USING FLOW SIMULATION AS A TOOL FOR DEPLOYING ANALYTICAL METHODOLOGY TO DETERMINE THE MOST SUITABLE PARAMETERS FOR DESIGN FOR A DIE CASTING DIE

Swati Sambhajirao Patil (Sathe), D.G. Kumbhar, Swapnil S. Kulkarni

Address for Correspondence

1 ME Mech./CAD CAM-2nd yr, 2 Associate Prof., Bharati Vidyapeeth College of Engineering, Dhankawadi, Pune.
3 Director-Able Technologies India Pvt. Ltd., Pune India

ABSTRACT:-

Die casting process is one of the best process, which can produce component with best quality, reduced cycle time, & increased productivity. But to achieve fulfilment of these objects, die for die casting process should be best designed. This work includes overall study about die designing, its principles, and its required parameters with its calculation. The component assigned for this work is a cam shaft holder for which die design parameters have been decided while designing a die for above component. CAE flow simulation software is used as an analytical tool to validate the parameters, which could be a best alternative while designing a die. In experimentation trial run was conducted on the machine of selected tonnage, which gave favourable match with analytical methodology.

INTRODUCTION:-

The Die Cast component normally encounters processing problems that originate from the Design phase of the component. Further, the Design of the Die offer challenges in terms of increased defects due to the choice of alternatives selected by the Design Engineer. The component being identified for this dissertation work belongs to the consumer product/automotive segment having typical features needing cautious approach while designing the Die Casting Die.

Die casting is the process in which the molten metal is forced with high pressure into the cavity of a steel mould called die. Pressure die casting is the fastest and most economical way to produce a net shape component out of raw material. The component for which die is to be designed, is a cam shaft holder in the cylinder head of a i.c. engine of a two wheeler bike (200cc) which will be newly launched.

1. Types of die casting process are as follows:-
   - High pressure die casting
   - Low pressure die casting
   - Gravity Die Casting

Following is the diagram for pressure die casting:-

2. The die design process can be divided into two stages:
   - Analysis & Design stage
   - Casting

Block diagram for overall die design initiating from casting model:-

Overall die design process flow chart

3. Die Design Fundamentals:
   - Process selection
   - Material selection
   - Number of cavities selection
Casting die has four functions:-

- Hold molten metal in the shape of the desired casting.
- Provide a means for molten metal to get into the space where it is held in desired shape.
- Remove heat from molten metal to solidify it.
- Provide for removal of the solidified metal.

3. Design stage consists of:

Simulation helps to determine:

- Die design and gating design has been elaborated.
- Runner + overflow + gate projected area = 50% of part
- Part projected area (A) = 145 sq.cm

Calculation for selecting machine

Design calculation required for die design:

- Shaft holder, in a cylinder head of a two wheeler
- Goals & Objectives of HPDC Simulation:
  - Computer simulation can be a useful tool for rapid process development. Limitation of the conventional die design and gating design has been elaborated.
  - Simulation helps to determine:
    - Process routing and process Parameter configuration.
    - Verify the die design based on the revealed flow behaviour and solidification phenomena.
    - The filling and solidification behaviour related to product quality and defect forming mechanism.
    - Physical basis and useful information for product quality improvement and defect avoidance.

CAE simulation:-

Computer simulation can be a useful tool for rapid process development. Limitation of the conventional die design and gating design has been elaborated.

Simulation helps to determine:

- Process routing and process Parameter configuration.
- Verify the die design based on the revealed flow behaviour and solidification phenomena.
- The filling and solidification behaviour related to product quality and defect forming mechanism.
- Physical basis and useful information for product quality improvement and defect avoidance.

Goals & Objectives of HPDC Simulation:

- Reduce iterations in tooling development
- Reduce process development time:
- Better process understanding: helpful when negotiate with customers about necessary part design changes.

5. Case study:-

The component being identified for this dissertation work belongs to the consumer product/ automotive segment having typical features needing cautious approach while designing the Die Casting Die. The part for which die is going to be designed is a cam shaft holder, in a cylinder head of a two wheeler bike.

Design calculation required for die design:-

Calculation for selecting machine

Part projected area (Ap) = 145 sq.cm
Runner + overflow + gate projected area = 50% of part proj.
Area = 0.5X145 = 72.5 sq.cm
Total projected area (Ap) = 145 + 72.5 = 217.5 sq.cm
Die opening force (Fs) =
Total Projected Area X Sp. Casting pressure / 1000
= 217.5 X 700 / 1000
(Refer Table 3 from APPENDIX 1)
= 152.250 t

Die locking force (F) =
Die Opening Force X f.o.s
= 152.250 X 1.2
= 182.700 t

Therefore, selected machine should have minimum = 182.700 tonnage

Std. Machines available are 160t and 250t (from APPENDIX 2)

Therefore we select machine of 250 t.

Calculation for cavity fill time

\[ t = \frac{k \times T_i \times (T_f - T_d)}{(T_f - T) + S} \]

Where:
- \( k \) = empirically derived constant (sec / mm) = 0.034
- \( T_i \) = temperature of molten metal as it enters the die (deg C) = 660
- \( T_f \) = Minimum flow temperature (deg C) = 570
- \( T_d \) = Temperature of die cavity surface (deg C) = 340
- \( S \) = percent solid fraction allowable in the metal at the end of filling = below 0.3 = take 0.2
- \( Z \) = units conversion factor (C deg / %) = 3.8

\[ t = 0.034 \times 2.5 \times (660 - 570 + 3.8 \times 0.2) / (570 - 340) \]

Therefore, we select machine of 250 t.
Temperature & Velocity Simulation

Simulation up to gate entry.

Simulation up to 20% of cavity fill time.

Simulation up to 80% of cavity fill time.

Simulation complete.
6.1 Porosity and Solid Fraction Simulation

7. Experimentation
Trials and testing at the associate/s of Sponsoring Company once the die is designed and developed for effecting the trial run. The trial components achieved as a result has confirmed the validity of the assumptions made during the Design Phase of the project work. These results have been compared for favourable match with the analytical methodology for validating the Design. For experimentation, the machine with a capacity of 250T was deployed for engaging the Die for trial lot production. Typically, the tonnage requirement for the Die dictates the use of the machine.

7.1 Validation
The design has been validated by producing the component with the help of the developed die without affecting the component’s functionality. Flow lines, if any are minimized. Dimensional accuracy is measured and checked with the specified dimensions. Visual and actual inspection has been done while attempting to identify the defects. Design validation of Die is effected through trial lot production of defect free components with the needful attributes for physical appearance and properties. The simulation during design phase of development of a die gives itself a valid result.
CONCLUSION
The overall study about designing the die for cam shaft holder has been done, taking into consideration the fundamentals and basic principles of die designing. To make the Design and its calculation to its perfection the CAE simulation software is used for predicting defects and offer inputs during the Design phase. By the help of simulation we can analyse the flow characteristics, the effects of cores to the metal flow, the last filled form parts and the air ingates. The materials and the boundary conditions can change easily, so different experiments can be done in a short time. Thus the CAE simulation for a die casting product during its die design, is found to be the best alternative for producing a defect free component.

REFERENCES