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MOLD DESIGN FOR DIECAST OIL PAN

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Abstract: This paper presents the mold design for a die cast oil pan. The oil pan is the part of the internal combustion engine, serving as an oil reservoir. The oil pans can vary to a lot of shapes and sizes, the size depending of the capacity of the engine that is built for, and the shape depending of the elements that are in the proximity of the part or are being mounted on.

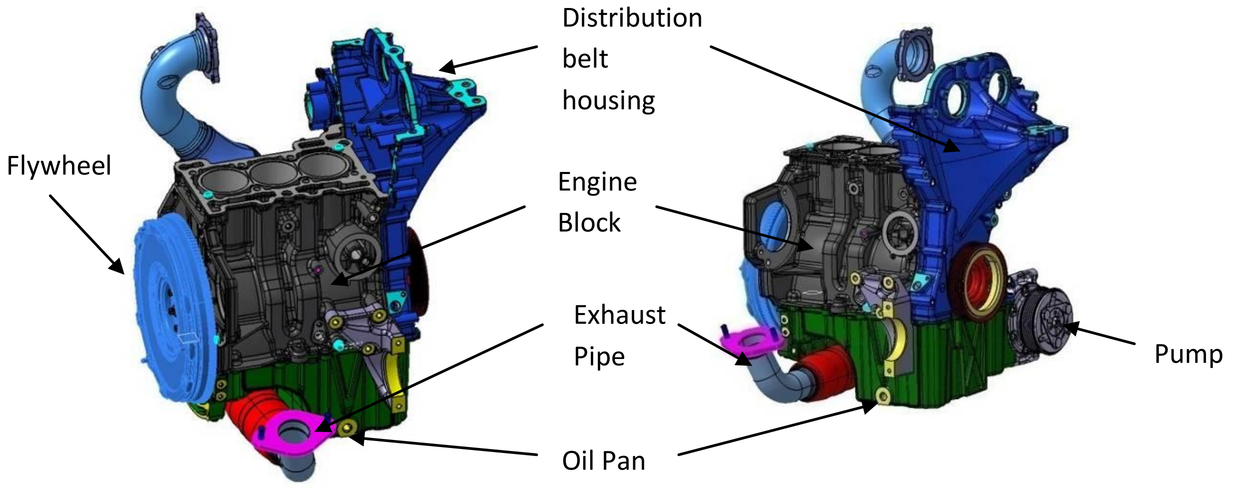


Figure 1.1 The oil pan in the engine

1. Introduction

The oil pan must store the necessary calculated volume of oil, for the type of engine that is built for. The oil pan must stand rigorous leak tests, to meet the high functional requirements.

2. Defining the injecting machine

2.1 The force against the closure

By introducing the liquid aluminum into the mold at high speed and highfinal pressure originates a force tending to open the mold and acts directly against the closure of the machine.

$$Fc = (Sp \times Pm) \div 1000 \qquad (1, \text{page } 56)$$

Fc (t) = force against the closure
Sp (cm2) = Projected Area
Pm (bar) = specific pressure metal

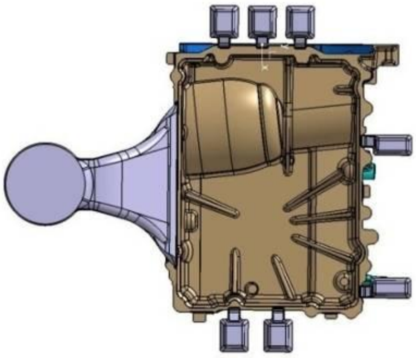


Figure 2.1. Surface of the cluster

Therefore, the force against the closure of the machine (Fc), is the result of multiply the front surface of the shot (Sp), (part, ingate chanel and overflow) by the pressure of the metal within the mold cavity (Pm).

2.2 Force against the wedge of the silder

Slides also have influence on the size of the mold, injection pressure on the front surface of the slide causes this move against the wedge.

$$Fcc = (Sp \times Pm) \div 1000 \qquad (1, page 57)$$

Fcc (t) = force against the wedge
Sp (cm ²) = Projected Area of slide
Pm (bar) = Pressure Spec. Metal

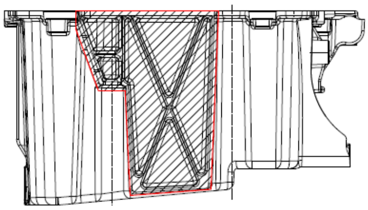


Figure 2.2. Surface of the slider

Therefore, the force against the wedge mold (FCC) is the result multiply the front surface of the slide (Sp), by the specific pressure metal into the mold cavity (Pm).

2.3 Force against the closure of the wedge Force against the wedge creates a component that acts directly against the closure of the machine.

$$Fc = (Sm \times Pm) \tan B \div 1000 \qquad (1, page 58)$$

Fc (t) = force against the closure
Sp (cm ²) = Projected Area
Pm (bar) = Pressure Spec. metal
B = angle of the wedge

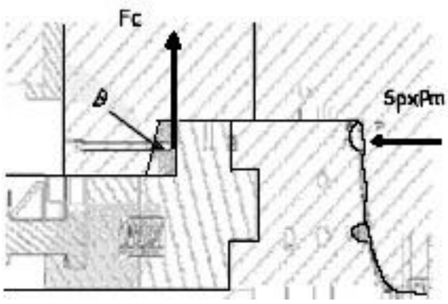


Figure 2.3. Force against closure [1]

The simple calculation is obtained by multiplying the force against the wedge by tangent of the angle of the wedge. If we divide by 1000, the result will be in tons, as we have done previously. We recommend using at least 10ºC angle to the wedges. And never lower than 7 ºC.

2.4 Closing force required

Finally, the necessary clamping force is given by the sum of all mould forces acting against the closure, multiplied by the factor "K ".This factor is a power reserve as collateral to secure the quality of the part.

$$Fcm = Fc \times K \qquad (1, page 59)$$

Fcm (Tn) = closing force required
Fc (t) = force against the closure, (Mold + slides)
K = 1.1 with sliders /1.25 widouth sliders

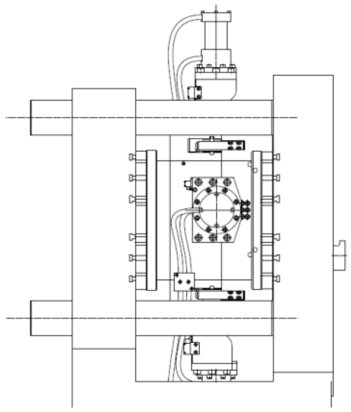


Figure 2.4. Closed mold on the machin

3. Mold design steps.

As in technological development, in mold design we need to follow standard steps for every mold.
The mold project creation is done from the inside out. For this reason the origin is the part
With a 3D model of the part, by dividing his form in two halves by a parting line we obtain if we will extract it from a solid the cavities. Therefore by definition, a mold is the negative of a model or part.

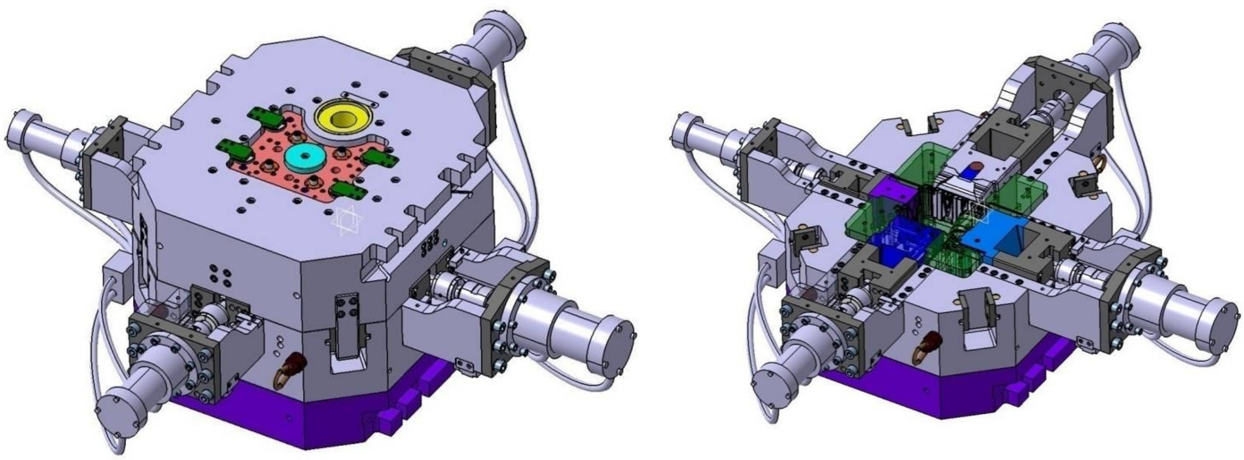


Figure 3.1 Mold assembly

3.1 Positioning the part. Feeding zone

New technologies greatly facilitate any type of work. In the present case, the CAD has become a tool essential for designing molds for casting.
Also with the CAD, will be easier to determine or design the shape of the feeding of the part. This step allows us to determine the direction of the flow line, and therefore the shape of the feeding channel.
The part for which we are developing the mold, is an oil pan a “box”. This is a typical case in which the best pull direction, (Determination of the fix and mobile side) is not friendly to the filling flow.
The selection of the fix and mobile side will depend on the height of the part. The 153mm of the inner side of the part is typing in this case the balance to put the male in the fixed part.
The removal of the part from the fix part of the mold is made with the help of four sliders, the piston pushing the shot, and an ejection system on the fixed side, which will complicate even more the mold.

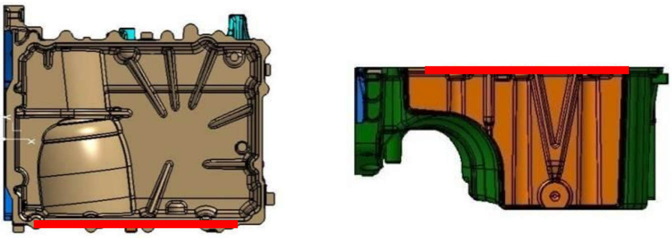


Figure 3.2 Feeding zone

3.2 Feeding system design

The geometry of the feed zone has a great influence on the shape of the runner. You have to avoid the attack on pin cores or perpendicular walls and to find the best direction for the flow of the material (Fig 3.3).
We have to provide areas to help the feeding of the critic points of the part, if necessary. We need to create curves to smooth the flow channel, this step it seems, almost a work of art. We are moving away from purely geometric forms to approach curves and a more pure design. The material gets a more “quiet” flow.
The next step (Figure 3.4) is to determine the sliders that the part needs, for the zones that are not in the opening direction of the injecting machine.

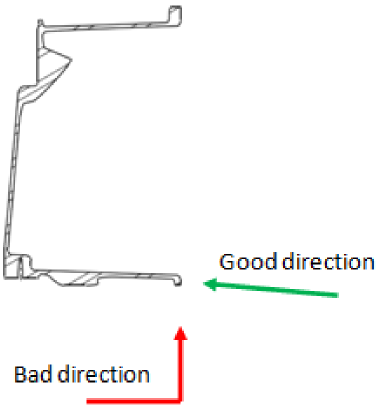


Figure 3.3 Runner direction

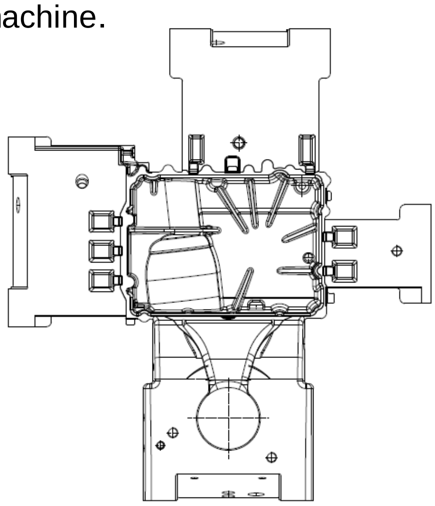


Figure 3.4 Definition of the sliders

The center of injection of the mold determines the position of the mold on the machine. For this reason, the definition of it in the mold has a great importance.
To ensure that the full force of the injection is absorbed by the four-column tension of the machine, equally, we must determine the center of gravity of the shot (Figure 3.6), and to coincide with the geometric center between the columns of the machine (Center of diagonals) (Figure 3.5).
A simple way to calculate the center of gravity of the shot, is dividing it into simple geometric shapes.
A balance between the center of the machine and the center of the gravity of the part ensures that the four columns of machine will work correctly.

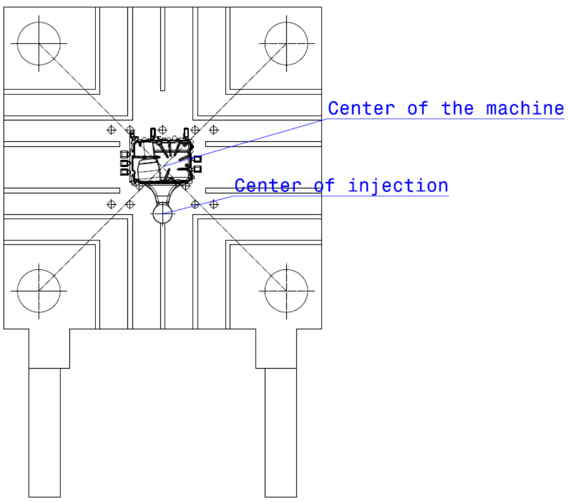


Figure 3.5 Position on the machine

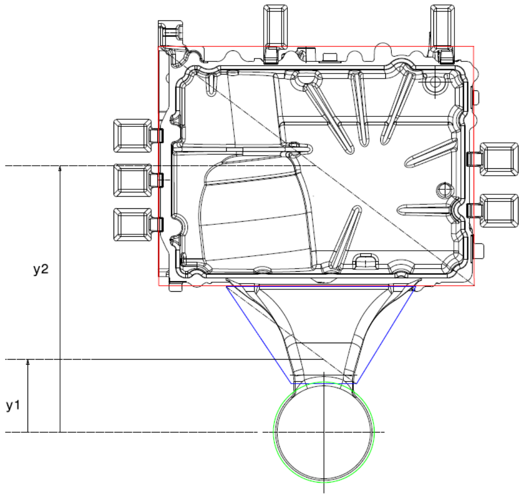


Figure 3.6 Definition of the center of gravity

$$Ys = \frac{[\sum Yn \times An]}{\sum An} \quad (1, page 103)$$

Ys (mm) = gravity of the shot
A (mm2) = Area of the geometric form

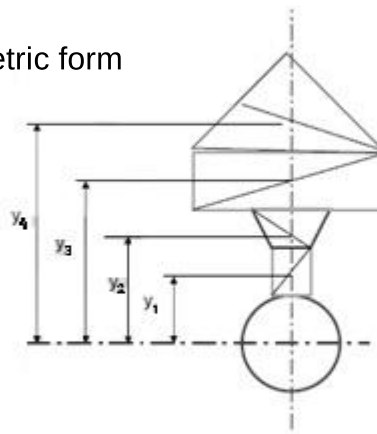
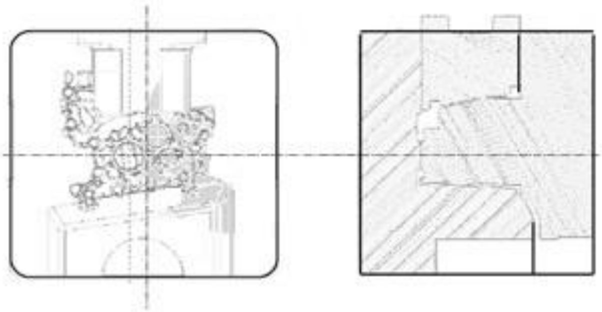


Figure 3.7 Definition of the center of gravity [2]

3.3 Mold dimensioning

a) Dimensions of the cavity's
The shot clearly gives the dimensions of the two key elements of the mold, the cavities.

First we determine the width and length on the partition of the mold and then the thickness. With this design guide of Bühler (Figure 3.9.), we can determine the distance from the part to the exterior of the insert, depending on the closing strength of the injection machine. You can also use this distance to determine the thickness, adding depth or height of the track.



Máquina / [KN]	A / [mm]
2.000 - 4.000	80 - 90
5.000 - 7.000	90 - 100
8.000 - 12.000	100 - 120
13.000 - 20.000	120 - 140

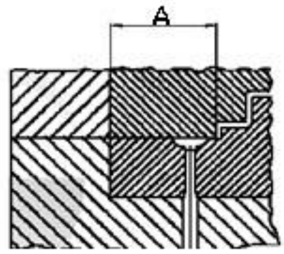


Figure 3.8 Dimensioning the cavity's ***Figure 3.9 Buhler information [5]***

b) Dimensions of the slider's

When areas of the part figure, cannot go in the opening direction of the mold, it is necessary to add a radial movement towards out of that part. This is called slider.

Usually the sliders are placed on the mobile side of the mold. In this way we can be assured from mechanical point of view that they do not move at the time of injection or when applying final pressure on the metal.

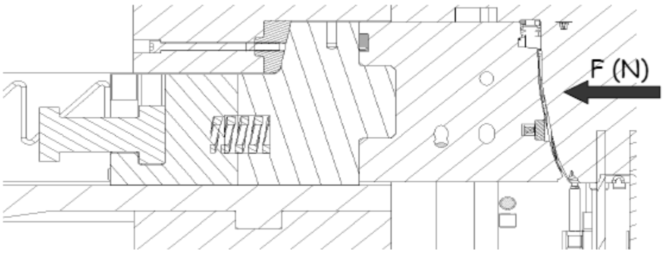


Figure 3.10 Force on the mold slider

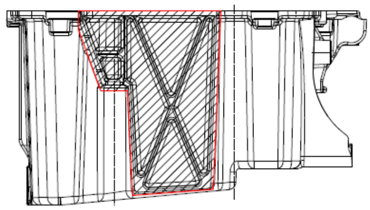


Figure 3.11 Slider area

First we need to know the sliding force exerted on the mold, at the time of the final pressure.

$$F = P \times Sp \times 9.81 \qquad (1, \text{page } 112)$$

F (N) = force in the mold
P (Kg f/cm2) = Maximum pressure
Sp (cm2) = Surface of the Part

The next step is to determine the minimum size of the wedge for withstand the force of the slide.

$$S_{min} = \frac{F}{R} \times c \qquad (1, \text{page } 112)$$

S_{min} (cm2) = Minimum area
F (N) = force in the mold
R (N / cm 2) = mold steel Resistance
c = Safety factor

$$h_{min} = \frac{S_{min}}{A} \times 100 \qquad (1, \text{page } 114)$$

h $_{min}$ (mm) = theoretical minimum height
S $_{min}$ (cm2) = Minimum area
A (mm) = Width of the slide

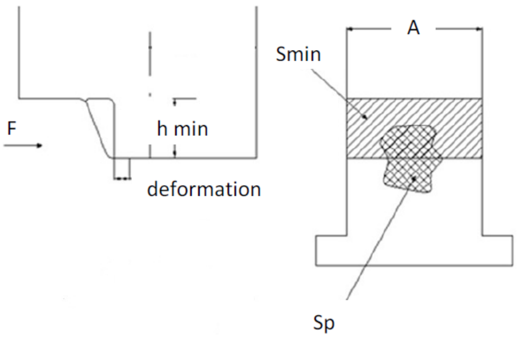


Figure 3.12 Dimension of the wedge [1]

We use a safety factor of 3.
The strength of the steel molds is carrying 110,000 Newton square centimeters.
On the wedge are acting on two types of forces:
Injection force - As we have seen is the sliding force exerted on the mold at the time of injection (Figure 3.13)
The force against the closure of the machine - The wedge of the slider like any other inclined plane acts directly against the closure of the machine.

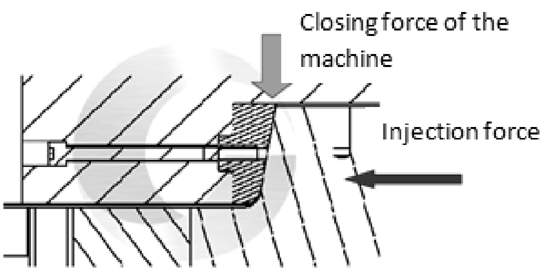


Figure 3.13 Injecting force on the slider

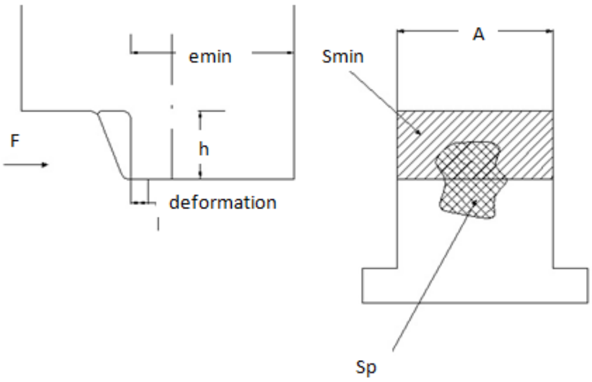


Figure 3.14 Thickness of the frame

Use the height (h), and the available width (A) of support wedge. Applying the formula, we get the minimum value for the thickness of the frame, in support of the wedge, in mm (Figure 3.14).

$$e_{min} = \sqrt[3]{\frac{3 \times F \times h^3}{2 \times E \times A \times def_{max}}} \qquad (1, \text{page } 116)$$

e $_{min}$ (mm) = minimum thickness
F (N) = force on the mold
h (mm) = height of the wedge
A (mm) = Width of the slide
E steel = 210,000
def $_{max}$ (mm) = maximum deformation

As can be seen in the Figure 3.15, the force Q, depending on wedge angle can be even higher than the closing force of the injection machine. It is advisable to place wedges with angles of 10^0 or more, and leave a gap that allows the closing of the mold without problems.

$$Q = \frac{F}{\tan(\alpha + \rho)} \qquad \text{(1, page 120)}$$

Q = strength of the wedge
F = Closing force of the machine
α = angle of the wedge
ρ = angle of friction = arc tang μ
steel friction coefficient μ = (0.03)

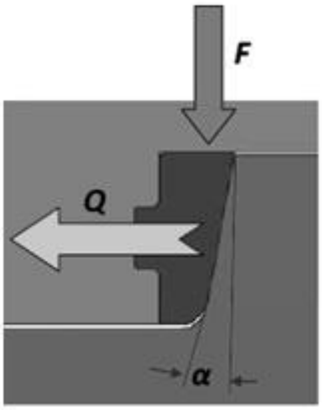


Figure 3.15 Strength of the wedge [1]

c) Dimensions of the frames
Once the size of the inserts and slider are over we proceeded to define the size of the mold frames.
We can use some design guidelines to make this work more easy, the minimum width of the frame has to be half of the most deep insert, and never less than 1.5 (Figure 3.16). The other dimensions you can see in Figure 3.17

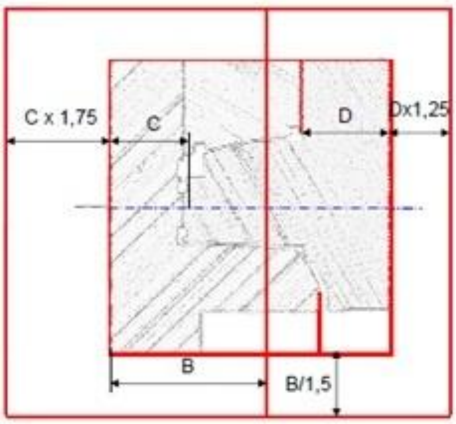


Figure 3.16 Force on the mold slider [1]

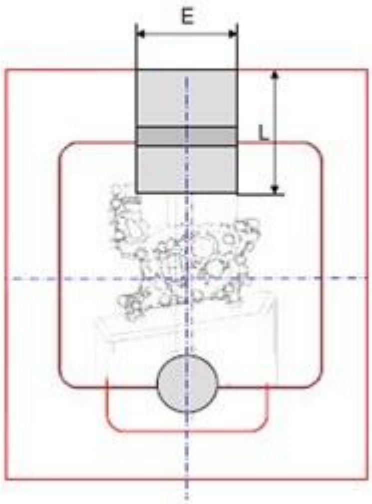


Figure 3.17 Force on the mold slider [1]

$$L = 1.5 \times E \qquad \text{(1, page 113)}$$

d) Dimensions of the ejecting side
It is recommended that the span of the bridge to be less than the size of the inserts (Figure 3.18).
Whenever possible, place support.

We can calculate the minimum thickness of the bottom of the frame (e_{min}) (Figure 3.19), assuming that we have a force uniformly distributed on a cantilever at both end

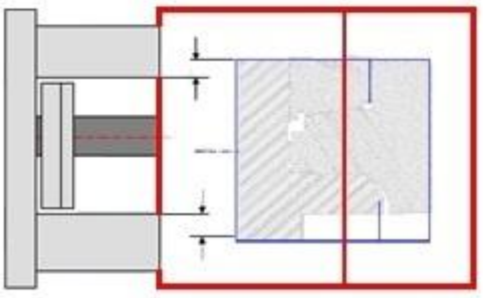


Figure 3.18 Dimensioning ejecting side [1]

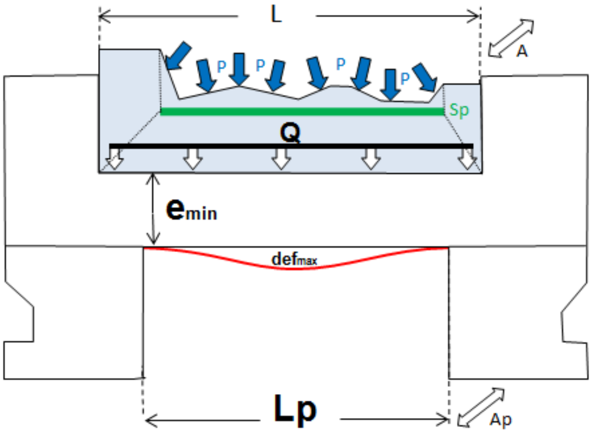


Figure 3.19 The bend of the frames [2]

$$def_{max} = \frac{Q \times Lp^3}{384 \times E \times I} \quad (1, \text{page } 113)$$

$$e_{min} = \sqrt[3]{\frac{Q \times Lp^3}{32 \times E \times A \times defmax}} \quad (1, \text{page } 113)$$

Values:
- Q (N) = force from the plate on the mold frame
- L p (mm) = length of bridge
- A (mm) = width of bridge
- E steel = 210,000

3.4 Use of standard elements and parts

Using cores and inserts for interchangeability (Figure 3.20), gives a high reliability for mold during her life.
Is recommended to use the same functional system for all the sliders (Figure 3.21) for an easier maintenance of the mold.

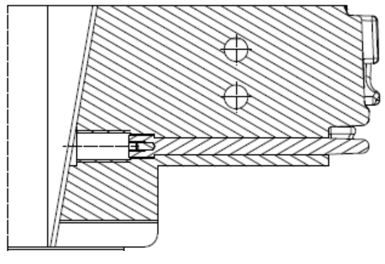


Figure 3.20 Use of inserts in the mold

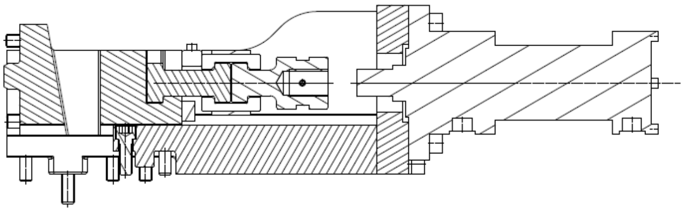


Figure 3.21 The same functional design for all the sliders

3.5 Cooling of the mold

We need to temperate the mold, or more simple to eliminate the heat that the mold receives in the injecting cycle to let it to an established temperature in this case 200^0C, prepared for the next injection.

You cannot work with neither with a very cold mold neither with a hot mold both of these situations will affect the part and the life of the mold.
Working with a cold mold will affect the quality of the part, we will have problems with the contraction of the part, cold flow on the part and the thermal shock it will be very big.
Working with a hot mold we will have problems with adhesion of the injected aluminum alloy on the cavity surface due to the extreme heat that burns the lubricant film.
Distance between the cooling circuit and the surface of the part 35-38mm, not to crack the mold.
We used the next type of temperate system:
- Cooling with water Figure 3.22
- Cooling with oil (thermal controlling) Figure 3.23

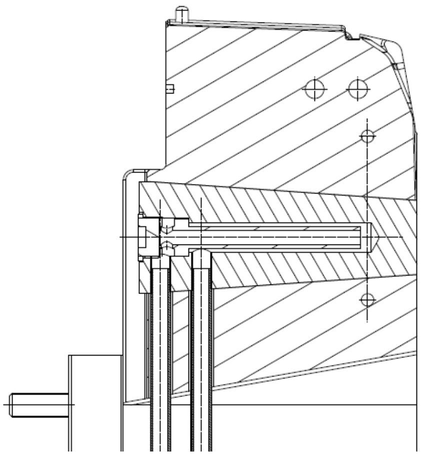


Figure 3.22 Cooling with water the runner tablet

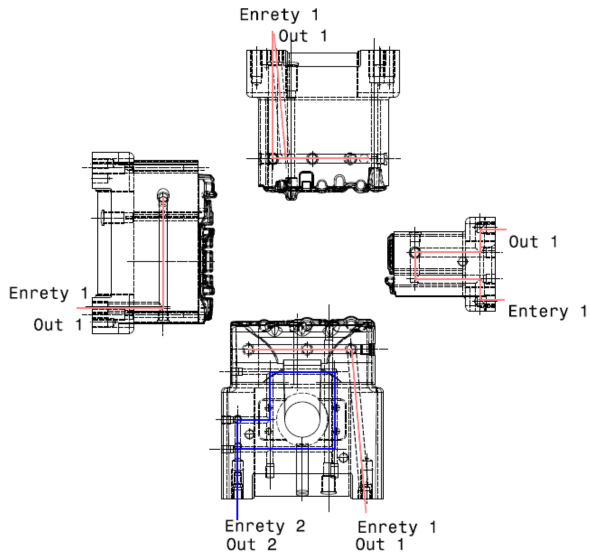


Figure 3.23 Cooling with oil of the mold sliders

4. Conclusions

Molds are very complex and expensive tools, for this reason in this process of the design of the mold we need to be very careful with the design of the mold from the start to involve all the departments in this work to obtain a good design.

The mold must be designed to work very efficient and to be very productive for the harsh conditions that is working in.
The mold design must take into account all the factors of the casing process all the elements and parameters that will interact with the mold in its life.

5. References

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