

# **High Pressure Die Casting**

## **(Die Casting)**

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Die casting is characterized by a source of hydraulic energy that imparts high velocity to molten metal to provide rapid filling of a metal die. The die absorbs the stresses of injection, dissipates the heat contained in the metal, and facilitates the removal of the shaped part in preparation for the next cycle. The hydraulic energy is provided by a system that permits control of actuator position, velocity, and acceleration to optimize flow and force functions on the metal as it fills the cavity and solidifies.

The variety in die casting systems results from trade-offs in metal fluid flow, elimination of gas from the cavity, reactivity between the molten metal and the hydraulic system, and heat loss during injection.

The process varieties have many features in common with regard to die mechanical design, thermal control, and actuation. Four principal alloy families are commonly die cast: aluminium, zinc, magnesium, and copper-base alloys. Lead, tin, and, to a lesser extent, ferrous alloys can also be die cast. The two primary variations of the die casting process are the hot chamber process and the cold chamber process.

Some selected die casting alloys are given below:

**Al alloys:** A360, A380, A383, A384, B390, A413, 518

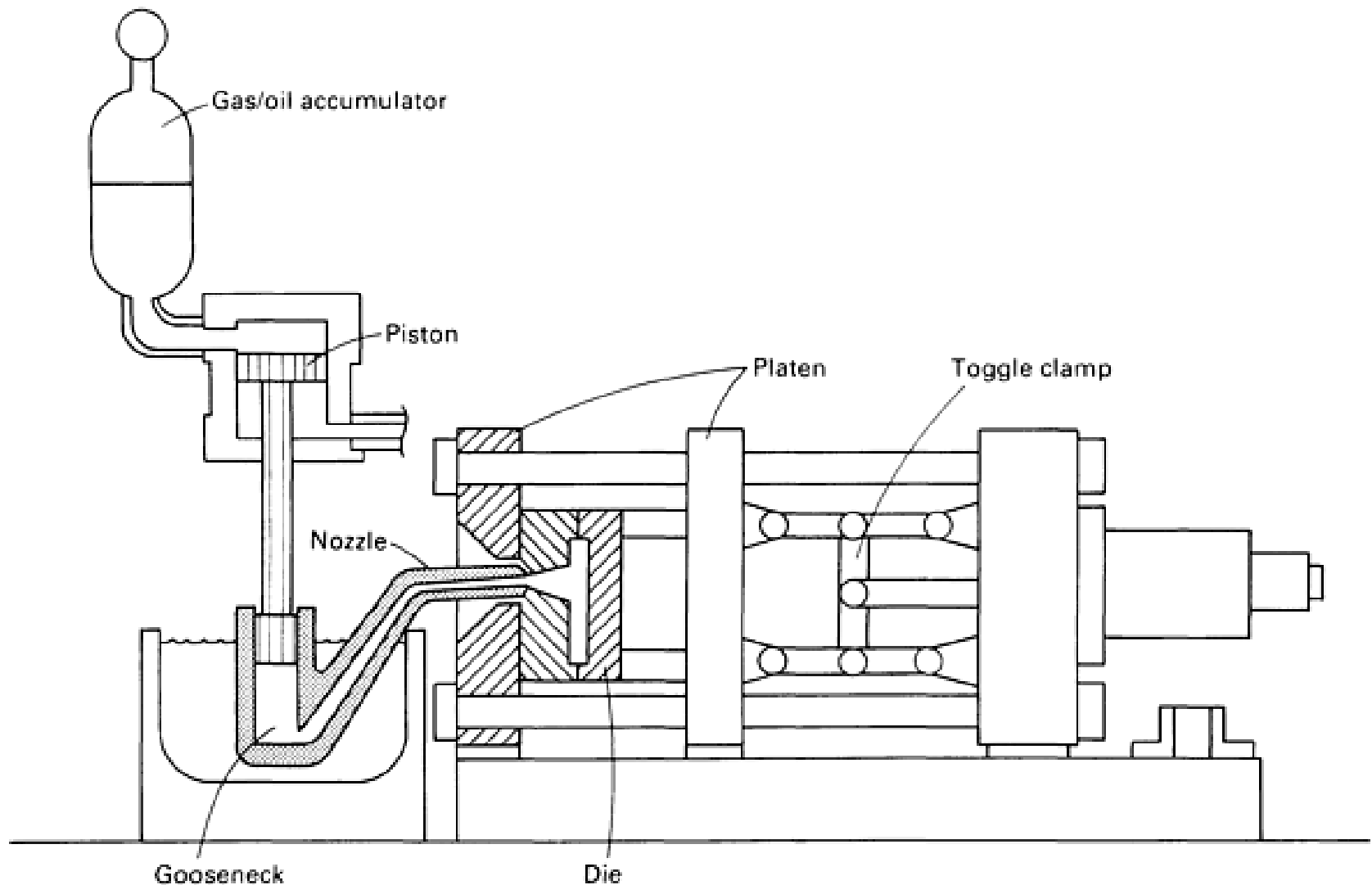
**Cu alloys:** C85800, C87900, C87800

**Mg alloys:** AZ91B, AM60A, AS41A

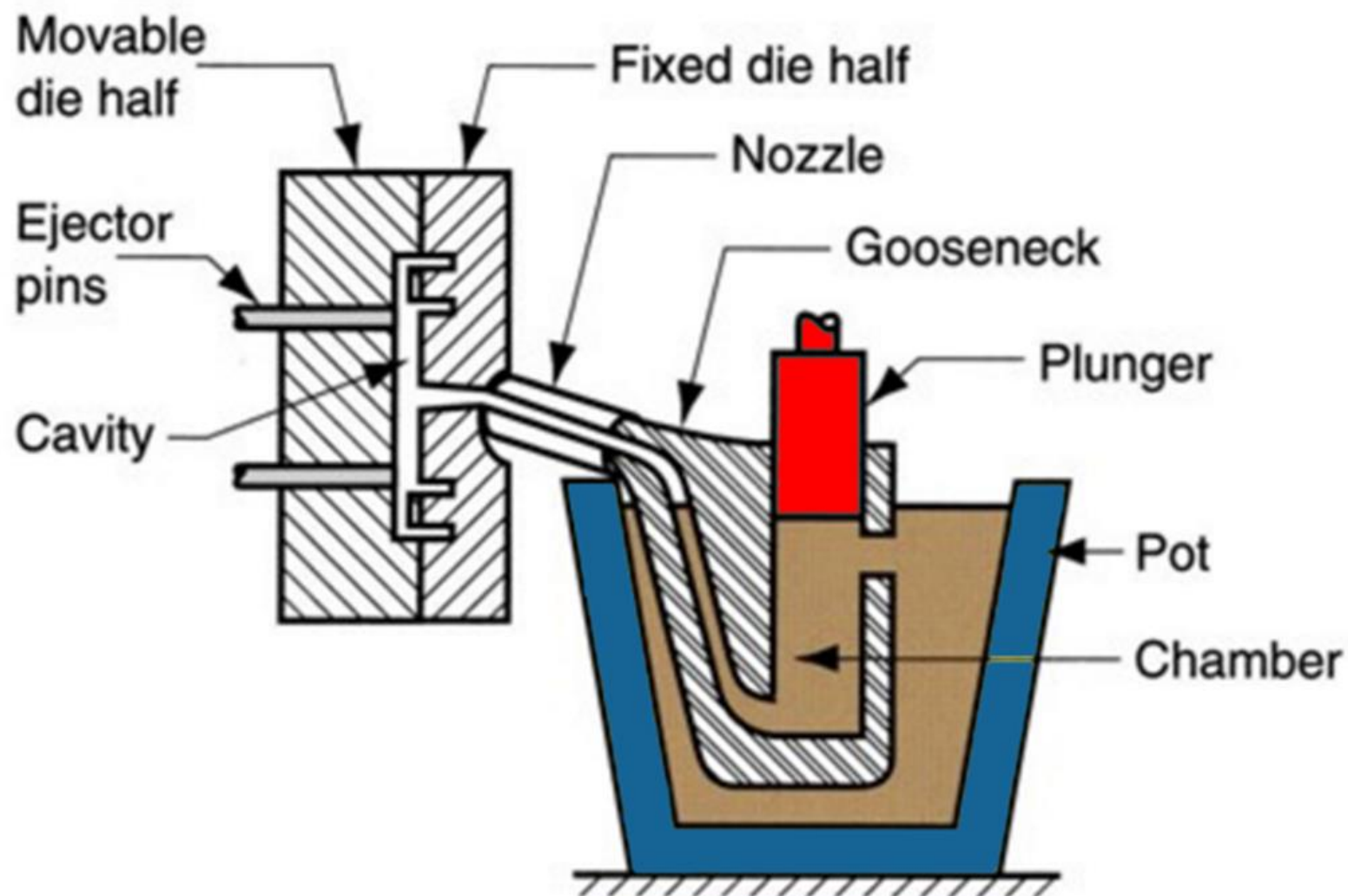
**Zn alloys:** AC40A, AG41A, Alloy 7, ILZRO 16, ZAMAK

## **The hot chamber process**

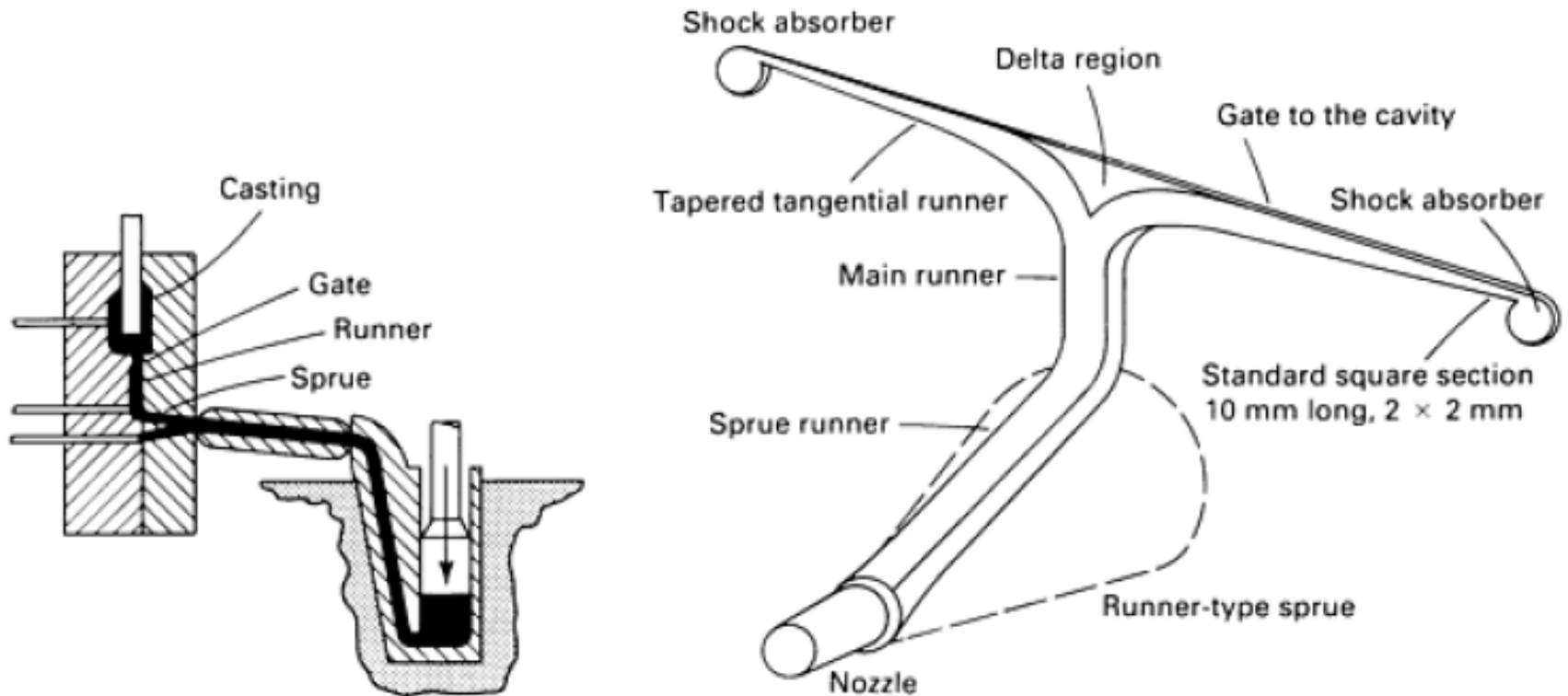
It is the original process invented by H.H. Doehler. It continues to be used for lower-melting materials (zinc, lead, tin, and, more recently, magnesium alloys). Hot chamber die casting places the hydraulic actuator in intimate contact with the molten metal. The hot chamber process minimizes exposure of the molten alloy to turbulence, oxidizing air, and heat loss during the transfer of the hydraulic energy. The prolonged close contact between molten metal and system components presents severe material problems in the production process.



Schematic showing the principal components of a hot chamber die casting machine





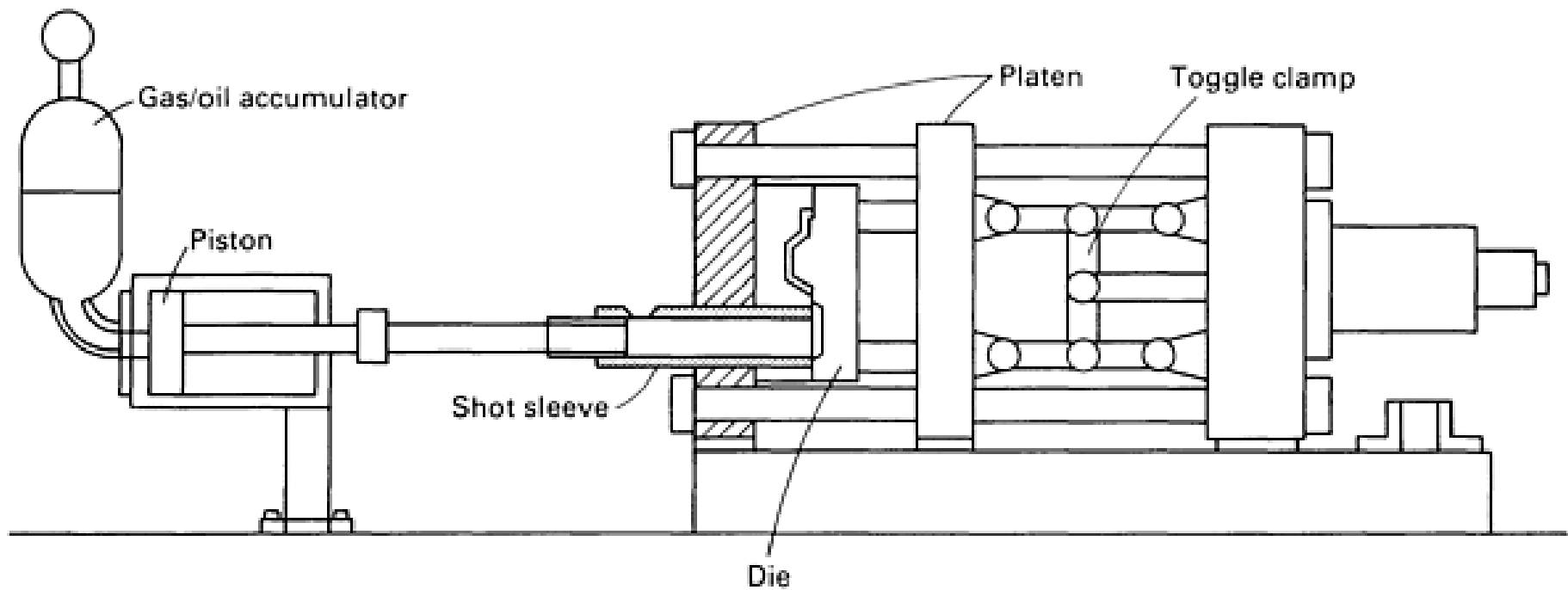


Schematics showing gating system hot chamber die casting machines

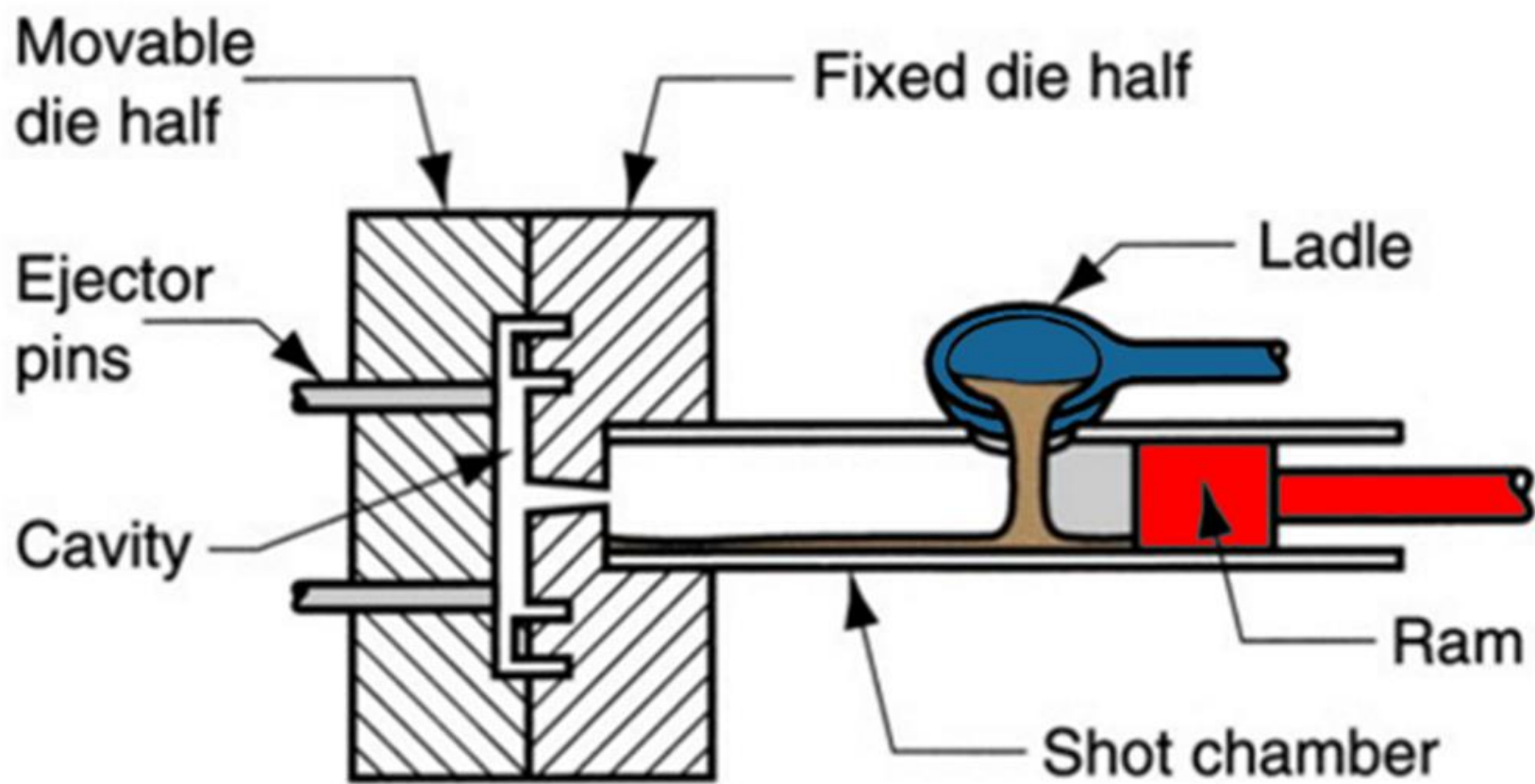


## **The cold chamber process**

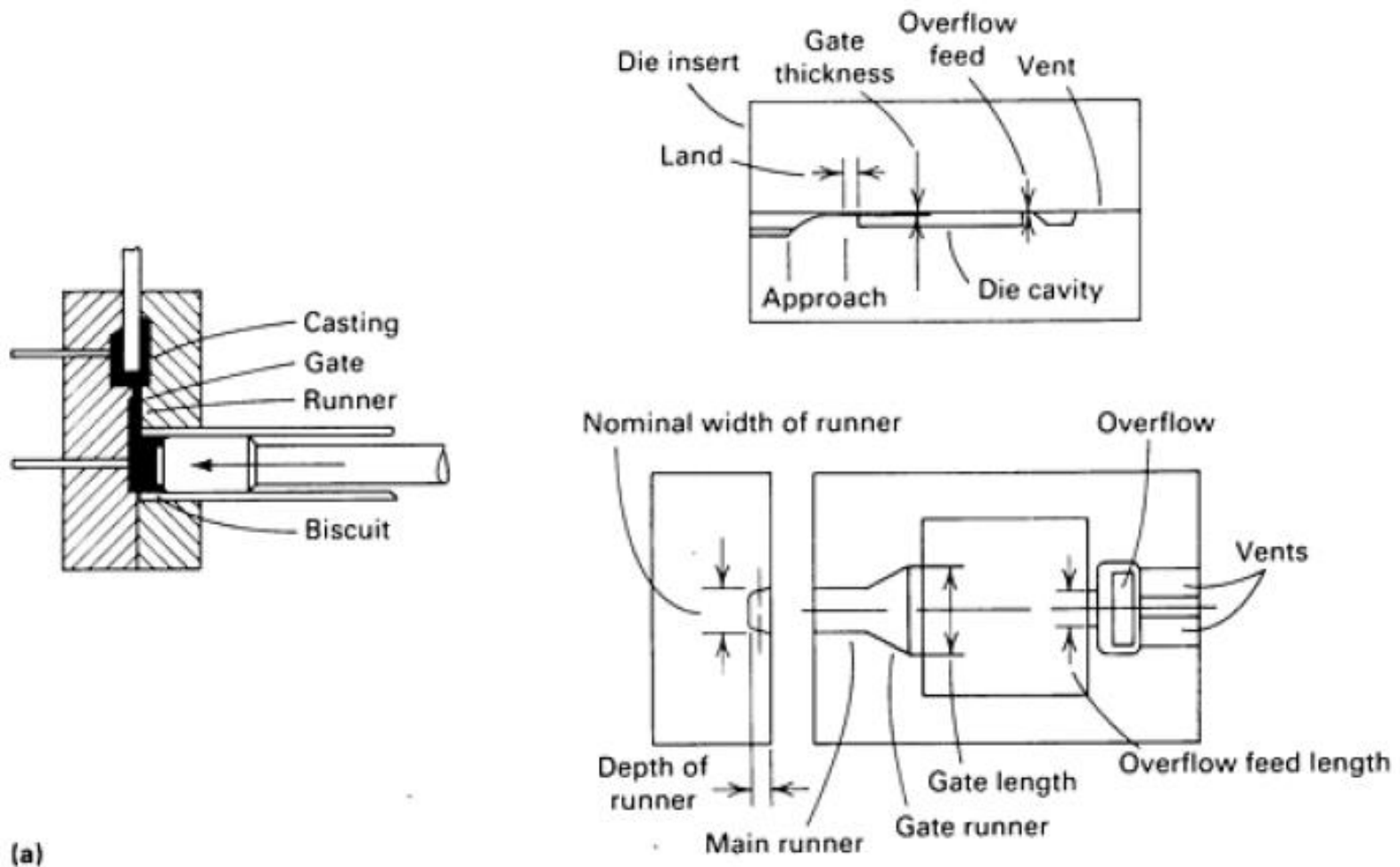
This process solves the materials problem by separating the molten metal reservoir from the actuator for most of the process cycle. Cold chamber die casting requires independent measuring of the metal and immediate injection into the die, exposing the hydraulic actuator for only a few seconds. This minimal exposure allows the casting of higher-temperature alloys such as aluminium, copper, and even some ferrous alloys. Also magnesium alloys can be cast with the cold chamber process.



Schematic showing the principal components of a cold chamber die casting machine

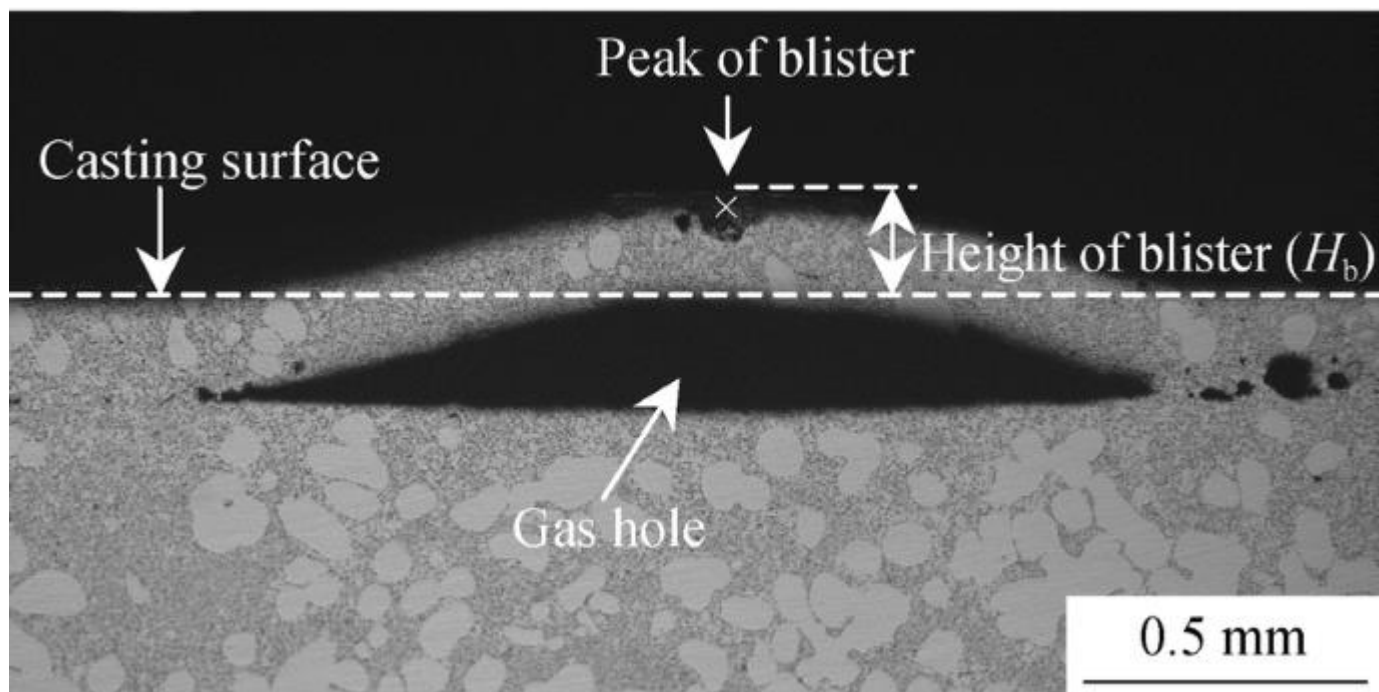






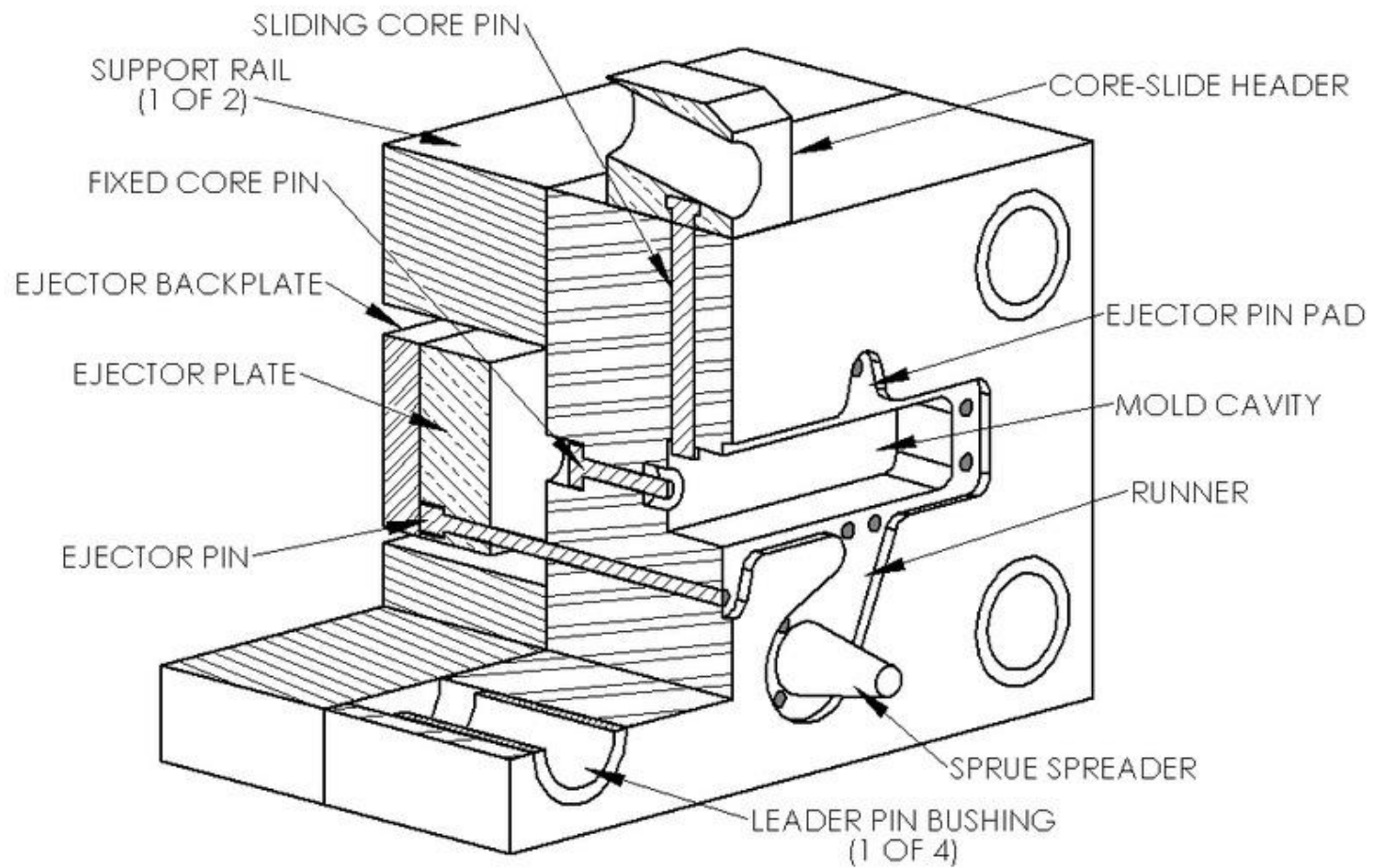
(a)

Schematics showing gating systems for cold chamber die casting machines



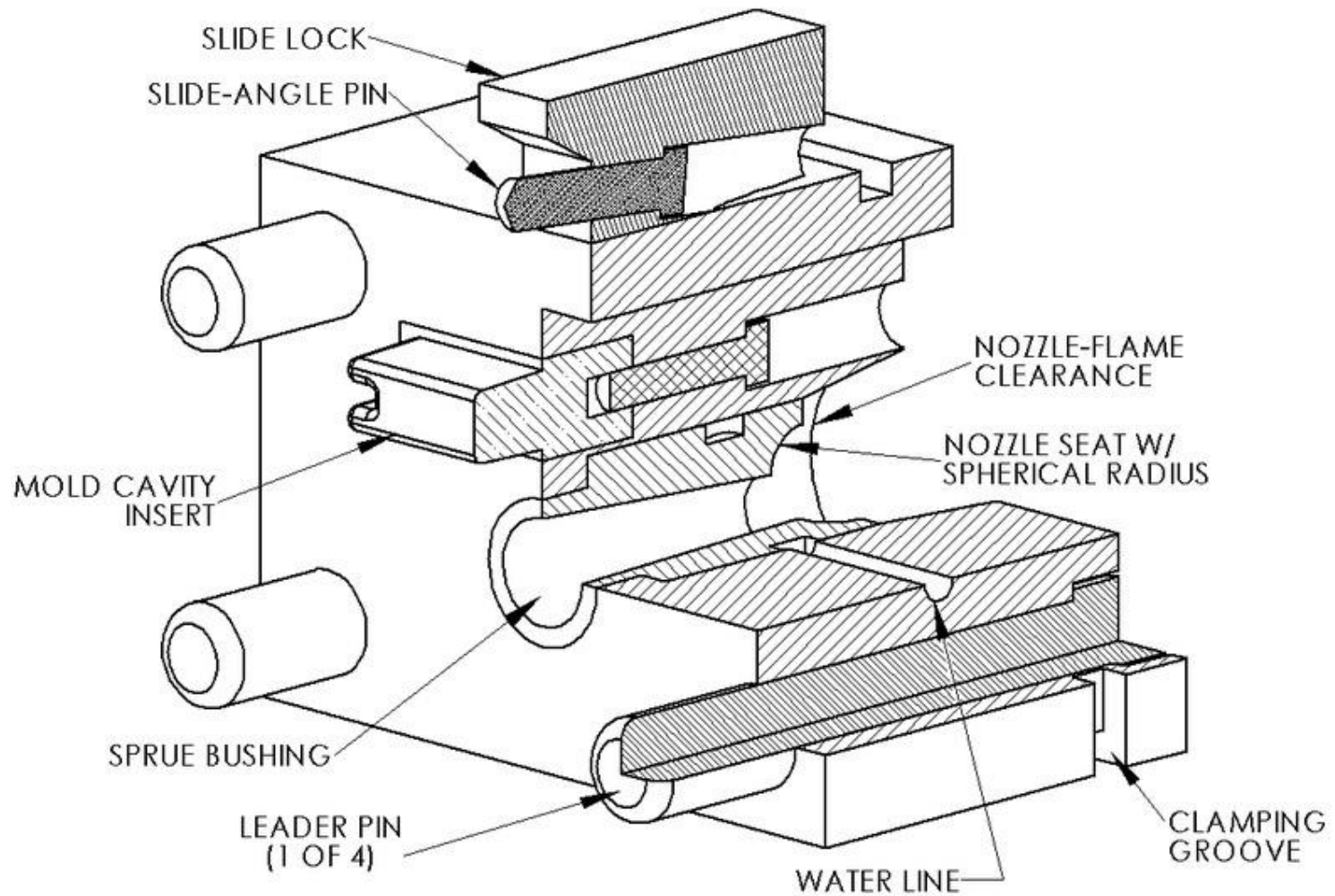
## **Product Design for the Process**

Product design and die design are intimately related. The principal features of a die casting die are illustrated in figures given below. The high-speed nature of the process allows the filling of thin-wall complex shapes at high rates (of the order of 100 parts per hour per cavity). This capability places additional demands on the casting designer because traditional feeding of solidification shrinkage is almost impossible. The inability to feed in the traditional sense demands that machining stock be kept to a minimum; high-integrity surfaces should be preserved.

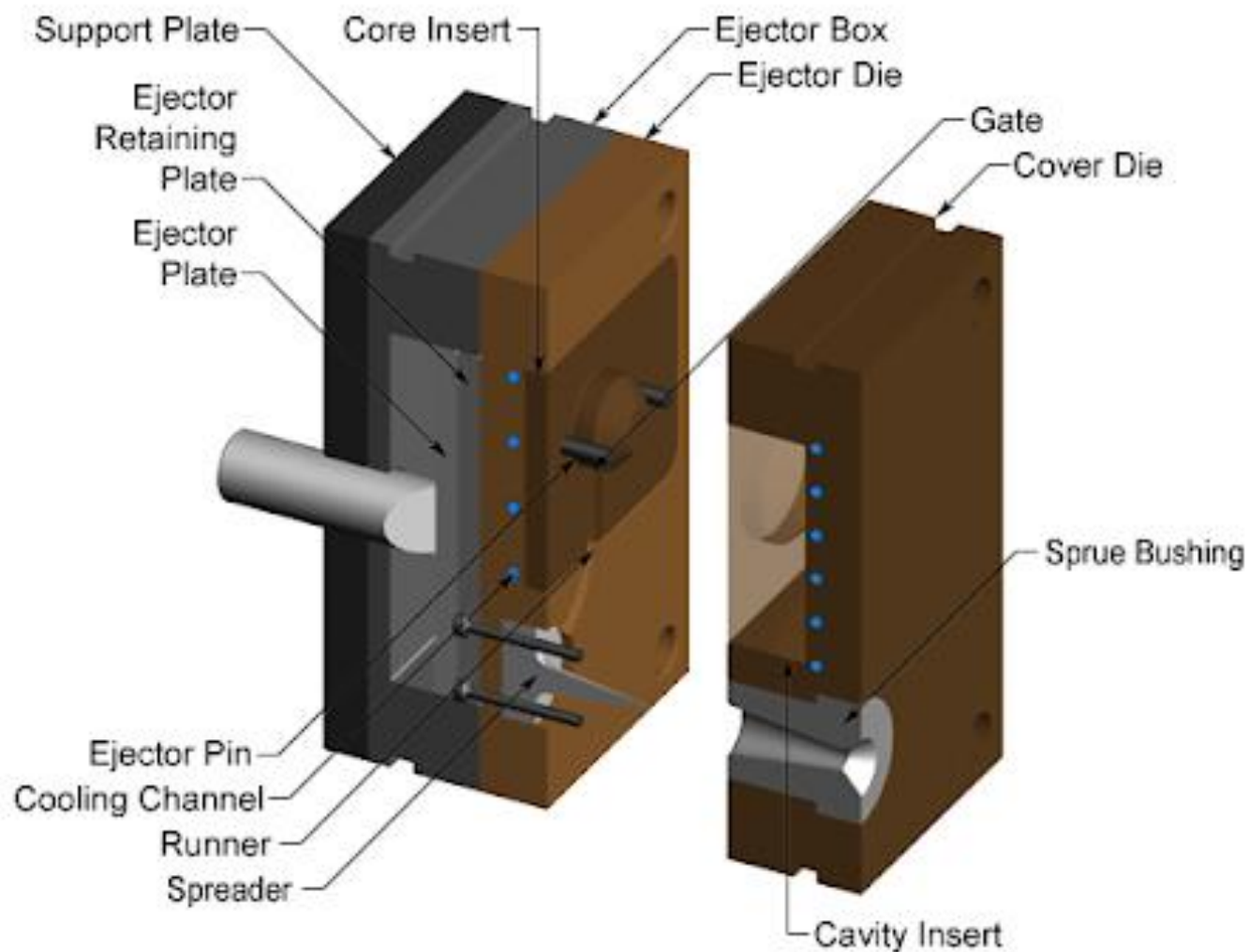


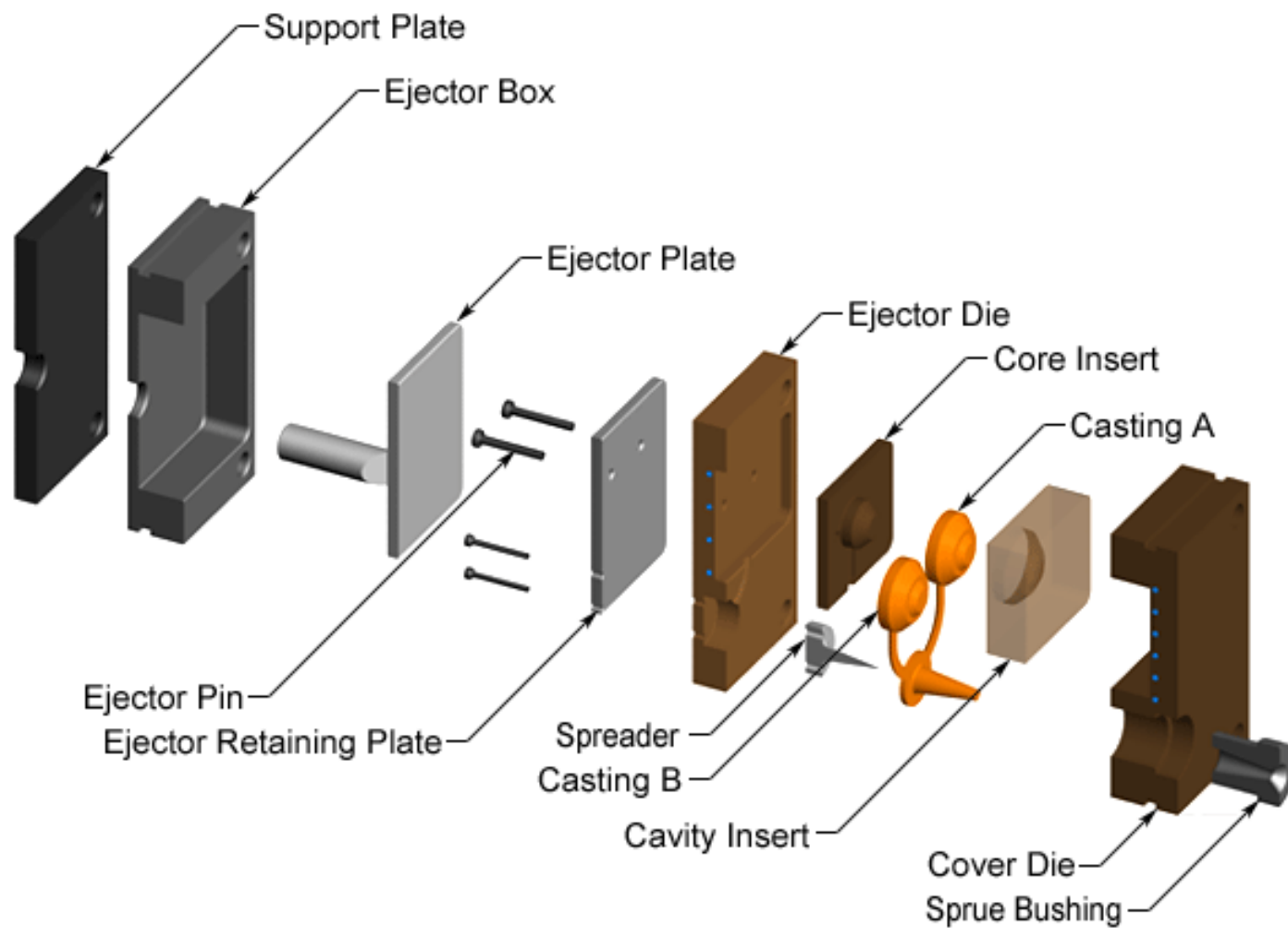
Ejector die half

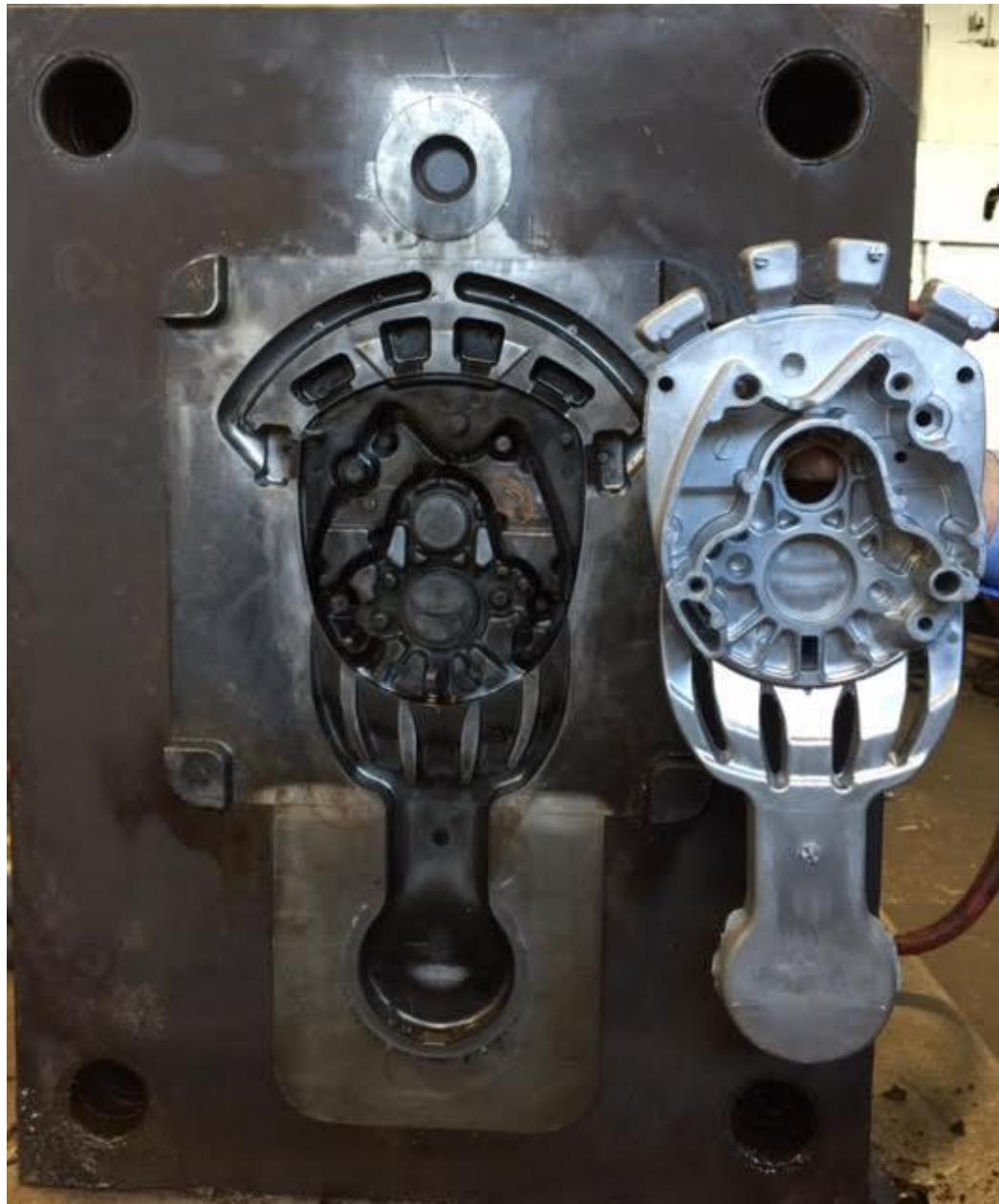


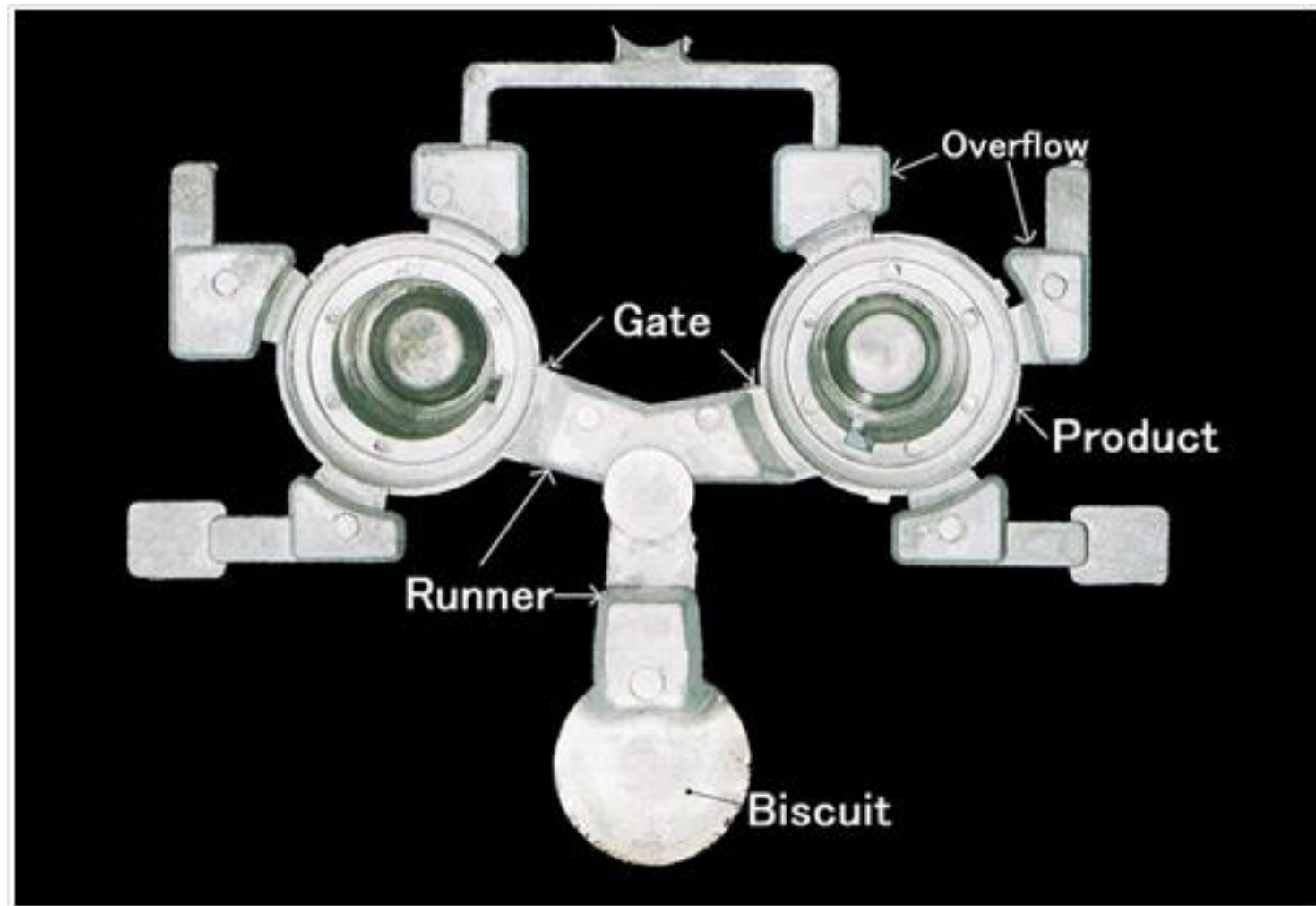


Cover die half



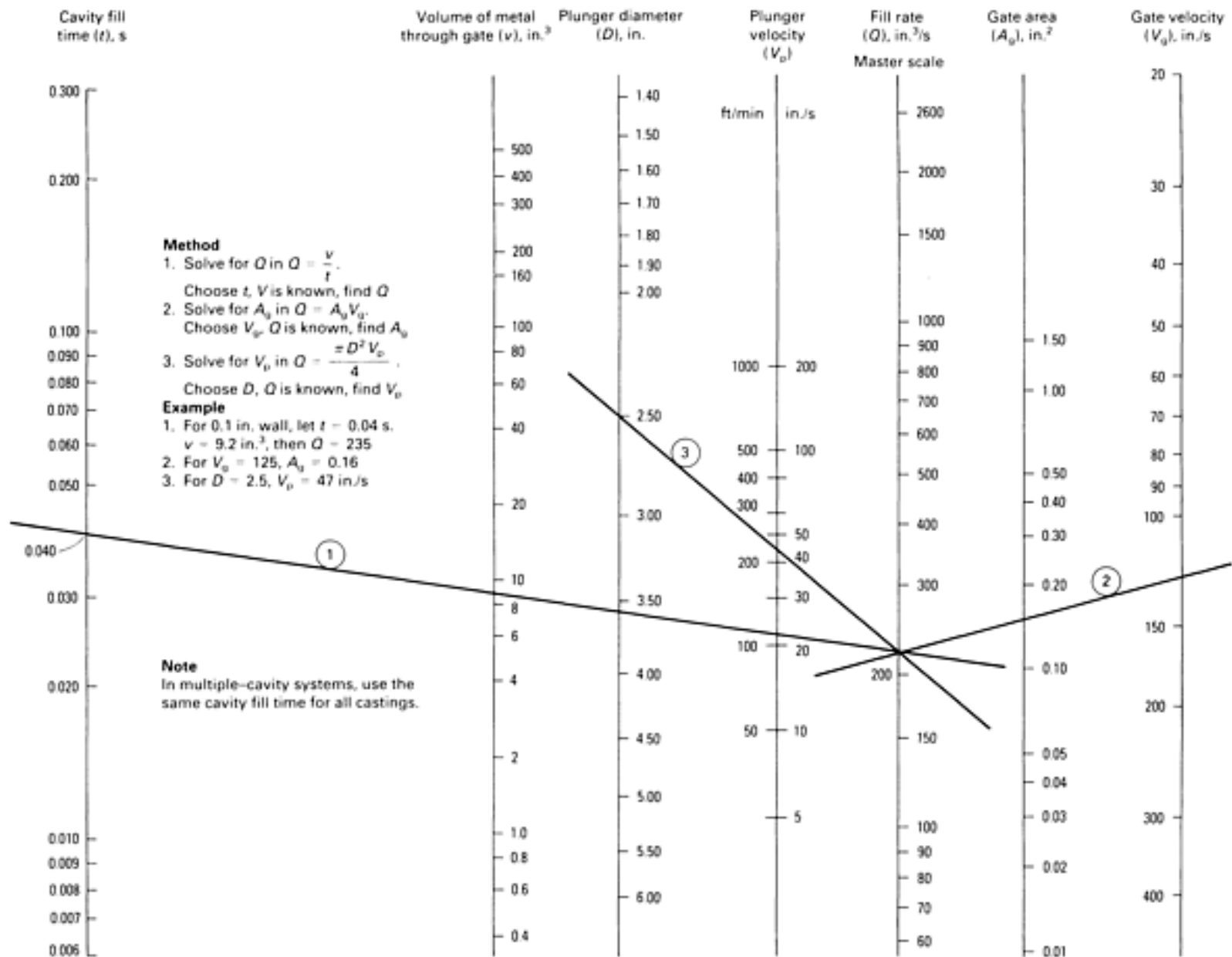






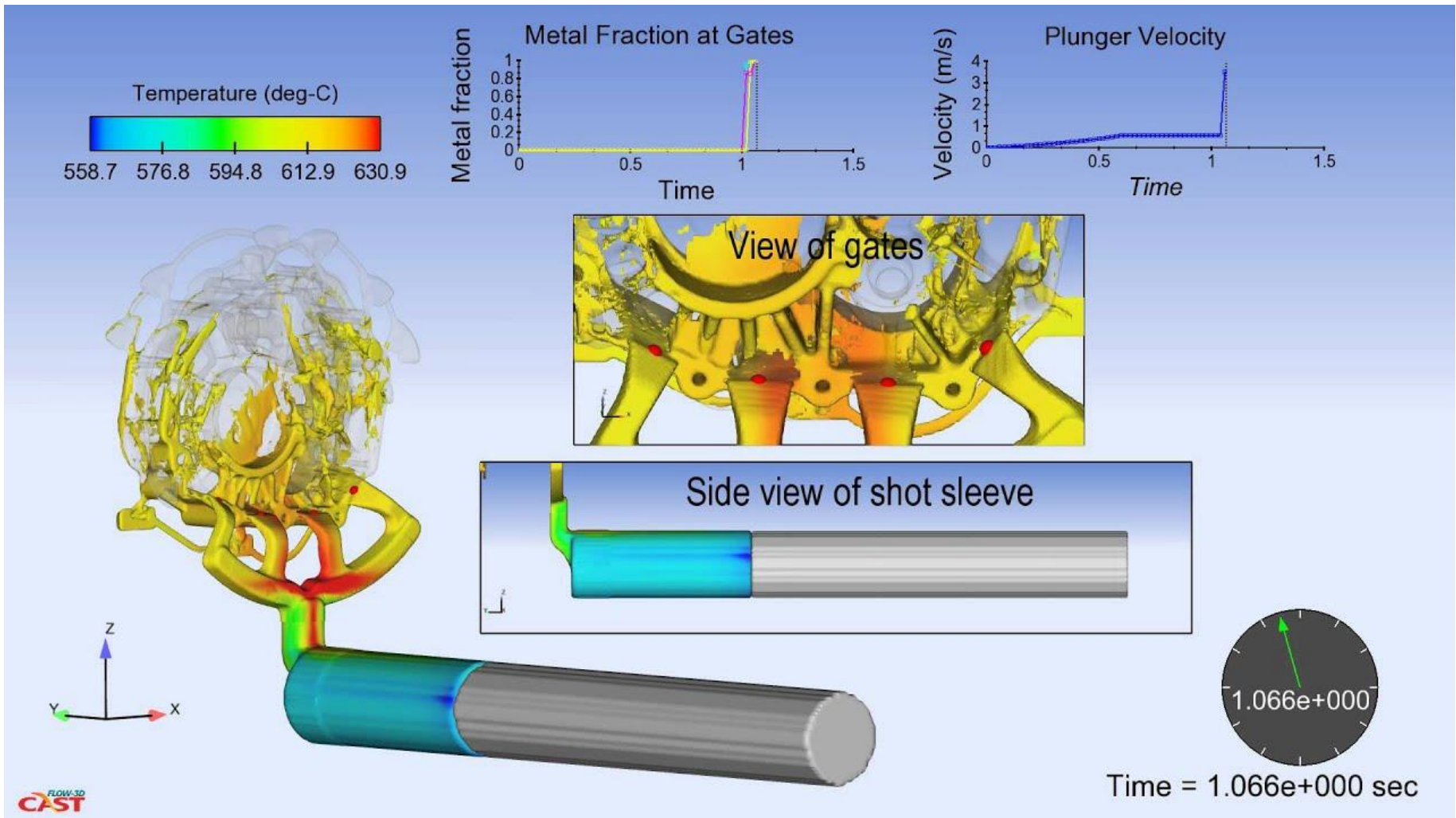
Since the invention of the die casting process, many die castings have been successfully made with gating systems designed by experience only. Each company has a reservoir of this closely guarded experience. Trial-and-error adjustments at the casting machine are frequently part of the learning. However, the decline of the presence of the artisan in the foundry is forcing a move toward analytically based gating design, but the analysis base is still tempered with the fine tuning of experience. This is especially true in gate location and local angle of entry, which are directly affected by part shape and secondary operations.

One of the first analysis methods was the ADCI/DCRF Nomograph which solves geometric relationships for the bulk flow design. The selection of a fill time for the casting is based on experience and experiment. The limited selection of plunger diameters for a given machine restricts the design. The cold chamber process links the volume of metal to plunger diameter by filling the shot sleeve about two-thirds full. The nomograph is used to develop a required volume fill rate  $Q$ .



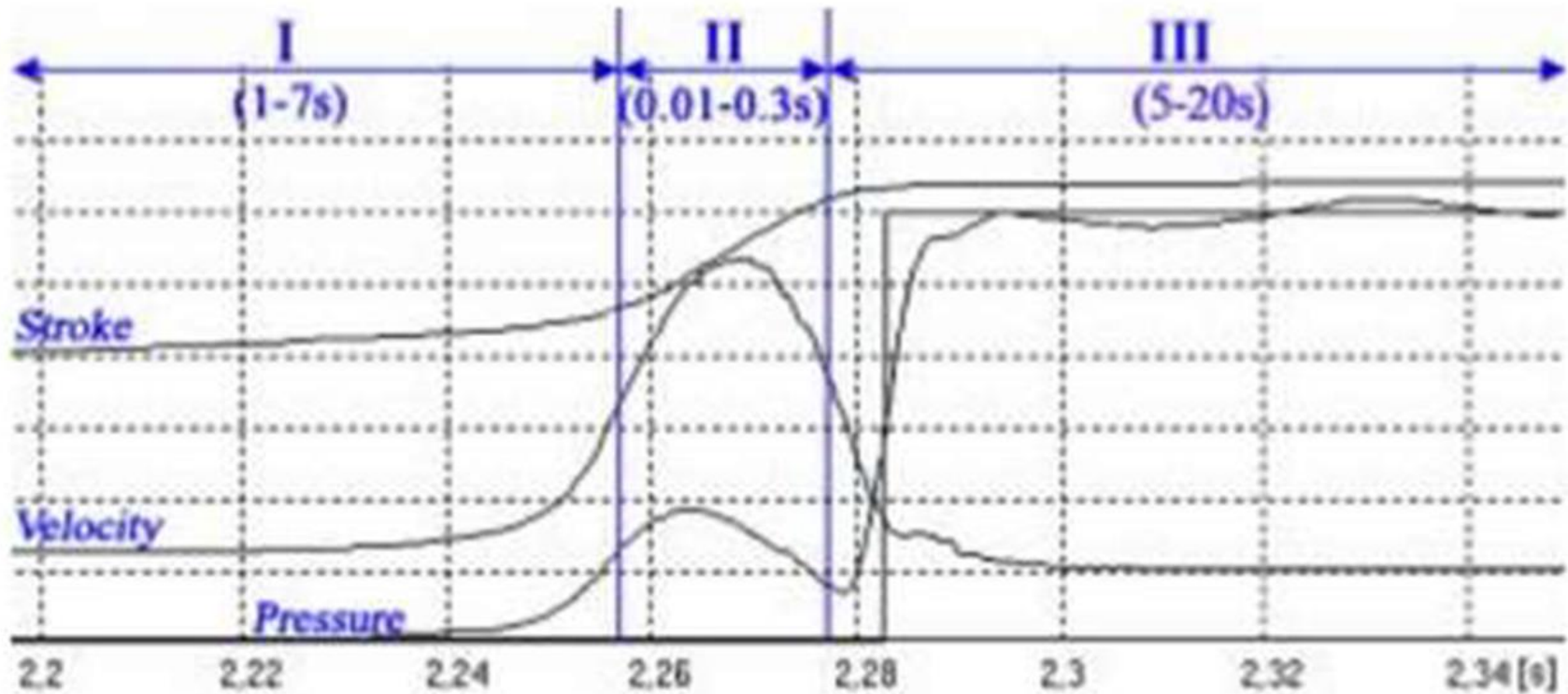
Nomograph used to determine the volume fill rate  $Q$  required for different casting process parameters

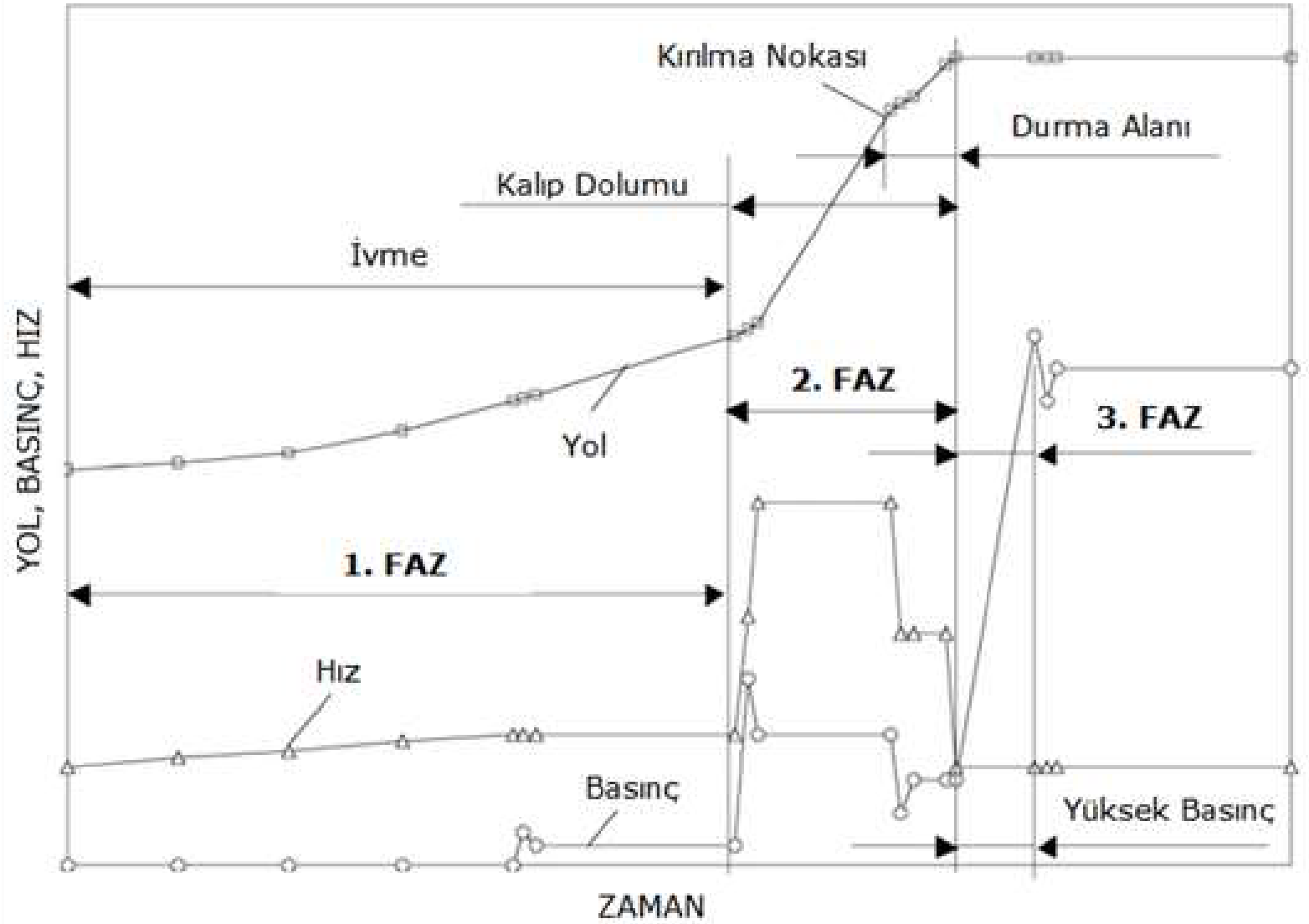




Casting simulation example for die casting

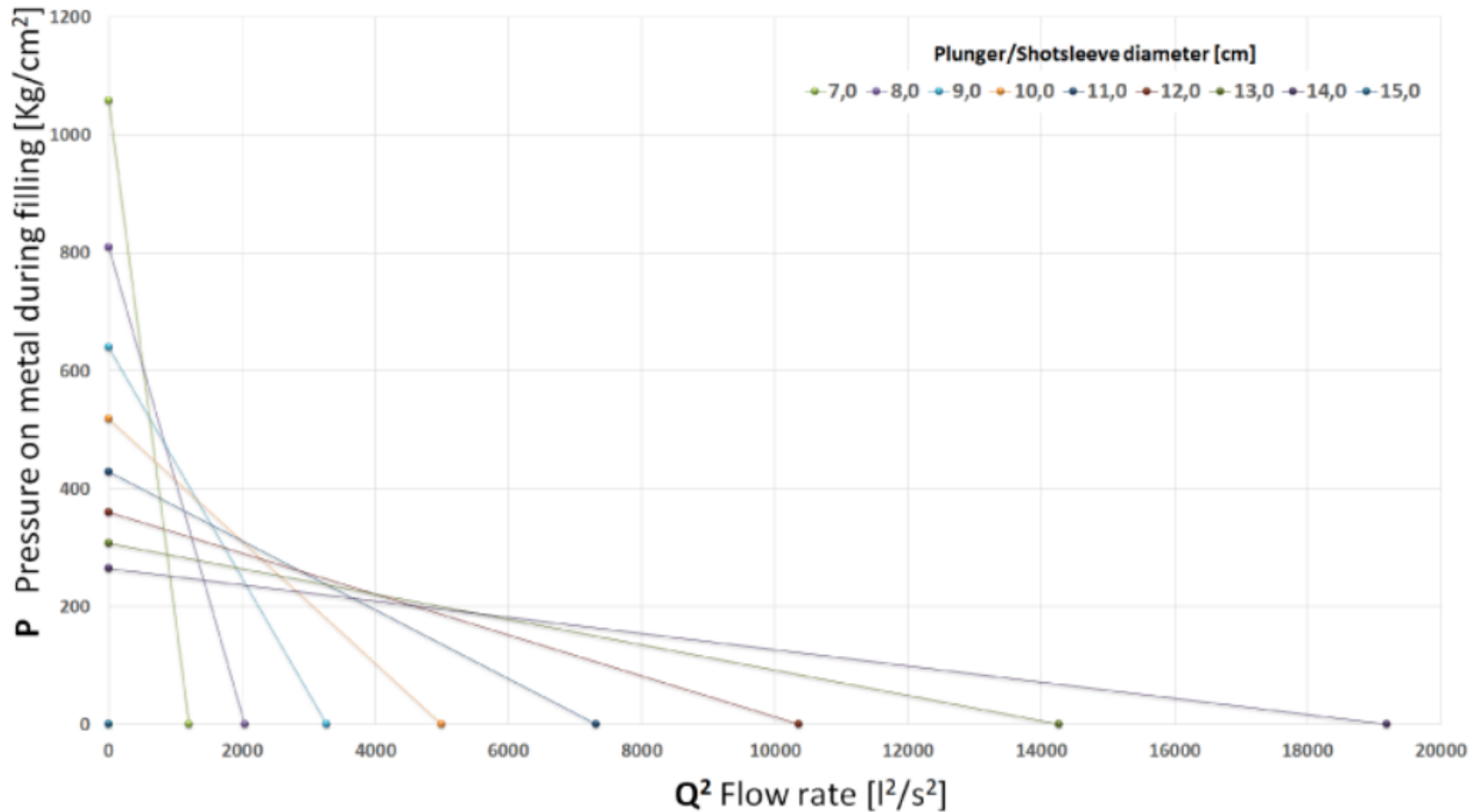
# Phases of Die Casting

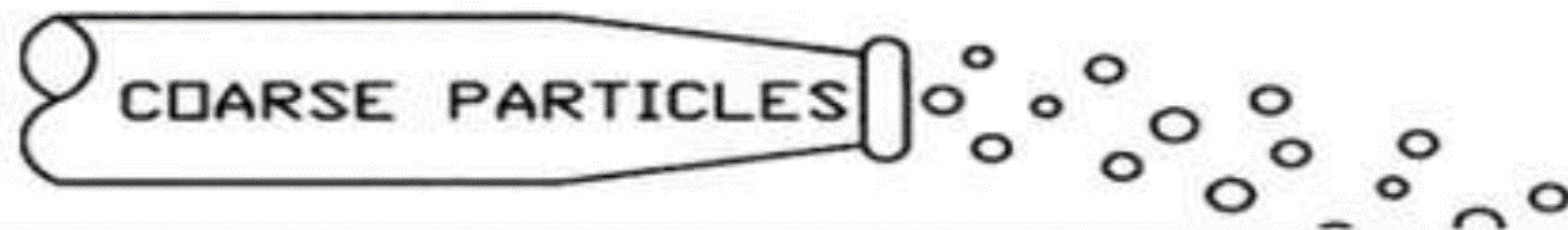
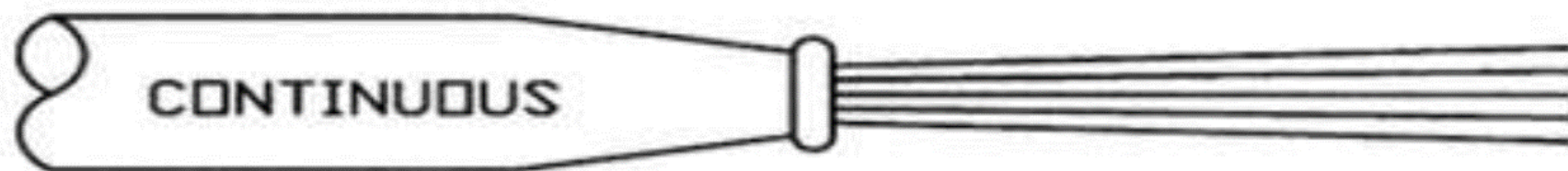
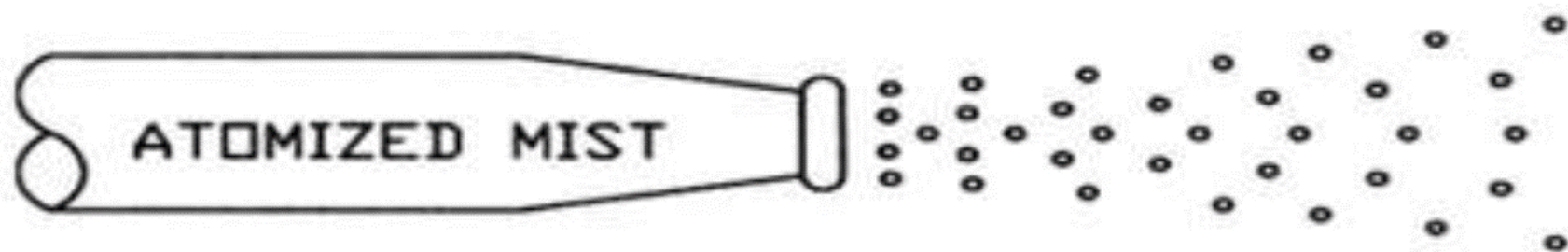


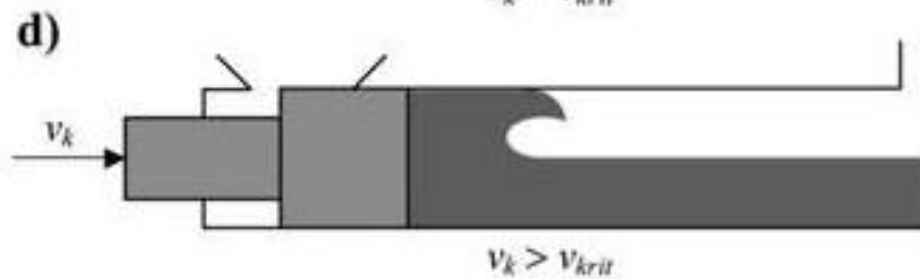
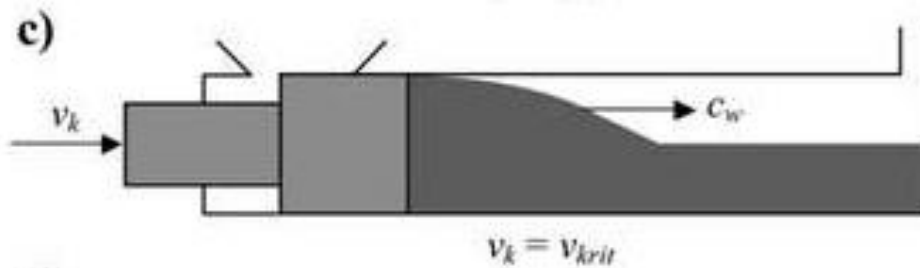
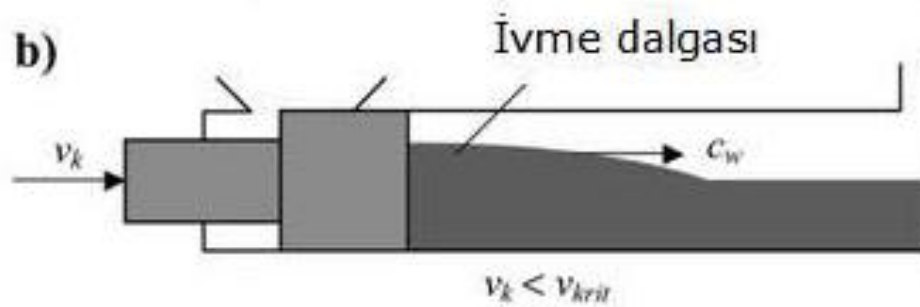
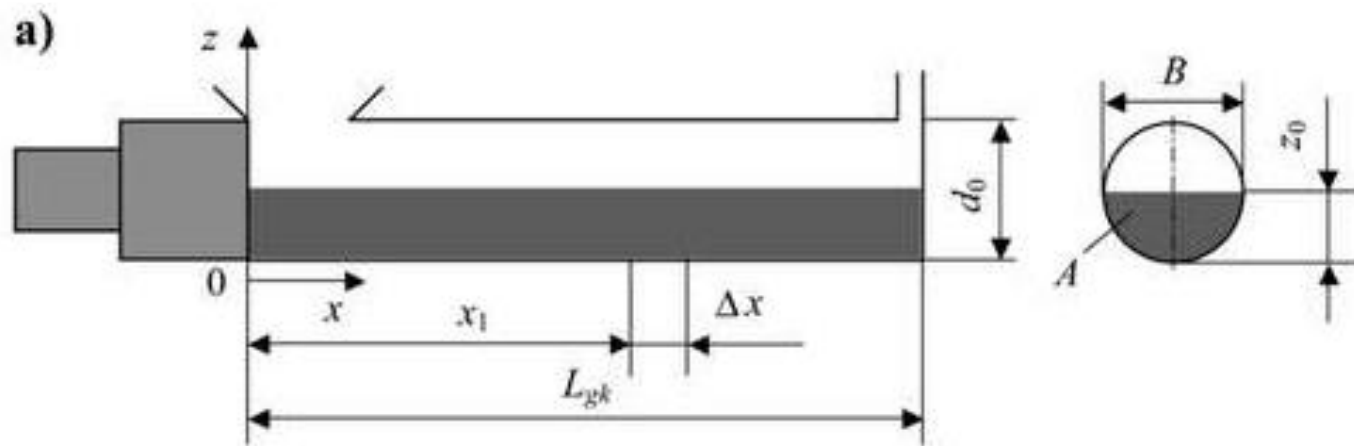


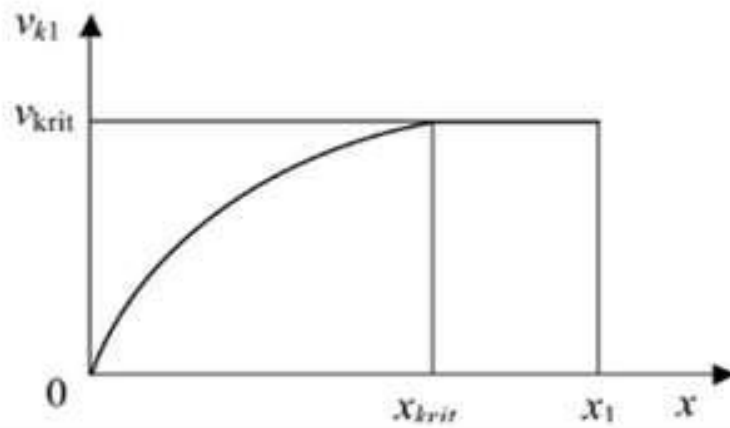
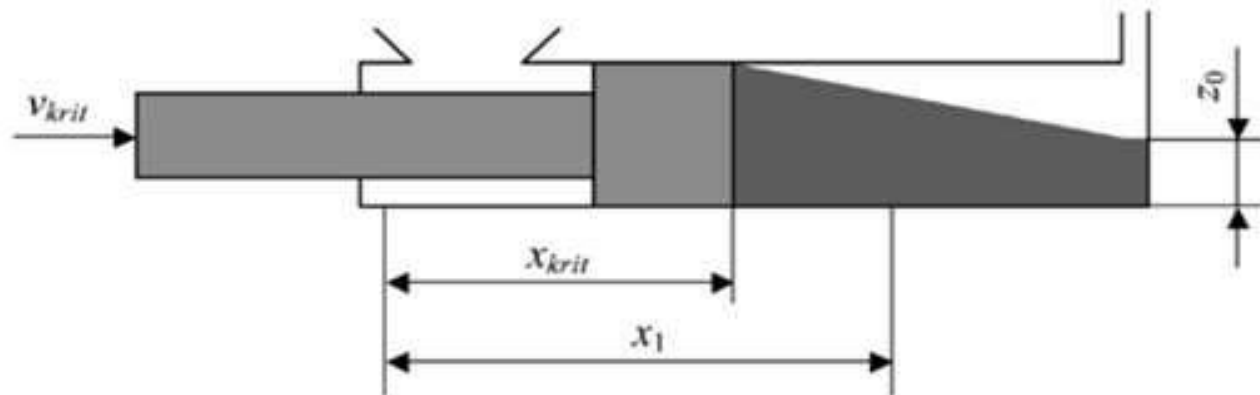
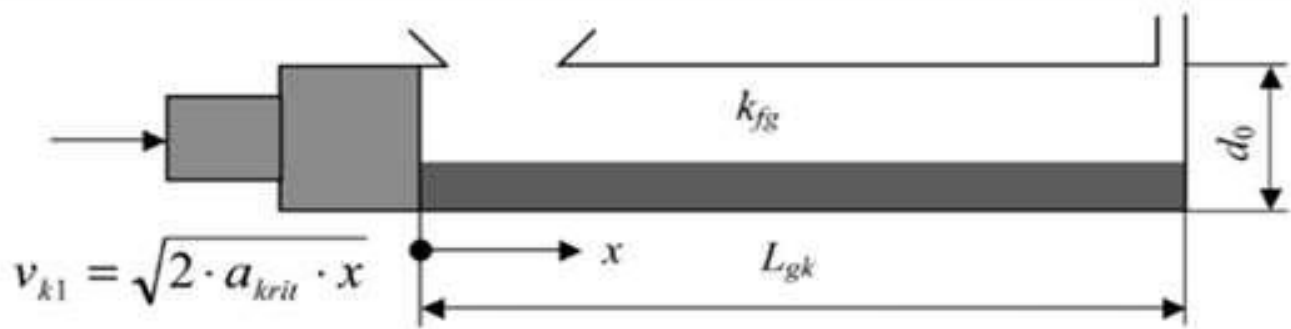
# P-Q<sup>2</sup> analysis

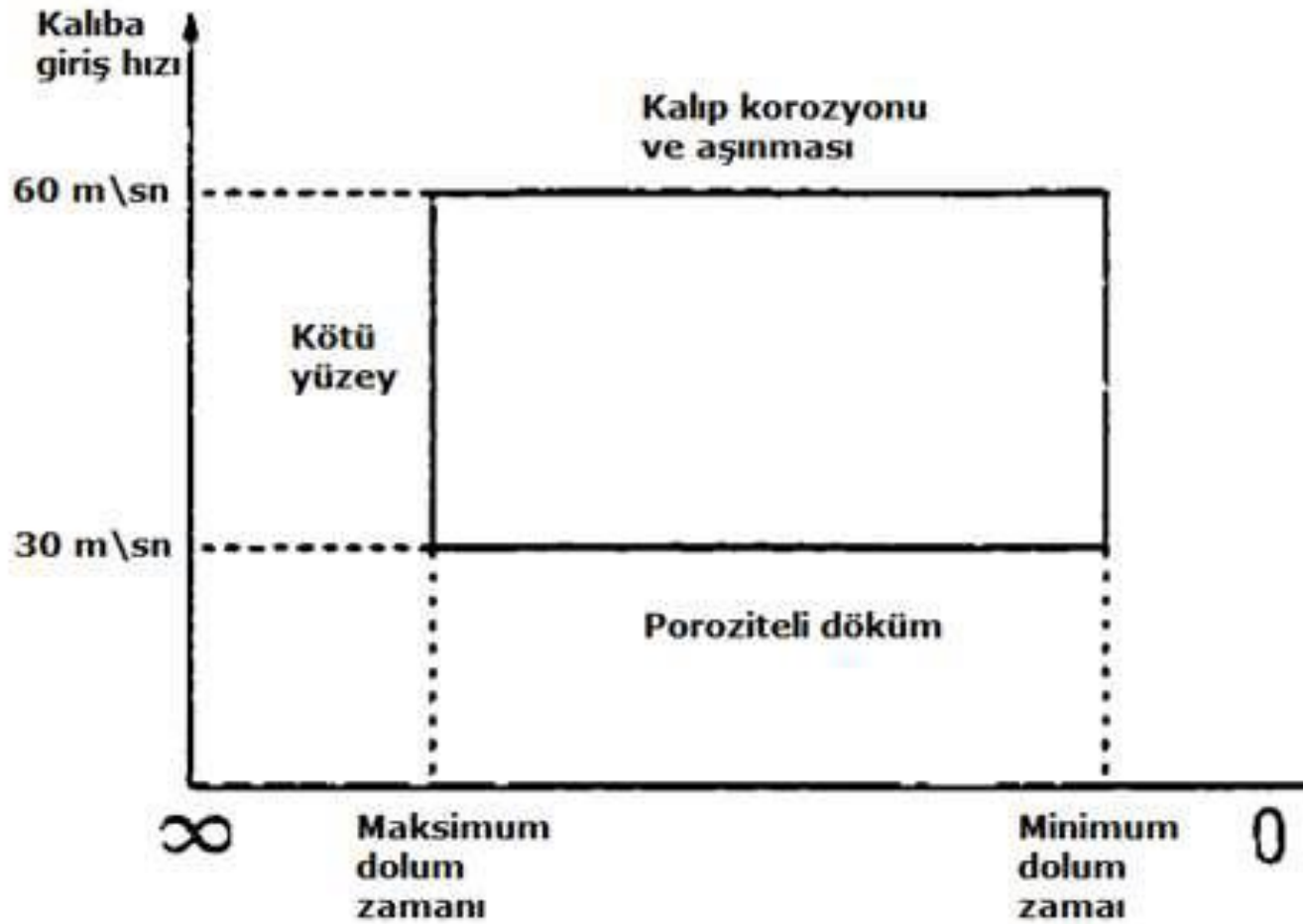
PQ<sup>2</sup> DIAGRAM of a HPDC PRESS











Velocity at the gate (m/s) =  $\frac{\text{Area of plunger} \times \text{plunger velocity}}{\text{Area of the gate}}$





## Video links

- <https://www.youtube.com/watch?v= LIrof0K0OQ>
- <https://www.youtube.com/watch?v=0JH2WEVruJc>
- <https://www.youtube.com/watch?v=9mN1HFyg3iM>
- <https://www.youtube.com/watch?v=h2A7oUMeLmM>
- <https://www.youtube.com/watch?v=h8MUjb-HeJw>
- <https://www.youtube.com/watch?v=VfbF3kW2kXk>
- <https://www.youtube.com/watch?v=zZMoMi0Un1A>
- <https://www.youtube.com/watch?v=Jh1tyvPgrL0>
- <https://www.youtube.com/watch?v=FEbJFbN4PfA>
- <https://www.youtube.com/watch?v=IBc9kNP0Oj4&t>