DESIGN A PRESSURE DIE CASTING DIE FOR IMPELLER

[1]Rahul P Suryavanshi, [2]Amar R Wargante, [3]Prakash M Kadam, [4]Sagar R. Joshi, [5]Vikram U. Ukirde
[1,2,3,4,5] Assistant Professor,
[1,2,3,4,5] Mechanical Engineering Department, ICOER, Wagholi, Pune.

Abstract: Pressure Die Casting is one of the most important processes in the casting manufacturing industry. This paper deals with designing a pressure Die casting for Impeller of two wheeler water cooling system. A wide variety of products are manufactured using Pressure Die Casting, which vary considerably in their size, complexity, and application. The Pressure Die Casting process requires the use of a Die casting machine, raw material, and a Die. The material characteristics and the associated process of manufacturing further underline the need to undertake the assessment of 'Design' for the Die in a critical manner and outlook. Quality of the component produced is depends upon the Design of the Die and the processing parameters. As Die casting Die design system is based on designers experience and capabilities, it takes lot of iterations for converging to ideal feeding system. Hence while designing a Die, the designer needs to consider many factors such as type of material, type of gate selection and position of gate, feed system details like gate size, sprue dimension & runner dimension. The Die designer also considers the various defects generated during casting process and work to reduce the defects.

Key Words: Impeller, Pressure Die Casting, MAGMAsoft analysis.

I. INTRODUCTION

Die casting is a very normally used type of permanent mould casting process. It is used for producing many components of home appliances (e.g. rice cookers, stoves, fans, washing and drying machines, fridges), motors, toys and hand-tools – since Pearl river delta is a largest manufacturer of such products in the world, this technology is used by many companies [2]. The main concept of pressure die casting is filling a molten metal into the die cavity, allowed to solidify so that the metal can take the required shape. It is essential to consider the collective effects of part geometry, material selection, mold design and processing conditions to avoid the high costs and time delays problems associated with the start of manufacturing,. With the help of different analysis tools to simulate the pressure die casting process can evaluate and optimize interactions among these variables during the design phases of a project, where the cost of change is minimum but the impact of the change is greatest. From the simulation and analysis, the software for flow simulation provides sufficient information regarding metal tracer, filling time, various defects like air traps, weld lines, sink mark, warpage etc. With the help of these results, we can avoid the defect of casting. The analysis will help to design a die with minimum modifications and which will also reduce the cost and time [2].

II. PRODUCT DETAILS

The Impeller is the essential part of a centrifugal pump. The performance of the pump depends on the impeller diameters and design. The pump's TDH is basically defined by the impeller's inner and outer diameter and the pump's capacity is defined by the width of the impeller vanes. In general, there are three possible types of impellers, open, semi open and enclosed impellers. For analysis open type Impeller is suitable for two wheeler water cooling system. This impeller is made of Aluminum Alloy [1].
The Impeller is as shown in fig 1

Name of Component: Open type Impeller

Casting type- Pressure Die Casting

Material- Aluminium alloy-AIDC12

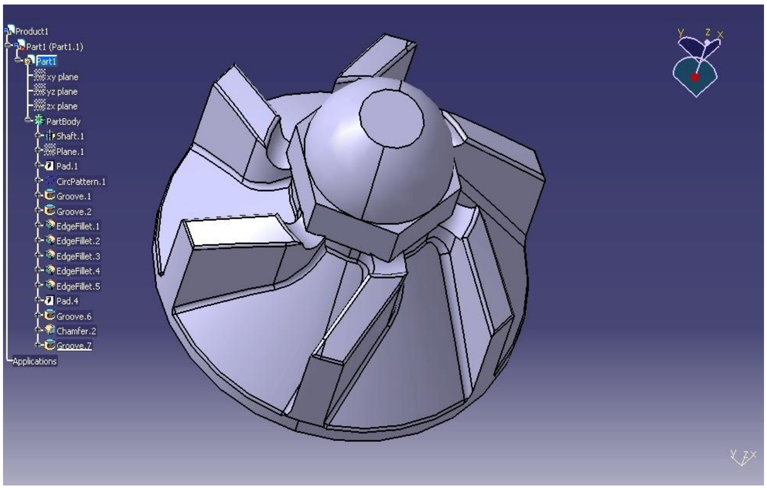

Fig. 1: 3D Image of Impeller

Table No. 1: Chemical Composition of AIDC12 [16]

Content	Wt (%)
Sillicon(Si)	9.6-12.0
Iron(Fe)	1.3 max
Cupper(Cu)	1.5-3.5
Maganese(Mn)	0.50
Magnesium(Mg)	0.30
Nickel(Ni)	0.50
Zinc(Zn)	1.00
Tin(Sn)	0.30

Table No. 2: Mechanical properties of AIDC12 [16]

Density (gm/cm3)	2.7
Heat Capacity (J/g. C)	0.963
Thermal Conductivity (W/m.C)	92
Melting Range (0C)	516-582
Ultimate tensile Strength (MPa)	331
Yield Tensile strength (MPa)	165
Elongation (%)	2.5

III. ANALYTICAL SOLUTION

A twin cavity die is to be designed. With a twin cavity die it is possible to manufactured two products in one shot. This will increase production rate [14].

1) Part Projected Area: 3600.00 mm2 …………………….....(1)

2) Overflow Projected Area: 364.00 mm2 …………………….....(2)

3) Slide Projected Area: (π x 6 x 6 x 2 x tan10)

   Slide projected Area = 19.93 mm2 …………………….....(3)

4) Total Part Projected Area:

   Total Part Projected Area = (Part Projected area) + (Overflow Proj Area) + (Slide Proj Area)

   Total Part Projected Area = (3600) + (364) + (19.93)

   Total Part Projected Area = 3983.93 mm2 …………………….....(4)

5) Runner Projected Area = (Part Projected Area) + (30-40% More)

   Runner Projected Area = 1195.18mm2 …………………….....(5)

6) Total Projected Area:

   Total Projected Area = (Total Part Projected area) + (Runner Projected Area)

   Total Projected Area = (3983.93) + (1195.18.00)

   Total Projected Area =5179.11 mm2 …………………….....(6)

7) Tonnage Calculation:

   Tonnage of Machine = (Total Projected Area) + (Casting Pressure)+ (Die Locking Force)

   Tonnage of Machine = (51.79) + (0.8) + (90.44)

   Tonnage of Machine =143.03 Tonnes …………………….....(7)

   Selecting Nearest Available value is 180 Tonnes

8) Shot Weight:

   Weight Per Cavity = 116.00 gm

   Runner + Biscuits = 313.00 gm

   Shot Weight = (Cavity Weight) + (Runner+Biscuits)

   = (116.00 X 2) + (313.00)

Shot Weight = 545.00 gm. ……………………....(8)

9) Filling Ratio:

$$\text{Filling Ratio} = \frac{\text{Shot weight}}{(\text{Plunger Area}) X (\text{active length}) X (\text{Density})}$$

$$\text{Filling Ratio} = \frac{545.00}{(\pi X2X2)\ X\ (4.3)\ X\ (2,7)}$$

Filling Ratio = 3.73 ……………………....(9)

10) Cavity Fill Time:

$$t = K \times T \times \frac{(Ti - Tf + Sz)}{Tf - Td}.$$

Here,

K - 0.034
T - 4mm
Ti - 6700C
Tf - 6200C
Td - 1500C
S - 20
Z - 3.8

$$t = 0.64 \times 4 \times \frac{(680-630+76)}{630-120}$$

t = 0.011 Sec …………………….........(10)

11) Gate Area:

$$\text{Gate Area} = \frac{\text{Weight after gate}}{(\text{Fill time}) X (\text{Dencity}) X (\text{Gate velocity})}$$

$$\text{Gate Area} = \frac{232}{(0.011) X (0.021) X (30000)}$$

Gate Area = 33.47 mm2 ……………………....(11)

Hence,

Gate length = 17 mm

Gate Thickness = 2 mm

12) Flow Rate :

$$\text{Flow Rate} = \frac{\text{cavity weight}}{(\text{Filling time})\ X (\ \text{Density})}$$

$$\text{Flow Rate} = \frac{232}{(0.011) X (0.021)}$$

Flow Rate = 1004329.004 mm3/sec ………………....(12)

13) Plunger velocity:

$$\text{Plunger Velocity} = \frac{\text{Flow Rate}}{\text{Area of Plunger}}$$

$$\text{Plunger Velocity} = \frac{1004329.004}{(\pi X11X11)}$$

Plunger Velocity = 2642.04 mm/sec

Plunger velocity = 3.01 m/sec ....(13)

IV. SIMULATION PROCESSING:

In simulation processing, MAGMAsoft analysis is carried out on Impeller part and Die casting die to calculate various thermal and physical properties of the metal like, melting temperature, heat capacity, viscosity versus temperature, Air pressure, Porosity solidification time etc. Once the geometry is meshed, MAGMAsoft uses a modified Navier-Stokes equation for modeling fluid flow. The user is prompted to first input the materials that make up the mold, the casting, and the filter if one is used. From the material entries, various thermal and physical properties of the metal are extracted from a central database built-in to MAGMA. This data includes melting temperature, heat capacity, viscosity versus temperature, etc. The user then enters the temperature of the various materials at the time of casting. Once all the data is entered into the system, the simulation is started. Simulations can run from hours to days, depending on the complexity of the part geometry and the number of elements/cells in the system. For the simulations performed in this experiment, each simulation typically run for 1 – 2 days. After the simulation is completed, the data generated during the simulation is transferred to a post processor. This portion of MAGMAsoft takes the data and manipulates it to show visual representations. For instance, raw data can be displayed as a bulk three-dimensional flow pattern with different colors representing varying temperatures in the melt.

V. Metal Tracer Result

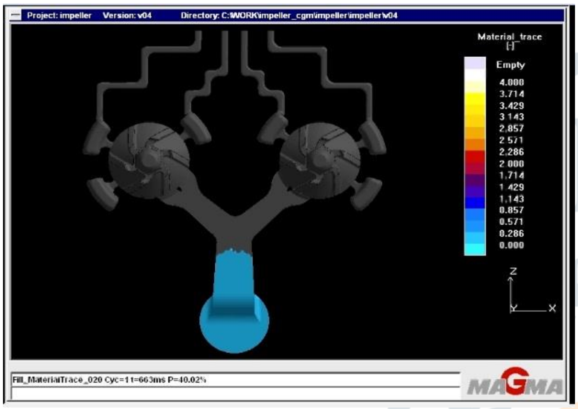

Fig 2: Metal Tracer Result for 40% filled cavity

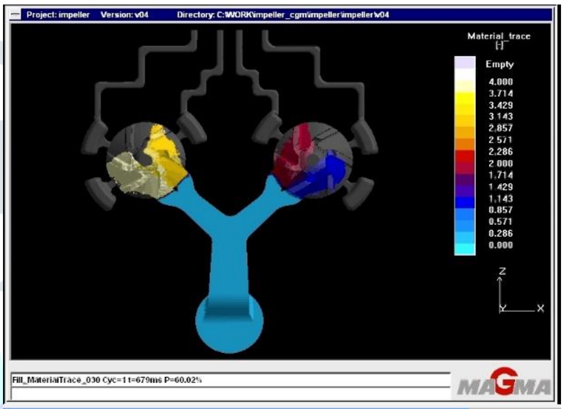

Fig 3: Metal Tracer Result for 60% filled cavity

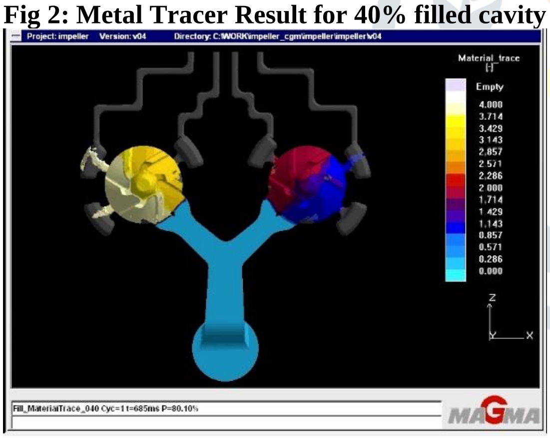

Fig 4: Metal Tracer Result for 80% filled cavity

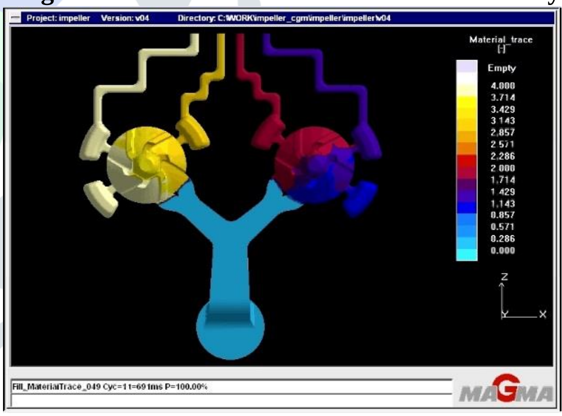

Fig 5: Metal Tracer Result for 100% filled cavity

Figure 2, 3, 4 and 5 are showing metal tracer results for consecutively increasing cavity filing of die. For good quality casting it is one of the main concern of die designer that total area of die cavity should fill evenly. Present case is dealing with twin cavity die, from above figures the metal propagation is observed equally and symmetrically. Figure 2 showing that metal first starts from biscuits after filling biscuits completely it get inserted into runner and both the runners are at a time getting filled by same amount. Figure 3 metal tracer result for die cavity when cavity is 60% filled, now runners are completely filled and next it's necessary to observe the metal traces when the component cavity is being filled. From the result it is observed that both the dies are getting filled symmetrically with the same amount for particular instance of time and metal is filling each and every section of dies evenly. From figure 4 also metal traces are observed in same manner. Figure 5 showing the result for metal tracer when cavity is 100% filled. It can be easily observed that all the individual portions like biscuit, runners, component cavity and overflows are filled completely at the same time. Here it is proved that current design of die has no issues with meal traces for cavity being filled. So, current design is free from uneven and unfilled areas in cavity.

VI. Metal Velocity Result

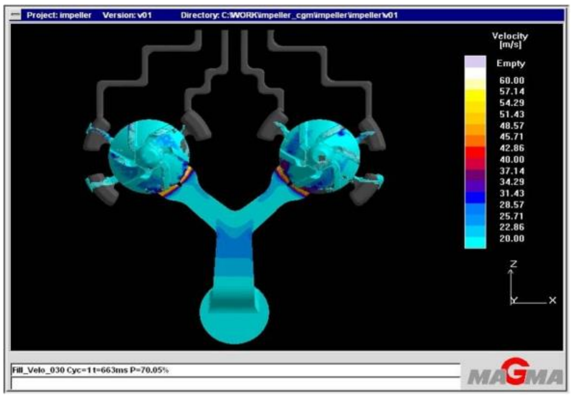

Fig. 6: Metal Velocity Results for Version 1

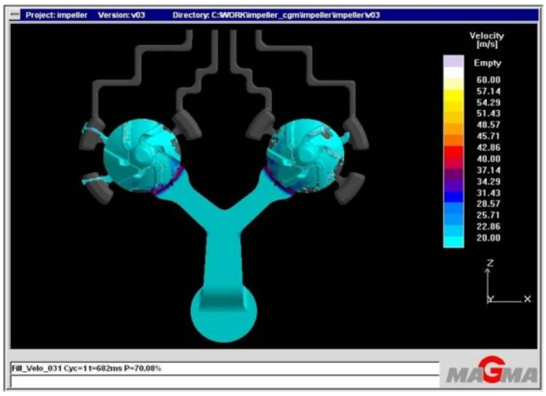

Fig. 7: Metal Velocity Results for Version 3

This result represents the velocity of metal at gate area (Figure 6, 7). The acceptable standard of gate metal velocity should be less than 62 m/sec to avoid erosion of the die. Hence, in the present investigation the criteria to finalize the gate metal velocity is that, it should match with the standard and also the analysis result should fall within optimum range of metal velocity scale which is on right side of analysis result.

Figure 6 shows the result of gate metal velocity for version 1, color at gate portion matches with upper most side of velocity scale. The gate velocity for version 1 is calculated as 62 m/sec which also deviates from standard hence, it is unacceptable.

As shown in Figure 7 the gate velocity of version 3 is 43 m/sec which is within the standard limit. However, from MAGMAsoft analysis result it is observed that color of gate portion falls on upper side which is nearby to middle range which is not satisfying the optimum condition. In case of version 2 and 4 analysis by increasing gate area and reducing 2nd phase velocity we have achieved a gate velocity approximate 40 m/sec, according to standard it will not lead to die erosion also from result it is clearly visible that gate velocity falls at middle range of velocity scale. It can be said that 40 m/sec is optimum gate metal velocity. The above discussion concludes that the gate metal velocity is finalized as 43 m/sec and it is safe from casting defect occurs due to incorrect gate velocity like early erosion of die.

VII. CONCLUSION

The pressure Die casting system is helpful to design a perfect Die with minimum modifications and which will also reduces the time and cost. In this paper the flow simulation software's used which provides important information regarding the Die design; hence the flow simulation software (MAGMAsoft) is a corrective and defensive tool that helps the engineer to analyze the process of Die manufacturing for reducing defects and improving quality of the product.

VIII. REFERENCES:

[1] Christian Allerstorfer "Bachelor Thesis Centrifugal Pumps".
[2] https://www.ielm.ust.hk/dfaculty/ajay/courses/ieem215/lecs/2_casting.pdf (Accessed Date 15 may 2014)
[3] Arman Rahimi "Introduction Of High Pressure Die-Casting And Common Defects In Die-Casting" Islamic Azad University of Saveh.
[4] John Compbell "The new metallurgy of cast metals Castings" 2nd edition, University of Birmingham, UK, 2003 PP.70-31.
[5] B.S. Sung, I.S. Kim "The molding analysis of automobile parts using the die-casting system" journal of materials processing technology, 20 1 (2008), 635–639
[6] Paul W. Cleary, Joseph Ha, Mahesh Prakash, Thang Nguyen "Short shots and industrial case studies: Understanding fluid flow and solidification in high pressure die casting" Applied Mathematical Modeling, volume34, Issue 2010, PP. 2018–2033
[7] Manjunath Swamy H. M., J. R. Nataraj, C. S. Prasad "Design Optimization of Gating System by Fluid Flow and Solidification Simulation for Front Axle Housing" International Journal of Engineering Research and Development, Volume 4, Issue 6 October 2012, PP. 83-88.
[8] Alexandre Reikhe "Numerical Analysis of Die-Casting Process in Thin Cavities Using Lubrication Approximation" The University of Wisconsin-Milwaukee, Theses and Dissertations, December 2012, PP. 65-70.
[9] K Maheswari and G Sureshkumar "Die Designing and molten metal flow analysis for intermediate flange" International Journal of Mechanical Engineering and Robotics Research India, Vol. 2, No. 4, October 2013, PP. 176-182.
[10] Sunil kumar, Ranjitsingh, Vijay Kumar Vinod Kumar "Automatic determination of parting line and number of cavities in die casting die" Volume- 2, Issue- 1, Jan. 2014, PP. 13-17.
[11] Dr. B. Ravi "Casting simulation-Best practices" Tranzactions of 58th IFC, Ahemdabad, 2010.
[12] Bodhayana M. R., N. Ramesha "Tool design for pressure dies casting of Housing Component" International Journal on Theoretical and Applied Research in Mechanical Engineering Volume -3, Issue-2, 2014, PP. 30-33.
[13] Chandan Deep Singh, Sukhjinder Singh, Varun Panwar, Sheetal Bansal "Computer Aided Design Library of Gating System for a Die Casting Die" International Journal of Applied Studies Volume: 1, Issue- 1, Jan 2014, PP. 1-11.
[14] E. A. Herman "Die casting dies" 2nd Edition, Society of die casting Engineers, USA 1985 PP.7-287.
[15] NADCA Product Specification Standards for Die Castings / 2012
[16] http://www.suppliersonline.com (Accessed Date 10 Jun. 2014).