Design and Analysis of an Aluminium Die Casting Die for a Compressor Rotor

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Abstract:

Pressure die casting is a process in which metal, heated above the solidus, is introduced into a metal mould or "die", and is subjected to pressure in order that it shall conform to the exact shape of the mould impression or "die cavity".

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 the world. In order to meet these challenges die casting processes play an important role in production.

For die casting components there is no need for further machining and getting components with good surface finish. Automobile industry is one where the life of product is short.

The components are rejected due to hot spots, shrinkage, porosity etc. Modification is done to reduce the above said defects which resulting in reduction of rejection of rotors and increasing the quality of the rotors and with the modification of the die casting die with single cavity die with multi cavity die which leads to increase the production rate of the rotors.

***Keywords** : pressure,metal mould, die cavity, moulding impression, shrinkage*

1. Introduction

2. The casting process is subdivided into two distinct subgroups:
3. 1. Expendable mould casting
4. 2.Non expendable mould casting

1.1 TYPES OF DIE CASTING
1. Gravity Die Casting
2. Low Pressure Die Casting
3. Vaccum Die Casting
4. Squeeze Die casting
5. High Pressure Die Casting
6. Hot Chamber Die Casting
7. Cold Chamber Die Casting

1.2 DIE CASTING ELEMENT
1. Feed System
(a) Runner
(b) Gate
(c) Over flow
2. Ejection System

1.3 MATERILA FOR DIE CASTING
1. Hot Die Steels
(a) Chromium
(b) Tungsten
(c) Molybdenum

1.4 HEAT TREATMENT
1. Annealing
2. Hardening

2. Design

2.1 MAIN COMPONENS
1. Runner plate
2. Gate & cavity plate
3. Runner Bush
4.Mould

2.2 ASSEMBLY COMPONENTS
1. Core holder.
2. Housing Insert.
3. Movable Core and Spacer.
4. Guide Pillars.
5. Core Back plate.
6. Ejection System.
7. Parallel Plates and
8. Movable Back Plate and other standard parts.

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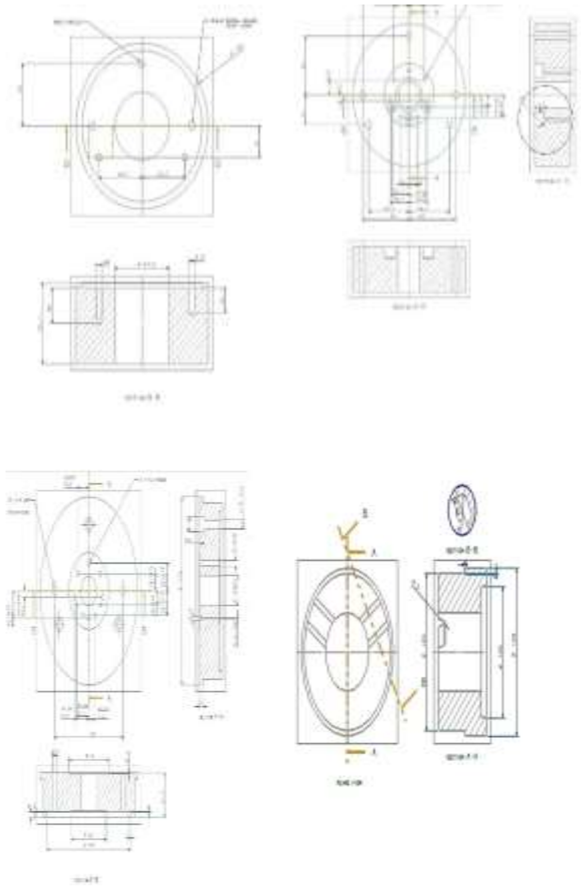
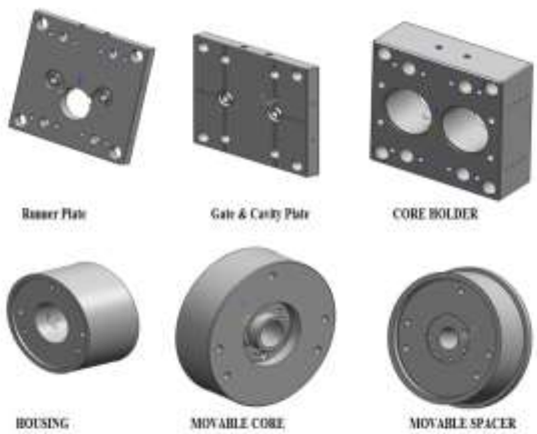
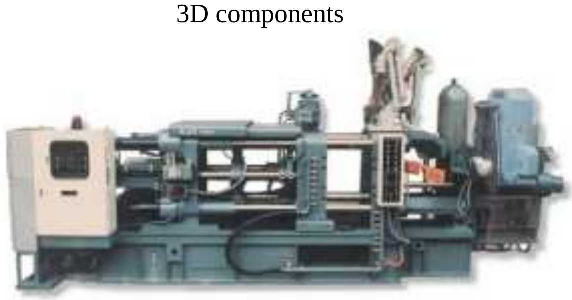
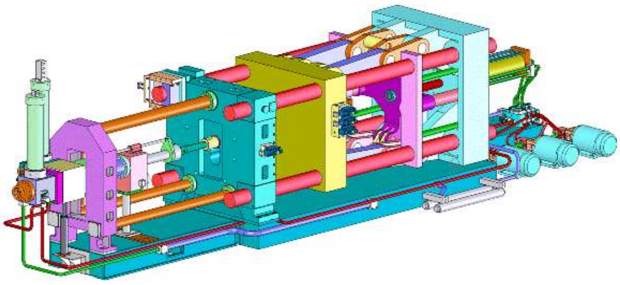


2D Components

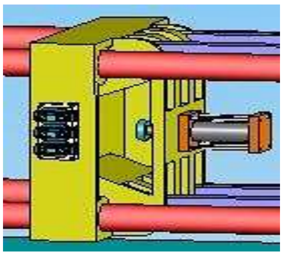


3D components

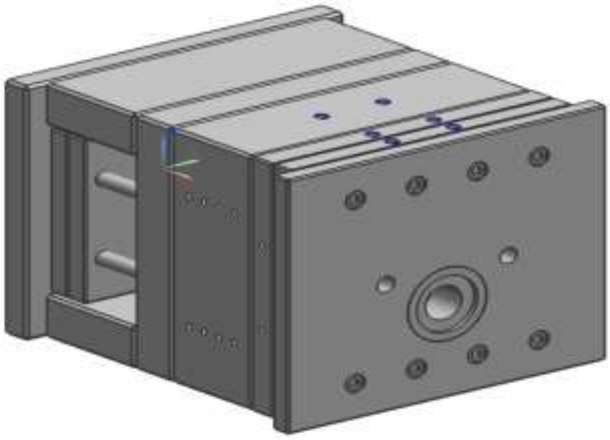




Horizontal Cold Chamber Die Casting MachineBUHLER 400 T capacity



Mould



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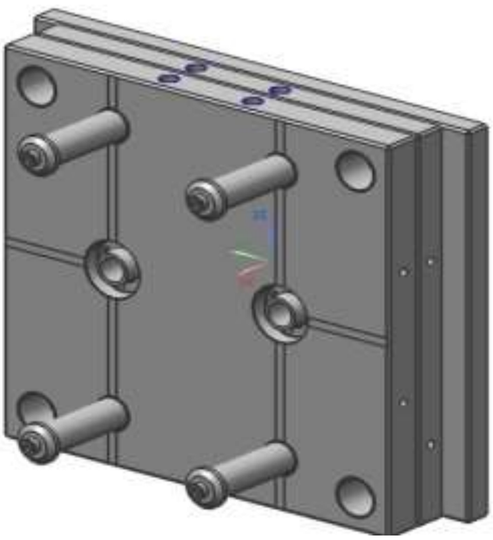

Fixed Side

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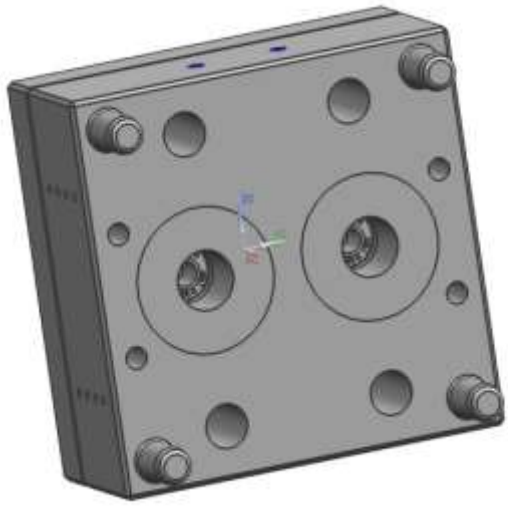

Fixed Side Assembly

Bran

Part property computation

1:1.25

3. Calculation

3.0 Weight of the component=300*2gms

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

Density of the aluminium = 2.7gms/cm^3

Volume of the component= 300/2.7 cm^3

=111.11cm^3

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

=111.11/2cm^3

= 55.55 cm^3

Component minimum wall thickness=2.8mm

3.1 Typical cavity fill times according to wall thickness:

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

Table.3.1 Typical Fill Time

Therefore the cavity fill time=0.041sec for minimum wall thickness of 2.8mm

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

FOR **ALUMINIUM ALLOYS**:

Thinnest wall dimensions any where in casting in mm	Gate velocity in 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

Table.3.2. Selection Of Gate Velocity According To Wall Dimensions.

Selected Gate velocity =3760cm/sec

Gate area =Metal volume through gate/(fill time x gate velocity)

=55.55/(0.041x3760)

=36 mm^2

3.2 Branch runner area :

The ratio to the Runner area to gate area is in between 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

3.3 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

3.3 (a) 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

3.4 FILL RATE*:*

Fill rate=Volume of one component x No. of impressions/Cavity fill time

=V x N/T

=111.11x2/0.041

=8130 cm3/sec

3.5 PROJECTED AREA CALCULATIONS:

Projected area of component=π/4 x(i.d^2-o.d^2)

=3.14 x(2.587 x 2.587-1.353 x 1.353)/4

=25cm^2

For 2 impressions projected area=2 x 25 cm^2 =50cm^2

As per designing,

Total semi main runner P.A =2 X 16 cm^2

Projected area of branch runner=6.6cm^2

Total P.A of branch runner =4 x 6.6 cm^2 =26.4cm^2

Semi Main runner projected area =16cm^2 =32cm^2

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

Total projected area=(50+26.4+32+30)cm^2

=138.4 cm^2

3.6 INJECTION PRESSURE:

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

3.7 FOR ALUMINIUM ALLOYS CASTINGS:

Standardcastings up to 600 kg/cm^2 (with out 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 = <u>Total projected area x Metal injection pressure</u> tonnes
1000

=138.4 x700/1000 tonnes

=96.88 tones

Required Locking force=1.5 x Die opening force

=1.5 x 96.88 tonnes

=145.32 tones

3.8 SHOT WEIGHT:

Weight of one component =300gms

Weight of 2 impressions =2 x 300 gms

=600gms

Estimated weight of runner, biscuit =80% of weight of 2 impressions

=0.8 x 600 gms

=480 gms

Total weight of casting = (600+480) gms

=1.08 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

For shot capacity **2 kg** the plunger diameter=60mm

Hence by above points the **<u>400 T capacity BUHLER</u>** die casting machine is selected

3.9 Specification

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

3.10 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 =13.57 x 4/ (3.14 x 19 x 19) tonnes/cm2

=47.88 kg/cm2

Die Calculations:

For die standard calculations are taken for designing the two cavity die-casting die

Over all dimensions of die casting=Length x Width x Height

=570mm x 520mm x 450mm

Maximum machine stroke is 100mm

4. CONCLUSIONS

The purpose of my project was to design and analysis the two cavity die casting die instead of a single cavity die casting die for arefrigeration compressor rotor

At the end of the design work it is observed that:

- By modification of the gating system filling problems due to imbalance volume has been solved. Hence the casting is filled completely.

- By modified design the defects of die casting are extremely reduced which intern helps in improving the quality of casting.
- By preferring for the Two Cavity instead of a Single Cavity die for each component around 30 to 40 % of total cost will be saved.
- With the selection of two cavity die casting die the production rate will be also increased.

Apart from the technical aspects, the project helped me to understand the correlation between the theory and practical aspects and also to learn various constraints of time and coat within products are produced. I could also understand the scope of 3D modeling, assembly and detail drawingin the product development process.

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