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Development of Customized Software for Designing Gating System of Compressor Rotor Dies

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Abstract
An important factor for obtaining defect free pressure die cast parts is good design of the gating system. Gating system is a path of flow of molten alloy during filling of casting. In this project a systematic approach has been developed to design gating system for pressure die casting die. This involved studying current design practices in the industry and translating this into a knowledge base of rules for machine selection, design of gate, gate runner, runner, and overflows. The entire approach has been implemented in a window based program using visual C#. It has been successfully tested on industrial case study. It is perhaps the first attempt of its kind in the area of pressure die casting die design, and is expected to be of significant interest and value to the industry.

Introduction
The gating system of a die casting die consists of a series of passages through which the molten metal can flow into the die and then through the interior of the die to fill the cavity. The molten metal is pushed into the gating system from outside the die by a plunger. The cold chamber die casting machine usually has that plunger mounted horizontally in a thick tube called the shot sleeve. The plunger pushes the molten metal directly into the parting surfaces of the die. Any excess metal remains in the end of shot sleeve between the plunger and the parting surface of the ejector die half is called the biscuit. The biscuit and other parts of the gating system solidify as integral parts of the casting and are removed from the die with the casting. Once the molten metal reaches the parting surface of the die it is conducted towards the cavity through channels called runners. The runners are usually trapezoidal in cross section. There may be more than one runner radiating from the biscuit, and any one runner may split into two or more as required to direct the molten metal to various places. As the runner approaches the cavity it blends from trapezoidal shape into a slit like opening into the cavity. The blended portion is called the gaterunner and the slit like opening into the cavity is called the gate. It is usually necessary to allow the gases in the cavity to be pushed out by in rushing molten metal and to

allow some of the molten metal to flow through and on out of the cavity. Such a flow through action flushes out the undesirable materials so only proper metal remains in the cavity. The basic function of the gating system is to provide a system of passageways for the molten metal to flow through to get into the cavity. Once in the cavity, the metal will solidify into the desired casting. Objective of gating system analysis is to achieve constant cavity fill time. The cavity fill time is influenced in the first place by the optimum setting of the die casting machine's shot end parameters and by the size, shape and position of various components of the gating system.

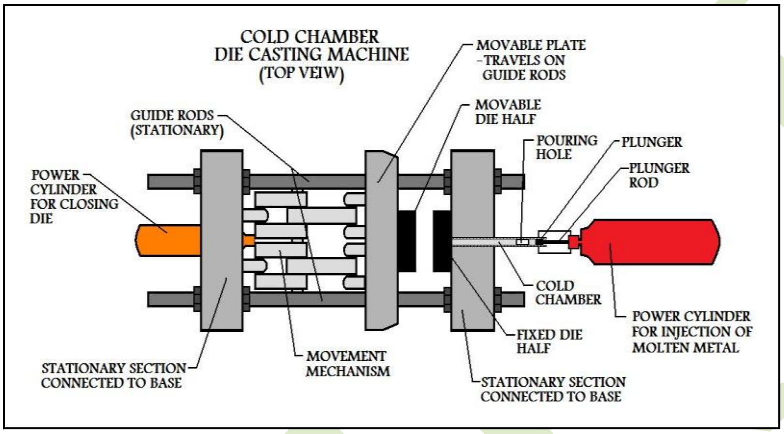

Fig.1. Pressure Die Casting Machine.

Literature Review

In this chapter, a detailed study of die casting die design practices is included, based on both literature and industry sources. Gate system is a path, through which the molten metal is forced into cavity. The configuration and dimensioning of gate system must be so that the flow is with least resistance and without whirling. There is a wide range of literature and papers about investigation and research work on this subject from various scientists and experts, the mention of which is made in the references. The position, size and shape of the gate system components are the most important factors to obtain a casting of high quality, particularly in respect of surface finish and structural soundness. Since the castings differ widely in size and shape, the gate system design has to be done on case to case basis. Till now, no equation has been developed successfully, on which basis the size of gate system design can be decided. Years of experience and records of past performance have been the basis in the development of certain rules which are till date generally followed. However, it is quite common that for intricate component designs, more than one of the rules mentioned hereunder might be applicable, which are often contradictory.

Considering this fact, it is essential for the die designer to keep all possible difficulties in mind which may occur, and decide on a design with the possibility to alter later if so required. Following points should be followed for designing gate system [1].

1. Preferably only one gate should be provided. In case of more gates, care should be taken that the individual metal streams entering the cavity do not interfere.
2. The cavity should be filled from one direction to another, to avoid incoming stream getting divides into several jets.
3. It is preferable, especially on large castings, to provide the gating point on casting periphery, which will shorten the distance; the metal has to travel through the cavity.

4. Care should be taken while deciding the place and direction of gates, so that no air pockets can develop during the filling period.
5. On a correct directed gate, the metal entering the cavity should push the air to the overflow.

Theory of cavity filling:

The filling of the die cavity can be roughly classified in the main groups as free jet filling, mass flow filling and a mixed system of free jet and mass flow. Free jet filling represents the most ideal form of cavity filling, in which the free jet of metal can traverse the entire cavity without resistance. So the cavity is gradually filled from the back. Since most die castings have an extremely complicated configuration, it is seldom possible to lead the metal jet so that it can get across to the opposite side unhindered. In most cases it hits an obstruction after a short distance, for instance a slide or core, so that the free jet is totally destroyed. So the die cavity is then filled according to the principle of mass flow. Obviously there is a relation between the gate thickness and the adjoining wall thickness. In order to attain a jet fill, a ratio of 1:2 to 1:3 is necessary between gate thickness and wall thickness. For thin parts this ratio can hardly be kept, so that also here we shall have to do with a mass flow filling. The jet fill, which is the ideal condition, occurs rather seldom in practice. Very often a mixed system which is a combination of jet fill and mass flow fill takes place. In order to have better control over the mass flow fill most experienced die casters tend to lead the metal flow into a corner so that the filling of the cavity remains clearly under control [2]. For the fishtail runner the angle of diffusion should not be more than 30 percent since otherwise a flow shadow will be formed in the runner . The multiple gates were popular for a long time. At the convergence of runner and distributor channel there is a sudden widening, which causes reduction of the flow velocity. This is a reason why now days the multiple gates are not used [3]. Following steps are normally followed for designing gate system for pressure die casting die –

1. Computing filling time. 2. Selecting gate velocity. 3. Establishing gate thickness.
4. Determining gate area and its dimensions, 5.Calculating runner dimensions, 6.Finalizing overflows.

System Design

The objective of the project is to develop knowledge based systematic approach for gating system design and implement it in a computer program. Diecast is designed where total procedure for gating system design was broken into logical steps, each interdependent with previous or the next step. Equations or logic required for each of them was collected and verified. In the product module Diecast gets the casting data input either from the user or in the form of text file generated from known 3D CAD system, its flow design module calculates the flow variables for gating system by help of available material and machine database. Gate design module calculates dimensions for gating system, where as analysis modules evaluates the calculated gating system

Database:

It comprises of data required to design gating system for pressure Die-casting die, which is stored in simple text file format.

Gate design:

Gate design module calculates all dimensions related to gating system it also calculates machine settings parameters to get best results. Gate design is subdivided into five modules which are as follows – Gate, Gaterunner, Runner, overflow and Machine settings.

Gating System Design calculation

a) Wall Thickness of Product (Ct) = 7mm
b) Actual Projected Area= πr12 =1033.1 mm 2
c) Overflow Area=20%of Actual Projected Area=206.6 mm 2
d) Runner Area + Gate Area= 70% of Actual Projected Area= 723.142 mm 2
e) Total Projected Area= Actual Projected Area + Overflow Area + Runner Area + Gate Area= 1962.8 mm 2
f) Cavity Filling Time (t) = K*T*(Ti-Tf+SZ) / (Tf-Td)
=0.08671 Sec
g) Gate Velocity (Gv) = 38700 mm/ sec.
h) Gate Area (Ga) = GA= W/ (g*t*Gv) = 155.9 mm 2.
i) Gate Thickness (Gt) = Gate Thickness Factor * Casting Avg. Thickness = 4.0 mm.
j) Gate Width (GW) = Ga / Gt = 38.9 mm
k) Runner Area (Ra) = relation between gate area and runner area is 1: 2.5= 389.7 mm 2
l) Runner Thickness (Rt) = 5* Gt = 20.0 mm.
m) Runner Width (Rw) = Gw /4 = 9.7 mm.
n) Runner Velocity (Rv) = (Gv) / 2.5 = 15480 mm
o) Overflow Volume (Ov) = Casting Volume/ 3= 17217 mm 3.
p) Overflow Depth (Od) = Casting Thickness (Ct)/ 3= 2.3mm.
q) Overflow width (Ow) = 2 * (Od) = 4.6 mm.

Development of Software

The Diecast is programmed using Visual C++ 5.0 language on Windows NT / 95 operating system. A typical session for Diecast is given below.

Session

1. Click on Diecast icon in the windows desktop, the program will display the start-up screen.
2. On Start-up screen shows different rotor models.
3. Click on suitable model of rotor for which have gating system required.
4. At bottom display all the parameters which are required to design 3D model of gating.
5. Click on these parameters, 2D model of gating will display by software.
6. Collect all this parameters & drawing given by software.
7. With this data develop 3D model of gating system in Catia V5.
8. As per this model develop gating system in die.
9. Use this die to manufacture new rotor.
10. Finally test this rotor for finishing, accuracy etc parameters.

Software

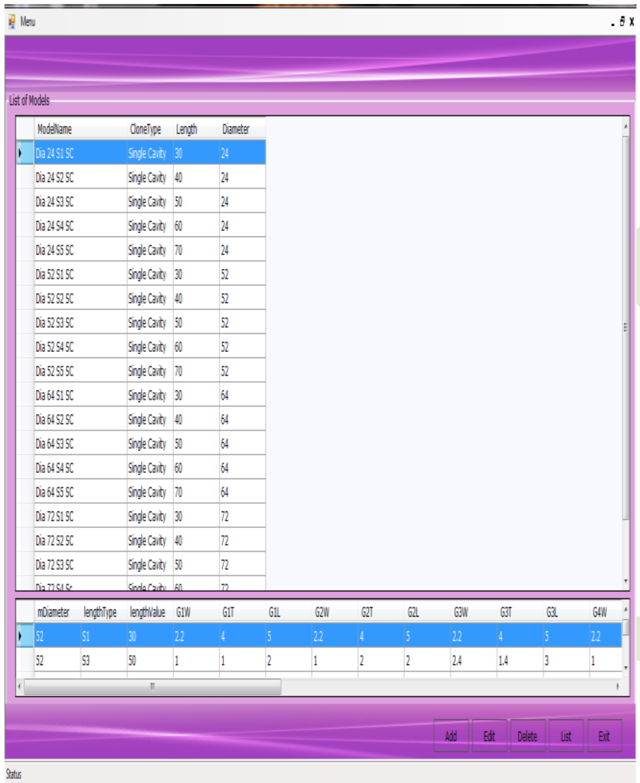

Fig. Different Gating Model Screen

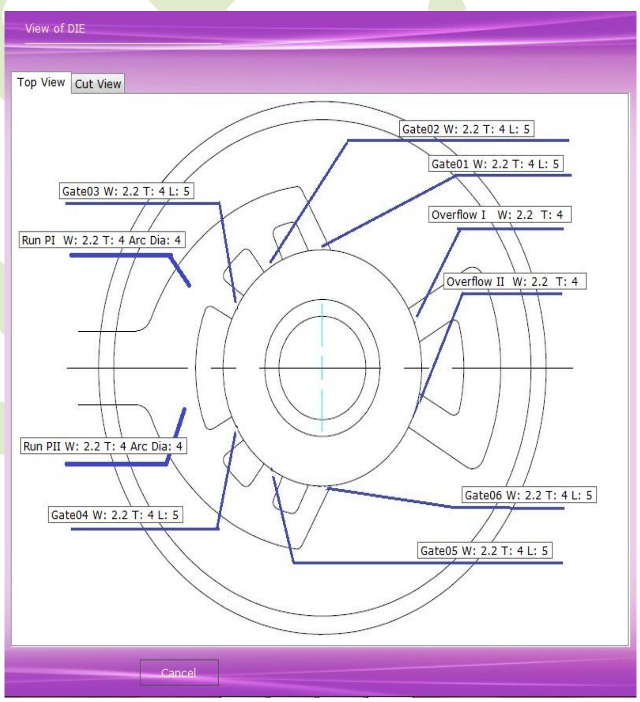

Fig. Top View Output parameters of software.

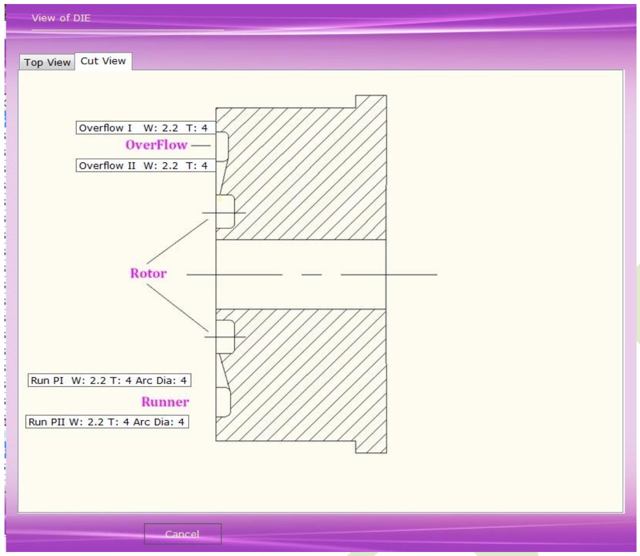

Fig. Side View Output parameters of software.

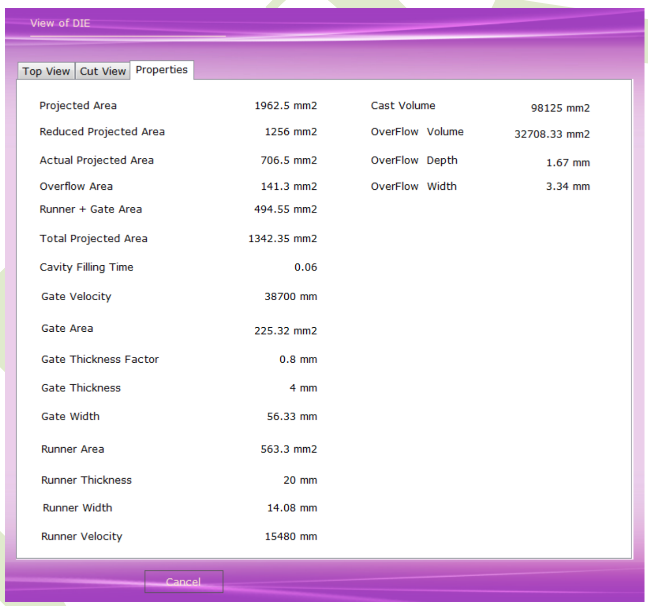

Fig. Output parameters of software.

Testing of Software

Selection of one rotor for output parameters:

Testing of Die Cast software was carried out by selecting one rotor. The diameter of the rotor is 52mm and length of rotor is 70 mm. Input these values to the software so software gives the all parameters values which are required to design gating system for this rotor.

Rotor manufacturing with new developed Die:

In company with the help of new manufactured die actual rotor manufacturing is carried out. Lot of rotors had manufactured with this die. After all the manufacturing process we selected two rotors for testing of finish and accuracy of rotors

Fig. Gating System with Rotor.

New die manufactured Rotors have more dimensions accuracy and very good finish as compared to previous rotors.

Conclusion

This work "Computer aided gating system design for pressure Die casting" started with the objective of developing a PC based program, uses most of the available knowledge on design rules, to assist a designer in the design of gating system. It involved an extensive study of literature on gating system design to identify the knowledge base of the design rules. The Die cast has been developed and implemented using object oriented programming methodology and requires a personal computer for its execution. A considerable effort has been taken for verifying equations and logic used in the program.

Appendix

Variables affecting die casting process along with abbreviations used in program.

1. Casting volume (Cv).
2. Casting weight (Cw).
3. Casting average thickness (Ct).
4. Cavity fills time (t).
5. Gate velocity (Gv).
6. Gate thickness (Gt).
7. Gate area (Ga).

8. Gate width (Gw).
9. Runner thickness (Rt).
10. Runner area (Ra).
11. Runner width (Rw).
12. Runner length (Rl).
13. Runner Velocity (Rv).
14. Overflow Volume (Ov)
15. Overflow Depth (Od)
16. Overflow width (Ow)

Acknowledgments

It gives me immense pleasure in presenting my dissertation report on "Development of Customized Software for Designing Gating System of Compressor Rotor Dies". This dissertation has certainly rendered me a tremendous learning as well as practical experience.It is my proud privilege to work under the guidance of Dr. M. T. Telsang, Professor, and Mechanical Engineering Department. I am thankful to him for his precious, timely guidance and continuous inspiration throughout my M.E. course. I am thankful to him for his critical judgments in preparing this dissertation report. Finally I dedicate my study efforts to my parents, family and the Almighty.

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