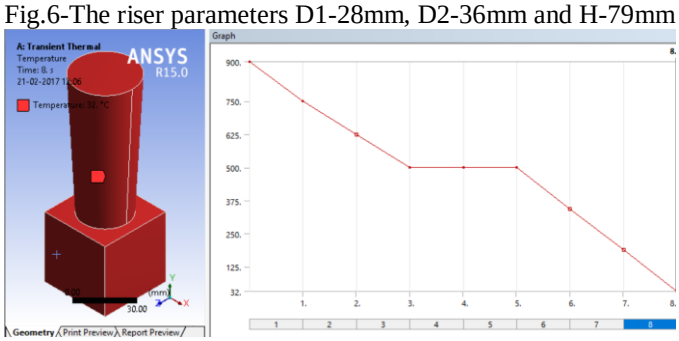
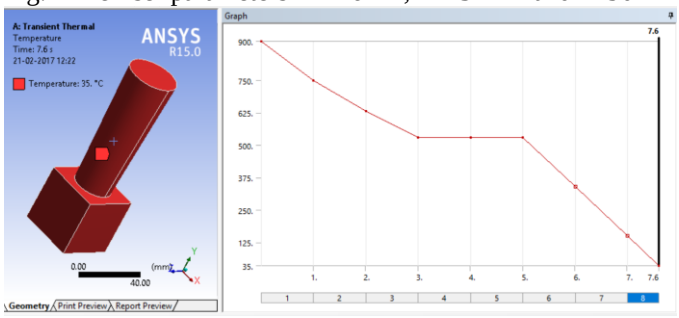


Fig.7-The riser parameters D1-26mm, D2-34mm and H-90mm



The best result for four parameters of the riser are analyzed and it is successfully completed by experimental work. the following four best parameters of riser geometry the solidification point at center of the riser is solidified successfully after solidification of mould cavity. the geometry of the riser is satisfied by the chvorinov's rule, and the 20% of volume is reduced in the riser. from this work the optimized riser design is evaluated.

B. Applications of riser design in sand casting:

Casting riser design are in regular use by aluminum, copper, iron and steel foundries using processes reaching in replacement of green-sand, resin and shell-bonded sand to investment and gravity die casting. Applications are

•By this method high yield and reduced fettling costs were achieved for large castings such as weighing turbine housing and stern frames.
• Casting of critical high pressure valve.
• Repetition castings such as ductile iron crank shafts, where modeling increases the chance of achieving 'right the first time' methods, so reducing the lead time for new castings. It is mainly used for small scale sand casting industries

V.CONCLUSION

The optimum riser design can reduce the excess volume in the riser part. This can reduce nearly 20% to 30% of volume in the riser. At the last point of solidification, the volume need not to be in the center point of riser, it is sufficient to that they are at the point just above the mould cavity. It is concluded that usage of optimal riser design can eradicate defects like porosity, shrinkage and to locate the hot spot regions which helps to design the components effectively. Since the volume loss in the riser is reduced which results in the reduction of raw material consumption. By this method, the exact time of solidification can be calculated which can increase the production rate in effective manner.

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