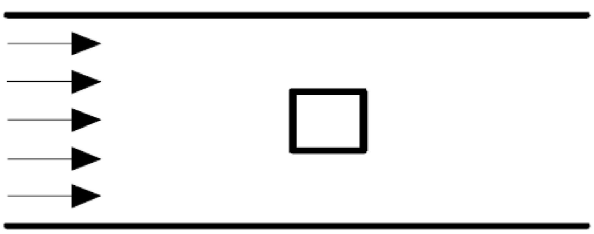
04: Basic Die design consideration, Roles of die lubricant and its efficiency, and HPDC defects

Internal Training เทคโนโลยีและปัจจัยที่ส่งผลต่อคุณภาพของ
อะลูมิเนียมผสมที่ผลิตจากกระบวนการ High Pressure Die Casting

Chaowalit Limmaneevichitr, Ph.D.

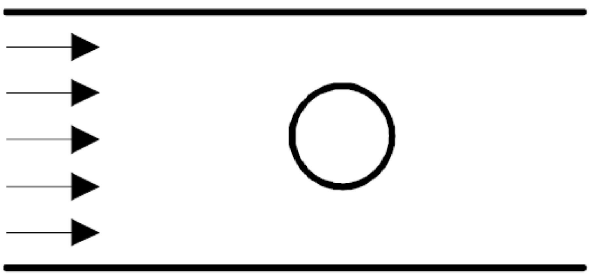
chaowalit.lim@mail.kmutt.ac.th

Flow examples



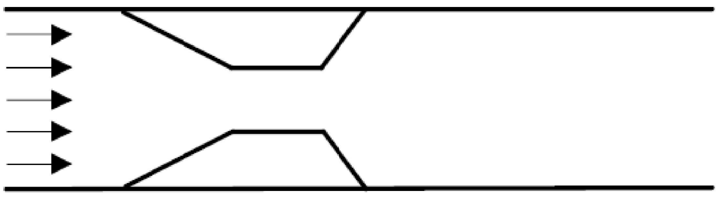
Flowing around an obstruction

Draw in the flow lines,
where can cavitation be expected?
where can erosion be expected?

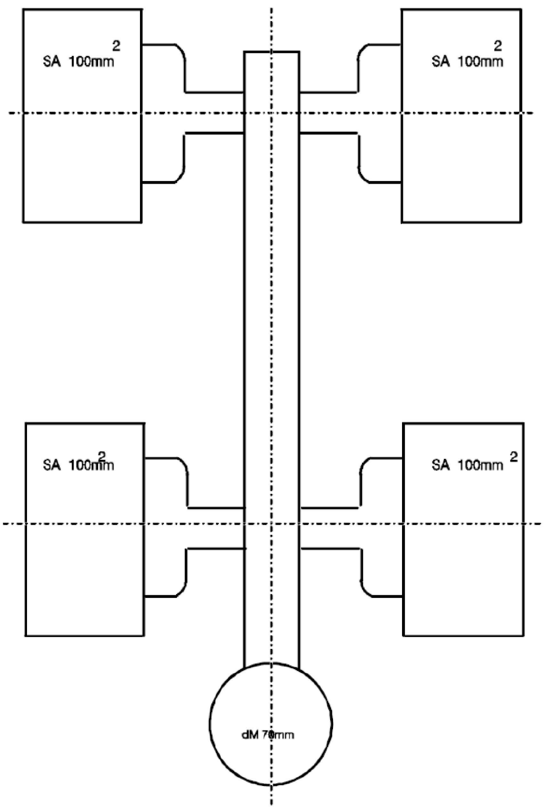


Flowing around an obstruction

Draw in the flow lines,
where can cavitation be expected?
where can erosion be expected?



Draw in the flow lines,
where can cavitation be expected?
where can erosion be expected?



-What is happening here during the prefilling phase?

....

Are all cavities filled simultaneously?

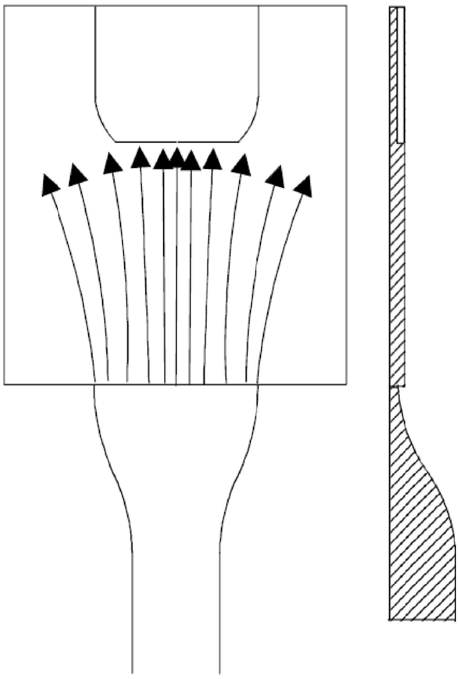
....

-What are the hazards of this gating sytem?

....

-How can they be eliminated?

....



-What is happening at the end of the die filling?

....

-Draw in the flow lines.

....

-Where do the overflows have to be placed?

....

....

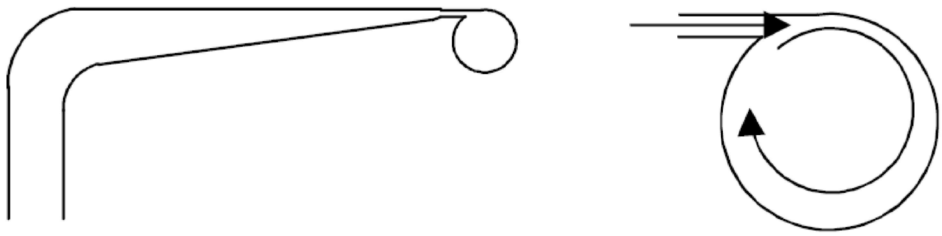
Maximum permissible gate velocity vMA
40m/s - 60m/s oder grösser

Which problems will be arise with this contour
if the gate velocity is too high?

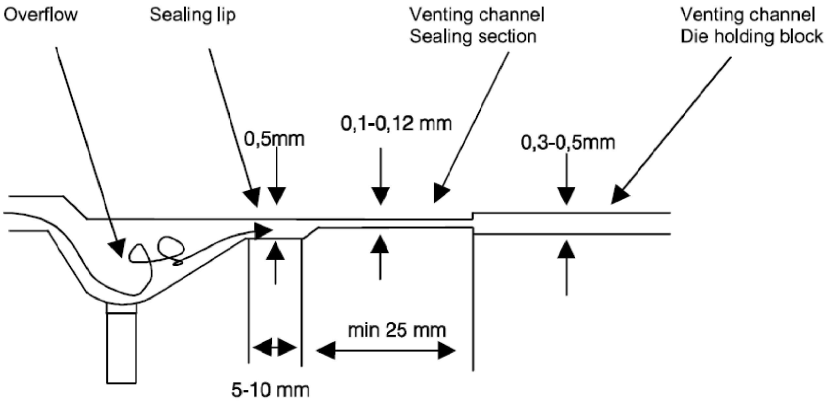
....

....

The air is whirled into the shock absorber and provides a dampening cushion. The shock absorber has the task of cushioning the pressure peak at the end of the runner fill, thereby preventing an uncontrolled prefilling of the alloy.



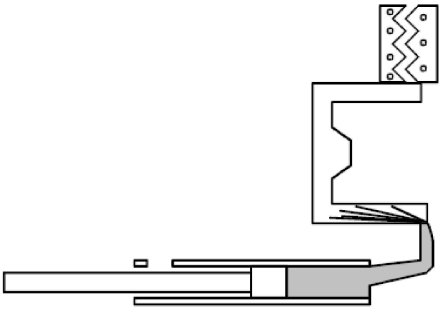
Die Venting

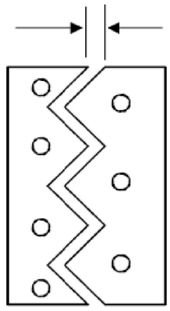


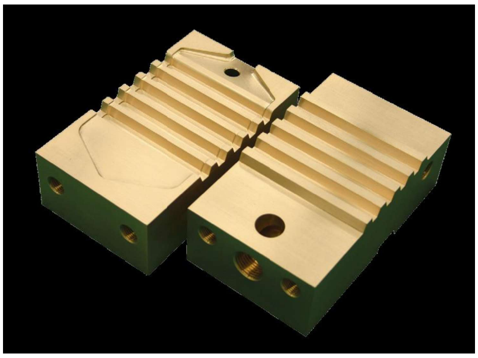
	Sealing lip	Sealing section TE
AlSi9Cu3 DIN 226	0,5 mm	0,12 mm
AlSi12 (Cu) DIN231	0,3 mm	0,10 mm

Die venting is very important
The venting in many dies is designed too small which leads to quality problems
There are two types of venting, **standard venting (overflows)** and **forced venting (vacuum).** Most of the dies are operated with standard venting, however, there are applications where very good results can be achieved with forced venting.

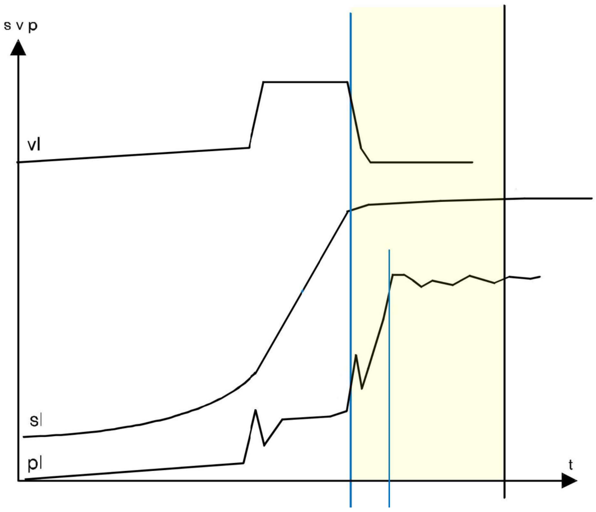
Chillblock





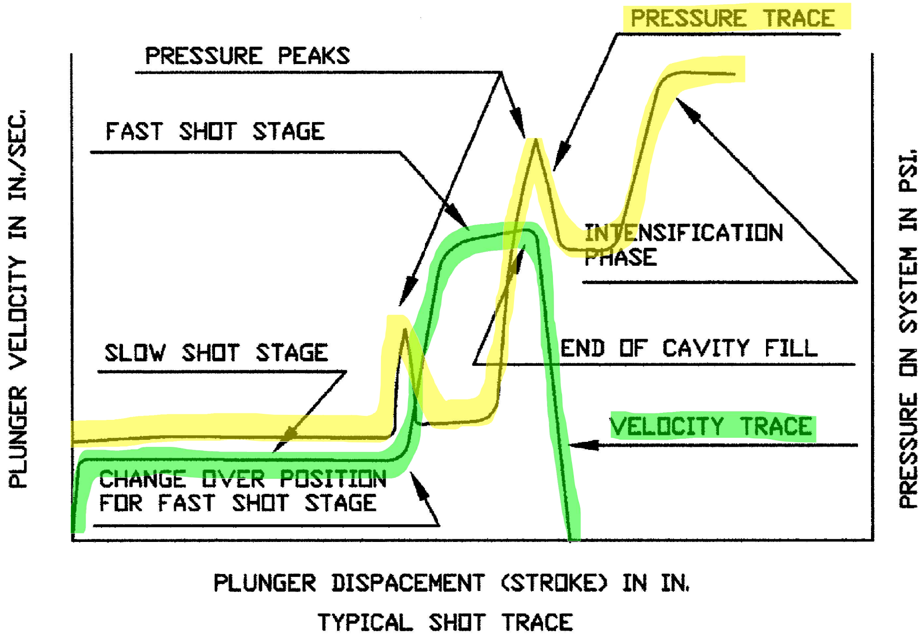


3rd Phase (Intensification Pressure)



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.

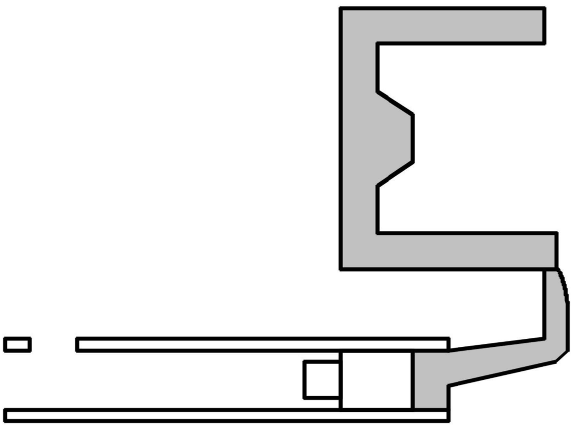
- To reduce "gas and shrinkage porosity" to its minimum level. That is, intensification does not eliminate porosity, it merely compresses it to an acceptable level.
- Intensification is a controlled increase of the metal pressure at the end of the die cast "shot" immediately following impact or "cavity full".
- Accomplished by increasing the hydraulic pressure above the "nominal" pressure by one of the following means: shifting to alternate relief valves, opening high pressure accumulators, or operating "multipliers" also called cylinder intensifiers.



Delay time: Delay time is defined as the amount of elapsed time from "impact" or the end of the cavity filling cycle to the point where the "intensifier pressure" begins to rise. This time is normally measured in milliseconds with an acceptable range being 15 to 200 milliseconds. This is best defined by the Process Engineer at the time of sample. The procedure is to start out with the fastest rise time that doesn't blow and is otherwise stable.

Rise time: Rise time is defined as the time required for the intensifier to reach its maximum pressure. Sometimes it is acceptable to consider intensification complete when it reaches 80 to 85% of maximum.

Intensifier pressure: As stated the intensifier pressure is the maximum hydraulic pressure generated by the circuit at the end of the shot in an appropriate period of time.



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.

Pressure on the Metal during the Pressure Intensification Phase

Al - , Mg Alloys	Testing pressure bar	Intensification pressure bar
Standard Parts Components without mech. requirements		up to 400
Technical Parts Components with mech. requirements		400 - 600
Pressure-Tight Parts	0.5 -1.5	500 - 600
Pressure-Tight Parts	5 -15	700 – 900
Pressure-Tight Parts	20 - 200	800 - 1200

Fill Time

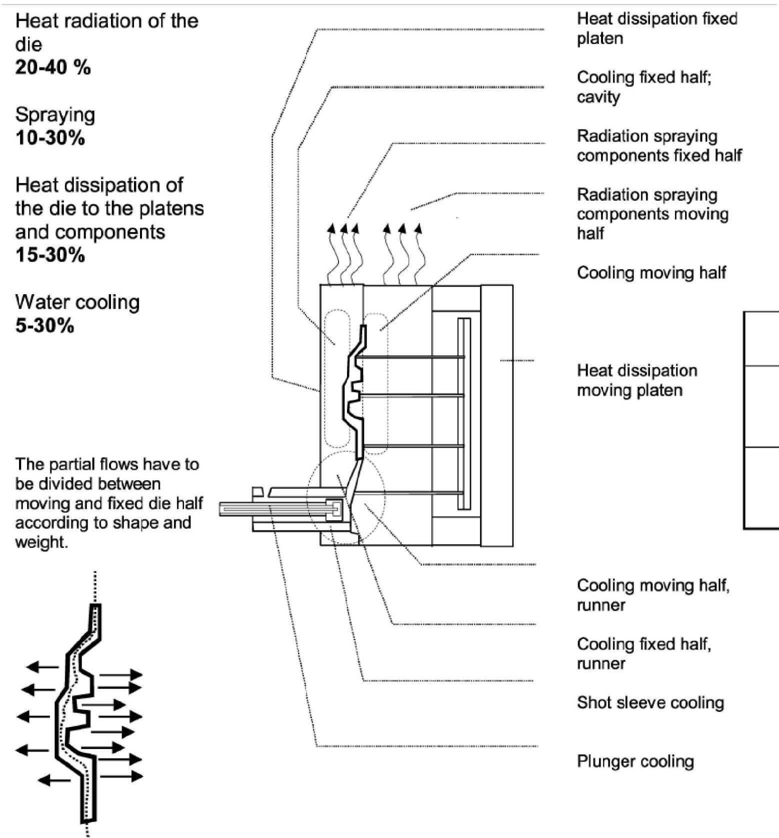
The fill time begins when the alloy first arrives at the gate and ends after the cavity is filled with metal. Rough guidelines for maximum fill times that are applicable to most castings:

Wall thickness [mm]	Filling time [ms]
1,5	10-30
1,8	20-40
2,0	20-60
2,3	30-70
2,5	40-90
3,0	50-100
3,8	50-120
5,0	60-200
6,4	80-300

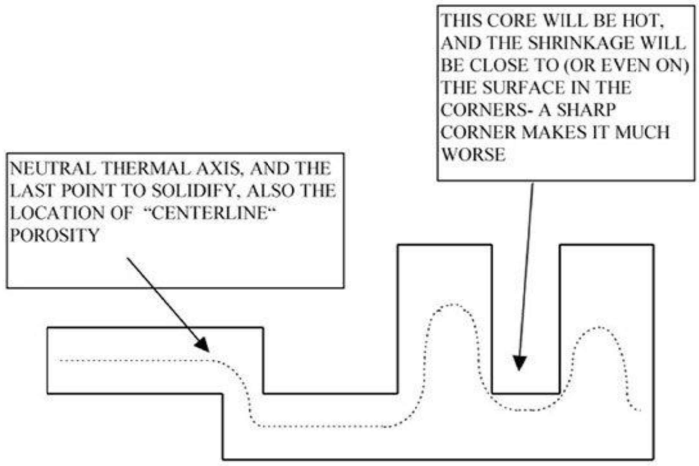
Solidification and heat conducting

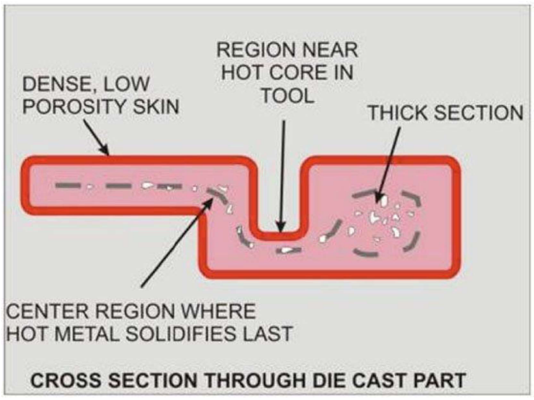
The heat has to be dissipated from where it is generated

- This principle we have to consider when we design the cooling bores. The heat flow to be dissipated subdivides itself into many partial flows which often are extremely difficult to measure and influence.
- The listed partial flows are only estimates and can vary from die to die and shot weight.
- Die surface temperature for aluminum die casting approx. 150-220°C



Cooling capacity / 1 cm Cooling channel length	Channel bore	Cooling capacity
Gate area	13-15mm	ca 500kJ/h
	9-11mm	ca 360kJ/h
	8mm	ca 300kJ/h
Die section	13-15mm	ca 250kJ/h
	9-11mm	ca 190kJ/h
	8mm	ca 150kJ/h



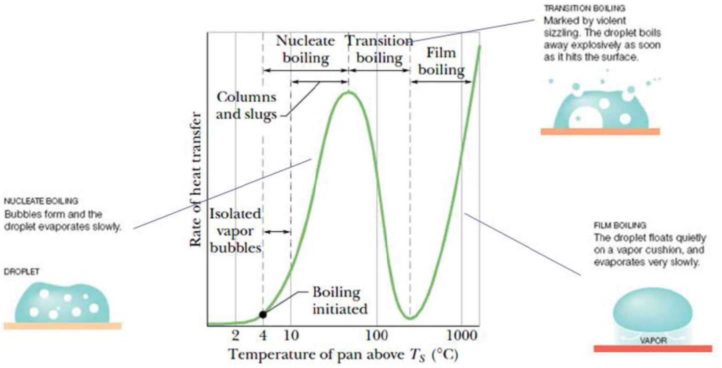


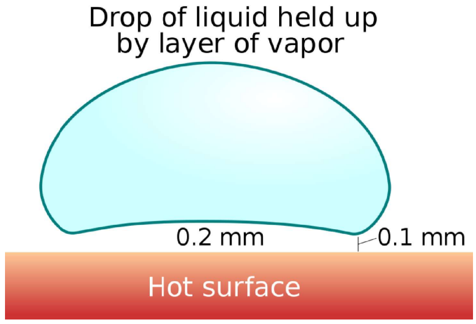
Basic principles of spray technology

- Cooling with water soluble lubricants only
- Evaporation causes heat to be extracted from the environment: 2245 kJ/kg H_2O
- Heat is conveyed by convection and heat absorption
  - c of H20 water 4.16 kJ/kg/K
  - e.g. If 1 kg of water is heated from 20˚ C to 100˚ C, following quantity of heat is extracted from the die: 1 kg H20 x 4.16 kJ/kg x delta T 80 K = 333.3 kJ
- During casting with 70 – 80 bar filling pressure, 1 cm^3 lubricant produces approx. 4,800 cm^3 gas in the die casting die.

Heat transfer for water (@ 1 atm)

S-shaped graph when heat flux (q") is compared to temperature.

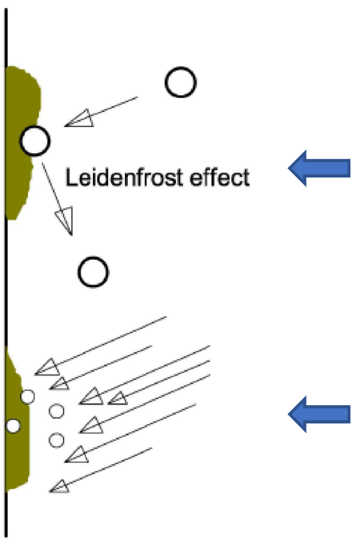




Leidenfrost's vapor effect (dancing water droplets on a hot plate)

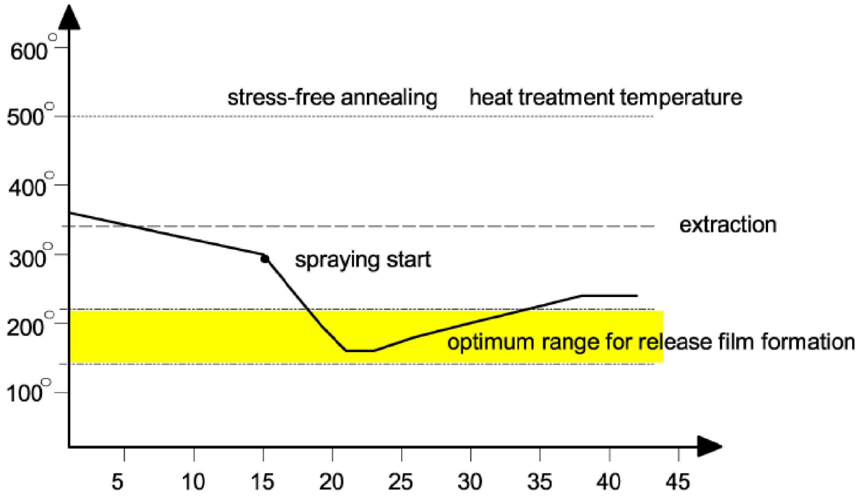
- With temperatures from 180°C- 200°c, according to droplet size.
- This effect can be kept within certain limits by propelling small droplets with a high kinetic energy onto the plate.

With temperatures above 200°c Leidenfrost's phenomenon has to be overcome, i.e. an insulating vapor barrier is formed on the die surface. To avoid this vapor it is important to



spray small droplets with a very high velocity onto the die, to enable them to pierce through the vapor barrier.

blow away the vapor as good as possible with the spraying air, to suppress the formation of vapor.



The diagram shows the progress of the temperature on the die surface after opening.
This shows that the die surface has to be brought to the optimal temperature for the formation of the release film and that the actual formation of the release film is only very short, approx. 0.5 - 1.0 s.
If the spray is applied longer the release film is washed off again from the die surface.

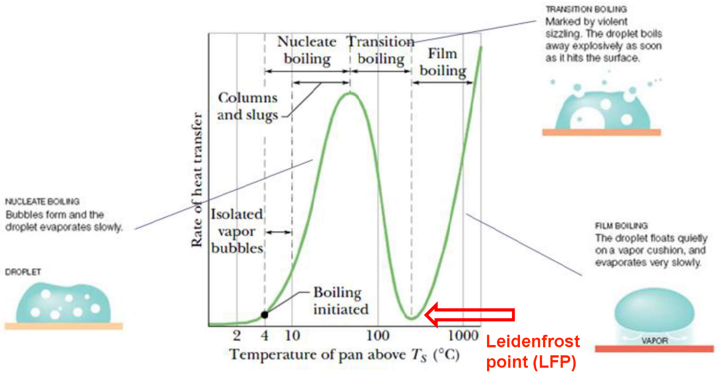
Roles of Die lubricants

- Die lubricants are sprayed onto the inner contour of the die cavities for many reasons:
  - to cool and balance the die temperature;
  - to create a lubricating film that facilitates the filling and the extraction of the part acting as release agent;
  - to create a protecting film that, together with the surface oxide layer, prevents die soldering phenomena.

Source: L. Andreoni, M. Casè, G. Pomesano, “Lubrificazione della cavità dello stampo”, Quaderni della colata a pressione delle leghe di alluminio 7, 1996, pp.9-26.

What are the properties of good lubricants?

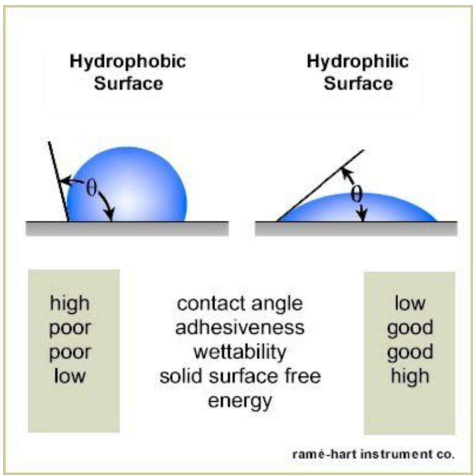
- At the Leidenfrost point (LFP), a vapor film forms a continuous barrier over the die surface that lubricant cannot penetrate, and the formation of the protective film that prevents die soldering is not formed.



Source: Zabala, B., et al. "Evaluation HPDC Lubricant Spraying for Improved Cooling and Die Protection." *LUBMAT 2016 Conference Proceedings*. 2016.

What are the properties of good lubricants?

- The wettability is the ability of a liquid to cover a solid surface, assuring full contact. This physical property is measured by the contact angle (CA) between the die surface and the lubricant droplet. Covering a larger area through reduced contact angle, the heat transfer capacity is improved, and a wider lubricant film is formed at the die surface.



Source: Zabala, B., et al. "Evaluation HPDC Lubricant Spraying for Improved Cooling and Die Protection." *LUBMAT 2016 Conference Proceedings*. 2016.

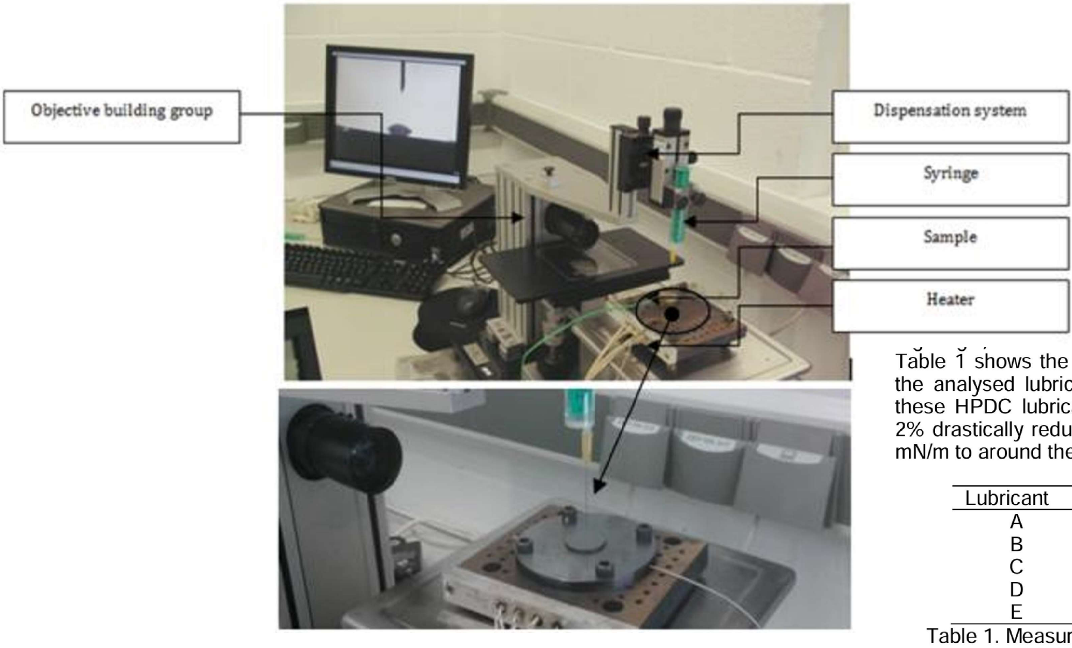


Table 1 shows the measured surface tension values for the analysed lubricants. It is important to highlight that these HPDC lubricants at such a small dilution rate as 2% drastically reduce the water surface tension from 72 mN/m to around the half of this value.

Lubricant	Surface Tension (mN/m)
A	48.7
B	53.2
C	35.1
D	33.9
E	31.5

Table 1. Measured surface tension of the analysed lubricants at 2% dilution ratio.

Source: Zabala, B., et al. "Evaluation HPDC Lubricant Spraying for Improved Cooling and Die Protection." *LUBMAT 2016 Conference Proceedings*. 2016.

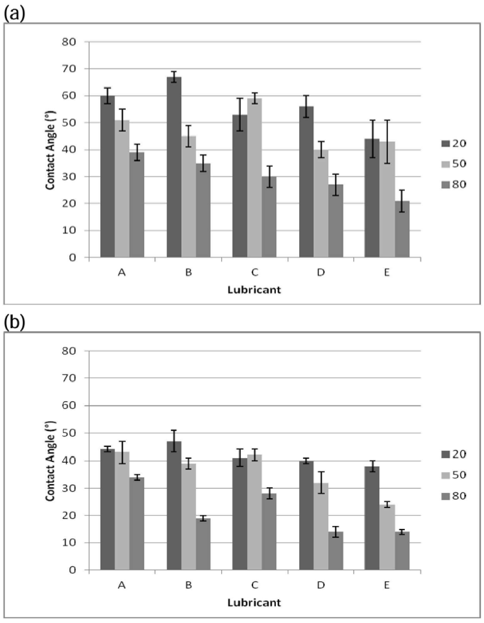


Figure 6. The CA at 20, 50 and 80°C on (a) H13 and (b) H11 steels

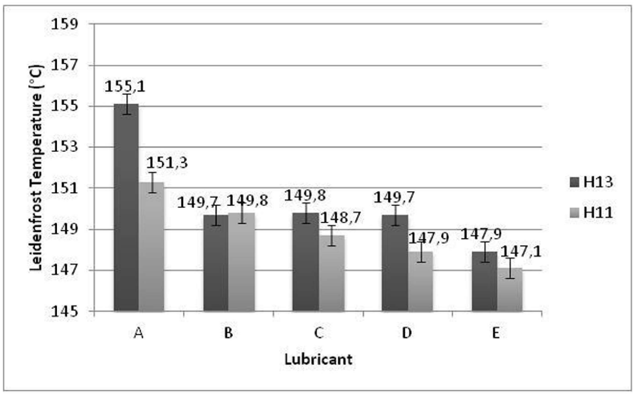
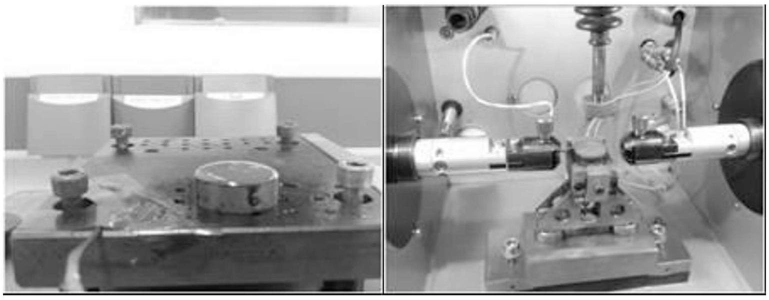


Figure 5. The LFP for soft water-based lubricants on H13 and H11 die materials.

Source: Zabala, B., et al. "Evaluation HPDC Lubricant Spraying for Improved Cooling and Die Protection." *LUBMAT 2016 Conference Proceedings*. 2016.



(a) (b)

Figure 3. (a) Preparation process of the sample with a ''coating'' of the lubricant and (b) sample that is ready to start the pin on disk test

	A	C	D	E	B
Time to Failure (cycles)	39750	21625	16025	6500	5000
COF (-)	0,167	0,166	0,177	0,155	0,187

Table 2. Time to failure and friction coefficient of the different lubricants in the pin on disc tests at 50N, 25Hz and 365°C

Source: Zabala, B., et al. "Evaluation HPDC Lubricant Spraying for Improved Cooling and Die Protection." *LUBMAT 2016 Conference Proceedings*. 2016.

2.4 Film thickness measurement

The procedure for film thickness formation of lubricants is quite simple. A lubricant film is formed similarly to the samples of pin-on-disc tests and leaving drying for 5 hours. Afterwards a general tool for measuring thickness's of non-magnetic coatings, EASY-CHECK FN from NEURTEK Instruments, is used for thickness measurement, shown in Figure 4. About 20 measurements are taken in different points of the sample surface.

(a) (b)

Figure 4. (a) Steel sample coated with a lubricant film (a) and (b) thickness measurement device

Source: Zabala, B., et al. "Evaluation HPDC Lubricant Spraying for Improved Cooling and Die Protection." *LUBMAT 2016 Conference Proceedings*. 2016.

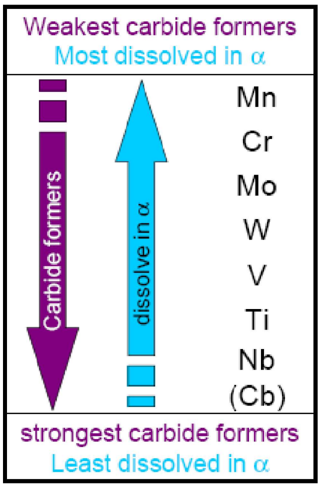
- Lubricant A has the highest Leidenfrost point (LFP) among the tested lubricants, indicating superior filming capacity and effectiveness on heat extraction, which is crucial for preventing die soldering.
- Synthetic lubricants A and C, which contain synthetic oils with a high viscosity index, show lower variation in contact angle with temperature, suggesting better stability and performance under varying conditions.
- Lubricant A demonstrates the highest film thickness compared to other lubricants tested, which is essential for creating a protective film to prevent die soldering.

Source: Zabala, B., et al. "Evaluation HPDC Lubricant Spraying for Improved Cooling and Die Protection." *LUBMAT 2016 Conference Proceedings*. 2016.

Die metal

- เหล็กเกรดที่ระบุมาเป็นเหล็กกล้าเครื่องมือ เกรด Hot Work Tool Steel เกรด H13 หรือ SKD61 (Chromium Base)

Typical analysis %	C 0,39	Si 1,0	Mn 0,4	Cr 5,3	Mo 1,3	V 0,9
Standard specification	AISI H13, W.-Nr. 1.2344					
Delivery condition	Soft annealed to approx. 185 HB					
Colour code	Orange/violet					



Die metal

At time 0.0, metal enters the die. The metal in the die quickly cools and solidifies. The die is opened and the solid component is ejected while the die surface continues to cool. An equilibrium temperature is reached with the bulk mass of the die. Die lubricant is sprayed onto the surface of the die. Once the spray stops, the surface temperature quickly rises back to the temperature of the bulk die mass. The events described are noted in Figure S7.

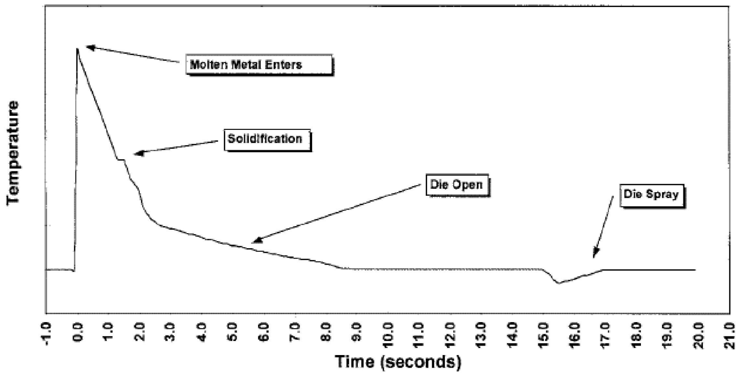
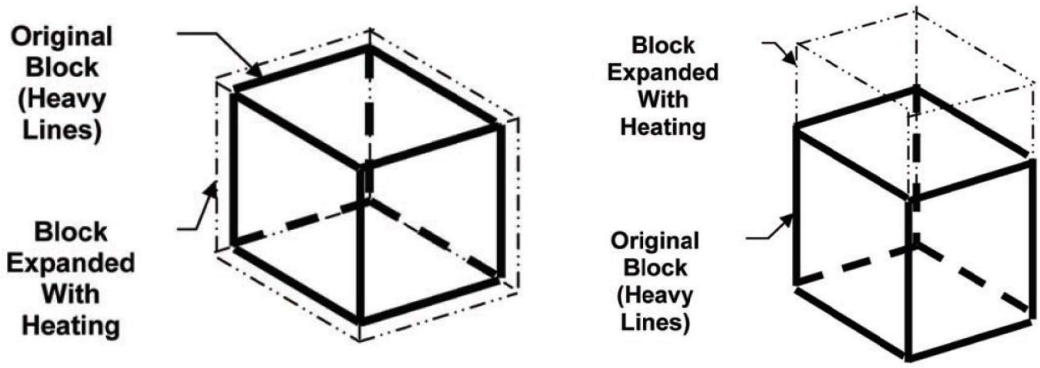
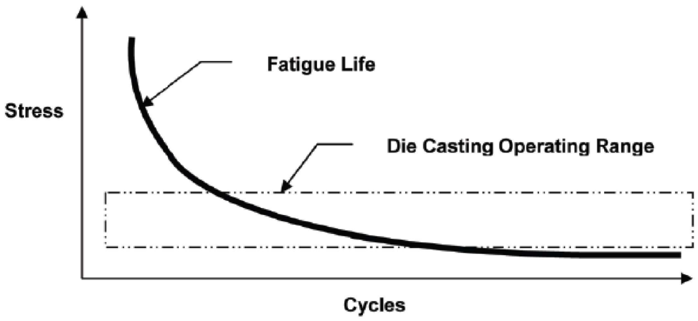
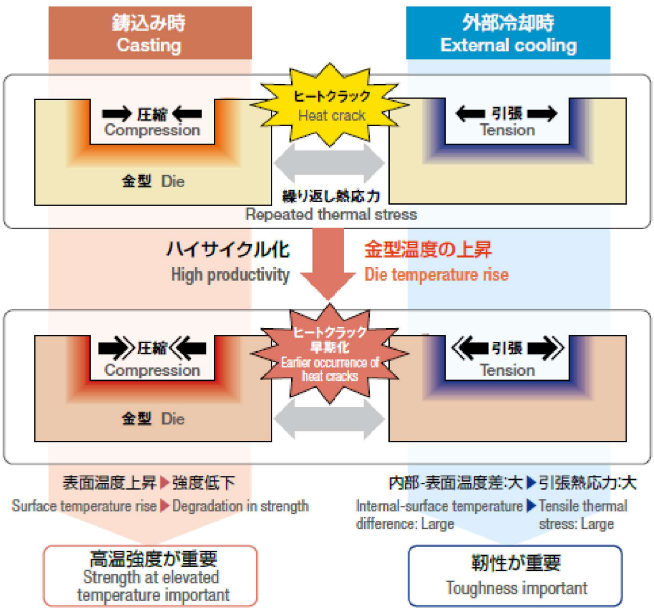


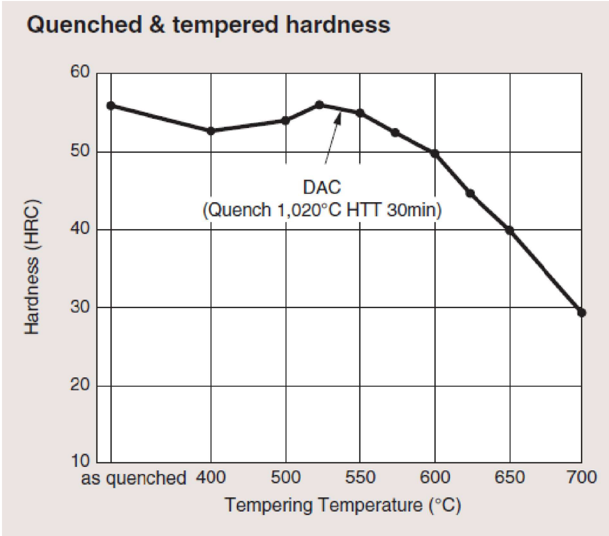
Figure S7 Die surface temperature over one casting cycle with casting phases noted.





If the casting cycle time becomes short, heat cracks occur at early stage.
Die steel with higher strength at elevated temperature and better toughness is strongly required.





Double temper

γ

↓ quench

- Carbides
- Martensite
- Retained γ (high alloy)

→ 1st temper →

- More carbides
- Tempered martensite
- Retained γ (low alloy)

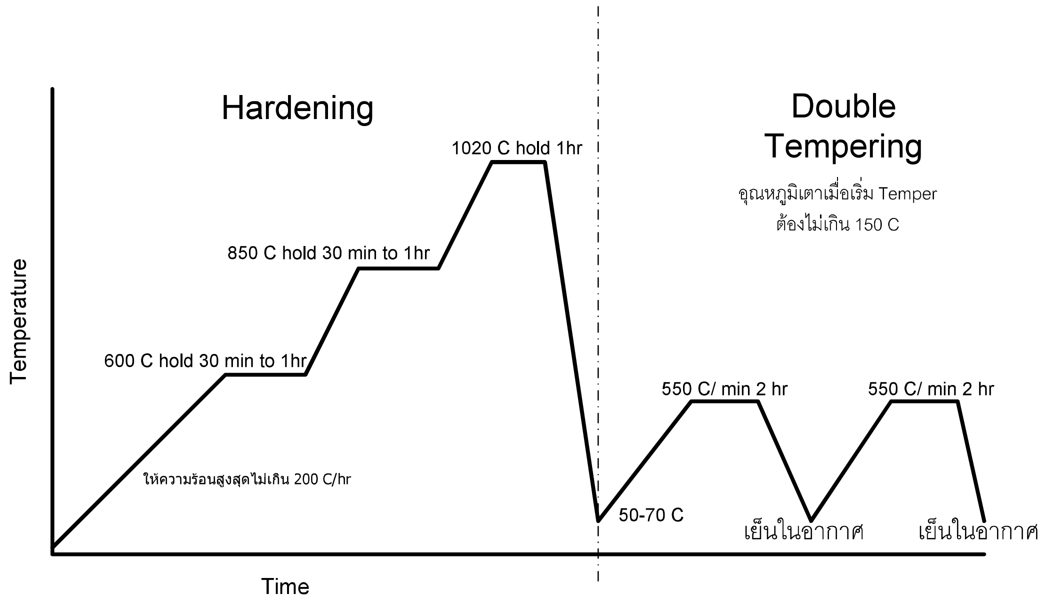
↓ quench

- Carbides
- Martensite
- Tempered martensite

→ 2nd temper →

- Carbides
- Tempered martensite

ผังกระบวนการอบชุบเหล็กกล้าสำหรับผลิต Die

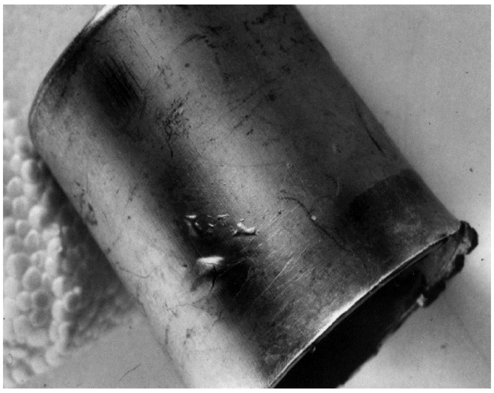


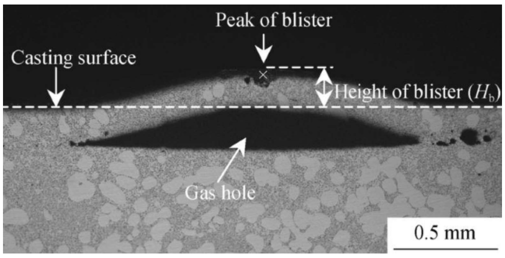
HPDC process relies on controlling critical variables. Specifically, they are:

1. Melt treatment and Metal temperature
2. Die temperature distribution
3. Slow shot profile (velocity vs position)
4. Slow shot total time
5. Elapsed time to runner full position
6. Fast shot profile (velocity vs position)
7. ~ fast shot total time
8. Transition point from slow to fast shot speed
9. Intensification pressure
10. Intensification pressure response time (Rise time to intensification) (milliseconds)
11. Biscuit length (actual measurement)
12. Overall machine cycle time
13. Die open to die closure time
14. Lockup pressure
15. Ladling time

Blisters

- Bubble-like bumps on the casting
- Gases trapped in the casting near the casting surface cause them
- When casting is ejected and the casting surface is not strong enough to withstand the gas pressure, the surface yields and the blister forms





Causes

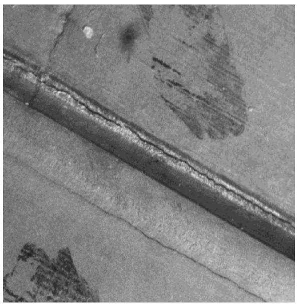
- Involved gases during the injection process;
- Poor performance of venting caused by unreasonable design of gating system;
- No degassing treatment of molten alloy, or overheated smelting temperature;
- Overheated die temperature, insufficient pressure-holding time, insufficient solidification time, all of which result in less strength of die casting parts and cause the gas expansion in the casting.
- Too much use of mold release agent, or too much use of lubricant on the piston;
- Insufficient blowing time after spraying of mold release agent.

Possible Solutions

- Adjust die casting processing parameters and injection speed;
- Optimize the gating system, add venting launders and overflow launders;
- Lower die temperature of where the defects may occur, so as to reduce the pressure effect of gas;
- Adjust smelting process;
- Prolong the pressure-holding time, and blowing time after spray;
- Optimize the using quantity of mold release agent and lubricant;

Cracks

- Cracks appear on the surfaces of die casting as linear or irregular patterns, which have the tendency of extension with the external force. Crack includes cold crack (the material is not oxidized at the crack) and hot crack (the material is oxidized at the crack). This defect can be identified by visual inspection.
- Two major causes for cracks are:
  - Heat
    - Insufficient
    - Excessive
  - Externally applied stresses



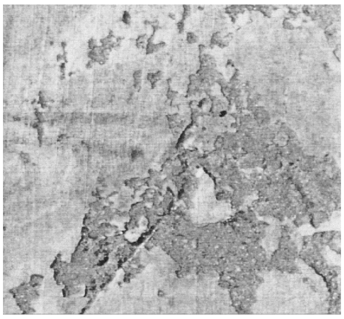
Causes

- Too high Fe element content or too low Si element content in molten alloy;
- Excessive harmful elements that lead to the decrease of plasticity of die casting parts;
- Too high Zn element content in Al-Si alloy, or too high Mg element content in Al-Mg alloy;
- Too low die temperature;
- Non-uniform wall thickness results in abnormal shrinkage of die casting;
- Too much stayed time of die casting in dies results in the adding of internal stress;
- Unbalanced ejection of the die casting;

Possible Solutions:

- Ensure correct alloy elements content during smelting;
- Optimize the structure of die casting part, and avoid non-uniform wall thickness;
- Adjust or add ejection positions to ensure balanced ejection of die casting parts;
- Shorten opening time or core-pulling time properly;
- Improve die temperature properly (the working temperature of dies between 180° and 280°);

Other Defects: Soldering



- The fusion of aluminum in the alloy with iron from the steel surface of the die cavity
- When soldering occurs, the casting sticks to the cavity; casting must be torn away
- Aggravated by higher than usual die temperatures, high gate velocities and high metal pressures
- Enhanced if the iron content in alloy is low
- Can be caused by insufficient draft angles

Possible Solutions:

- Repair the damages of die cavity surfaces, and improve the roughness;
- Make sure the hardness of dies(HRC45-48), and adjust the draft angles;
- Optimize the ejection mechanism to ensure balanced ejection;
- Choose high quality mold release agents;
- Control molten alloy temperature and die temperature;
- Adjust Fe element content;
- Adjust the direction of ingate to avoid molten alloy impacts the die cores;

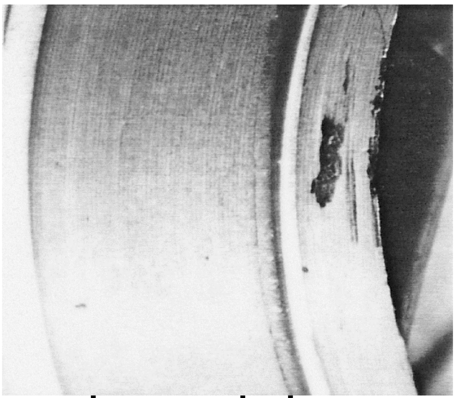
Impact of Internal Defects

- Mechanical properties include:
  - Tensile strength, elongation, hardness, impact strength and others
- Measured on samples; results are published to help designers pick best suited material
- Internal defects reduce mechanical properties

Impact of Internal Defects

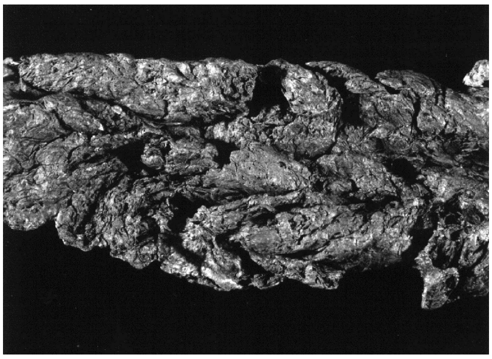
- Pressure tightness
  - An important property for some applications
  - The process has to be controlled while making solid, low porosity castings
  - Internal defects can cause loss of pressure tightness/leaks
- Machineability
  - Affected by porosity and inclusion defects, the two types of internal defects

Internal Defects: Inclusions



- Most inclusions are non-metallic aluminum oxide (corundum)
- Oxides get into the bath
- Most is removed, but some remains and ends up in castings
- Size and shape of the individual corundum particles varies widely

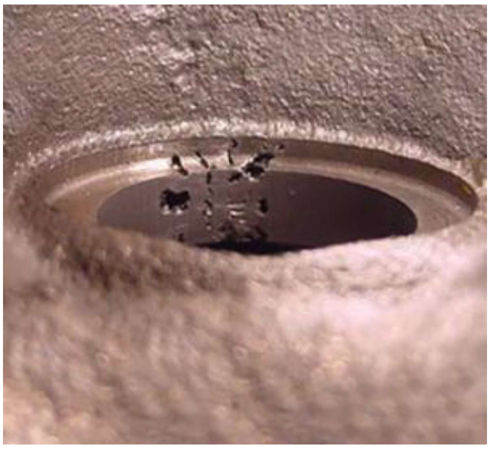
Internal Defects: Inclusions-Oxide Films and Dross



- Inclusions of oxide films and dross are major cause for leakers and excessive tool wear
- This is generally gamma aluminum oxide
- Oxide films prevent divergent alloy steams knitting together properly as the cavity fills

Gas Porosities

- Gas porosities appear in the body of the die casting parts, round or oval, with smooth surface and bright white or bright yellow color. The machined surface can be identified by visual inspection after machining, and the non-machined surface needs to be identified by X-ray detection.



Causes

A: Released hydrogen from molten metal alloy

The higher the smelting temperature, the higher the solubility of hydrogen in molten metal alloy. With the cooling and solidification of the die casting, the solubility of hydrogen decreases and is released from the molten metal to form the gas porosities. Sources of hydrogen:

- Moisture in the air enters the molten metal alloy and decomposes into hydrogen;
- Moisture, greases on metal alloy ingot enter the molten metal alloy and decomposes into hydrogen;
- Moisture on smelting tools enters the molten metal alloy and decomposes into hydrogen;

B: Involved gases during molten metal alloy filling

In die casting process, the molten metal alloy is filled into dies with high pressure and high speed, if the alloy liquid can't flow orderly and stably, it is easy to cause turbulences and gets gases involved. Turbulences are caused by:

- Unreasonable designing of venting launders or overflow launders;
- Blind areas in gating system;
- Unreasonable die casting parameters and injection speed;

C: Gases from mold release agents

- Mold release agents decompose and produce gases when get heated by molten metal alloy. Or too much use of mold release agents causes gas volatilization.

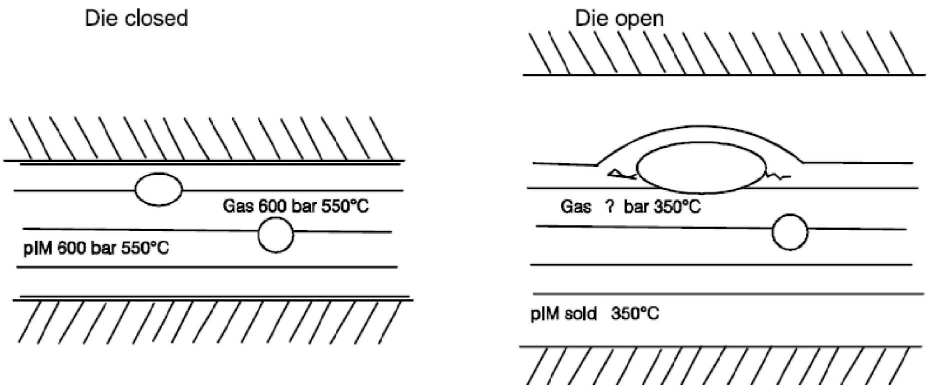
Solutions

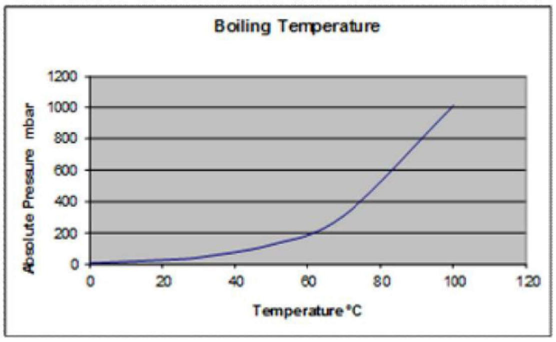
- Make sure metal alloy ingots dry and clean;
- Control smelting temperature in case of overheating, and do degassing treatment to molten metal alloy;
- Chose reasonable die casting parameters, especially the injection speed;
- In order to molten alloy flows stably and gases discharge easily, make sure sufficient length of sprue and runner (>50mm);
- Use mold flow analysis software, set up venting launders and overflow launders at the positons that may form gas porosities;
- Chose high quality mold release agent and control spraying quantity;

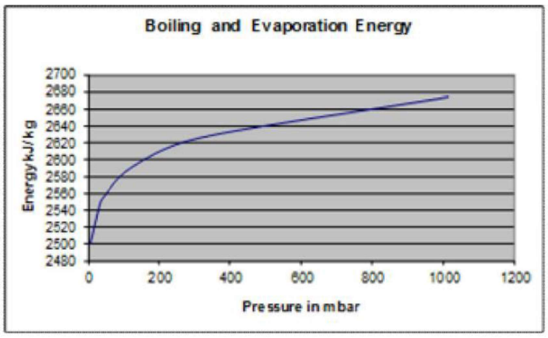
Internal Defects: Porosity-Trapped Gas

- Excessive lubricants: can result in gas from two sources
  - Release of combustion products when some of the die lube burns when the alloy hits
  - Most releases are diluted with water
  - Water in lube will turn to steam and produce a great volume of gas
  - Gas forms when alloy runs over puddled plunger tip lube

With the increased pressure in the die the air gas mixture is absorbed into the atomized alloy. The oxygen contained in the gas combines with the alloy to Al_2O_3 (aluminium oxide), the remaining gas appears in the shape of **micro porosity**. Conglomerates of gas result in visible porosity and with larger porosity directly under the surface blisters are formed.







Even if the die temperature exceeds the boiling point of water, residual moisture may remain in the die.

The boiling point is reduced by the vacuuming, however, the energy required for evaporation only changes very slightly.

Flow Marks

- On the surface of the die-casting part, there are stripes in the same direction as the flow of the metal liquid, and there are clearly visible non-directional lines that are different from the color of the casting base. These stripes and lines have no tendency to extend. Flow Marks can be identified by visual inspection.

Causes:

- The liquid metal that first enters the cavity forms a thin and incomplete metal layer, and the incomplete parts are filled with the liquid metal that enters later, thereby leaving traces.
- Die temperature is too low;
- The cross-sectional area of the ingate is too small and improperly positioned, causing molten metal to splash during filling;
- Insufficient filling pressure on the molten metal;
- Too much mold release agent and lubricant;

Possible Solutions:

- Increase die temperature;
- Adjust the position and cross-sectional area of the ingate;
- Adjust the injection speed and pressure of molten metal in the runner;
- Choose suitable mold release agent and lubricant, adjust the amount as well;

Cold Flow

- On the surface of die-casting parts, there are obvious, irregular, and depressed linear lines. These lines are small and narrow, and the edges of the junction are smooth, which may extend if with external forces. Cold flow can be identified by visual inspection.

Causes

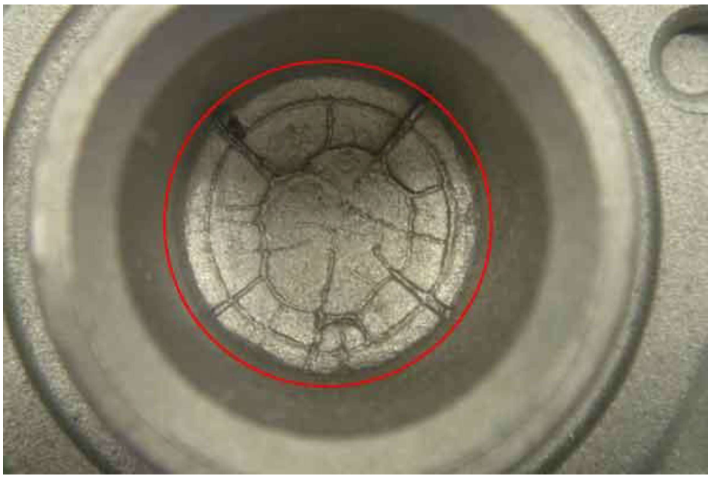
- Two streams of metal liquid butt together, not fully fused;
- Moten metal temperature or die temperature is too low;
- Fluidity of metal alloy is poor;
- The design of gating system is unreasonable, resulting in long flow distance of molten metal.
- Injection speed or injection pressure is too low;
- Metal liquid does not flow smoothly in the die cavity;

Possible Solutions

- Properly increase pouring temperature and die temperature;
- Increase injection pressure, and shorten filling time;
- Increase injection speed, as well as the cross-sectional area of the ingate;
- Improve venting condition of die cavity;
- Choose proper metal alloy to improve the fluidity;
- Ensure metal liquid flowing smoothly in the die cavity;

Turtle Cracks/Network Cracks

- There are net-like, hair-like protrusions or depressions on the surface of the die-casting. With the increase of die-casting times, these protrusions or depressions expand and extends continuously. Turtle cracks can be identified by visual inspection.



Causes

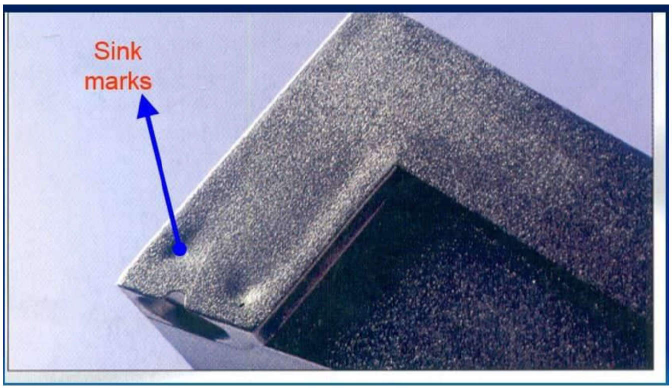
- Turtle cracks occurs on the surface of die cavity;
- Improper material of die casting mold, or improper heat treatment process;
- The temperature difference of the die-casting mold changes drastically in a very short time;
- Filling temperature is too high;
- Preheating of die casting mold is insufficient or uneven;
- The die cavity is rough;

Possible Solutions:

- Choose proper material of die casting mold and heat treatment process;
- The filling temperature should not be too high, especially for high melting point alloys. Under the premise of not affecting the quality of die castings, adopt the lower filling temperature as possible;
- Preheating of die casting mold must be sufficient and even;
- After reaching a certain service life, the die must be annealed to eliminate internal stress;
- The surface of the gating system and the die cavity is regularly polished to ensure good roughness;
- Choose proper cooling method to ensure thermal balance of die cavity;

Sinks

- In thick-walled areas, there are depressions on the surface of die casting parts. This defect can be identified by visual inspection.



Causes:

- The uneven wall thickness of the casting results in uneven shrinkage during solidification.
- The die is partially overheated, and the casting solidifies slowly in the overheated area;
- The injection pressure is too low;
- Due to the poor venting performance of die cavity, the gas is compressed between the cavity surface and the metal liquid surface;
- Short pressure-holding time results in poor feeding effect;

Possible Solutions:

- Optimize casting structural design to avoid uneven wall thickness;
- Avoid partial overheating of die cavity;
- Increase injection pressure;
- Improve venting performance of die cavity;
- Prolong the pressure-holding time;

Short Filling

- Some material is missing in partial area of the casting surface. This defect can be identified by visual inspection.

Causes:

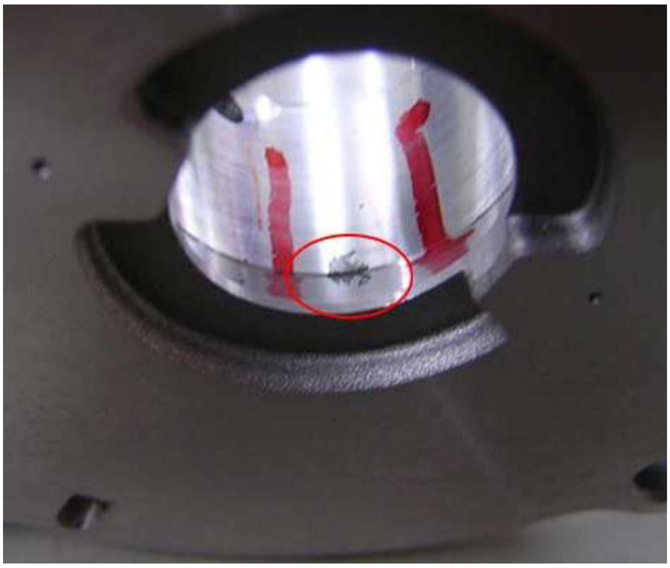
- Poor fluidity of molten metal alloy caused by:
- Metal liquid involves gases, inclusions, or contains too much Fe element;
- Filling temperature is too low, or die temperature is too low;
- Poor filling condition caused by:
- Injection pressure is too low;
- Too much gases involving results in high back pressure in the die cavity, and high back pressure hinders the filling process eventually;
- Using too much mold release agent or lubricant leads to too much gas release in the die cavity;

Solutions:

- Choose proper metal alloy and improve the quality;
- Increase filling temperature or die temperature;
- Increase injection pressure and speed;
- Improve the design of gating system and the flow diversion of metal liquid, add overflow launders and venting launders in the short filling areas;
- Choose proper mold release agent and lubricant, and control the using amount;

Inclusions

- Irregular-shaped holes are on the surface or inside of the casting, with inclusions inside. Inclusions on the surface of casting can be identified by visual inspection, while inclusions inside the casting must be identified by UT or X-Ray.



Causes:

- Purity of furnace charge is low;
- Metal alloy liquid is not purified properly, or slags are not removed thoroughly;
- Metal alloy liquid is polluted by garbage when ladling out;
- Die cavity is not cleaned up;
- Too much graphite inclusion in the mold release agent;

Possible Solutions

- Ensure the purity of furnace charge;
- Purify metal liquid properly, and thoroughly remove slags;
- Clean up the ladles, and prevent involving slags;
- Clean up die cavity;
- Graphite must be stirred and mixed evenly, if mold release agent contains graphite;

Principle:

- Since every defect may be caused by various factors, to solve defects in die casting production, you are strongly recommended to follow ‘easy things first’ principle as below:
  - Clean up parting surface, die cavity, ejection pins—improve the quality of mold release agent, improve spraying process—increase clamping force, increase molten metal amount. All of these simple actions may solve big problems.
  - Adjust die casting processing parameter, injection speed, injection pressure, injection time, pressure-holding time, die opening time, filling temperature, die temperature.
  - Change metal alloy ingots to high-quality ones—change the ratio of new material to recycled material—improve smelting process.
  - Repair the die—mending gating system—add ingates—add overflow launders—add venting launders.

"#1 make good decisions, #2 everything else."
-Rand Fishkin