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Die Casting Defect Analysis & Experimental Validation for Compressor Housing

A. P.Wadekar[1], B.A.Ahire[1], L.G.Navale[1], S.H.Gawande[1], R. Mathai[2], R.Mishra[2]
[1](*Mechanical Department M.E.Societys College of Engineering, Pune, India)*
[2]*(Design Department, Spark Minda Co. Ltd, India)*

ABSTRACT :*Gravity die casting is used to manufacture the complex metal components where there is a need for high structural integrity. The casting defects that are caused by molten metal include air entrapment, porosity, and shrinkage. But the control of casting defects has been based on the experience of the foundry engineers. This paper describes these defects in casting with the help of computer aided simulation. These are demonstrated using a simple two dimensional example which contains the essential features of compressor housing. The computer simulations have been carried out to analyse the flow of molten metal .The, flow ranging in 0.7 to 1 kgs/s in 5mm thin wall casting was examined to find the optimal parameters for the die-casting process. The results for compressor housing body are obtained by simulation and required corrective measures are implemented in actual component. It is seen that the most important physical situation during a casting process is solidification by cooling its surroundings where numerous defects can generate through changes during the heat transfer process from liquid form to a solid form. The design, simulation, analysis and testing work is carried at Spark Minda Co. Ltd, Chakan, Pune.*

Keywords -*Gravity die casting ,Simulation, Compressor housing, Casting defect*

I. INTRODUCTION

Gravity die casting is used to manufacture complex metal components where there is a need for high structural integrity. In this process, liquid metal is fed from below into the die used to form the component under a positive pressure.A new approach is developed in [1] for analyzing liquid metal flow in die casting which, compared with conventional methods which shortens the time required to calculate a solution. The method allows for generally curved, branched cavities, venting of the cavity gas, energy dissipation at gates, and a variable injection speed. Number of problems are considered which illustrate the performance of the analysis under several geometric and process conditions. The effect of the addition of silicon and grain refiner on the reduction of the susceptibility to cracking was examined in [2] in order to evaluate the susceptibility to cracking, by both the “I-beam casting cracking test” and the “TIG spot welding cracking test”. In [3] low-pressure die casting (LPDC) process has been used to produce sound magnesium alloy AM50 castings by considering the influence of process parameters: filling time, pressure holding time, die temperature, holding pressure and casting temperature, on the mechanical properties, microstructure and density of LPDC castings. The casting defects that are caused by molten metal were cold shut formation, entrapment of air, gas, and inclusion. But the control of casting defects has been based on the experience of the foundry engineers. Computer aided simulations have been carried out to analyze the flow of molten metal as explained in [4]. During die casting process, liquid melt injected fills die cavity with high velocity, which commonly results in entrapment of gas and induces final porosities [5]. As per [5] the tensile specimens were obtained from the casting of different parts, and mechanical properties of the specimens were measured. The fractions and maximum size of porosities induced by gas entrainment were analyzed quantitatively. The effect of the fraction and size on the mechanical properties was analyzed and discussed, and the critical porosity fraction and size were proposed for ADC12 die castings. Advances in modeling of casting processes using smoothed particle hydrodynamics (SPH) are described in [6] in which three-dimensional simulations of high pressure die casting are presented for two realistic dies. Developments for both visualization of these systems and for their simulation are described.

This paper is organized as; section1 describe literature survey, problem formulation and objectives are stated section 2. Section 3 explore design and modeling of compressor housing, experimental set up is shown in section 4, results & discussion is explained in section5, concluding remark is given in section 6.

II. PROBLEM FORMULATION AND OBJECTIVE

As per the past literature and industrial survey carried in different die casting manufacturing industries located in Pune MIDC namely Spark Minda Ltd., Chakan and Shiva Tools and Dies, Bhosri, it is seen that the manufacturing of compressor housing generally performed in single plane [Fig.1]. But as per the requirement of vendor of Spark Minda Ltd team ask us to design and develop the compressor housing for the product under consideration [Fig.2].
Hence in order to satisfy vendor requirement following objectives were set.

1. Designing and modeling of compressor housing.
2. Computer aided flow analysis of die casting.
3. Experimentation for validation

Fig. 1 Old compressor housing Fig. 2 Developed compressor housing

Compressor housing shown in Fig1 is conventional type which is casted in single plane whereas the compressor housing shown in Fig 2 is newly developed which is comparatively very difficult to cast because of its shape. This work focus on compressor housing which has geometry in different planes as shown in Fig.2.

III. DESIGN AND SOLID MODELLING OF COMPRESSOR HOUSING

In this section the design with solid modeling of compressor housing is explained which comprises following steps.

1. Generation of solid model

The main task was to create solid model of the compressor housing according to customer's requirement. Through study of 2-D drawing is performed. After studying the details of 2D drawing, the solid model of compressor housing [Fig.3] is generated with the help of Unigraphics-7 software.

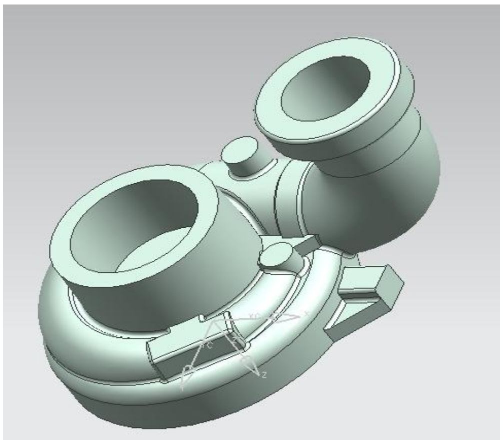

Fig.3 Solid model of compressor housing

2. Generation of die cavity

The main aim of generation of solid modeling of compressor housing is to identify shape and draft angle provided by the customer. After analysing the shape next step is generation of die cavity. The die cavity made in four halves because of its critcal shape. While generating cavity some errors were occured as shown in Fig.4. In highlighted region of Fig 4, there was error in parting line selected at the time of cavity generation. Due to this error there was probem in removing the casted component and also problem was faced at the time of filling of cavity.

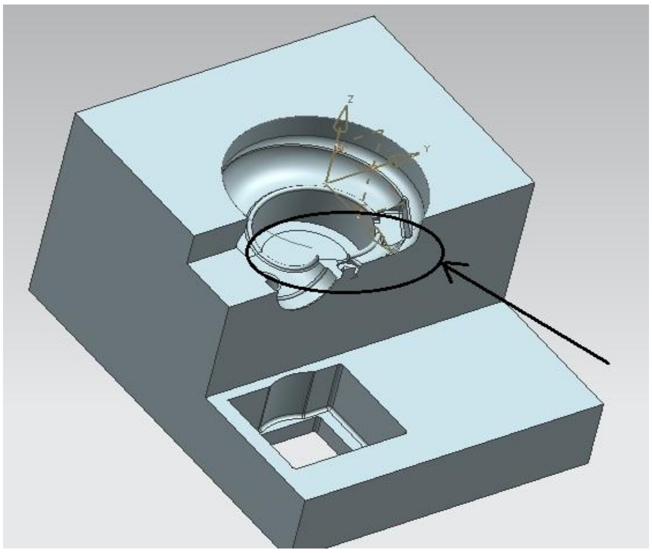

Fig.4 Die cavity [Before modification]

To remove these errors, parting line is shifted slightly inword as shown in Fig.5. So that filling of cavity takes place correctly because barrier is removed by shifting parting line. Problem of casted component removing is also solved, at the time of removing two halves of pipe section slides in opposite directions and component can taken out easily, which was very very difficult before shifting of pating line.

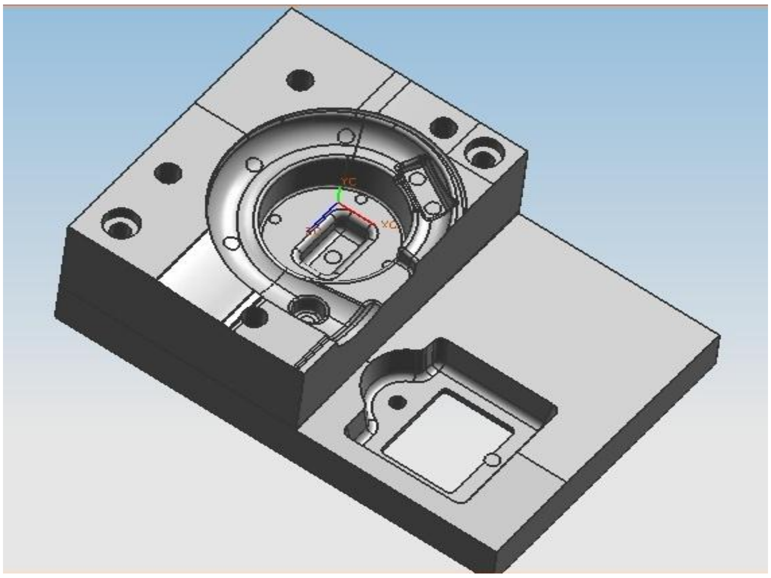

Fig.5 Die Cavity[After Correction]

3. Assembly of die cavity

After workout on errors assembly of die cavity is developed as shown in Fig. 6.

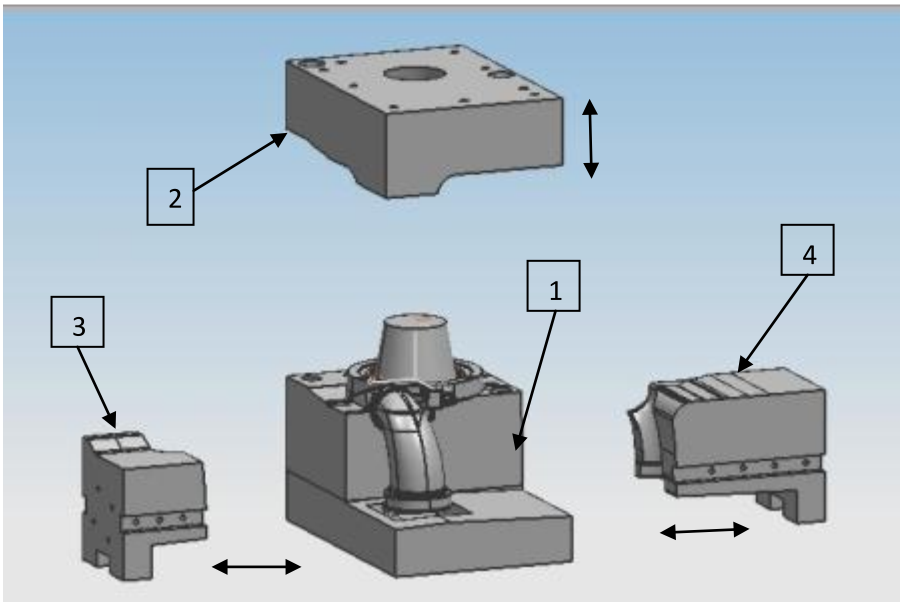

Fig.6 Exploded View Of Die Cavity

Die cavity comprises of four halves 1) bottom half 2) upper half 3) left half 4) right half and there respective

IV. EXPERIMENTAL SETUP

The experimental set up shows the complete assembly of the die which comprises following main parts 1.base plate 2.die cavity 3.side plates 4.top plate 5.guide rods 6.pnumatic cylinders.

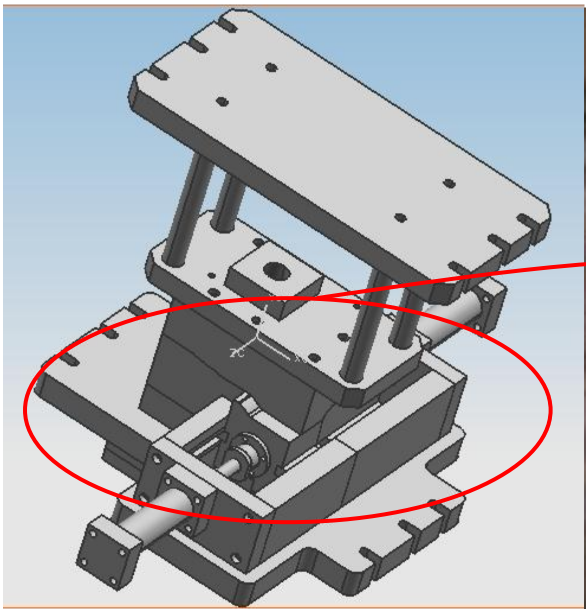

Fig.7 Experimental setup

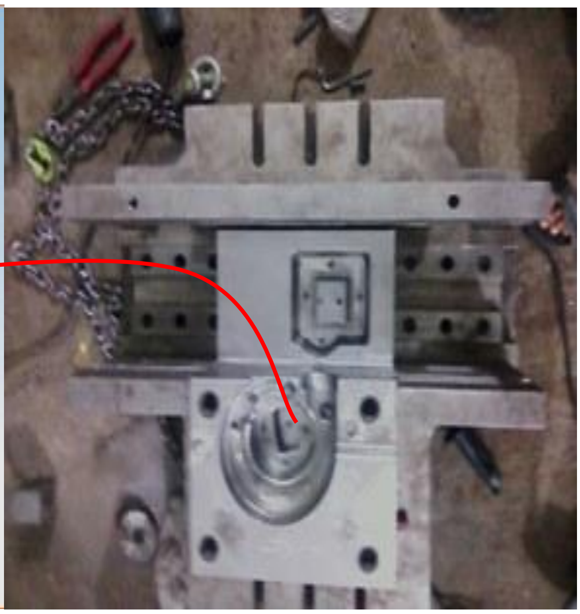

Fig.8 Exploded view of die

Fig.7 shows the experimental set up as per CAD Software while Fig.8 shows exploded view of actual experimental set up as marked in highlighted region, it shows the assembly of base plate, side plates, and bottom half of the cavity and further assembly takes place as shown in Fig.7 Detail working of die cavity which will be included in experimental set up is explained in Fig.6.

V. RESULTS AND DISCUSSION

Computer aided simulation work is carried out to visualize the extent of defect and to reduce those defects during manufacturing; necessary modifications are performed in experimentation. Then extensive experimentation is carried out to observe defect-less die casting. Fig.9 shows the simulation in which the molten metal is poured from top side of the mould cavity as indicated by highlighted area. This region shows the unfilled area which leads to reduction in strength of the component. So to overcome this problem the necessary changes into the cross section of the die are made which results in defect free component as shown and highlighted in Fig.10.

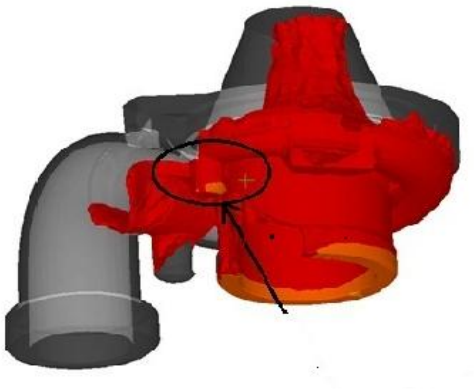

Fig.9 Simulation

Fig. 10.Actual solution

Fig.11 shows the chances of air entrapment in highlighted region, this problem leads to bubble formation which can reduce the strength of the casting. So to overcome this problem, venting pin is provided. Hence we can avoid air entrapment which results in defect free component as shown in Fig.12.

Fig 11 Simulation

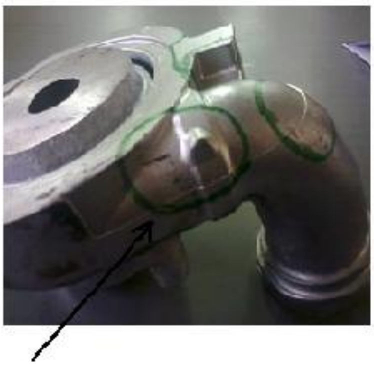

Fig 12 Actual solution

Fig.13 shows the possibility of air entrapment in highlighted region, that problem leads to bubble formation which can reduce the strength of the casting. So to overcome this problem, venting pin is provided. Hence we can avoid air entrapment which results in defect free component as shown in Fig.14.

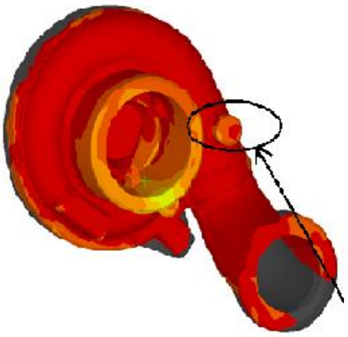 

Fig 13 Simulation Fig 14 Actual solution

Fig.15 shows the chances of air entrapment in highlighted region this problem leads to bubble formation which can reduce the strength of the casting. So to overcome this problem, venting pin is provided. Hence we can avoid air entrapment which results in defect free component as shown in Fig.16.

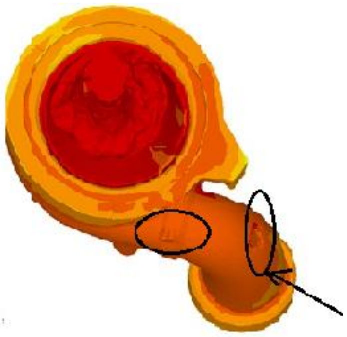 

Fig 15 Simulation Fig 16 Actual Solution

Fig.17 shows the chances of air entrapment in highlighted area this problem leads to bubble formation which can reduce the strength of the casting. So to overcome this problem, venting pin is provided. Hence we can avoid air entrapment which results in defect free component as shown in Fig.18

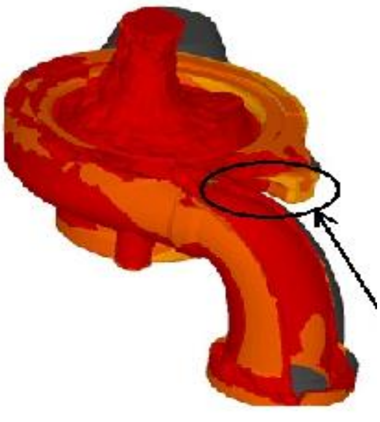 

Fig 17 Simulation Fig 18 Actual solution

VI. CONCLUSION

After performing the simulation with the help of high end package it is seen that designer can easily identify various defects of casting before actual production starts, which helps to reduce reworkandfinallyproduces good quality product in minimum time.

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