Design of Three Cavity Diecasting Die for Rotors

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Abstract:- **Die casting components play an important role in every aspects of modern world. Their influence ranges from house hold utensils to automobile components. Requirement of today's world is production, accuracy and interchangeability, which helps to meet the competition. In order to meet these challenges die casting process plays an important role in production. Mass Production aims at high productivity to reduce unit cost and interchangeability to facilitate easy assembly. For die casting components there is no need for further machining and getting components with good surface finish. The Computer Aided Design which helps to reduce the design and production lead time. This paper gives an engineering approach towards design of die casting die for rotors and deals with the design of a three cavity die casting die by using the CATIA V5 Software. In this work the computer aided design of three cavity die casting die is the replacement of traditional design of two cavity die casting die for rotors which is existed .In this paper we also replace cavity and core impressions on hchcr block with hchcr inserts.**

Keywords- Design, Die casting, CATIA, Rotors

I. INTRODUCTION

Die castings are highest volume, mass-produced items manufactured by the metalworking industry, and they can be found in thousands of consumer, commercial and industrial products. Die cast parts are important components of products ranging from automobiles to toys. Parts can be as simple as a sink faucet or as complex as a connector housing. The earliest examples of die casting by pressure injection as opposed to casting by gravity pressure occurred in the mid-1800s. A patent was awarded to sturges in 1849 for the first manually operated machine for casting printing type. The process was limited to printer's type for the next 20 years, but development of other shapes began to increase toward the end of the century. By 1892, commercial applications included parts for phonographs and cash registers, and mass production of many types of parts began in the early 1900s. The first die casting alloys were various compositions of tin and lead, but their use declined with the introduction of zinc and aluminum alloys in 1914. Magnesium and copper alloys quickly followed, and by the 1930s, many of the modern alloys come in to existence and become available. The die casting process has evolved from the original low-pressure injection method to techniques including high-pressure casting at forces exceeding 4500 pounds per square inch squeeze casting and semi-solid die casting. These modern processes are capable of producing high integrity, near net-shape castings with excellent surface finishes. Refinements continue in both the alloys used in die casting and the process itself, expanding die casting applications into almost every known market. Once limited to simple lead type, today's die casters can produce castings in a variety of sizes, shapes and wall thicknesses that are strong, durable and dimensionally precise.

A. *Types of Die Casting*

In this the mould is generally not destroyed at each cast but is permanent, being made of a metal such as cast iron or steel. There are a number of die casting processes, as summarized in Figure 1. High pressure die casting is the most widely used, representing about 50% of all light alloy casting production. Low pressure die casting currently accounts for about 20% of production and its use is increasing. Gravity die casting accounts for the rest, with the exception of a small but growing contribution from the recently introduced vacuum die casting and squeeze casting process.

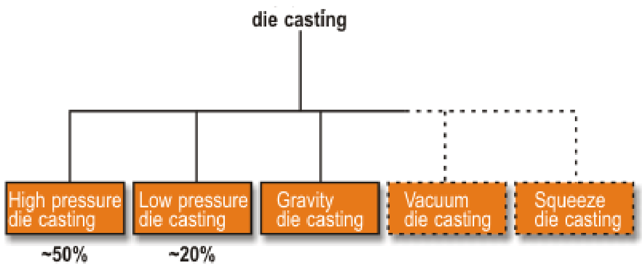

Fig: 1 Types of die casting

B. *Advantages of Die Casting*

1) Die casting component parts, decorative trim or finished products offer many features, advantages and benefits to those who specify this manufacturing process.

2) Die casting provides complex shapes within closer tolerances than many other mass production processes.

3) Die castings are produced at high rates of production. Little or no machining is required.

4) Die castings can be produced with thinner walls than those obtainable by other casting methods and much stronger than plastic injection moldings with the same dimensions.

5) Die casting provide parts which are durable, dimensionally stable, and have the feel and appearance of quality.

6) Die casting dies can produce thousands of identical castings within specified tolerances before additional tooling may be required.

7) Zinc castings can be easily plated or finished with a minimum of surface preparation.

8) Die castings can be produced with surfaces simulating a wide variety of textures.

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9) Die cast surfaces, as cast, are smoother than most other forms of casting.

10) Holes in die castings can be cored, and made to tap drill sizes.

11) External threads on parts can be readily die cast.

12) Die castings provide integral fastening elements, such as bosses and studs, which can result in assembly economies.

13) Inserts of other metals and some non-metals can be die cast in place.

14) Corrosion resistance of die casting alloys rates from good to high.

15) Die castings are monolithic. They combine many functions in one complex shaped part. Because die castings do not consist of separate parts, welded or fastened together, the strength is that of the material not that of threads or welds etc.

16) Die casting is an efficient economical process which when used to its maximum potential replaces assemblies of a variety of parts produced by various manufacturing processes at significant savings in cost and labor.

C. Hot Chamber Die Casting

The Hot-chamber process is only used for zinc and other low melting point alloys that do not readily attack and erode metal pots, cylinders and plungers. Development of this technology, through the use of advanced materials, allows this process to be used for some magnesium alloys. The basic components of a Hot-chamber die casting machine and die are illustrated below.

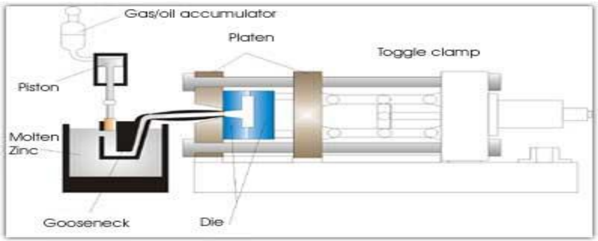

Fig: 2 Hot-Chamber Die Casting Machine

In this process, the plunger and cylinder, which constitute the injection mechanism, are submerged in the molten metal in the crucible (or pot), which is integral to the machine.

D. Advantages of Hot-Chamber over Cold-Chamber

1) Rapid cycling, starting from less than 1 second for miniature zinc components.

2) Precise control of metal temperature, improving fluidity, and allowing injection pressures to be lower, which places less strain on equipment. Better fluidity promotes good filling of the cavity, sounder castings and permits thinner walls.

3) The submerged shot cylinder (gooseneck), which fills automatically eliminates a variable reduces the cycle time and makes it easier to control metal temperature.

4) There is no cooling of the charge (measured shot), as there may be when molten metal is transferred to the shot cylinder of the cold-chamber machine.

5) The molten metal is less subject to oxidation and contaminants from atmospheric exposure.

E. Disadvantages of Hot-Chamber Process

1) Alloy limitations, as aluminium or zinc-aluminium alloys and certain magnesium alloys can only be ld-chamber processed.

2) Lower injection pressures and speed can be achieved, so castings may be less dense.

3) Higher maintenance costs.

F. Cold-Chamber Die Casting

Cold-chamber die casting differs from Hot-chamber in that the injection system is not submerged in molten metal. Instead, the molten charge (more material than is required to fill the casting) is ladled from the crucible into a shot sleeve, where a hydraulically operated plunger pushes the metal into the die. The extra material is used to force additional metal into the die cavity to supplement the shrinkage that takes place during solidification. The principle components of a cold-chamber die casting machine are shown below. Injection pressures over 10,000 psi or 70,000 KPa can be obtained from this type of machine.

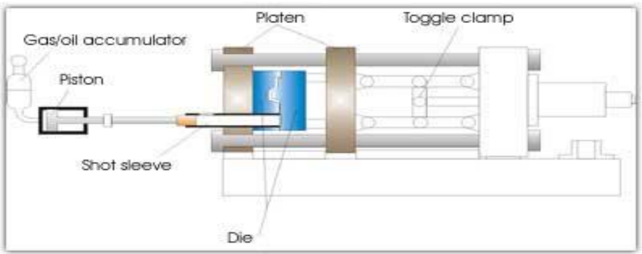

Fig: 3 Cold-Chamber Die Casting Machine

G. Advantages of Cold-Chamber over Hot-Chamber

1) Alloys such as aluminium or zinc-aluminium alloys and certain magnesium alloys can only be cold-chamber processed.

2) Higher injection pressures and speed can be achieved producing denser castings.

3) Lower maintenance costs.

H. Disadvantages of Cold-Chamber Process

1) Slower cycling.

2) Less control of metal temperature, reduced fluidity and thin wall capability.

3) The charge (measured shot) cools prior to injection.

4) The molten metal is subject to oxidation and contaminants from atmospheric exposure.

II. CASTING CYCLE TIME FOR TWO CAVITY DIE

1) The cycle time is established on the basis of past experience and trial production run. Changes may be required in dwell time, shot injection time, pouring temperature or Methods of die cleaning and lubrication. Adjustment in die temperature are usually made

2) By varying the rate of flow of the cooling water. Sometimes changes are made in the size

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3) And location of cooling passages gates and overflows.

a) cycle time for one shot=55sec

b) production requirement =3000 per day

4) Observation for Two Cavity

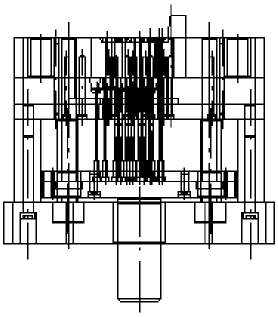
a) Approximate cycle time=60 sec.

b) For one hour 60*2=120 components.

c) Idle time for one machine=6 hours per day.

d) Working condition for 1 machine (minimum)=18hours/day.

e) Total production for two machines =18*120=2160 components.



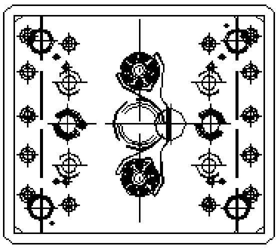
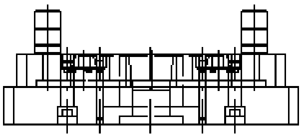


Fig: 4 Traditional two cavity fixed half die

The sectional views of the traditional two cavity die casting dies are as shown in the figures 4 & 5. The figure 4 shows the sectional view of fixed half die assemble of traditional two cavity die casting die and figure 5 shows the moving half die assemble of traditional two cavity die casting die.



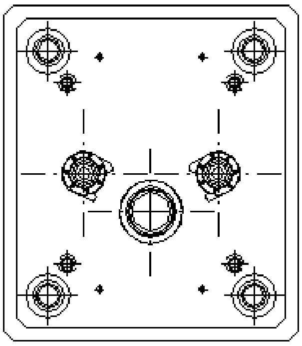


Fig: 5 Traditional two cavity moving half die

III. OBSERVATION FOR THREE CAVITY

- Approximate cycle time=60 sec.
- For one hour 60*3=180 components.
- Idle time for one machine=6 hours per day.
- Working condition for 1 machine (minimum)=18 hours per day.
- Total production for two machines =18*180=3240 components.

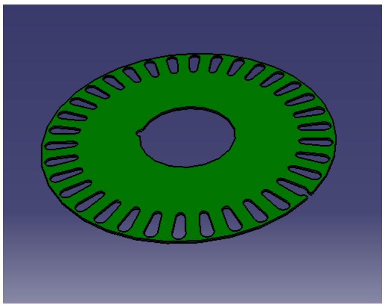


Fig: 6 Rotor lamination part

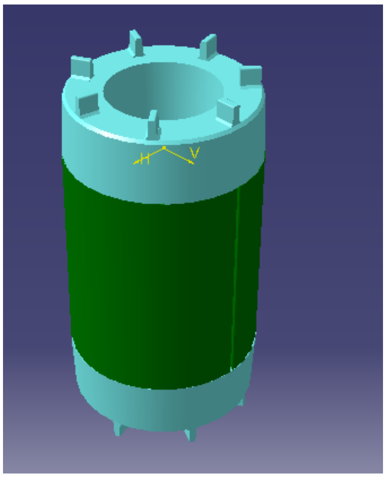


Fig: 7 Rotor Die casted component

Weight of the component=300gms

The non-ferrous metal which is using for rotor die casting is ALUMINIUM WROUGHT ALLOY having 99.6% of pure Aluminum and 0.4% composition of other metals

Density of the aluminum = 2.7gms/cm^3

Volume of the component = 300/2.7 cm^3

=111.11cm^3

Two gates required per component as per design.

Volume of metal through each gate =Half of total volume of single component

=111.11/2cm^3

= 55.55cm^3

Component minimum wall thickness=2.8mm

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Table I. Typical Cavity Fill Times According To Wall Thickness

Thickness of wall in mm.	Cavity fill time in Sec.
0.012-0.017	0.90
0.017-0.025	1.30
0.026-0.038	1.80
0.035-0.050	2.50
0.040-0.060	3.20

The cavity fill time=0.041sec

Gate velocity is taken according to type of alloy using for casting and also on wall thickness of aluminum alloys

Table II. GATE VELOCITIES

Thinnest wall dimensions anywhere In casting on mm	Gate velocity cm/sec
0.762	4600-5500
1.270-1.525	4300-5200
1.905-2.286	4000-4900
2.540-2.794	3700-4600
2.858-3.810	3400-4300
4.650-5.080	3100-4000
6.350	2800-3500

Gate velocity =3760cm/sec

Gate area =Metal volume through gate/ (fill time x gate velocity)
=55.55/ (0.041x3760)
=36 mm^2

Take thickness of gate or height =3mm
Width =13mm

Branch runner area:

The ratio to the Runner area to gate area is in between 1:1.25 to 1:1.6

Then the runner area =1.6X gate area
=1.6 x36 mm^2
=60 mm^2

In trapezoidal cross section of runner, the depth and width of cross section are in the ratio of 1:1.6 to 1:2

Thickness of branch runner=6mm
Width of branch runner =10mm

Semi Main runner area:

The semi main runner area =Area of two branch runners
=2 x60 mm^2
=120mm^2

Thickness of semi main runner=6mm
Width of semi main runner =20mm

Main runner area:

Main runner area =3 x semi main runner area
=3 x120mm^2
=360mm^2

Thickness of main runner =6mm
Width of main runner =60mm
Fill rate:

Fill rate=Volume of one component x No. of impressions/Cavity fill time
=V x N/T
=111.11 x 3/0.041
=8130 cm^3/sec

Projected area calculations:

$$\text{Projected area of component} = \frac{\pi}{4}\times\left((i.d)^2 - (o.d)^2\right)$$

$$= \frac{3.14\times\left((2.587)^2 - (1.353)^2\right)}{4}$$

=25cm^2

For 3 impressions projected area=3 x 25 cm^2

As per designing,
Total semi main runner P.A =3 X 16 cm^2

Projected area of branch runner =6.6cm^2
Total P.A of branch runner =6 x 6.6 cm^2
=40cm^2

Semi Main runner projected area =16cm^2
=48cm^2

Projected area of biscuit =30cm^2(estimated)

Total projected area =(75+40+48+30)cm^2
=193cm^2

Injection pressure:

For a die casting process the injection pressure is set depends on type of casting metal and also on casting requirements.

For aluminum alloys castings:

Standard castings up to 600 kg/cm^2
(without mechanical requirements)

Technicalcastings 600-800 kg/cm^2
(With mechanical requirements)
Pressuretightcastings 800-1000 kg/cm^2

For technical castings the injection pressure=700 kg/cm^2

Die opening force =Total projected area x Metal injection pressure /1000 tonnes
=193 x700/1000 tonnes
=135.1 tones

Required Locking force =1.5 x Die opening force
=1.5 x 135.1 tonnes
=202.65 tones

Shot weight:

Weight of one component =300gms

Weight of 3 impressions =3 x 300 gms
=900gms

Estimated weight of runner, biscuit =80% of weight of 3 impressions
= 0.8 x 900 gms
=720gms

Total weight of casting = (900+720) gms
=1.62 kgs

For getting good machine life, the die casting machines are used maximum up to 75% of their capacity, if uses the machine life decreases

Hence by above points the 400 T capacity Buhler die casting machine is selected for shot capacity 2 kg the plunger diameter = 60mm

Metal piston velocity:

Metal piston velocity =fill rate/Area of piston
=8130 x 4 / (3.14 x 36)
=2876.8cm/sec

Injection force required (F) =Area of piston x Metal injection pressure
= π x 36 x 700/4 kgs
= 19.78 tonnes

Required oil pressure calculation:

Injection force (F) =Hydraulic cylinder piston area x oil pressure

Hydraulic cylinder piston diameter for 400 T machine is 190 mm

Oil pressure =19.78 x 4/ (3.14 x 19 x 19) tonnes/cm^2
=70 kg/cm^2

Table III. Horizontal cold-chamber pressure die casting machine 400 T Buhler Specifications

Locking force	400 tonnes
Injection force adjustable (With intensifier)	43 tonnes
Hydraulic ejection force	22 tonnes
Die mounting plate's	920x980 mm
Space between tie bars	580x640 mm
Tie bar diameter	120 mm
Maximum die height	750 mm
Minimum die height	200 mm
Die opening stroke	600 mm
Injection plunger stroke	400 mm
Ejector stroke adjustable	145 mm
Free cycle time	7 sec
Motor capacity	22.4 kw
Machine area	6.1x1.65 m
Machine weight	12.5 tonnes
Capacity of oil tank	550 litre

Table IV. Production data

Plunger diameter mm	Shot capacity for kg	Aluminium Max. injection pressure kg/cm^2	Nominal casting area Above injection pressure cm^2
50	1.4	2190	182
60	2	1520	263
70	2.8	1115	358
80	3.6	855	467
90	4.6	675	592
100	5.7	545	733
110	6.9	450	88

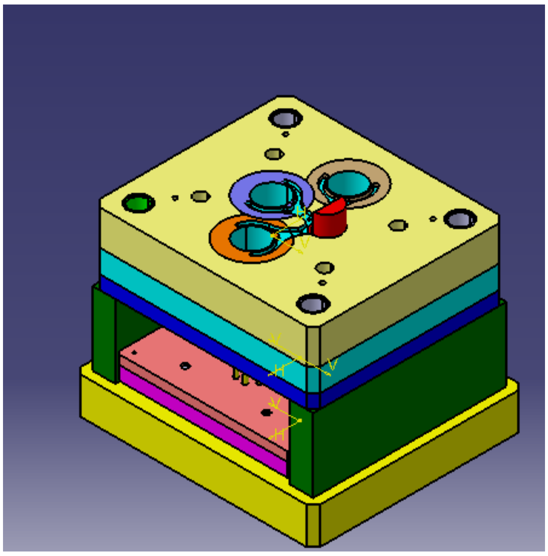

Fig: 8 Fixed half assembly of three cavity die

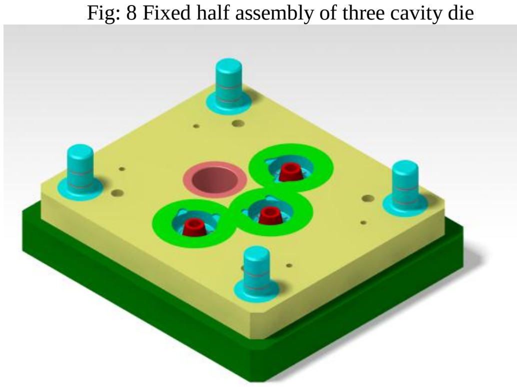

Fig: 9 Moving half assembly of three cavity die

The isometric views of the fixed half and moving half of three cavity rotor die casting die shown in fig:9 and fig:10 These assemblies are designed in Catia V5 software

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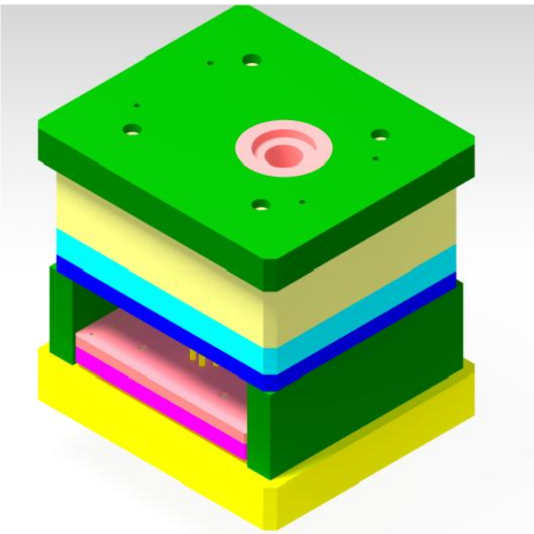

Fig: 10 Total assembly of three cavity die

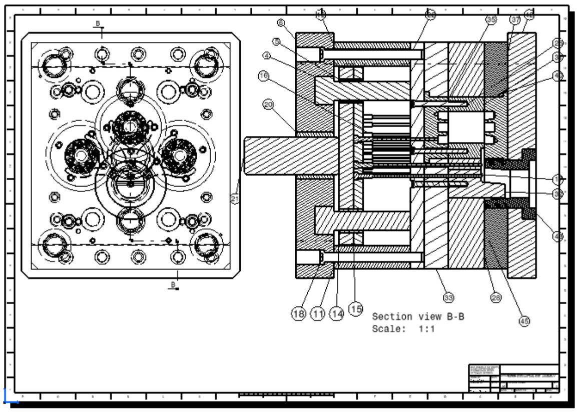

Fig: 11 Total assembly of three cavity die drawing

The isometric views of the Total assembly of three cavity rotor die casting die shown in fig:11.This assembly is designed in Catia V5 software.The sectional view of the three cavity die casting die is shown in fig:12

Table V. Bill of Materials

Bill of Material: ROTOR DIE CASTING DIE

Number	Part Number	Quantity	Material	Size	HRC	Remarks
1	Dowelpin	4	OHNS	Ø13X93	56-58	HD&GD
2	Dowelpin	2	OHNS	Ø13X140	56-58	HD&GD
3	Pushback pin	4	EN-31	Ø53X295	52-55	HD&GD
4	Auxlary guidpiller	2	EN-31	Ø63X203	48-50	HD&GD
5	guidbush	2	EN-36	Ø80X55	50-52	HD&GD
6	Bottom bolster	1	M.S	525X465X85	----	GD
7,8,9,10	Stopbottons	4	OHNS	Ø33X53	56-58	HD&GD
11,12	Rails	2	M.S	425X165X55	----	GD
13	M20	6	STD		....	...
14	Ejector back plate	1	M.S	425X380X35	....	GD
15	Ejector top plate	1	M.S	380X405X25	----	GD
16	Ejector pins-1	21	H13	Ø18X183	45-48	HD&GD
17	Ejector pins-2	4	H13	Ø20X275	45-48	HD&GD
18	Screws ejctor plates	4	STD	......	....	GD
19	M15	4	STD	----	----	---
20	Push rod bush	1	EN-36	Ø103X83	50-52	HD&GD
21	Push rod	1	EN-31	Ø83X203	48-50	HD&GD
22	Cavity back plate	1	M.S	485X425X35	---	GD
23,24,25	Guid bush	4	EN-36	Ø55X80	50-52	HD&GD
26	M10	13	STD	...	...	...
27	M11	4	STD	----	---	---
28	Core plate	1	M.S	485X425X55	---	GD
29,30,31	Core insert	3	H13	Ø135x80	45-48	HD&GD
32	Spreader	1	H13	Ø65X125	45-48	HD&GD
33	Corept.2	1	M.S	485X425X55	...	...
34,35,36	Cavity insert moving half	3	H13	Ø155x55	45-48	45-48
37	Corept.3	1	M.S	430X490X55	...	...
38,39,40	Cavity insert fixed	3	H13	Ø153X53	45-48	HD&GD
41	Guidpiller	4	EN-31	Ø73X123	48-50	HD&GD
42	Top bolster	1	M.S	465X525X65	---	GD
43	Spruebush	1	EN-36	Ø155X115	50-52	HD&GD
44	Screws fixed	4	STD	...	...	...
45	Dowel	4	OHNS	Ø8X42	56-58	HD&GD

The total number of parts and material required for manufacturing the three cavity die casting die, their dimensions and heat treatment processes are tabulated in table 5.

IV. CONCLUSION

1. By implementation of computer in design field accuracy of design is improved and design lead time is reduced than the traditional method.
2. Components produced per stroke increases that leads to increase the productivity.
3. By using three cavity die instead of two cavity die decreases labor cost and maintenance cost.
4. Replacement of cavity and core plates with cavity and core inserts which reduce the cost of the die and if any damage occurs in core and cavity inserts only that part is replaced with new one, no need to change of entire plate.

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