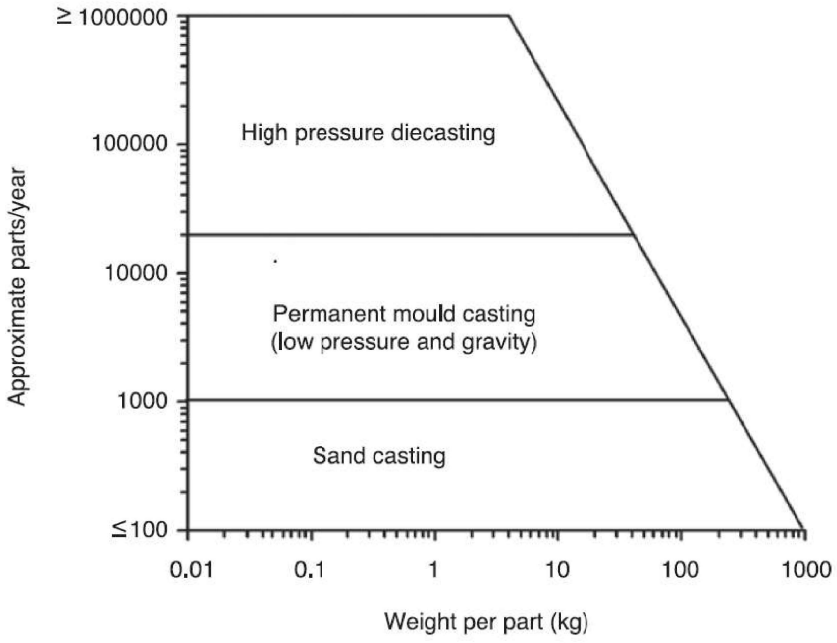
03: Aluminum die casting

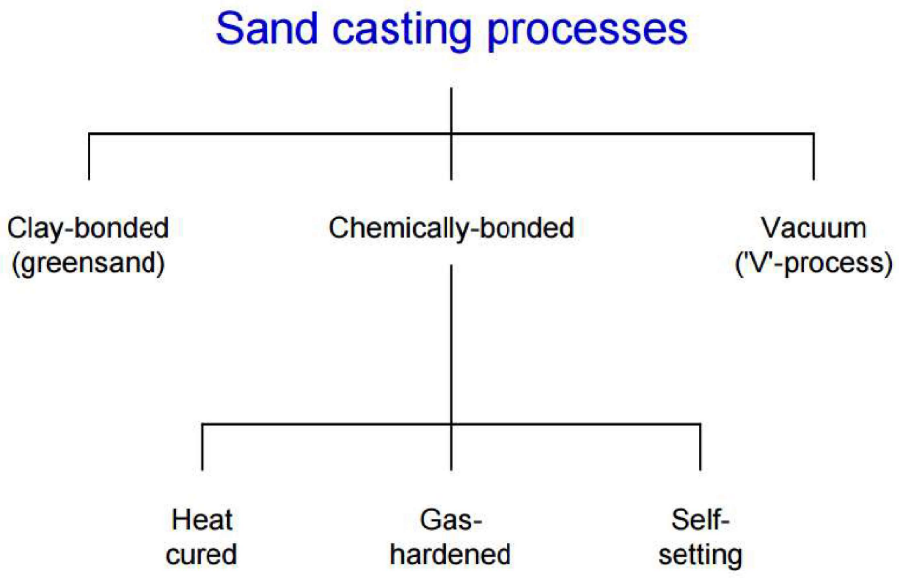
Internal Training เทคโนโลยีและปัจจัยที่ส่งผลต่อคุณภาพของ
อะลูมิเนียมผสมที่ผลิตจากกระบวนการ High Pressure Die Casting

Phromphong Pandee, Ph.D.
Phromphong.pan@mail.kmutt.ac.th

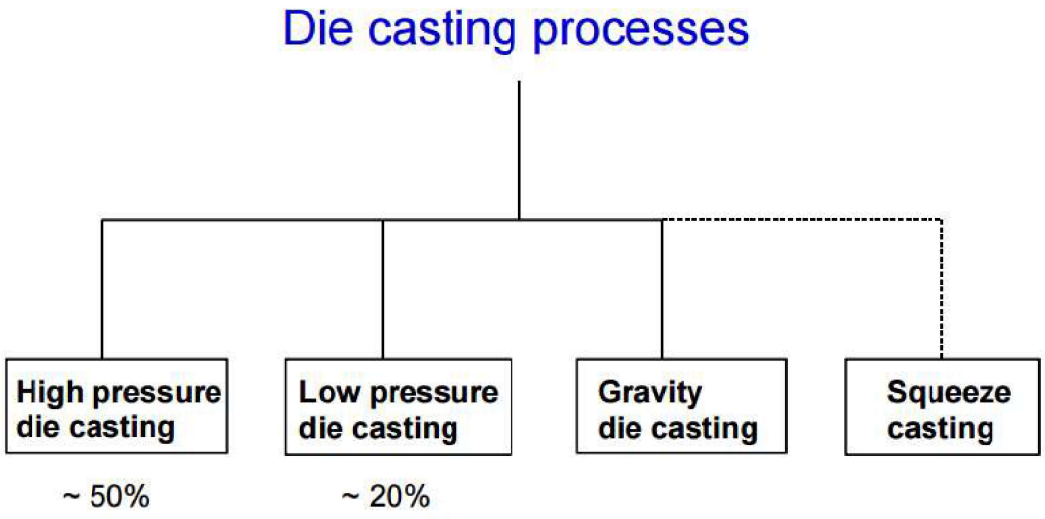
The (approximate) relationship between part size, production rate and casting process used for cast aluminum components



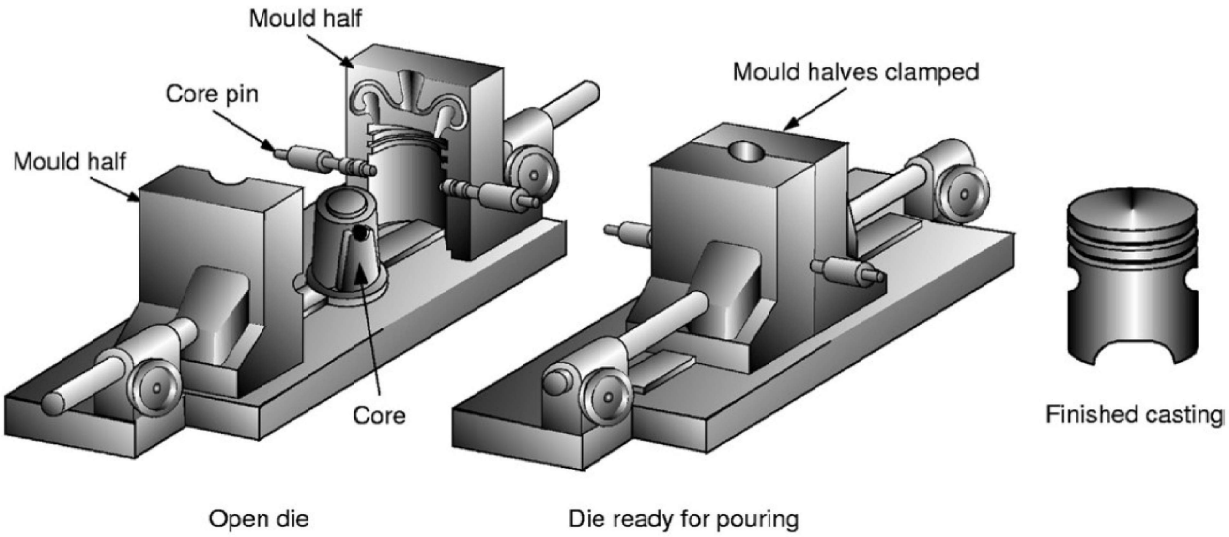
Expendable mold gravity-feed casting process



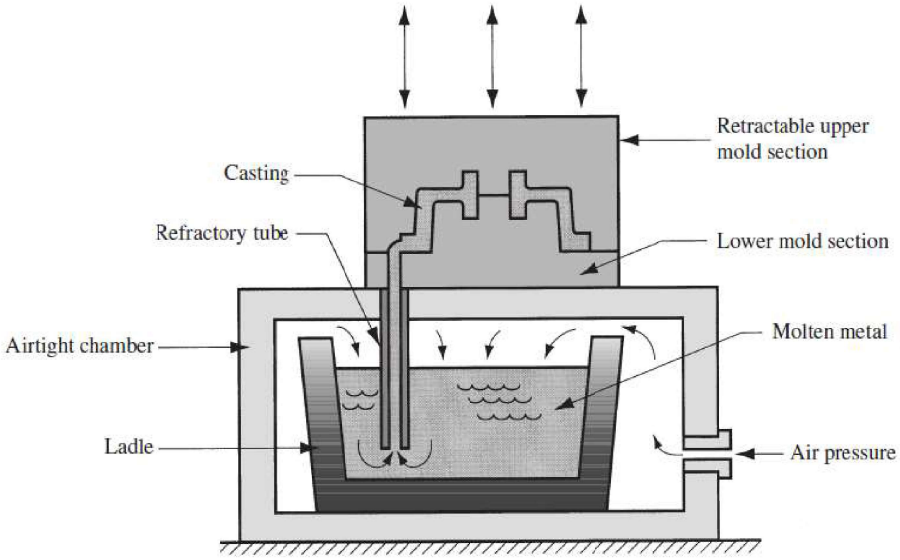
Nonexpendable (permanent) mold gravity feed casting process



Gravity die casting

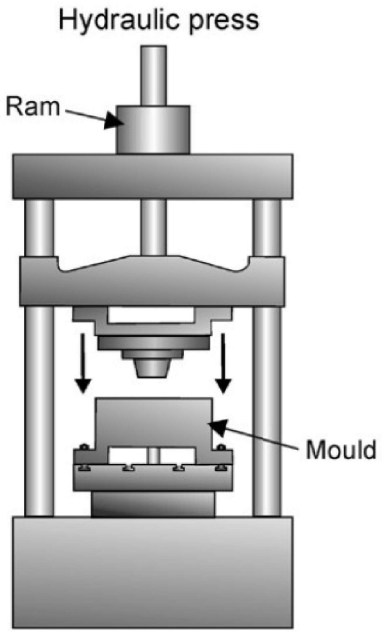


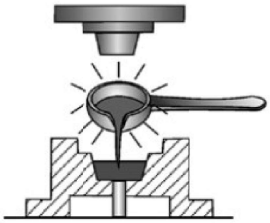
Low-pressure die casting (LPDC)



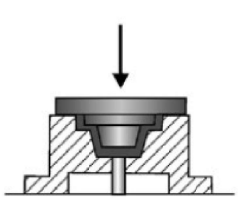
Alloy A356.0 alloy automotive wheels

Squeeze casting

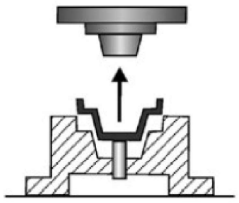




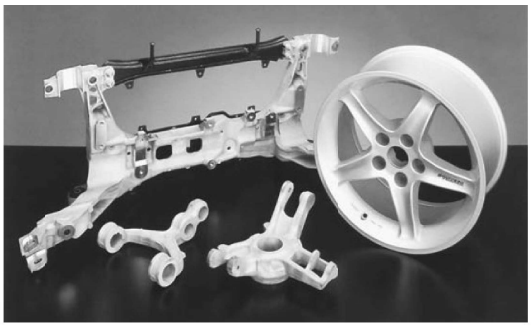
Pour molten metal into mould



Squeeze metal in mould and maintain pressure

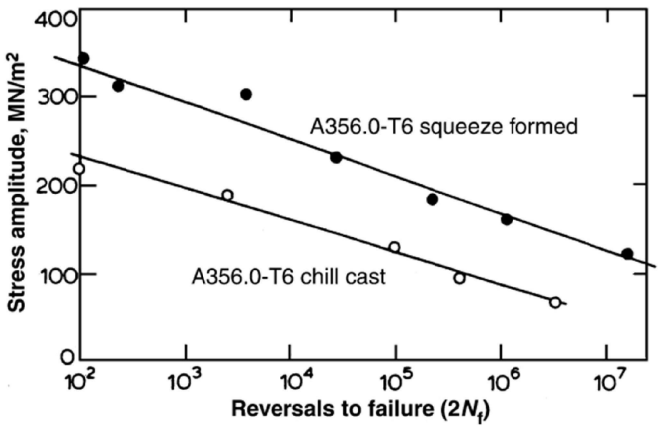


Eject finished casting and repeat process

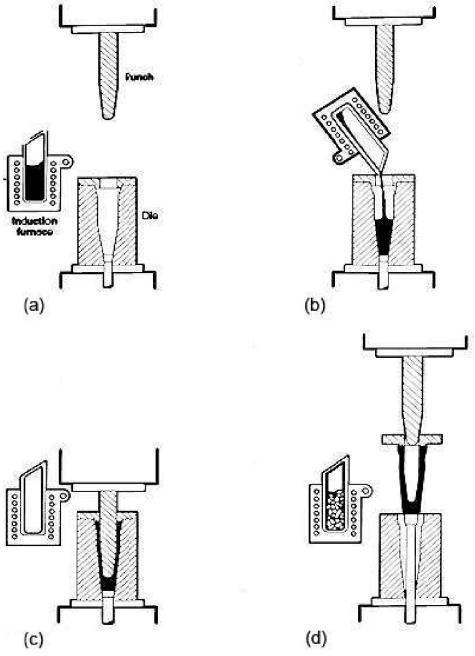


Automotive parts produced by the squeeze casting process

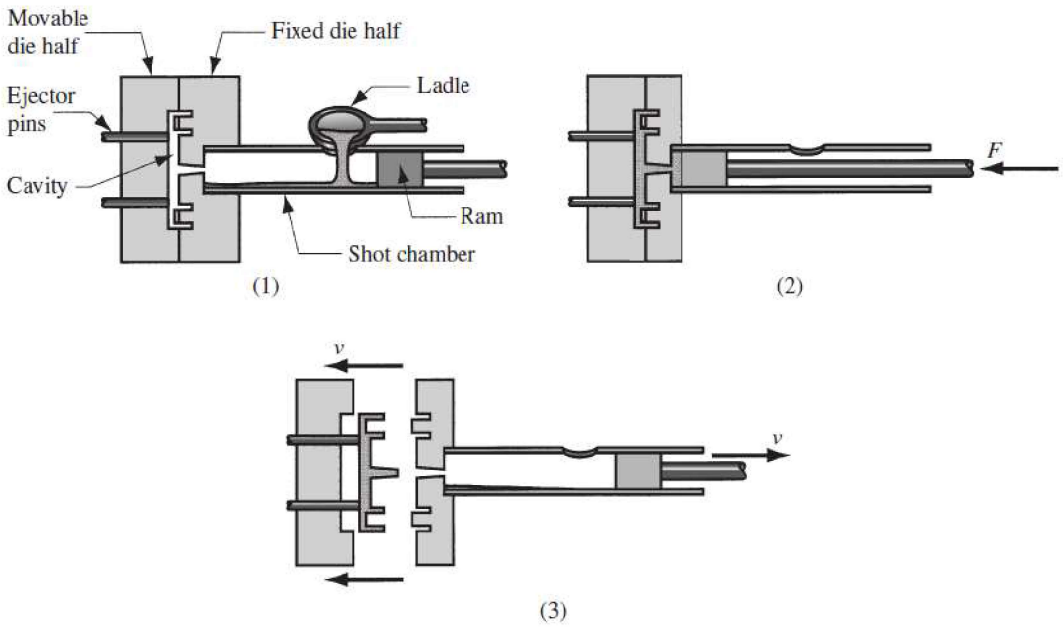
Squeeze casting



Fatigue properties of conventionally cast and squeeze cast aluminum alloy A356.0-T6.



High Pressure Die Casting Process



Heatsink with casted fins:
AlSi9Sr

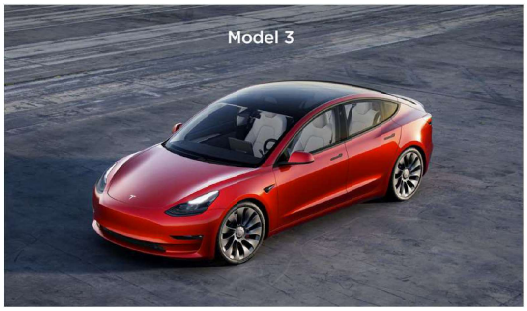
Heating plate for espresso machine
High pressure die casting, flanged
138 × 91 × 42 mm, weight: 0.71 kg:
AlSi9

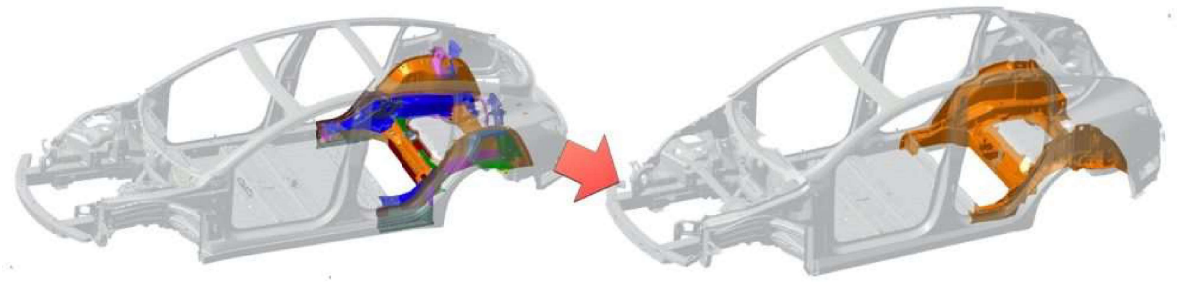
Cast node for glass dome design
Gravity die casting Ø 260 × 110 mm, weight:
2.3 kg: **AlZn3Mg3Cr**

Door handle
Gravity die casting, decoratively anodized
135 × 65 × 15 mm, weight: 140 g: **AlMg3**

Input housing for autopilot on offshore yachts
Sand casting, anodically oxidised
290 × 210 × 40 mm, weight: 0.4 kg: **AlMg5**

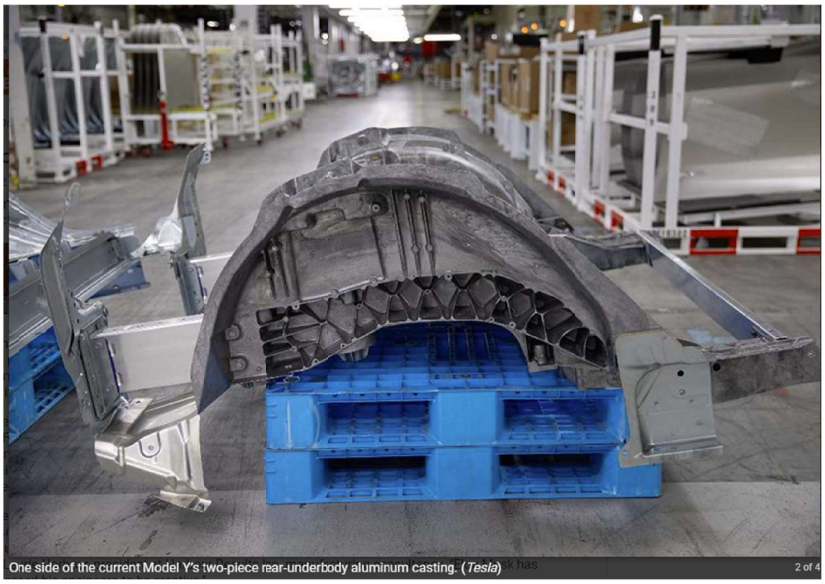
ICE II gearbox housing
artificially aged Sand casting
1800 × 850 × 250 mm, weight: 175 kg:
AlCu4Ti





Model 3 rear underbody
70 pieces of metal

Model Y rear underbody
2 pieces of metal (eventually a single piece)

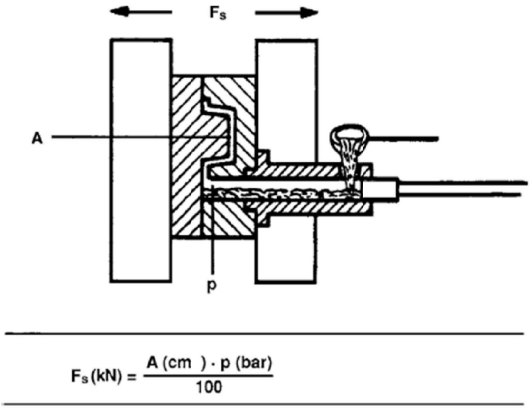



HDC8800


HDC8800

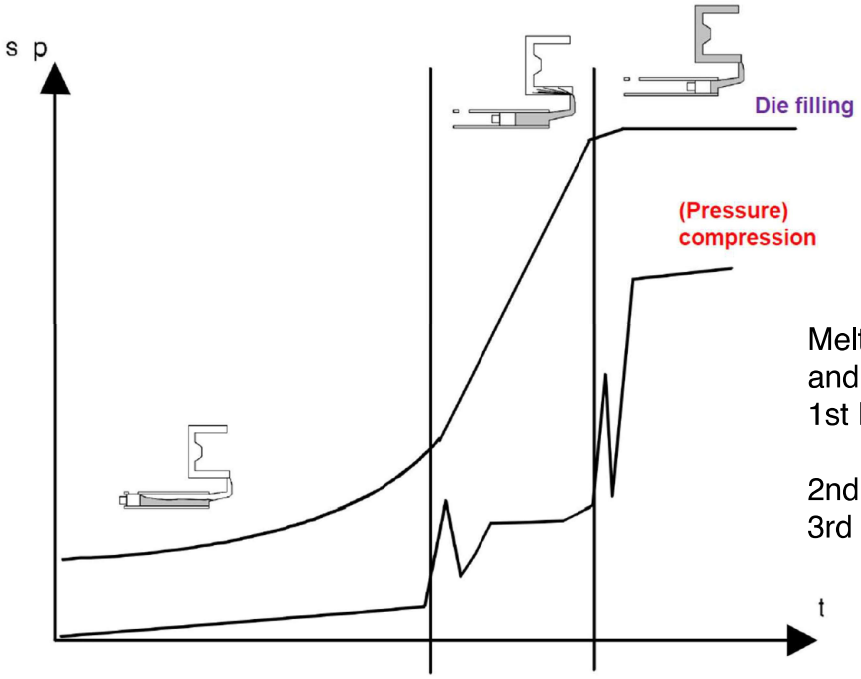

Giga Press

High Pressure Die Casting Process



Machines are described by their “locking force” which determines the cross sectional area of the casting which can be made, which is in turn related to the overall size and weight of casting. Machines can have locking forces from 100 to over 2000 tons.

Basic Principles



Melting and solidification diagram Die filling and compression in the three phases
1st Phase (Preliminary Injecting)
Filling test
2nd Phase (Die filling) Gate velocity vMA
3rd Phase (intensification pressure)

Basic Principles

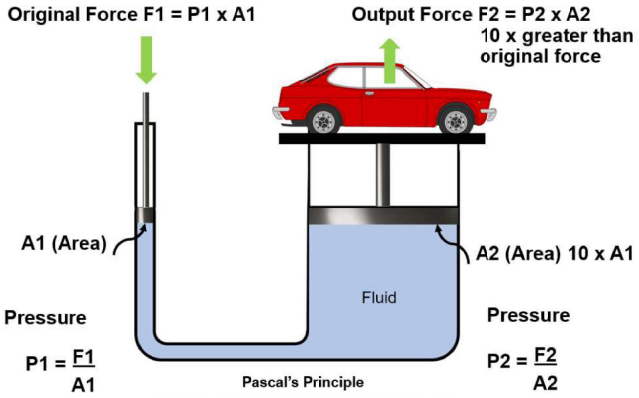
P1 = P2

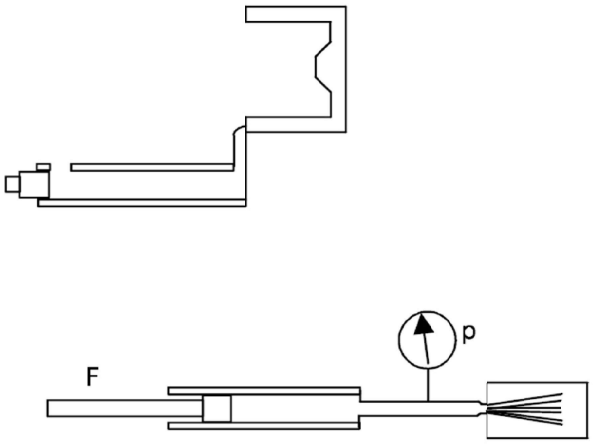
F1/A1 = F2/A2

เมื่อ A2 > A1

F2 > F1 จึงได้การผ่อนแรง

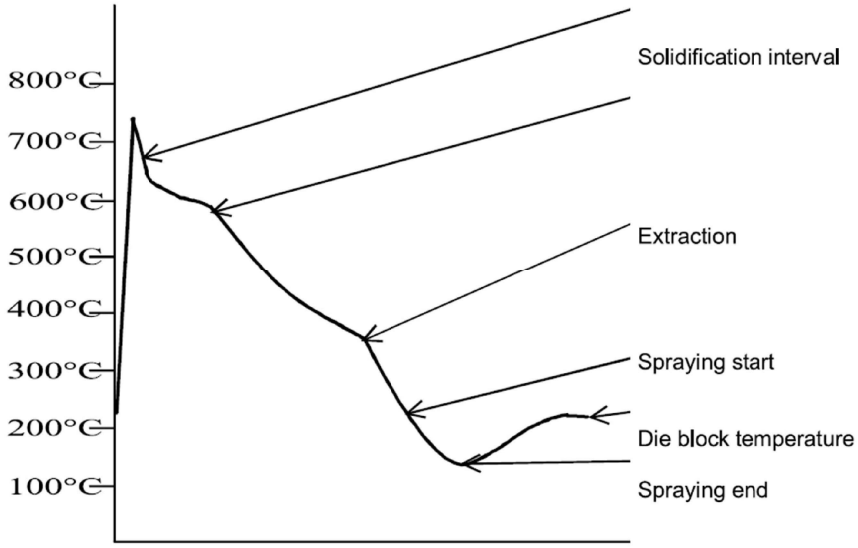
The die casting technology, especially the die filling technology, is based to a great extent on hydraulics.





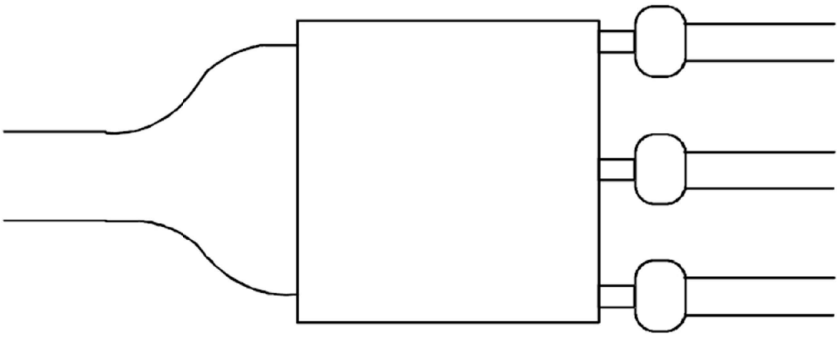
Basic Principles

Liquid alloy is injected into a die, which is at a temperature of about 300 below the alloy melting point, i.e. the solidification process starts as soon as the alloy touches the cavity surface of the die.



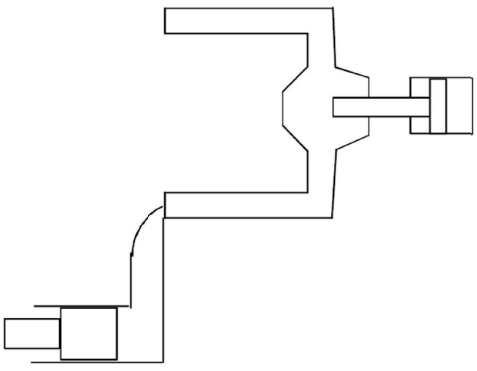
Basic Principles

The alloy is not injected into an empty cavity but into a die still of air and residues of die lubricant. The metal is atomized at the gate and injected into the die cavity. Air and metal which is dirty and too cold are extracted via the overflows.



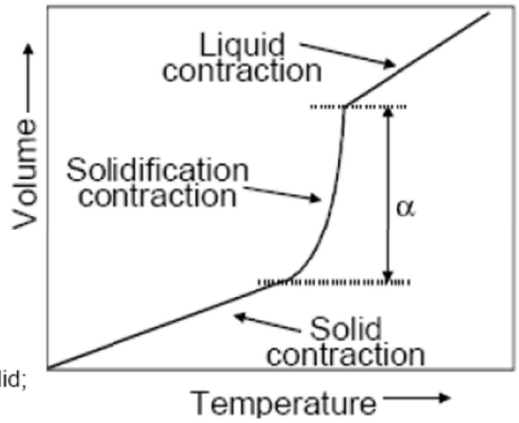
Basic Principles

Intensification
During the changes from liquid solid (solidus liquidus point) the metal shrinks about 4 depending on the alloys. With the application of a high final pressure, about 400 1000 bar, this loss in volume is compensated by feeding additional metal through the runner, or with an external squeeze pin.

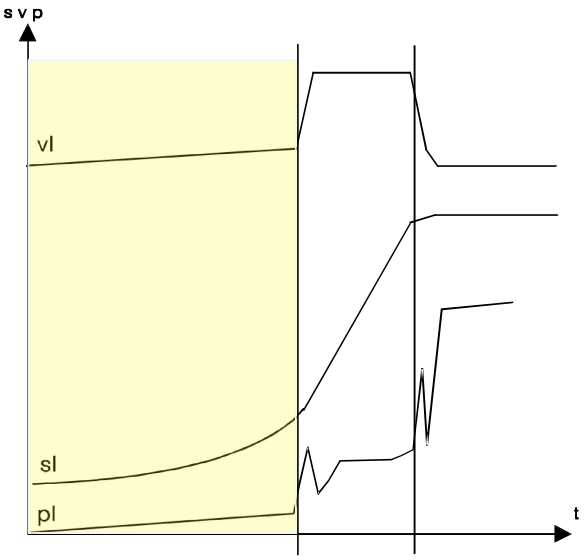


There are three types of shrinkage:

-Contraction of the liquid;
-Transformation of the liquid to the solid;
-Solid state contraction.



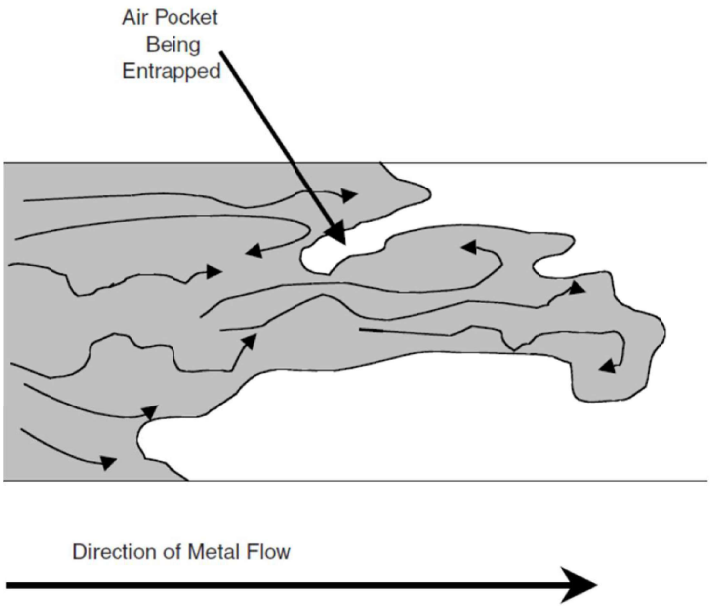
1st Phase

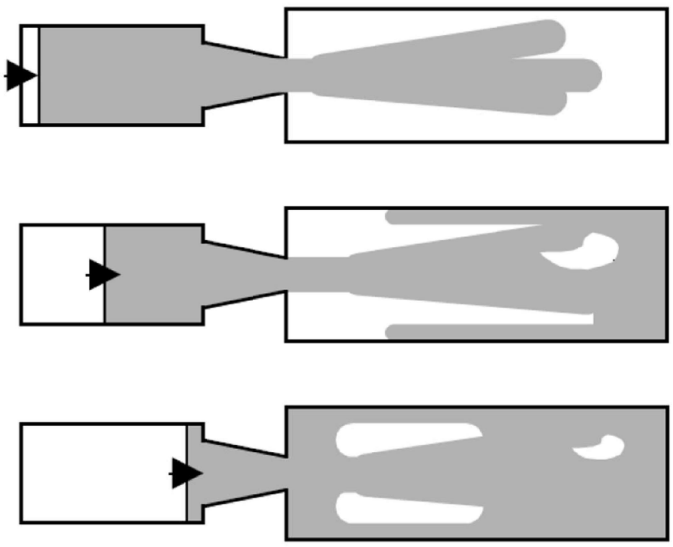


The metal is slowly moved into the area around the gate, depending on the volume and the process.
Depending on the size of the DCM and the shot sleeve length approx. 1 -7 s

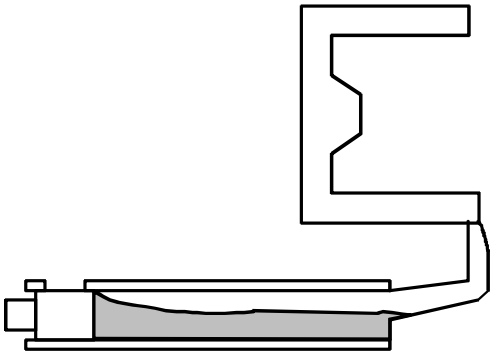
The shock-free start and the constant acceleration (Parashot) of the plunger make it possible to fill the shot sleeve without causing any turbulence.

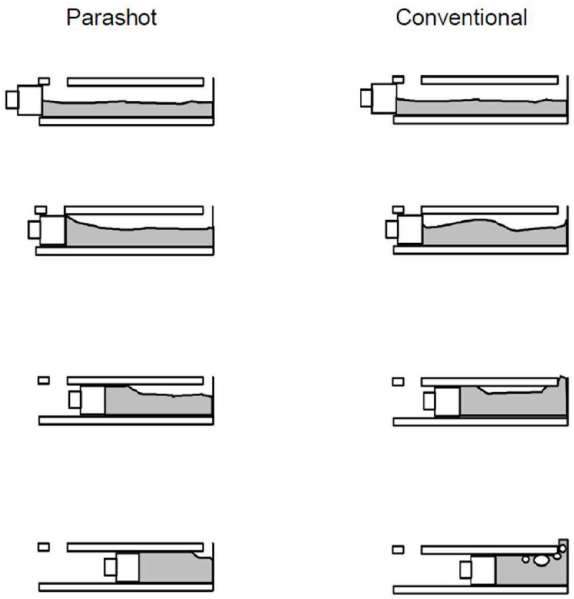
1st Phase



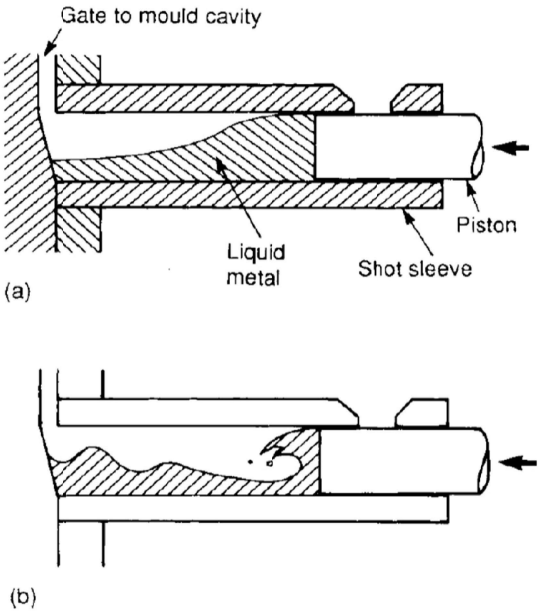


1st Phase



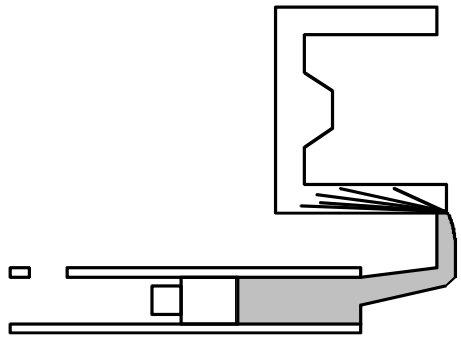


The shock-free start and the constant acceleration (Parashot) of the plunger make it possible to fill the shot sleeve without causing any turbulence.



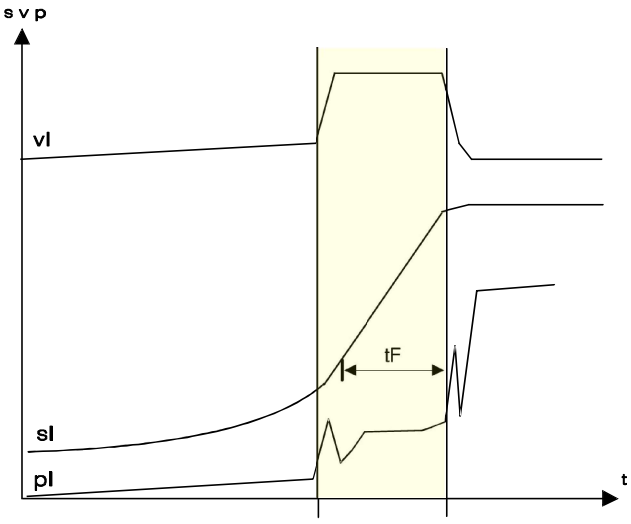
Injection of liquid into a horizontal shot sleeve of a cold chamber diecasting machine, comparing
(a) controlled and
(b) uncontrolled first stages of injection.

2nd Phase (Part Filling)



Start at the gate till the hole cavity is filled.
Depending on the volume and the process for approx. 0.01 - 0.2 s

2nd Phase (Part Filling)



The metal is injected into the die cavity during the filling phase.

In order to attain a good and gentle die filling process, certain parameters and their thresholds must be taken into account.

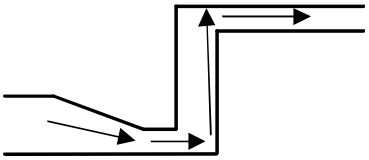
	v_{MA}
Standard gate velocity range	v_{MA} 20 - 60 m/s
Most used range	v_{MA} 40 - 60 m/s

	t_F
Standard filling time	t_F 0.01s - 0.2s
Most used filling time	t_F 0.03s - 0.1s

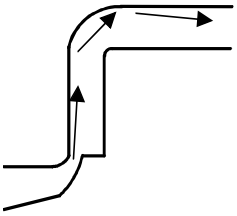
Wall thickness *	
	1.5 mm t_F =0.010 s - 0.030 s
	2.0 mm t_F =0.020 s - 0.060 s
	3.0 mm t_F =0.050 s - 0.100 s
	6.4 mm t_F =0.080 s - 0.300 s

*Based on thinnest wall thickness of the part and the last filling section.

2nd Phase (Part Filling)



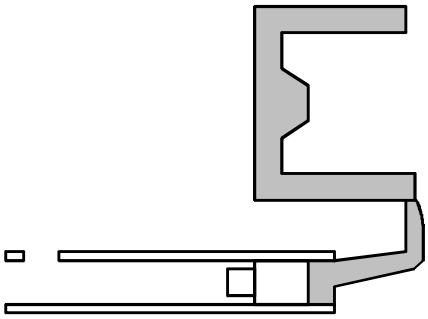
Lower gate velocity v_{MA} = 20 m/s – 30 m/s



Medium gate velocity v_{MA} = 30 m/s – 45 m/s

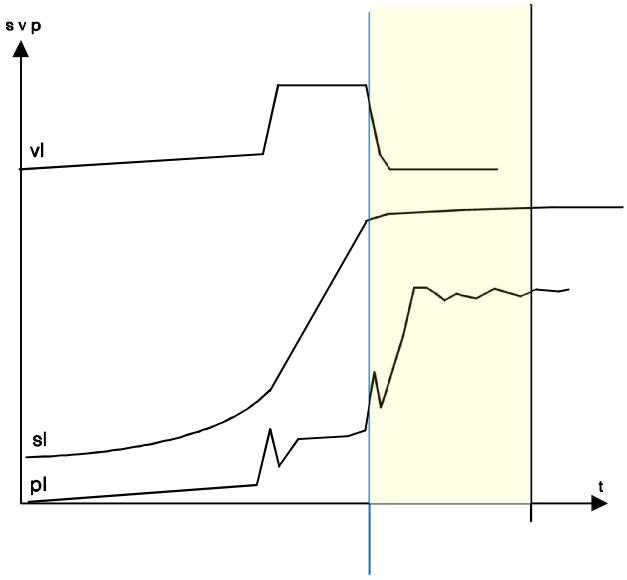
High gate velocity v_{MA} = 40 m/s – 60 m/s or more

3rd Phase (Intensification Pressure)



The molten metal is compressed in the die under high pressure at approx. 400 bar - 1000 bar.
Depending on the gate (part) and the process for 0.01–0.3 s

3rd Phase (Intensification Pressure)



Since aluminum loses approx. 4-7% volume when it changes from liquid to solid, (solidus-liquidus point), we have to compensate for it by using high pressure refill through the gate.

The gate remains open for only a short period of time after the die has been filled. The intensification pressure phase begins at the end of the die filling process and ends with the last movement of the plunger.

“สิ่งทั้งหลายทั้งปวง อันบุคคล ไม่ควรยึดมั่น ถือมั่น”

(ว่าเป็นตัวเรา-ของเรา)

(สพฺเพ ธมฺมา นาลํ อภินิเวสาย)