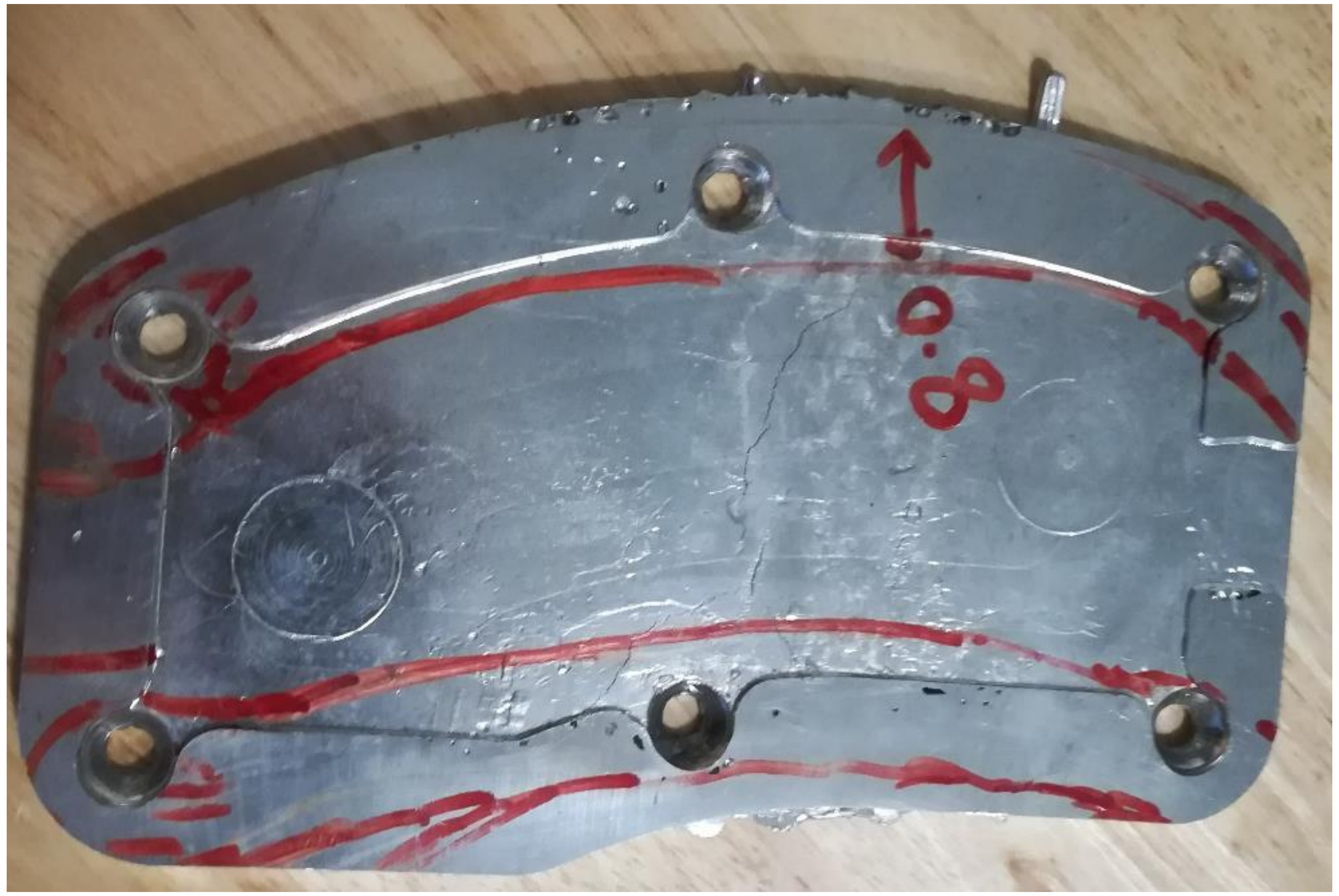
An Introduction to Metal Casting

MECH 392, UBC

Instructor: Ahmad Mohammadpanah

Antique Persian Lantern

(shown in class, Casted over ? Years ago)

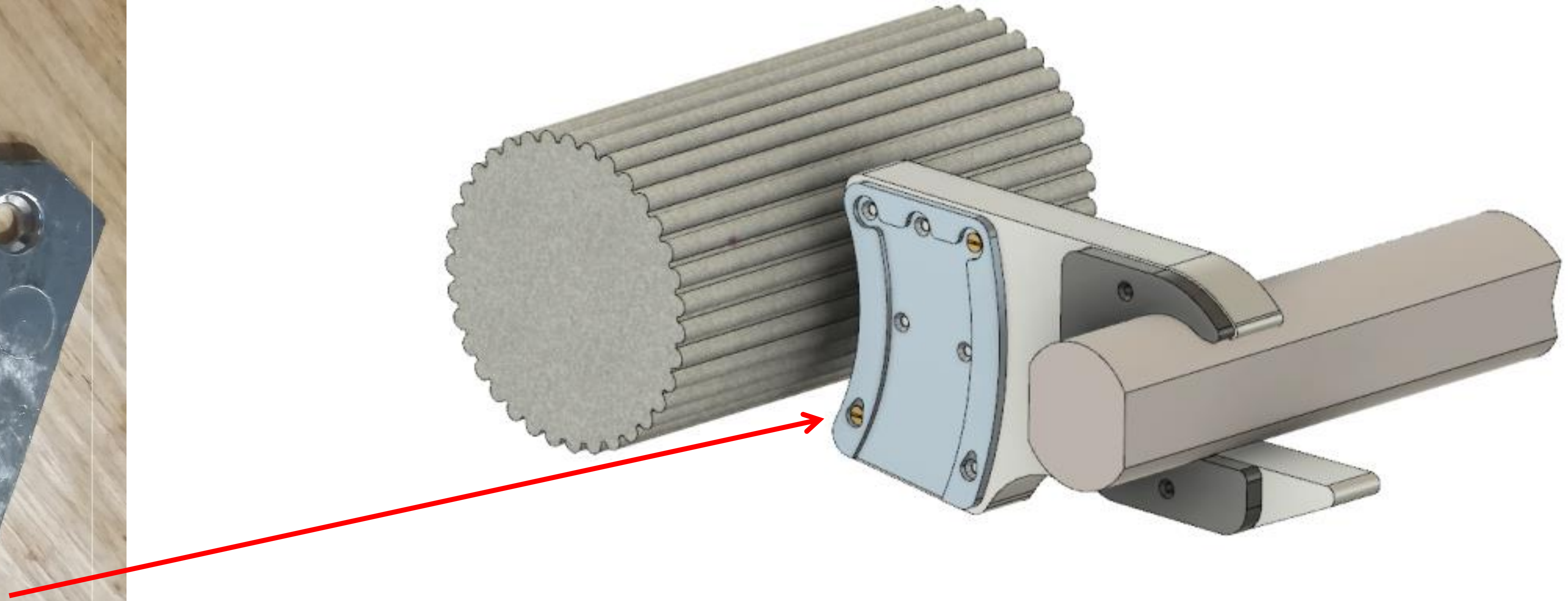


Saw Guide Bearing, Babbitt

(shown in class, Casted by Ahmad)

BABBITT BEARING

BABBITT BEARING (IMPORTANT COMPONENT IN MANY INDUSTRIES, SUCH AS WOOD INDUSTRY)



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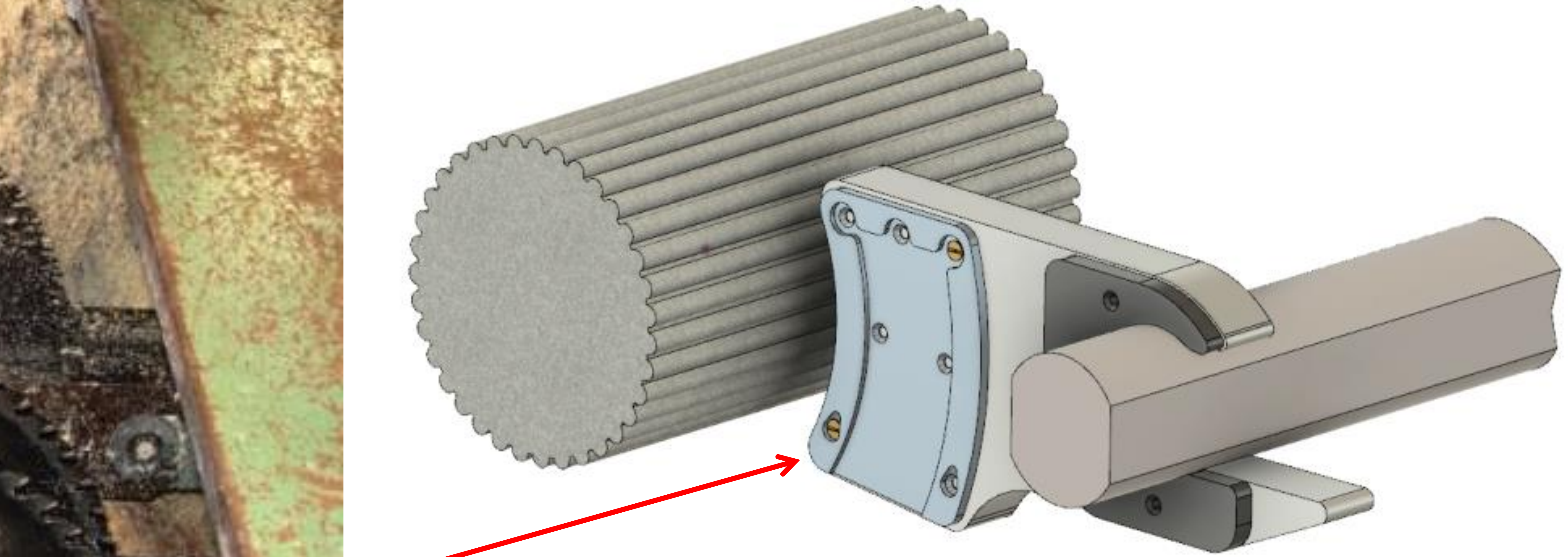

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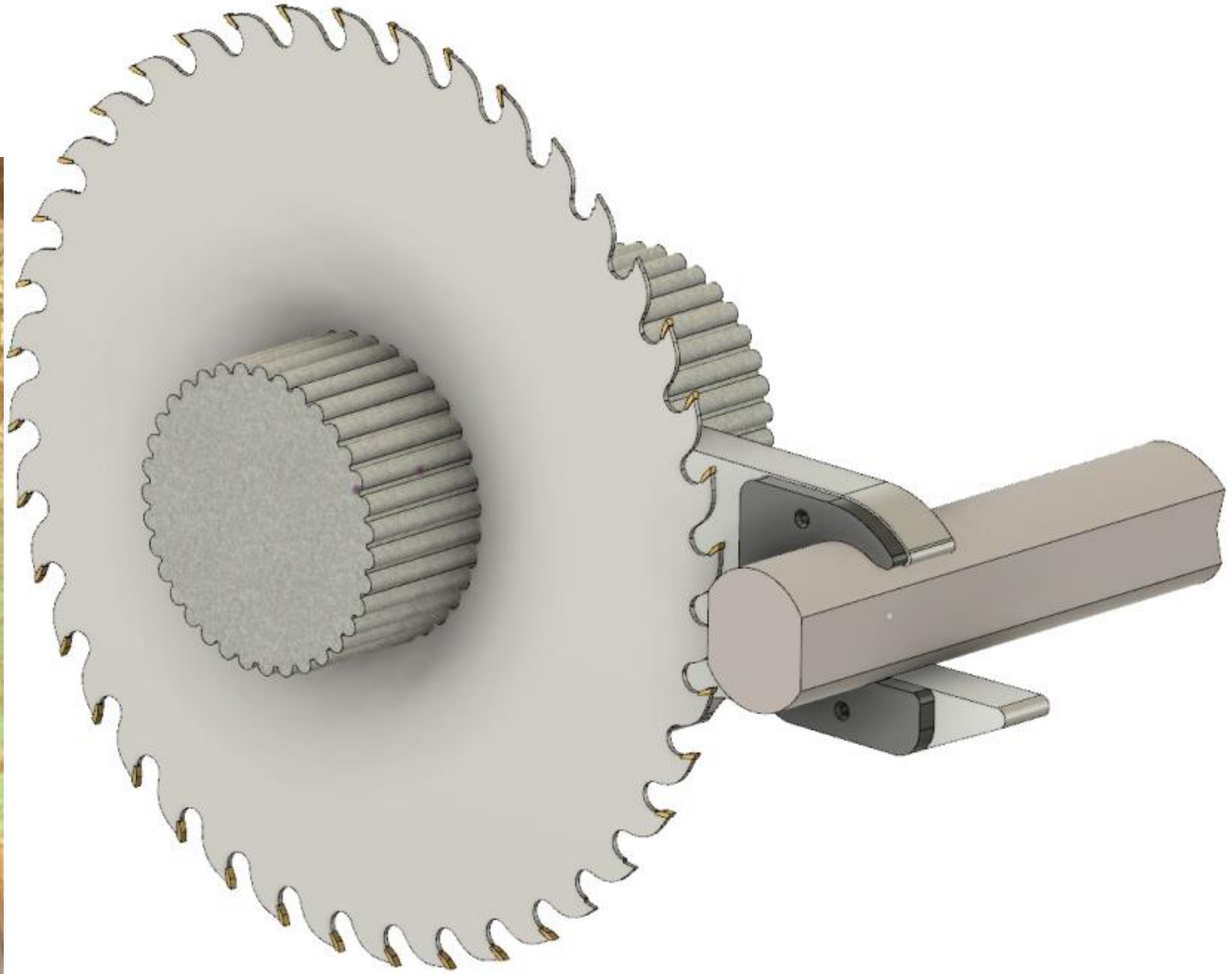

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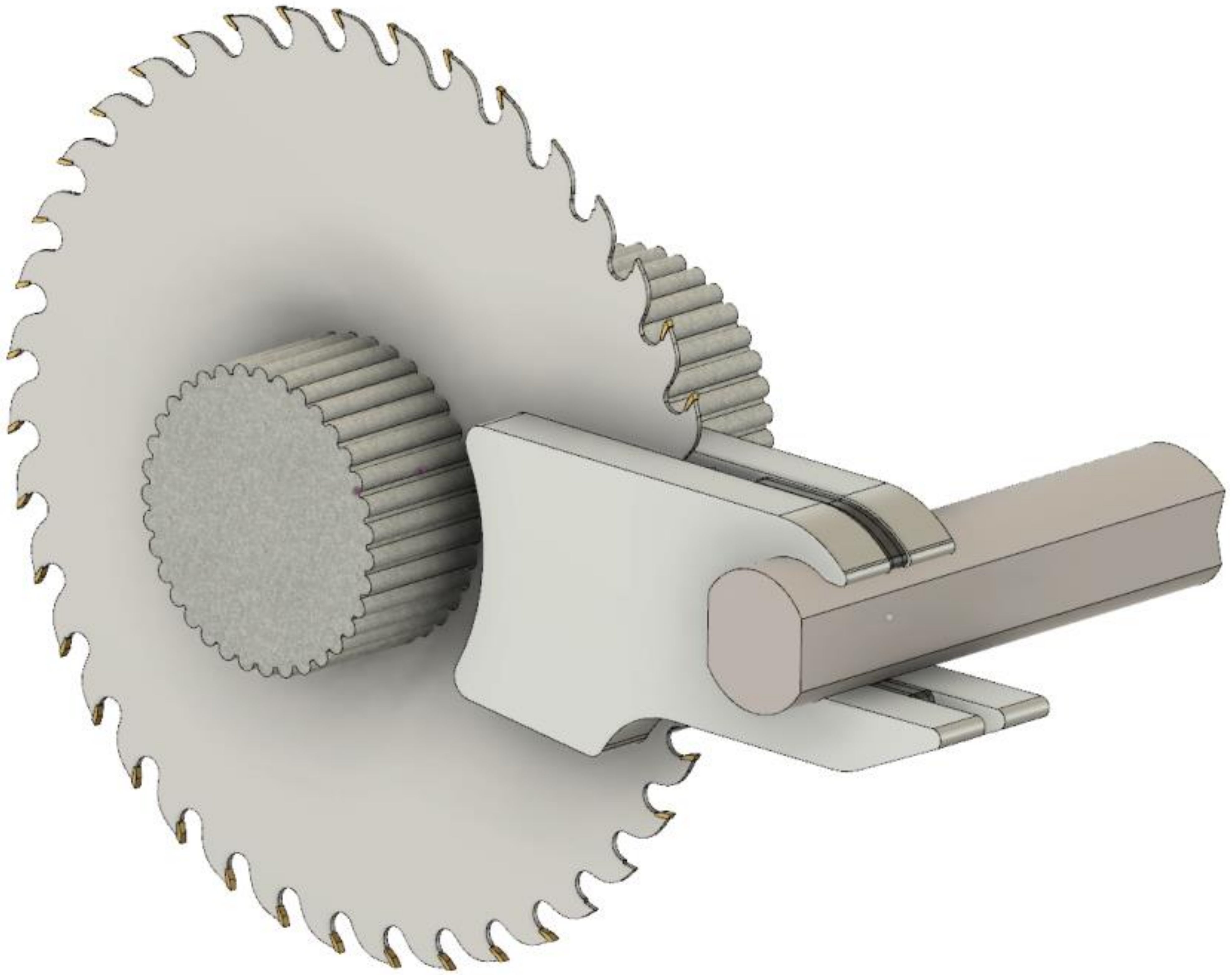

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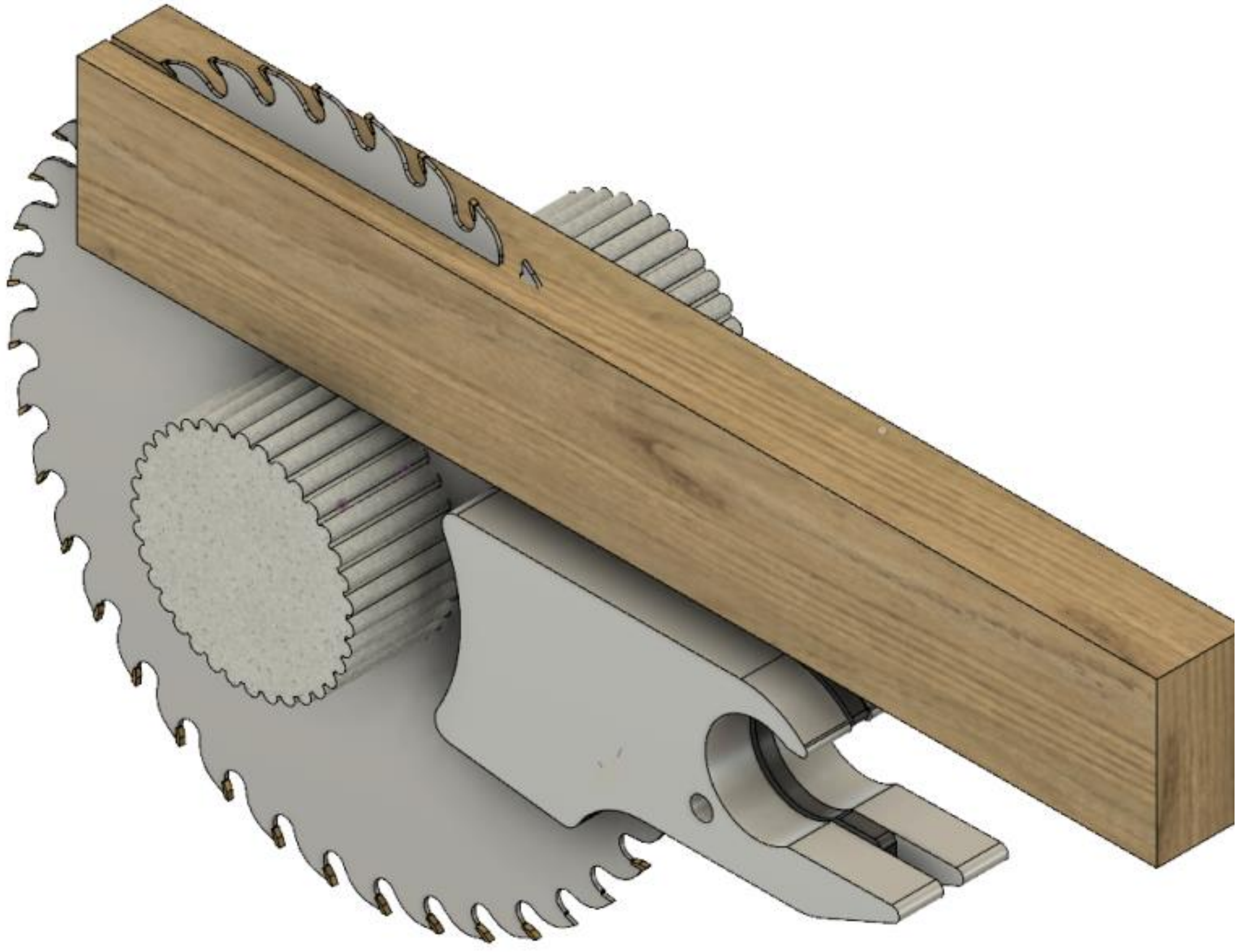

WHAT FEATURE OF THIS ESPRESSO FILTER HOLDER MAKES IT NOT SUITABLE TO BE MADE BY MACHINING?

WHY CASTING?

- Can be used for many types of metals
- Parts with complex geometries
- Wide range of sizes

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- Parts with complex geometries
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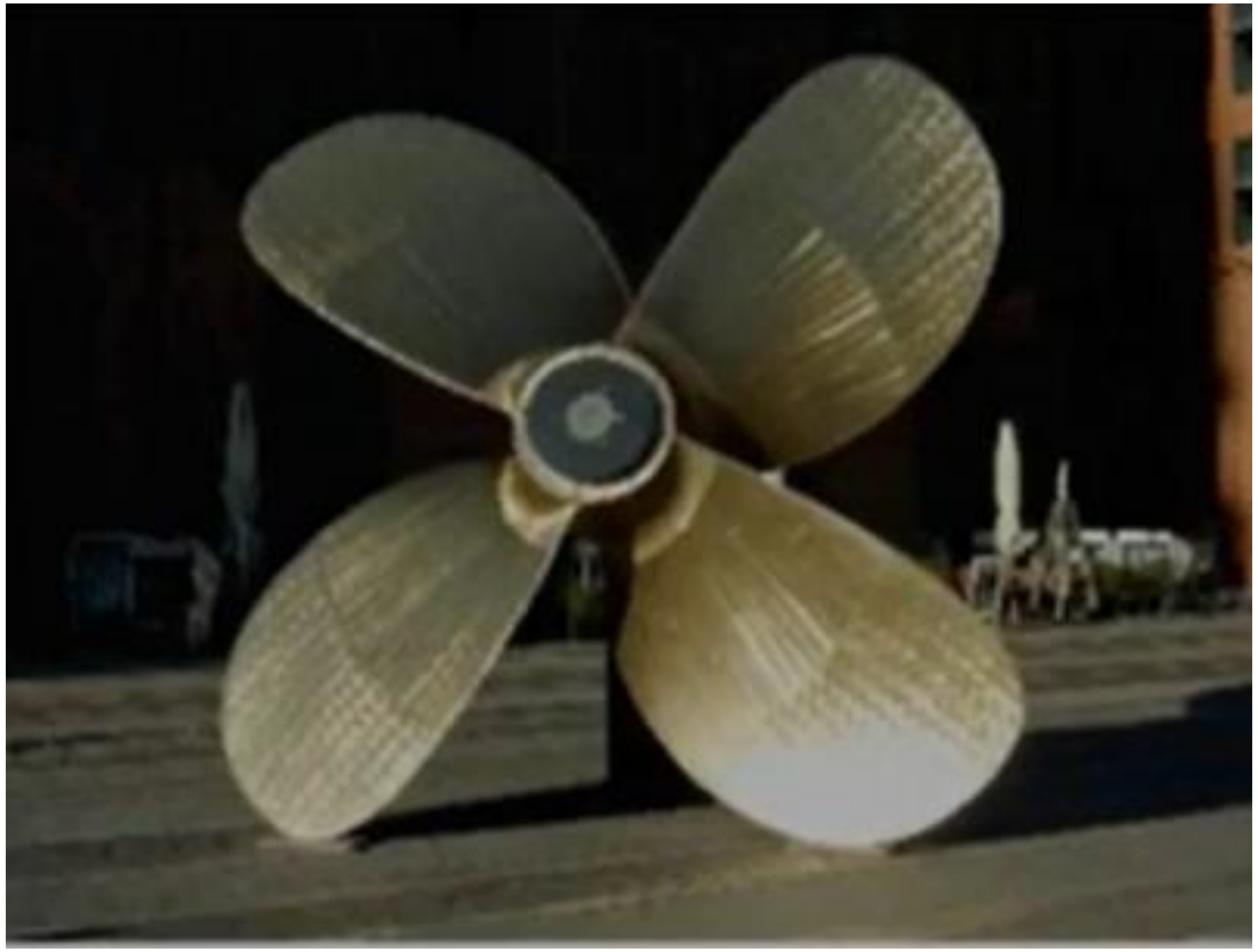
building

10 mm



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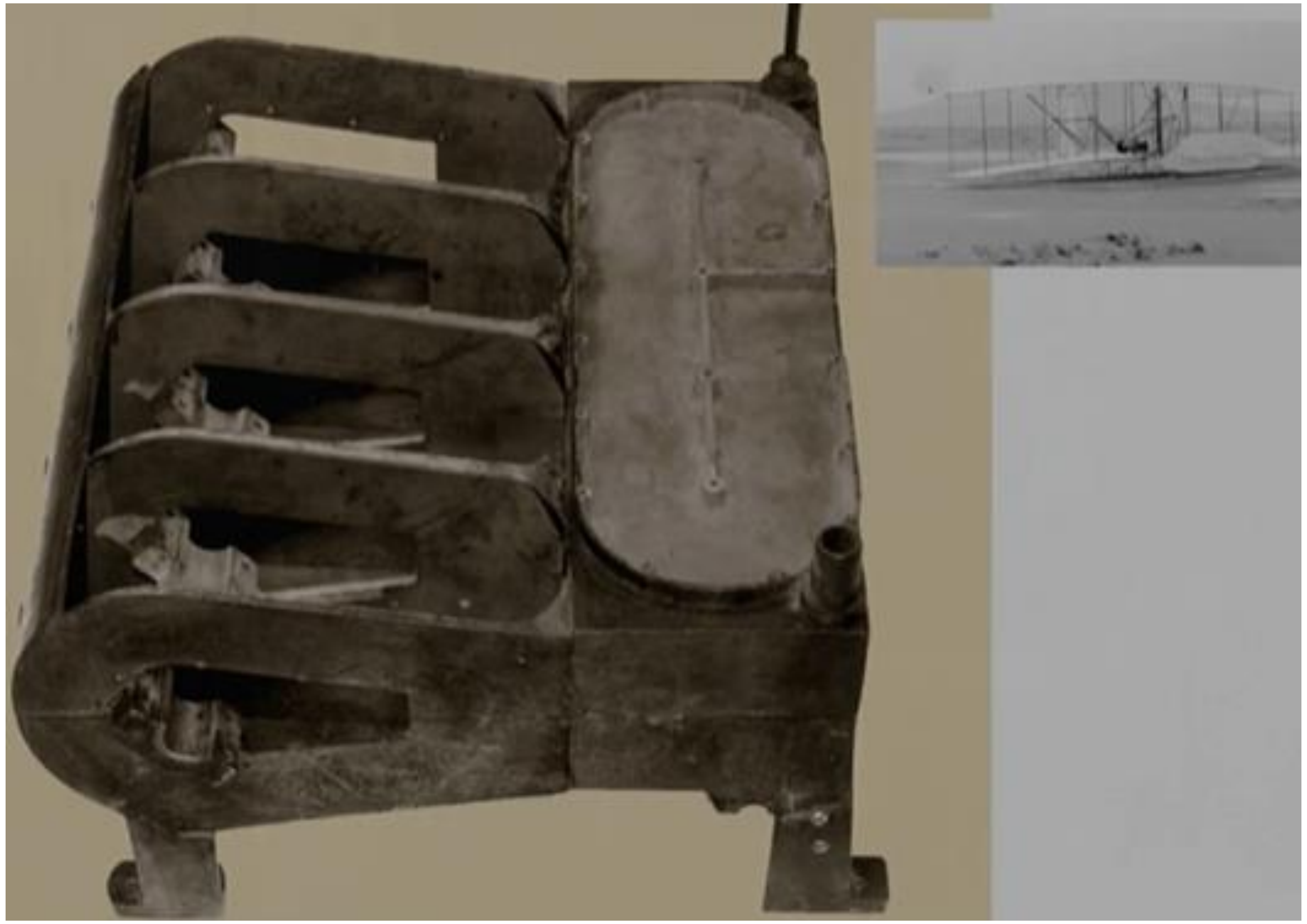
CASTING IS HISTORICALLY IMPORTANT!

- Wright brothers airplane aluminium die casting engine block



CASTING IS A LARGE INDUSTRY!

- Just cast Iron and steel, used in buildings, like I-Beams, over 10,000,000 Tons per year

AN OLD-AGE MANUFACTURING PROCESS (FROM 4000 B.C. TO NOW!)

Images from: https://en.wikipedia.org/wiki/Main_Page/

CASTING METHODS:

1. Sand casting

2. Die casting

3. Investment casting

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Application: Large parts, rough surface finish

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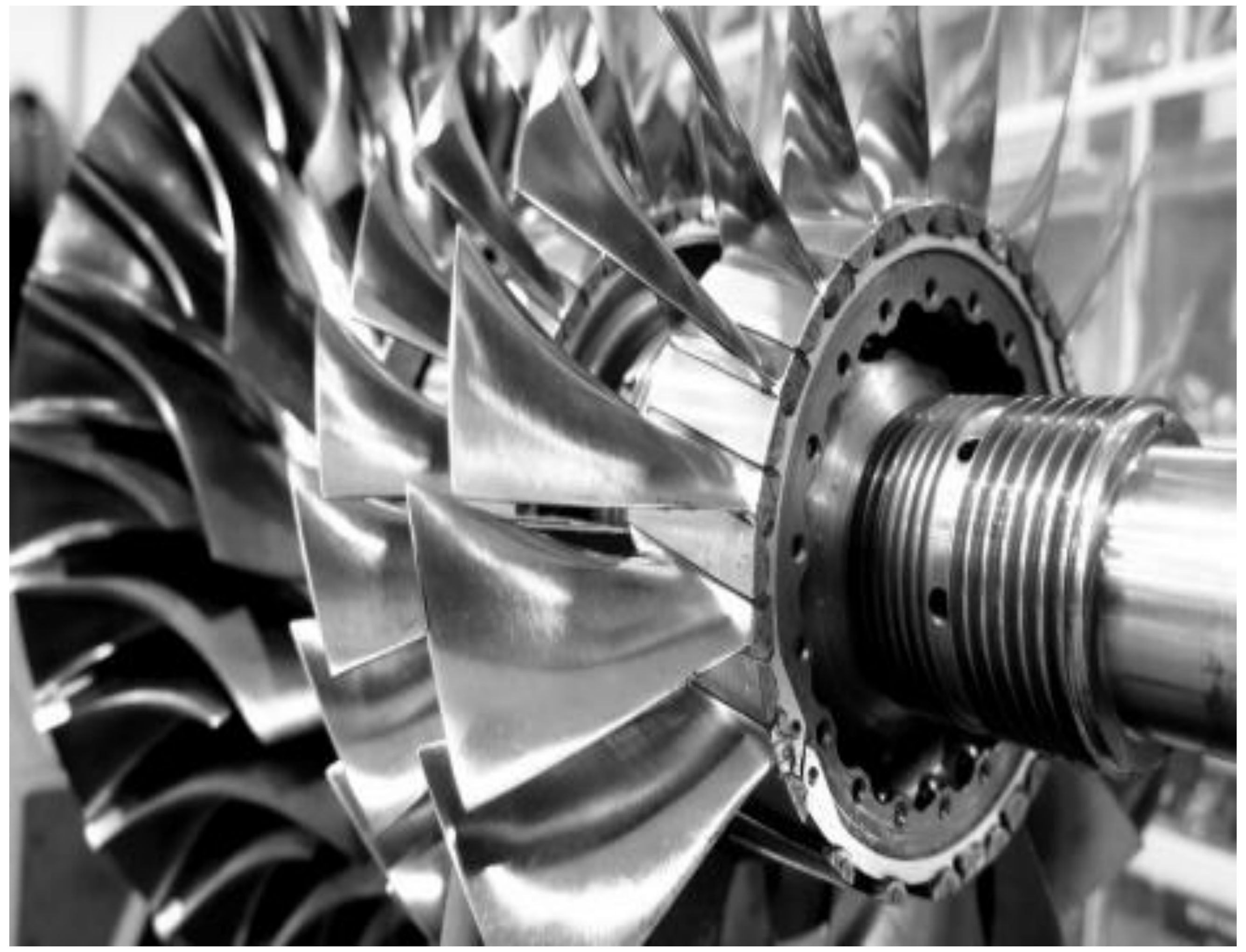

3. Investment casting

Application: Complex curves, good surface finish, complex internal cavities, higher melting point materials

SAND CASTING :

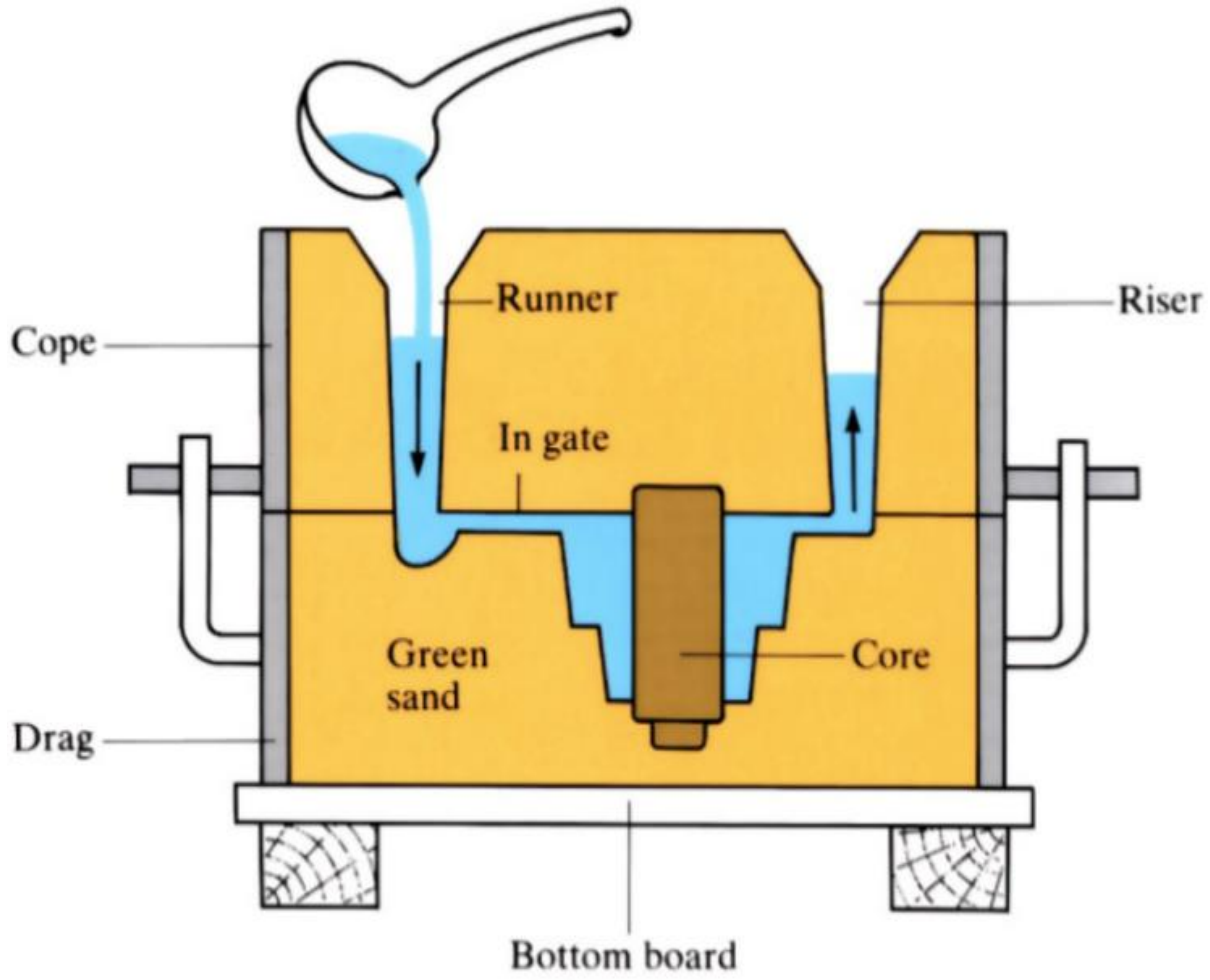

Image source: https://www.open.edu/openlearn/science-maths-technology/engineering-technology/manupedia/sand-casting

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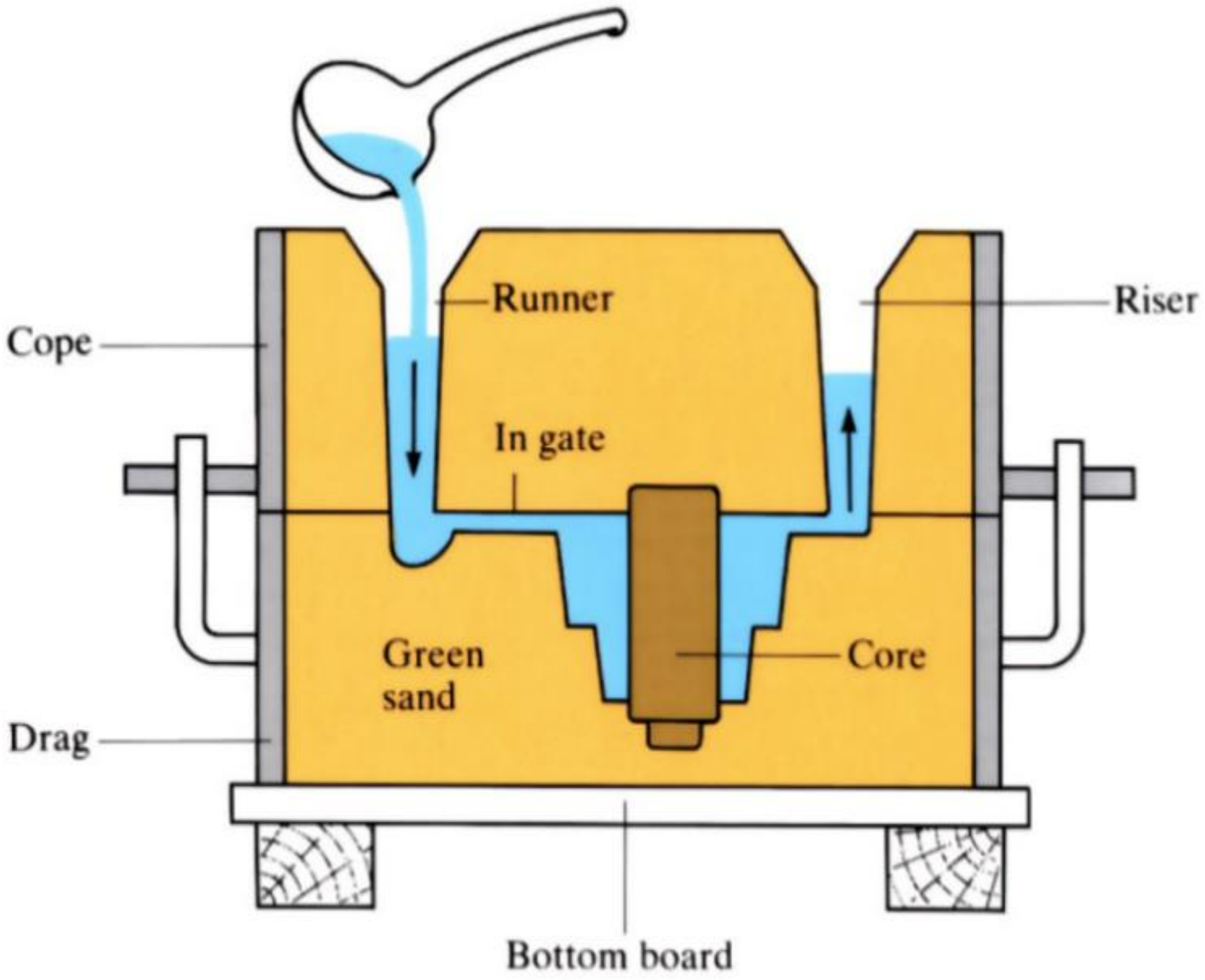

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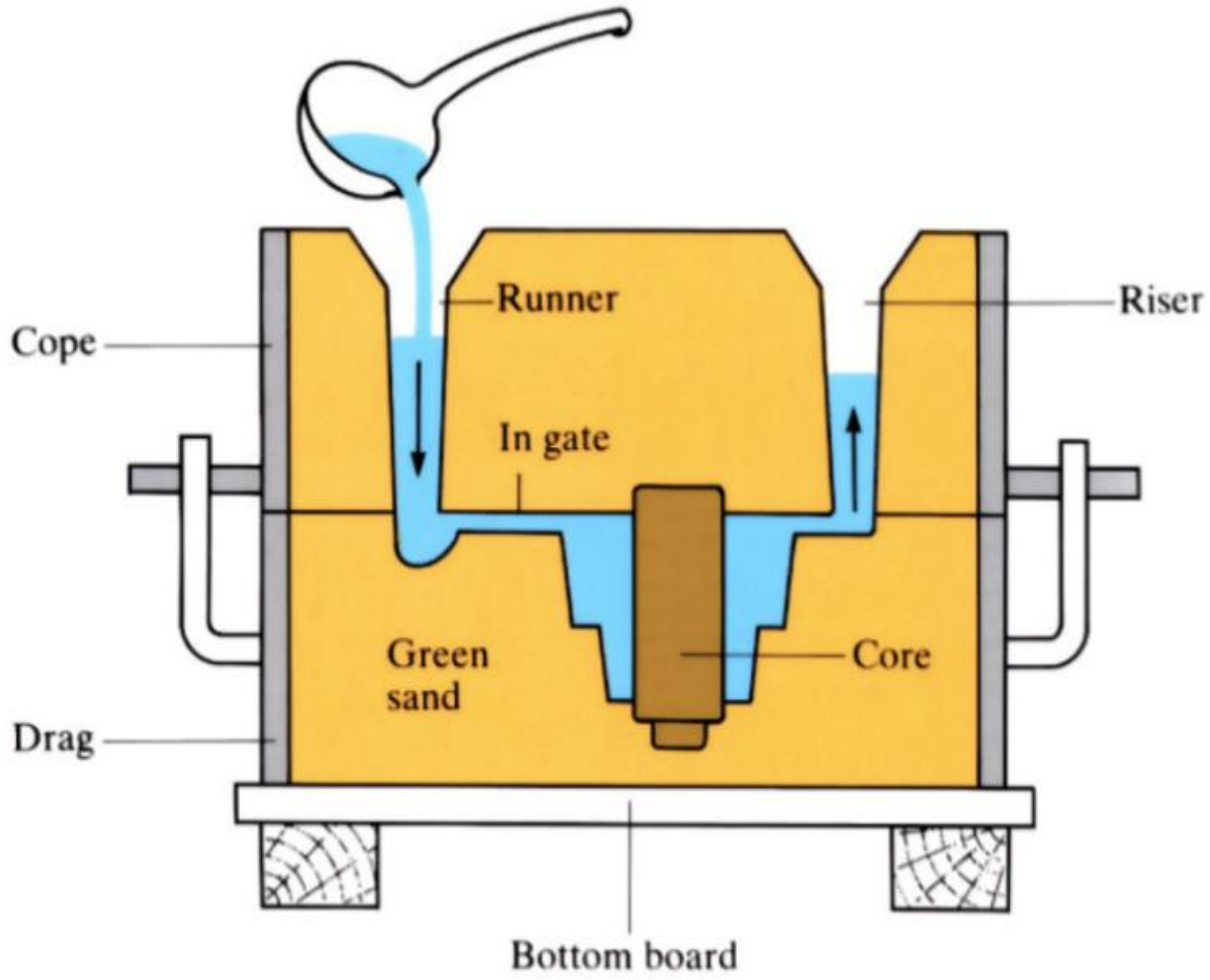

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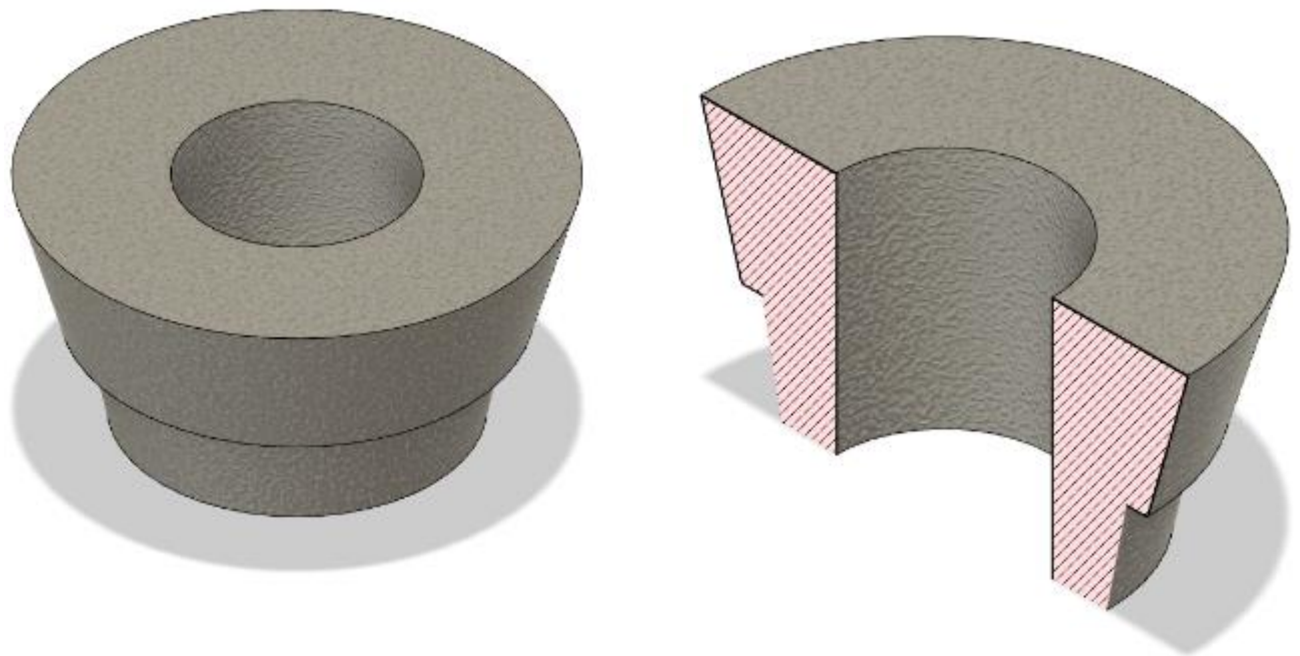

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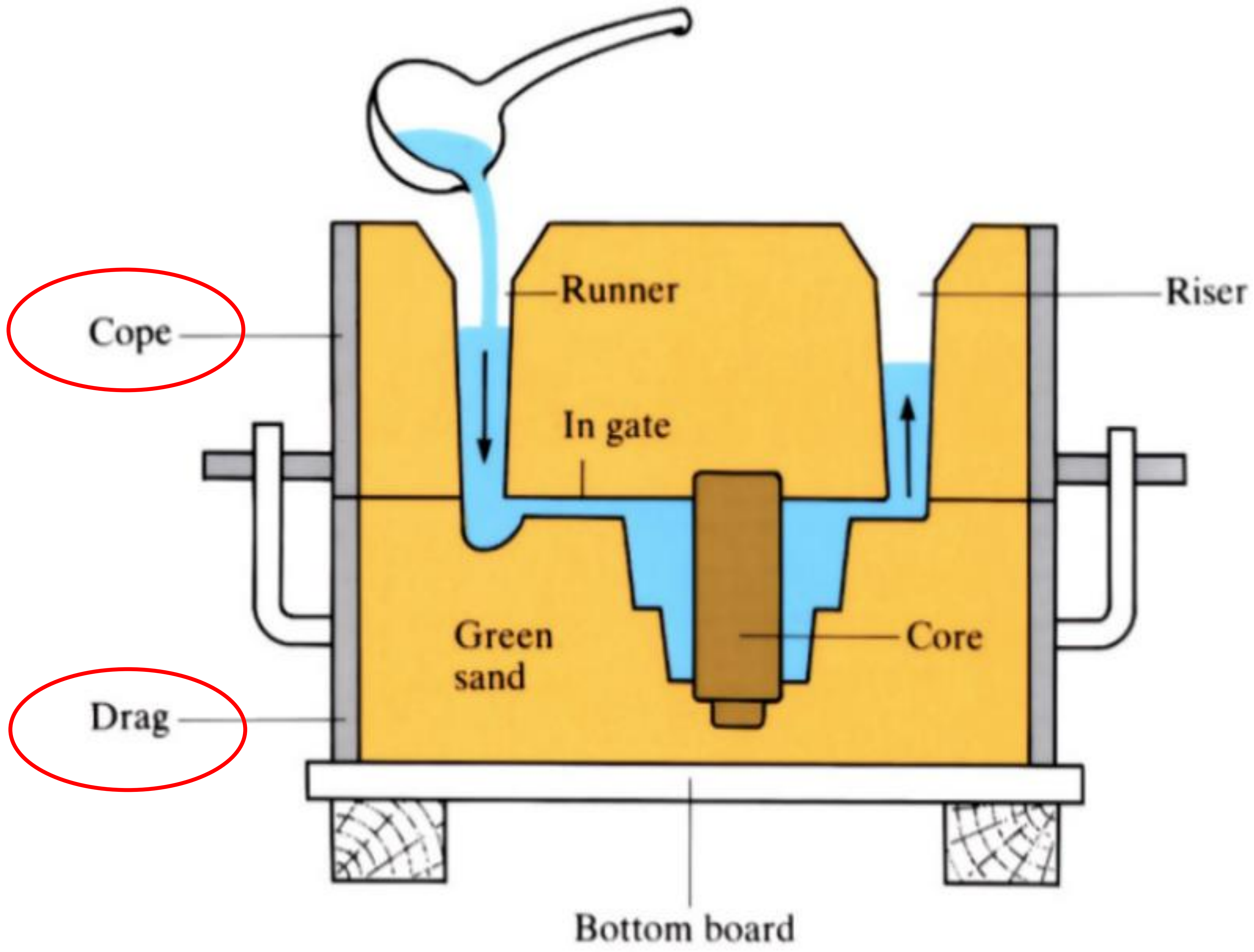

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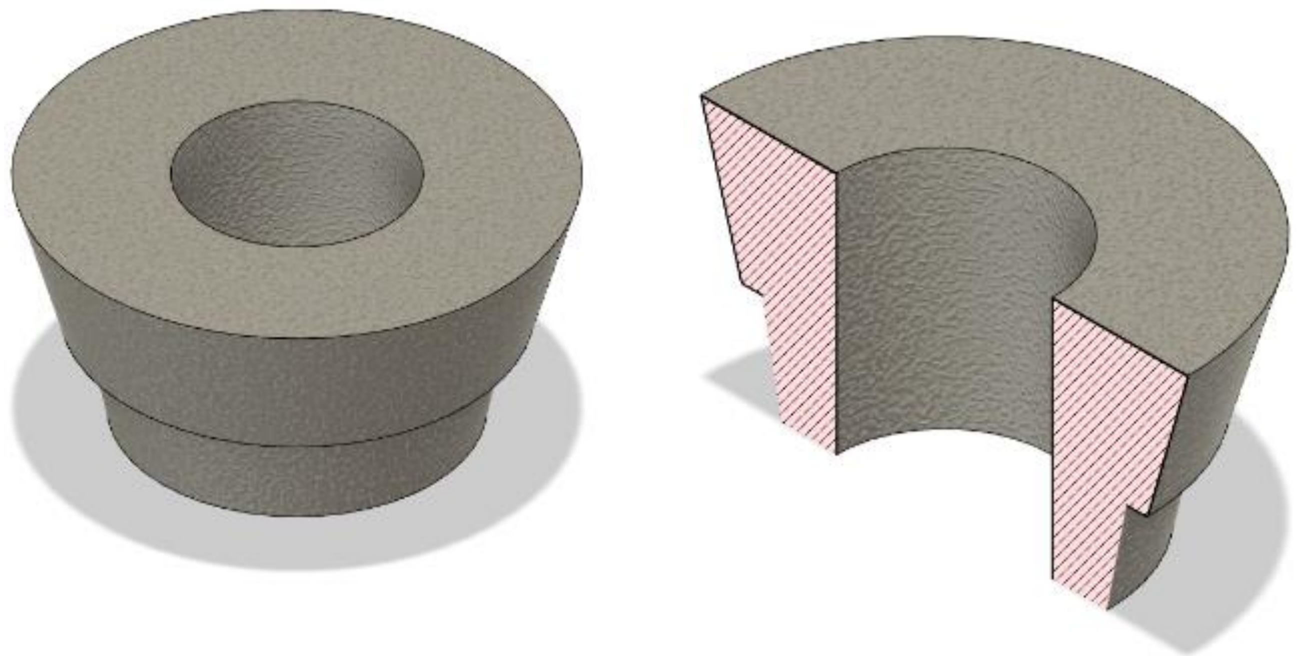

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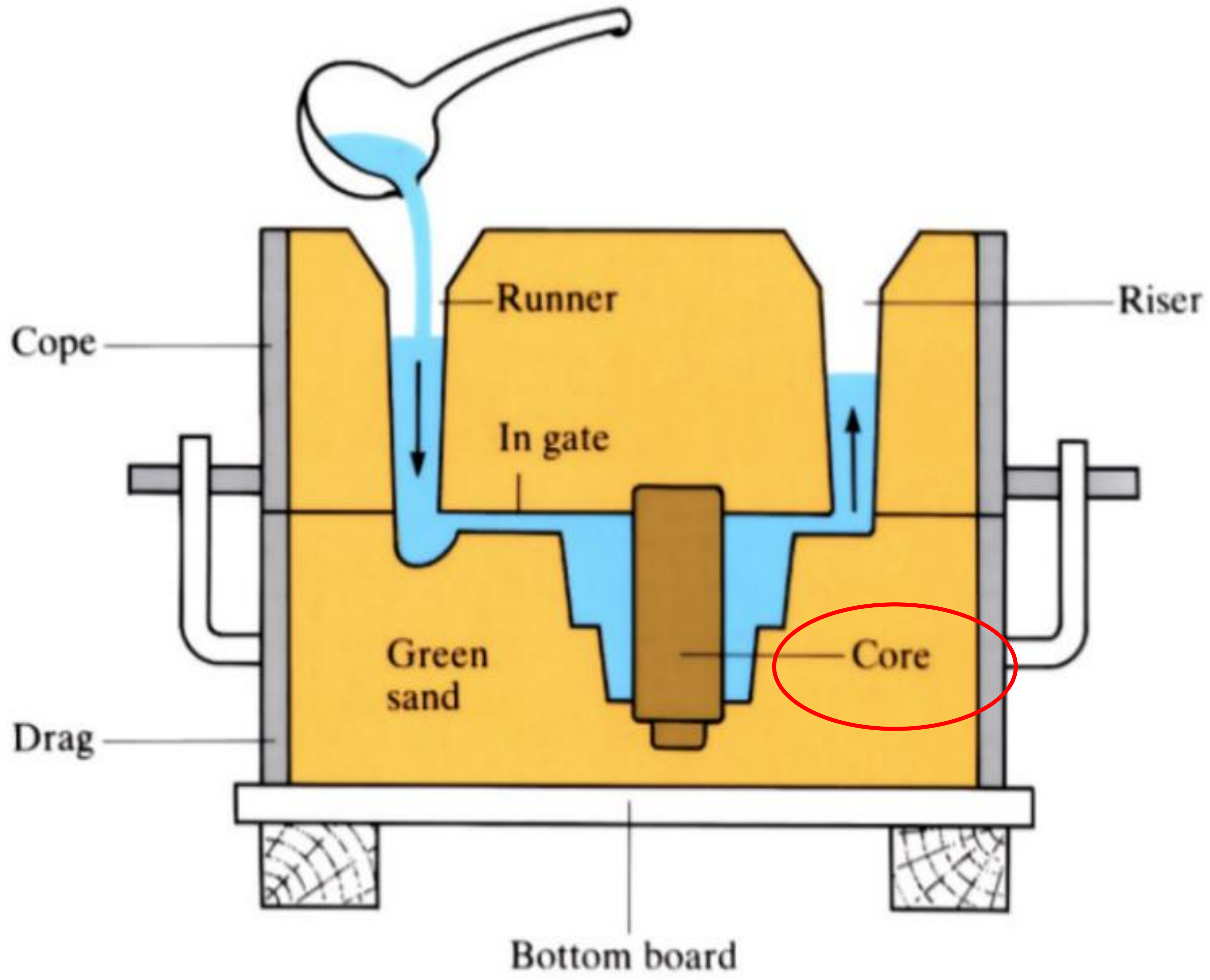

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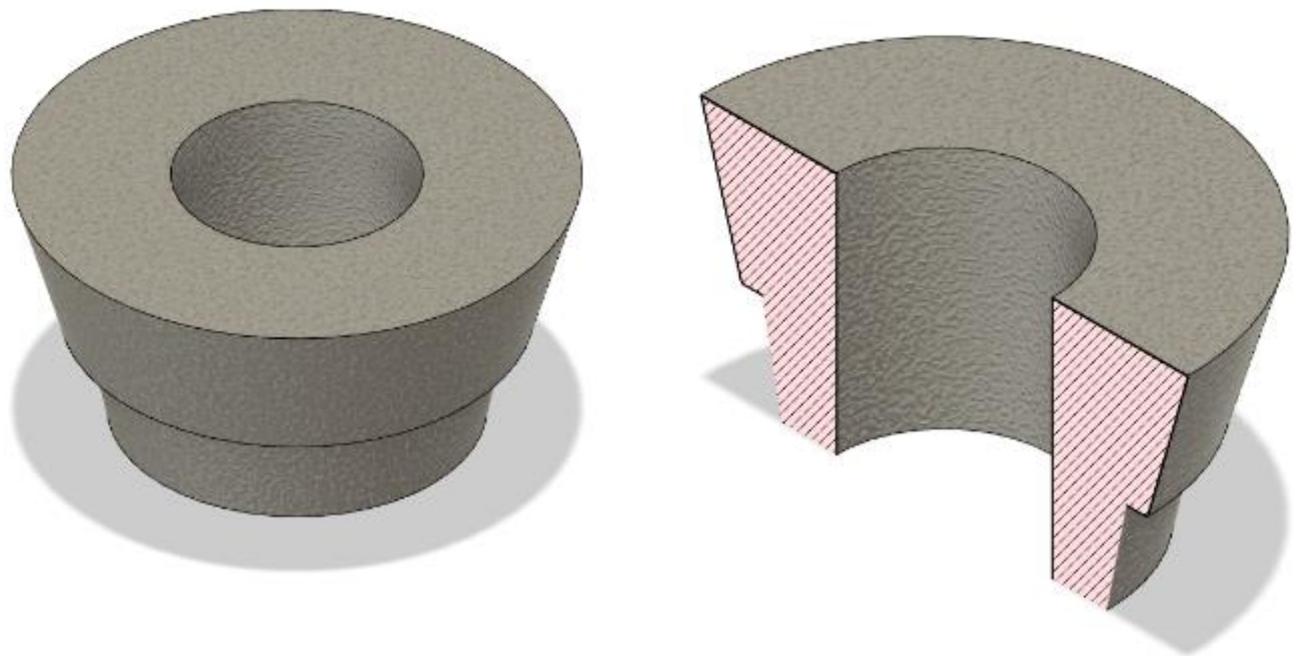

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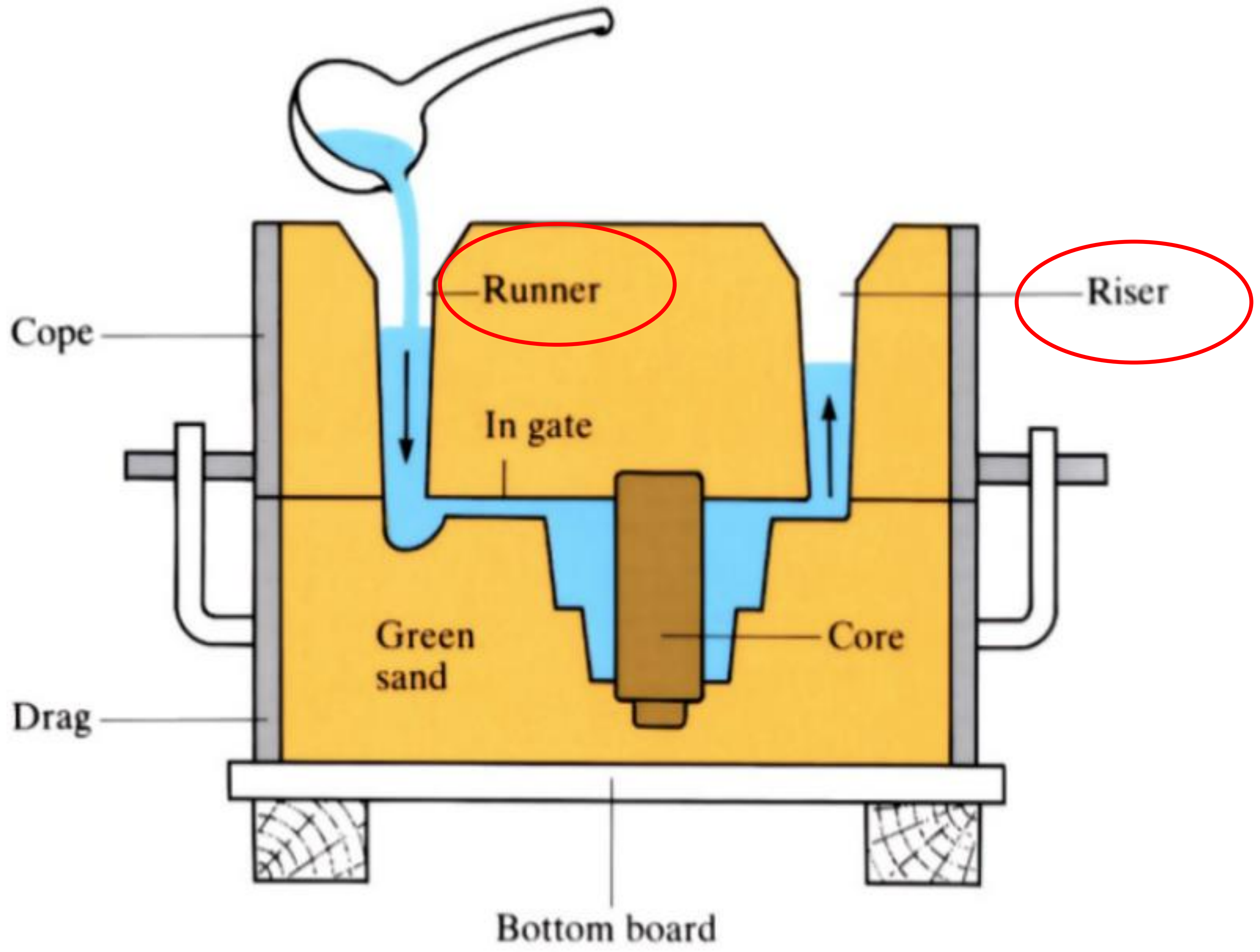

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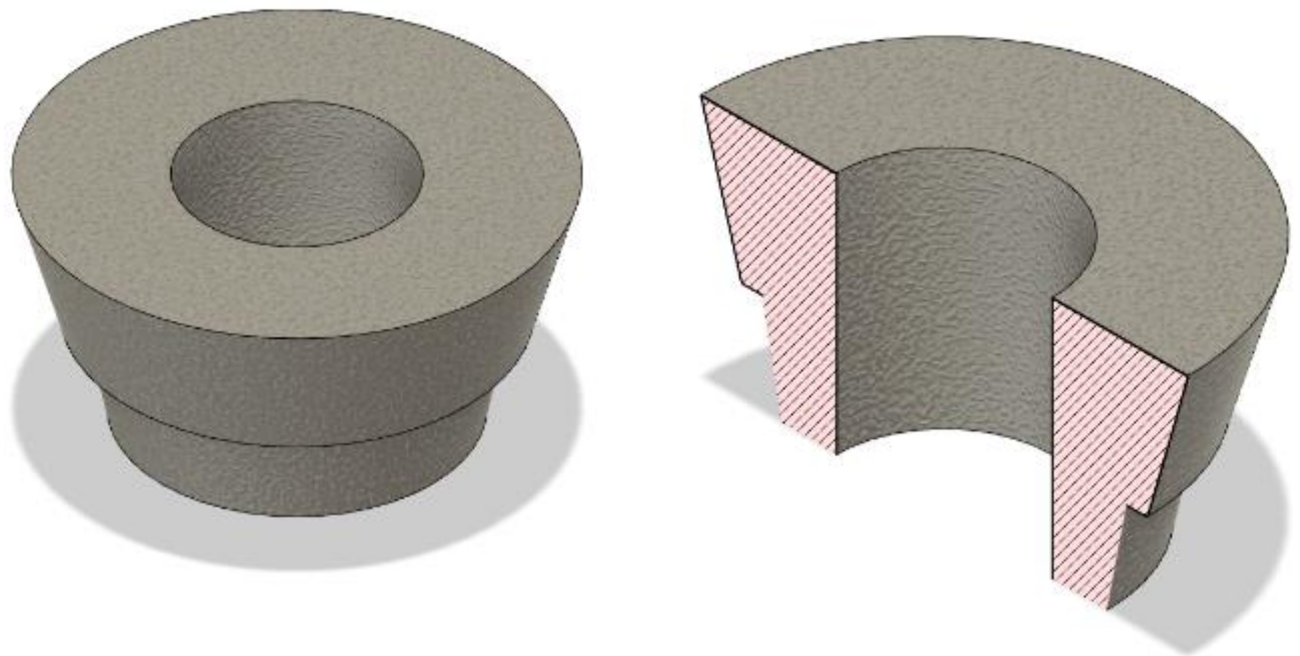

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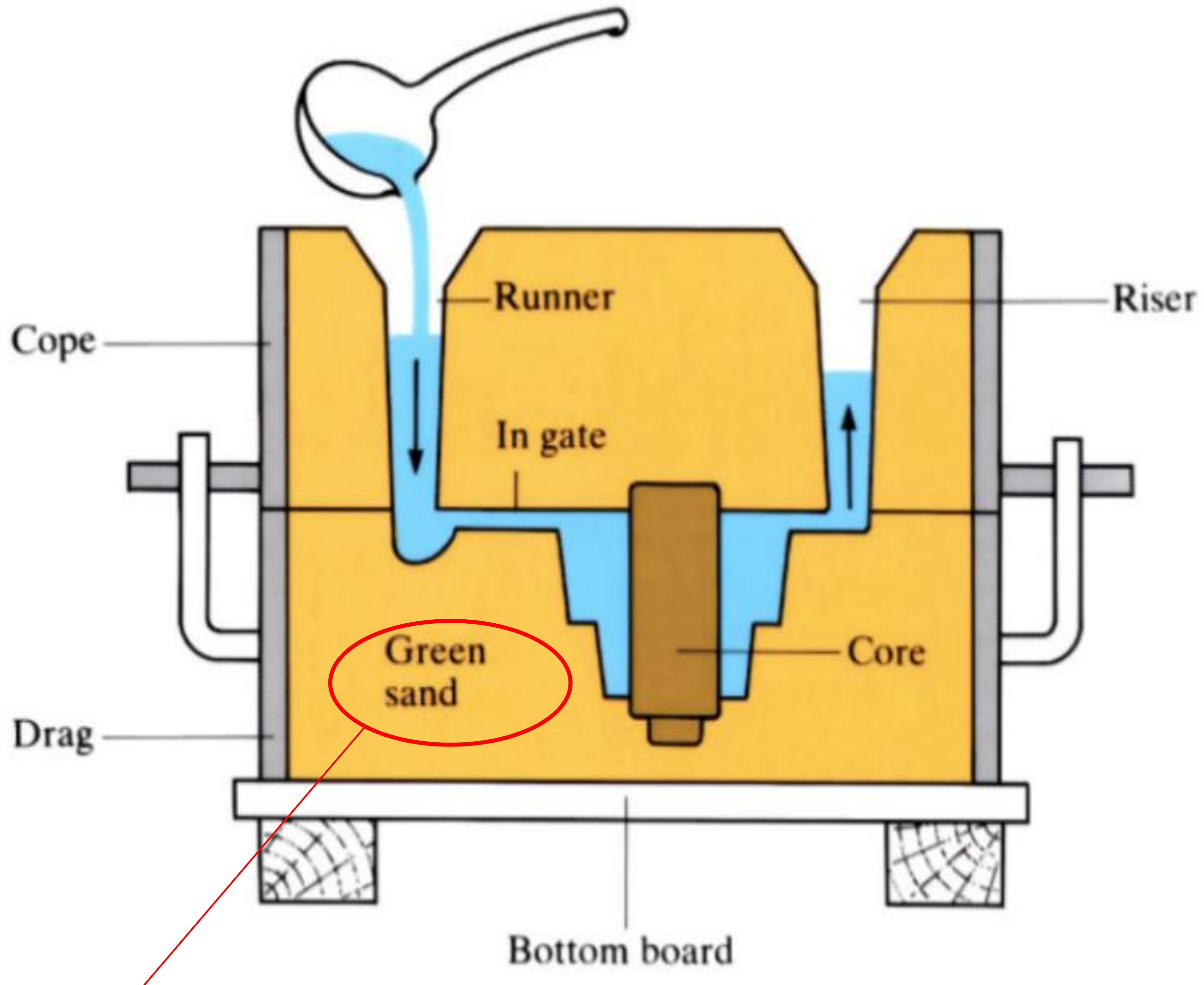

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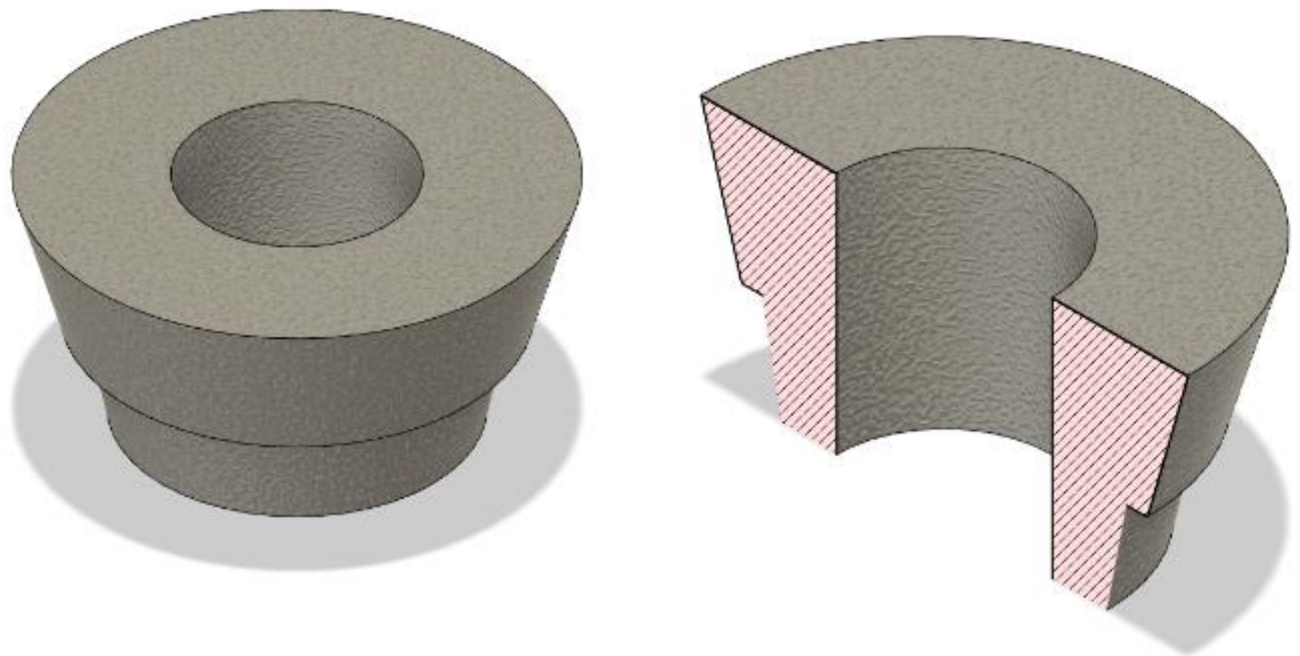

Mold: 90% sand +10% clay

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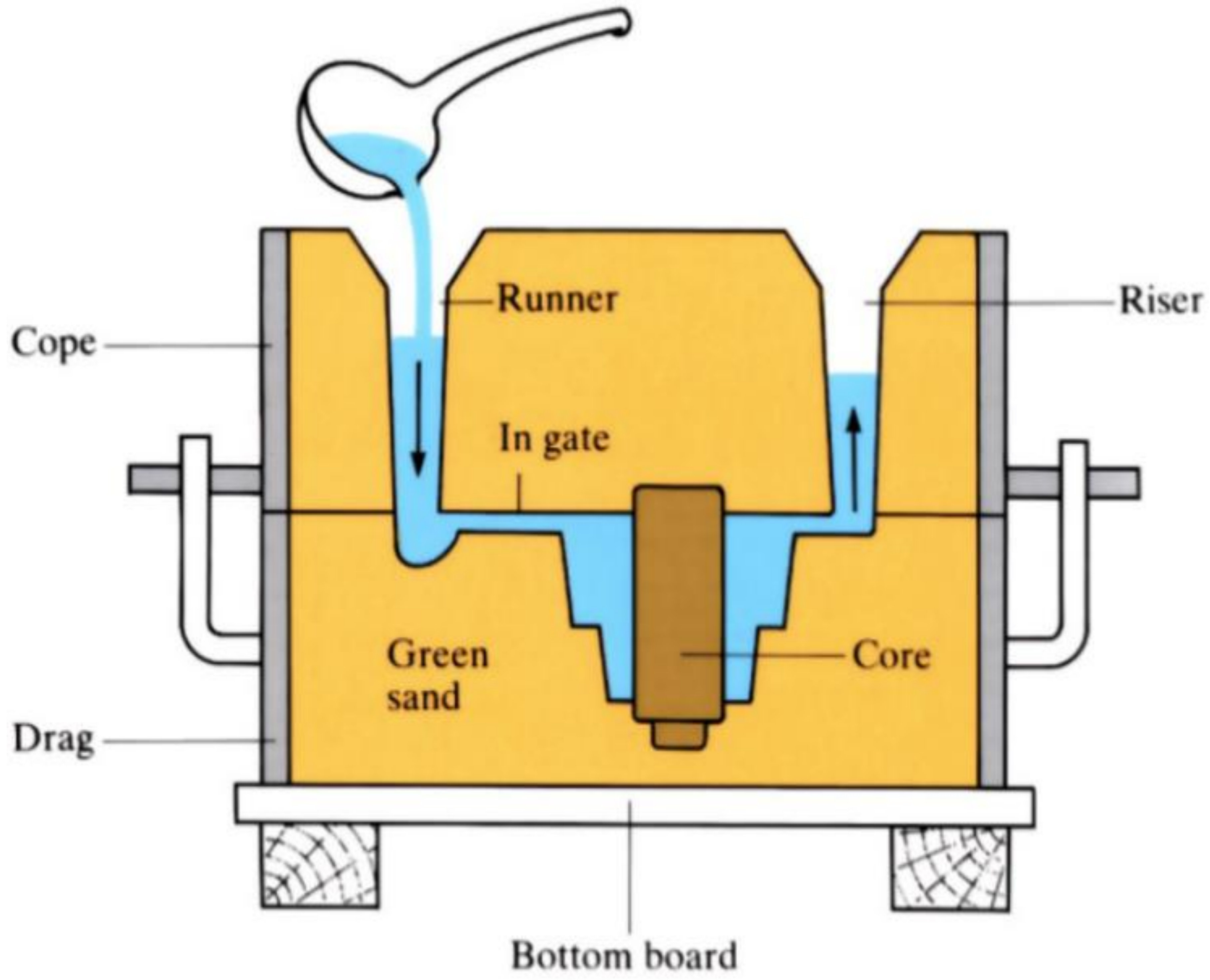

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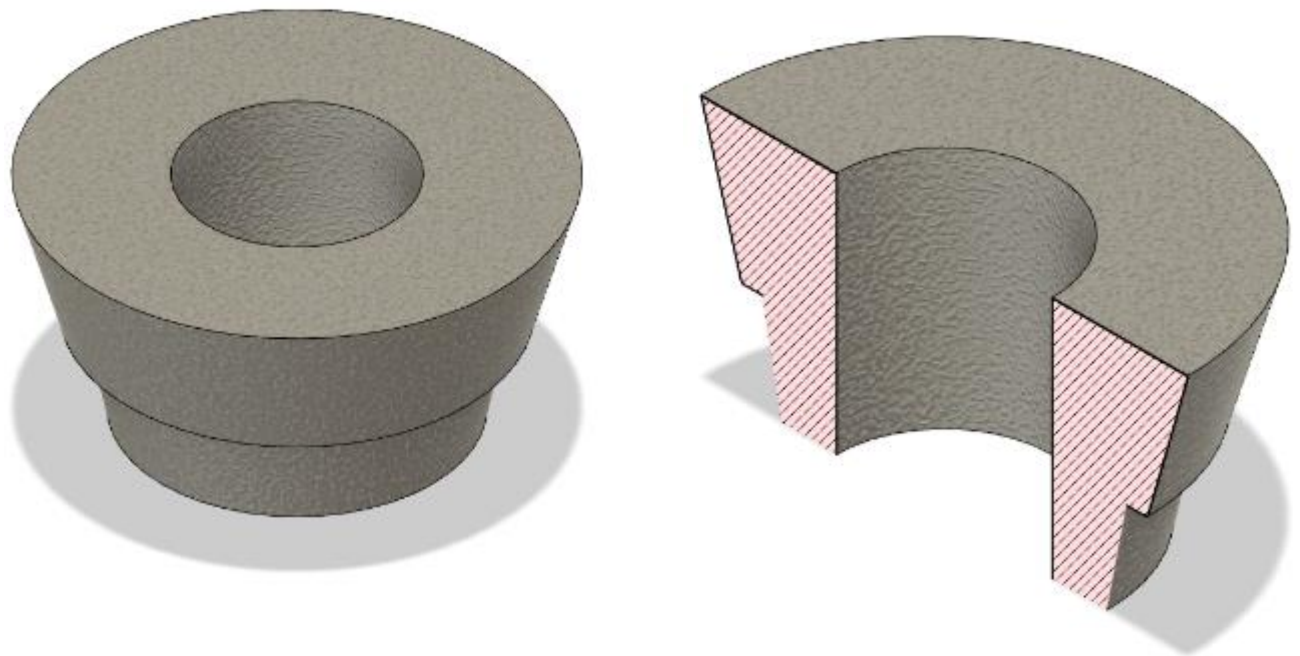

Main Application for: Cast iron, Aluminum alloys, Babbitt

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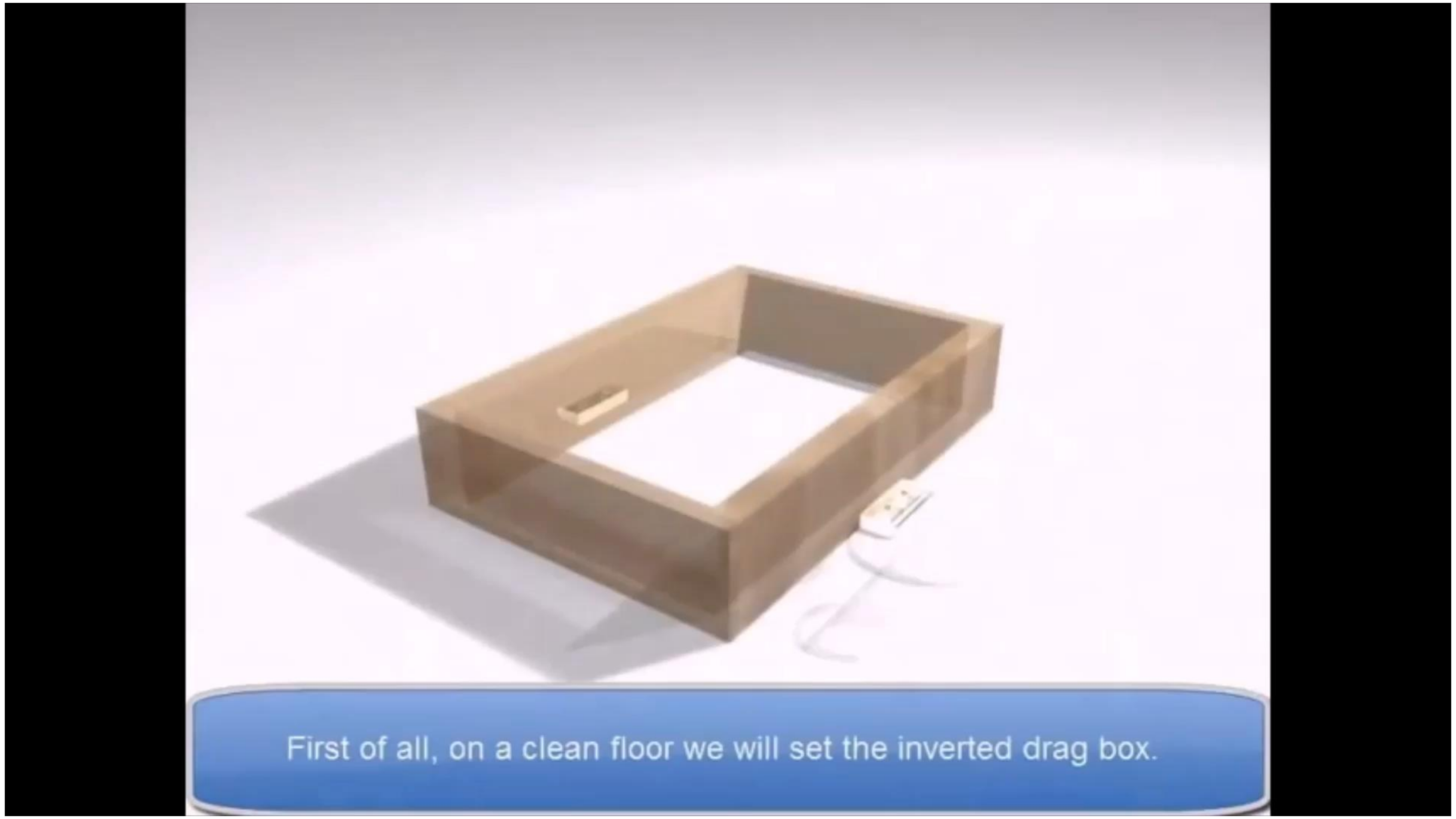

DIE CASTING :

Hot Chamber

Cold Chamber

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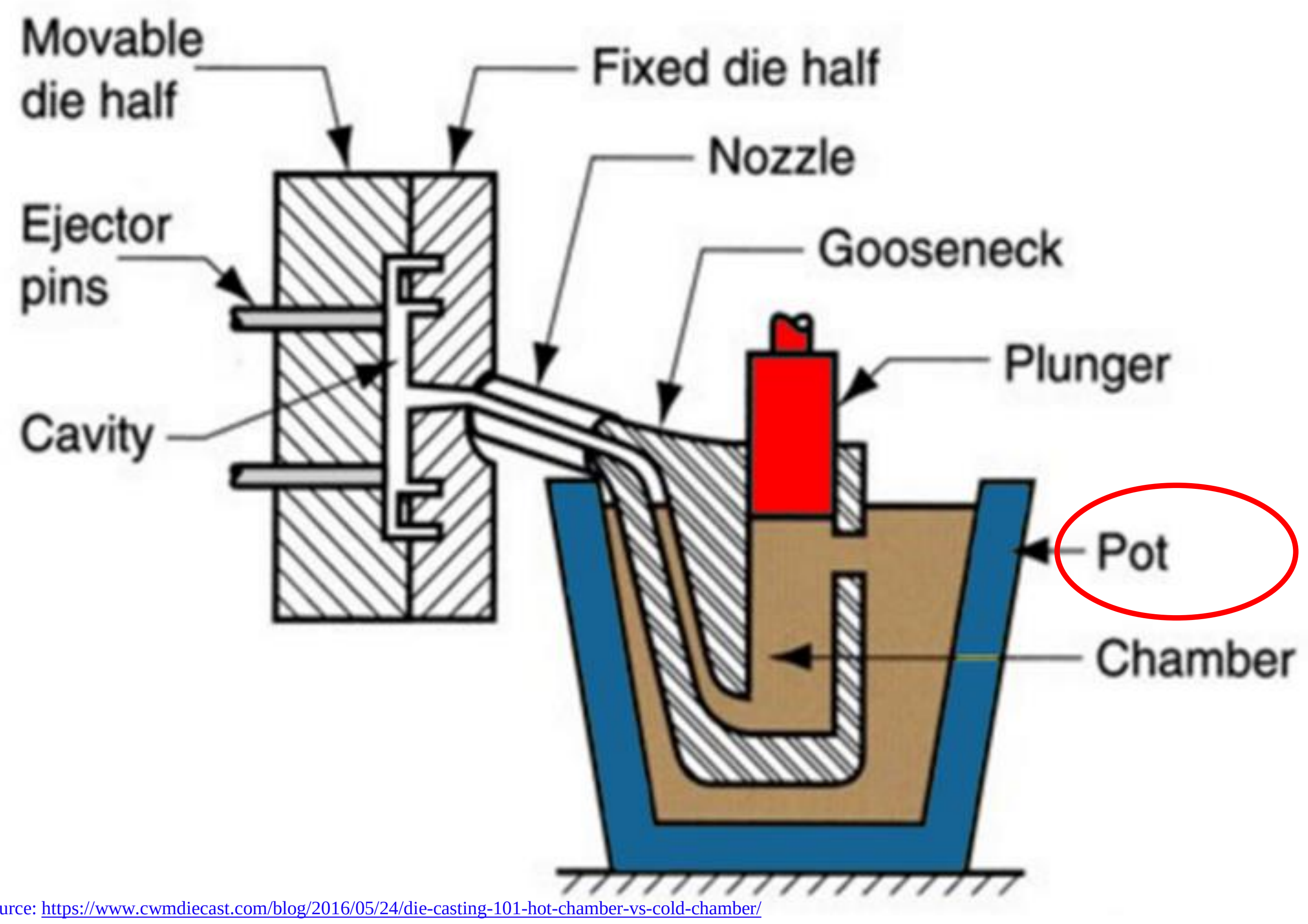

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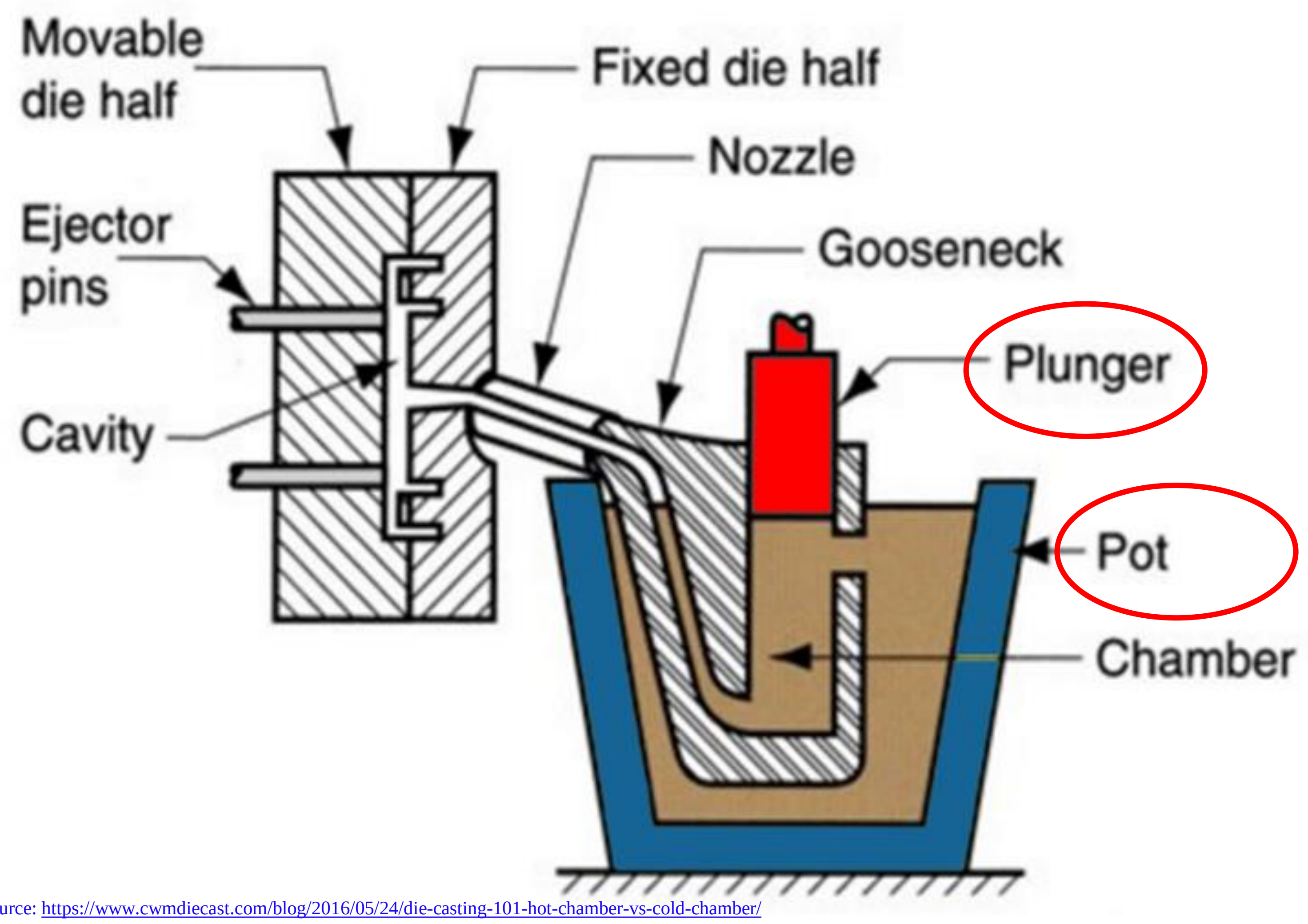

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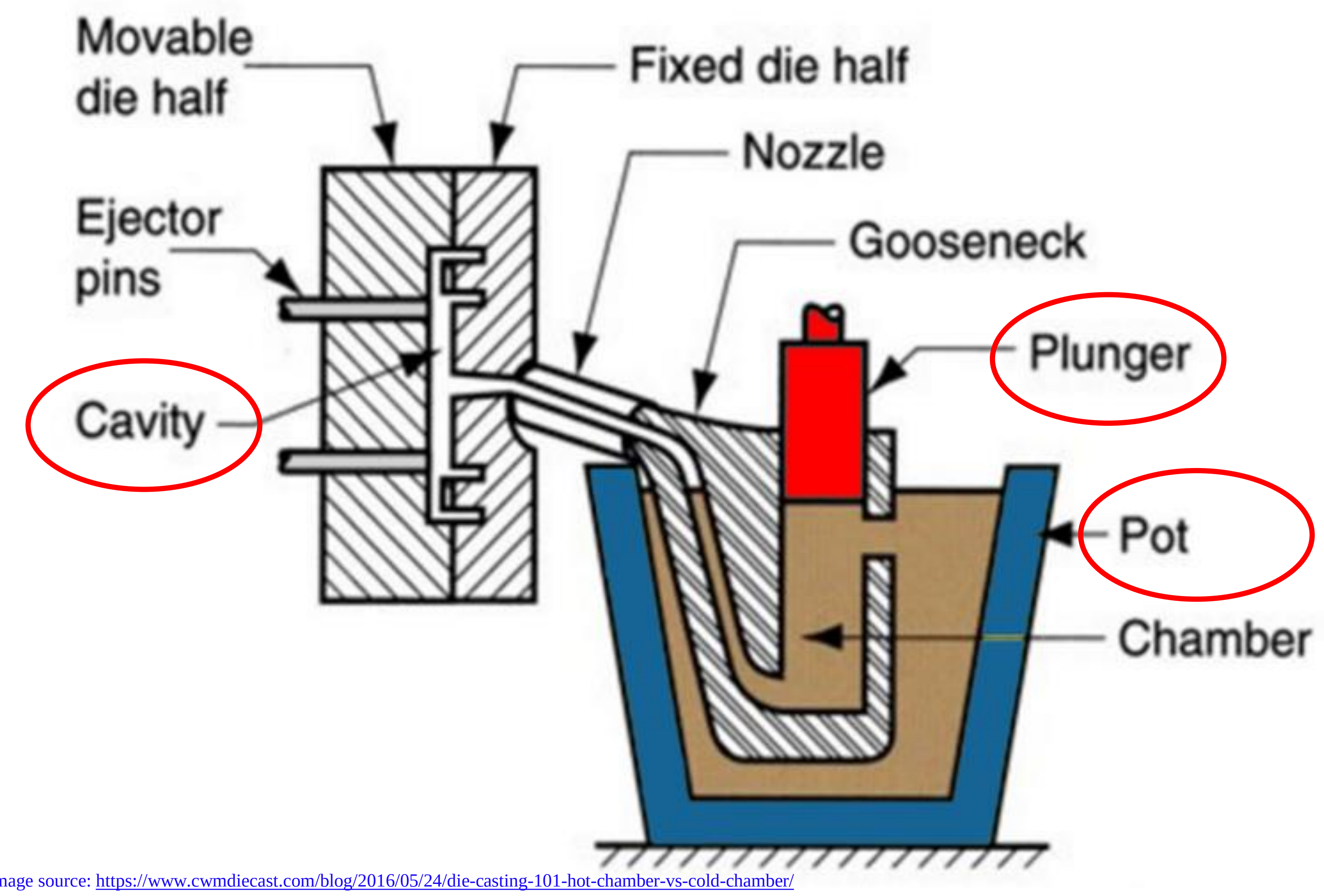

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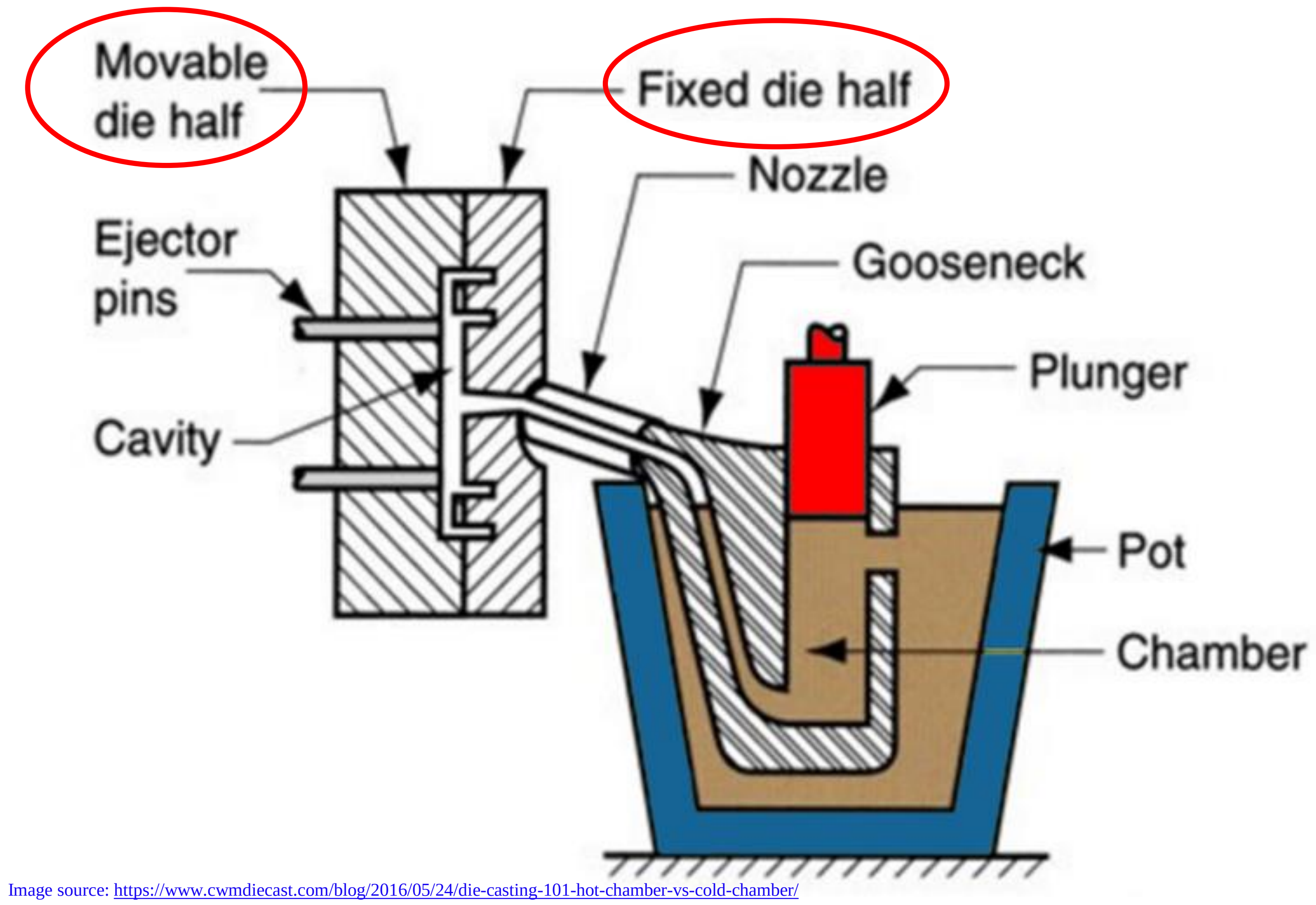

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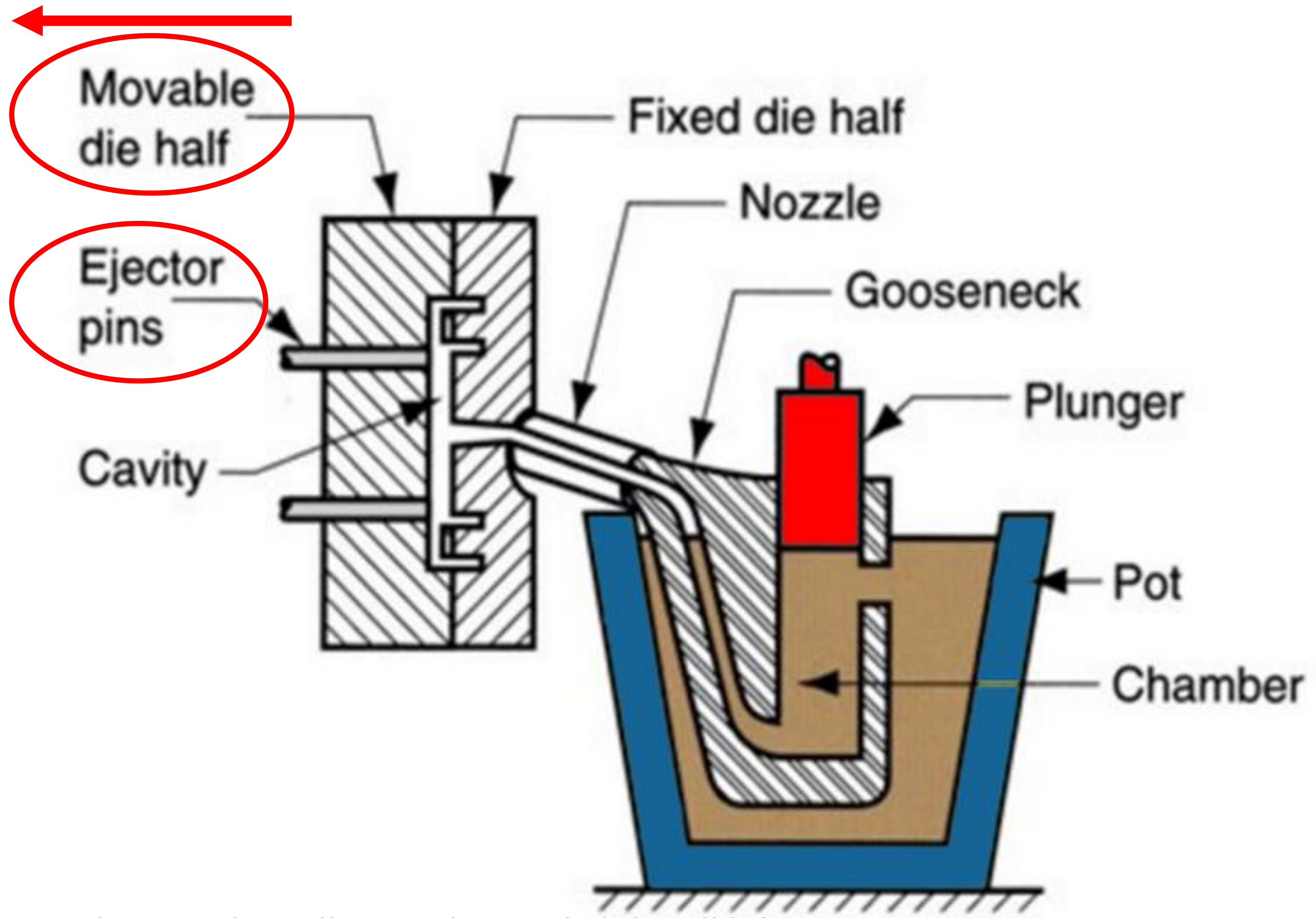

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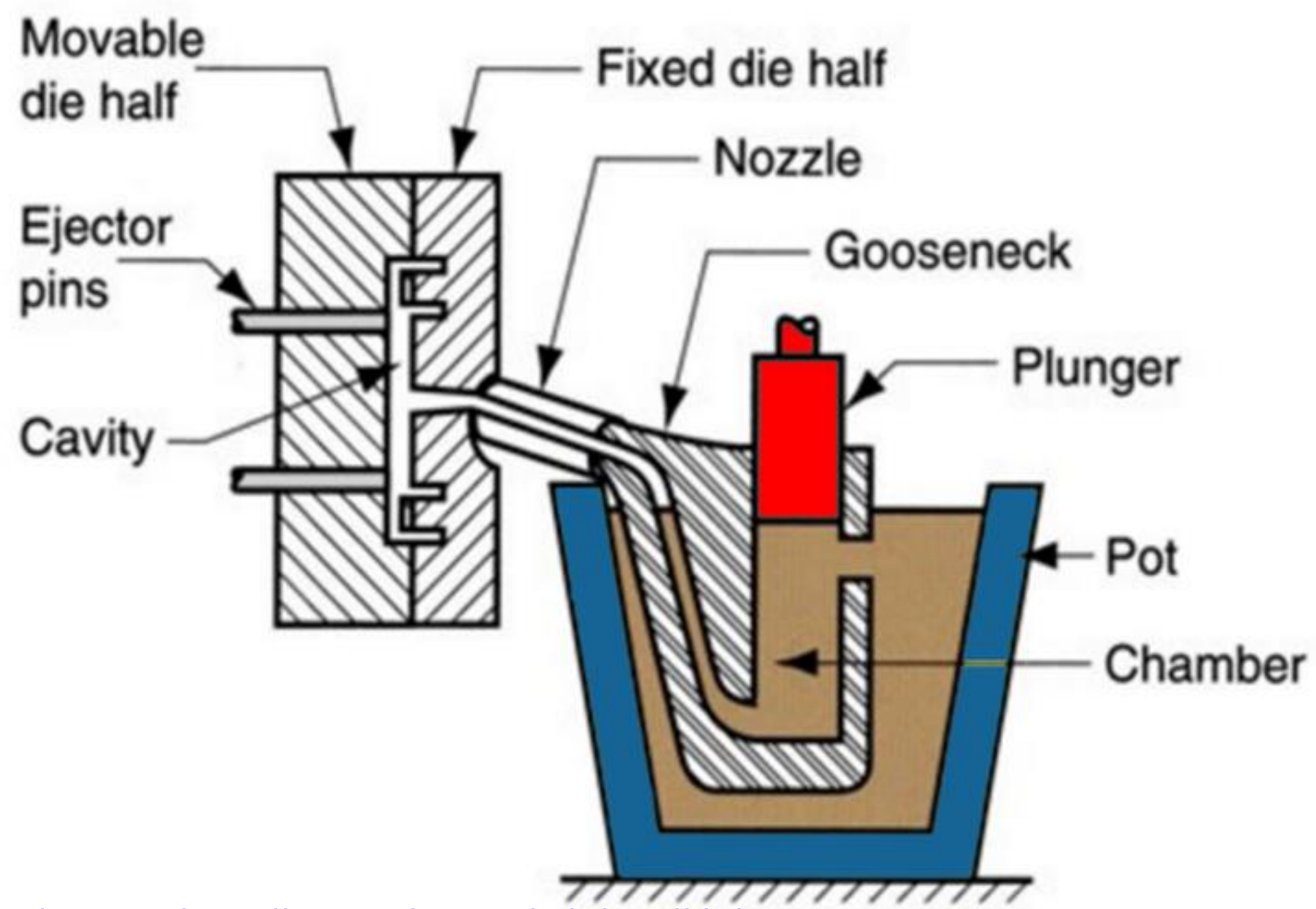

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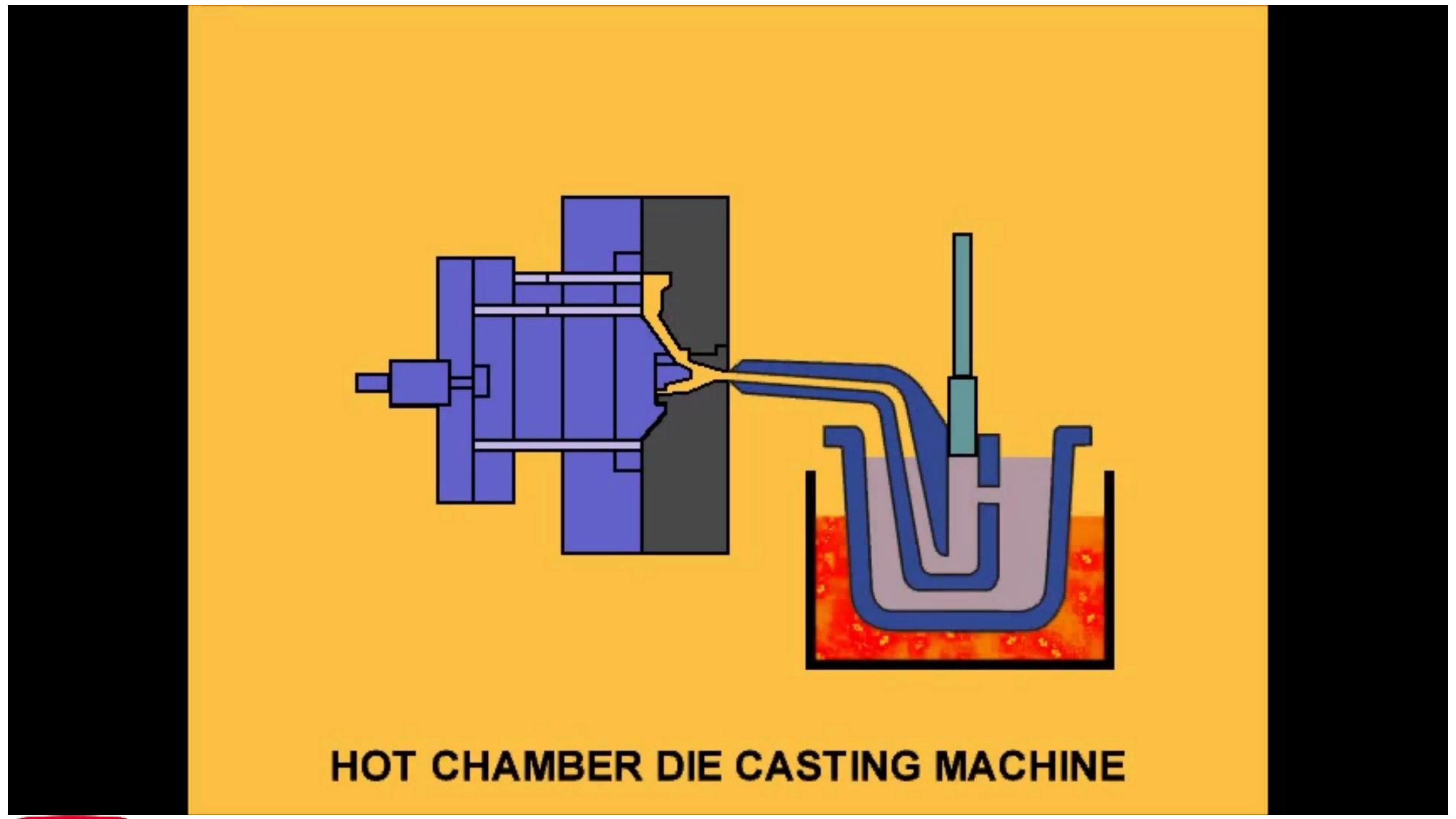

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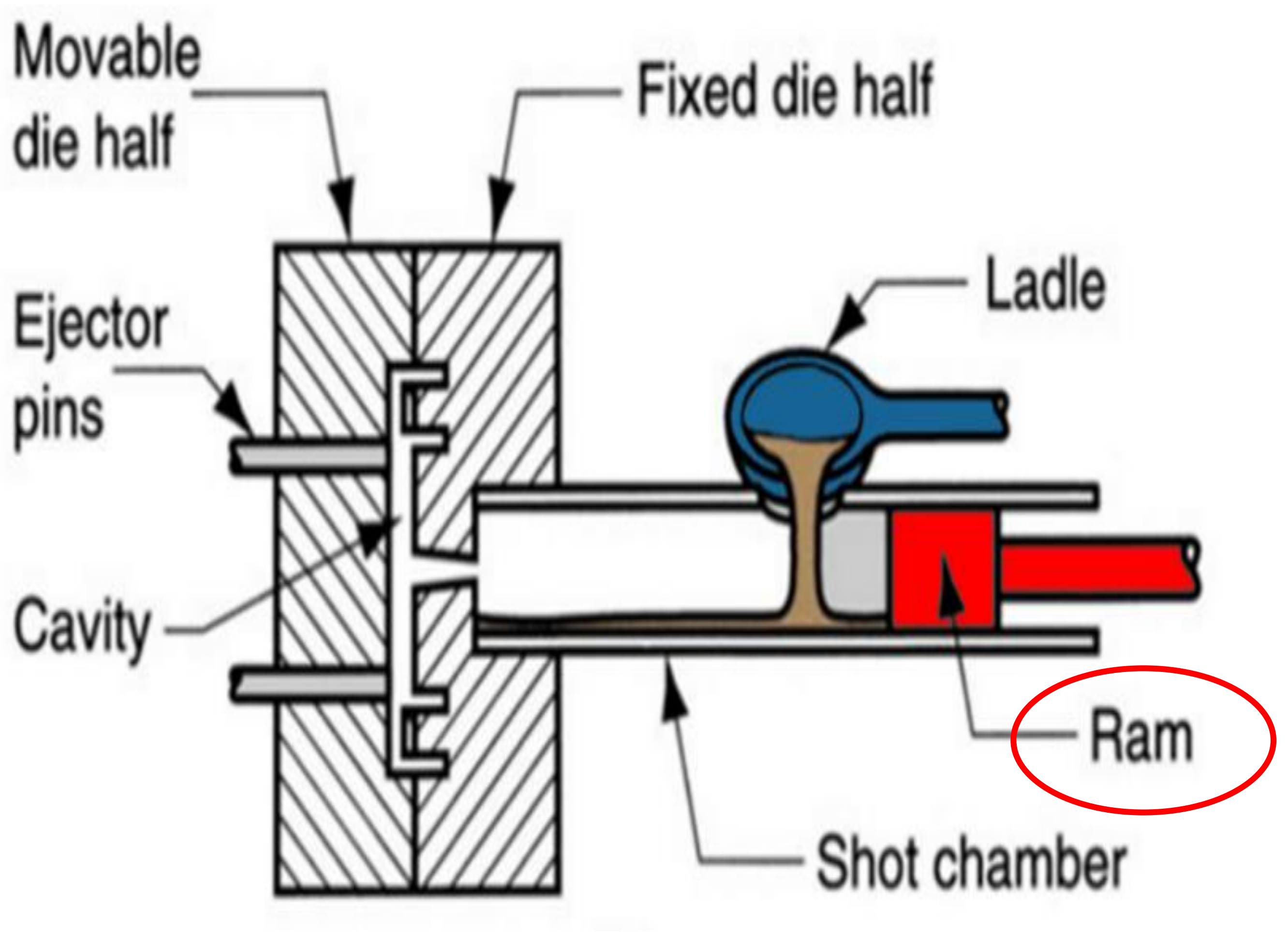

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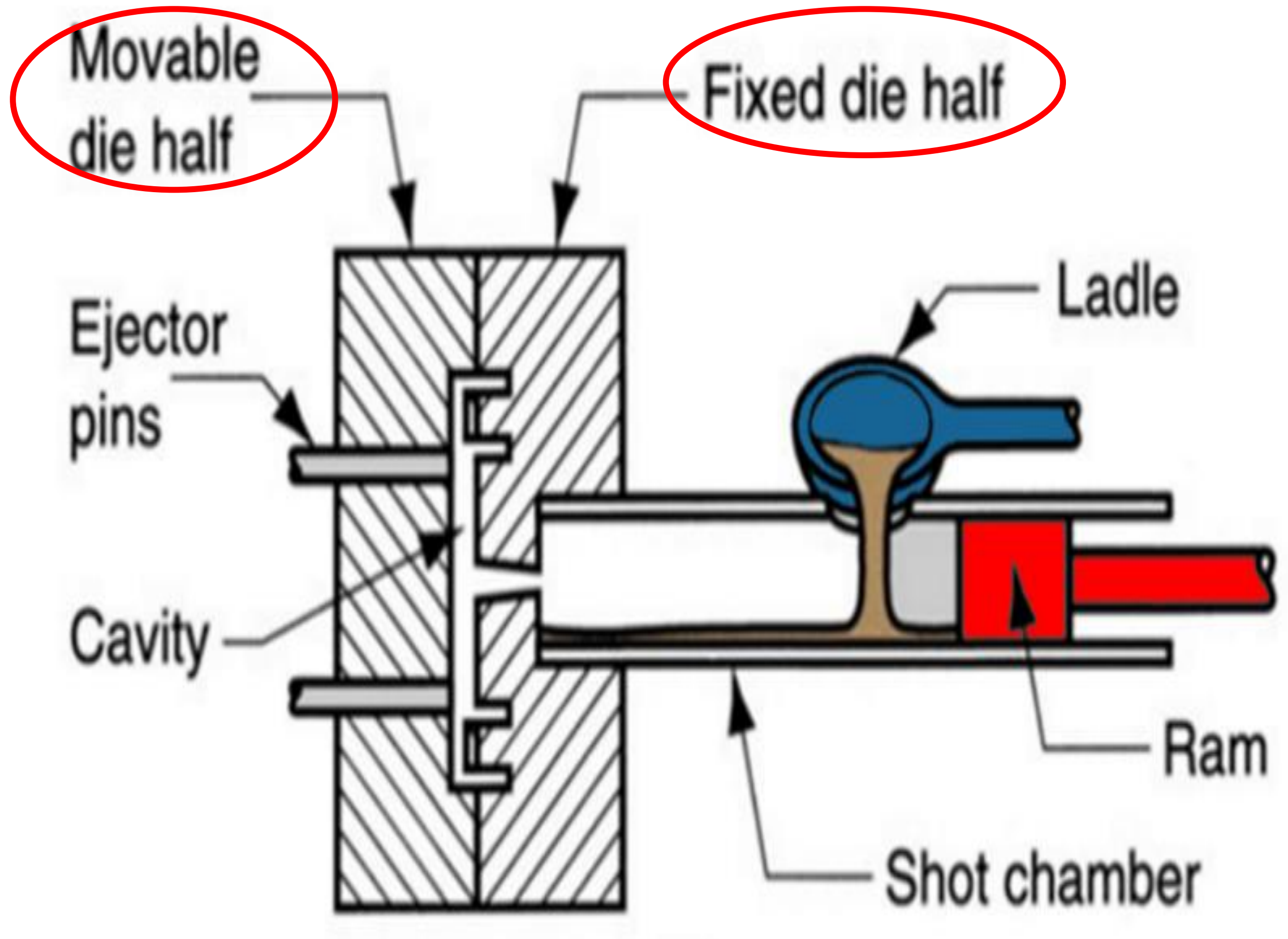

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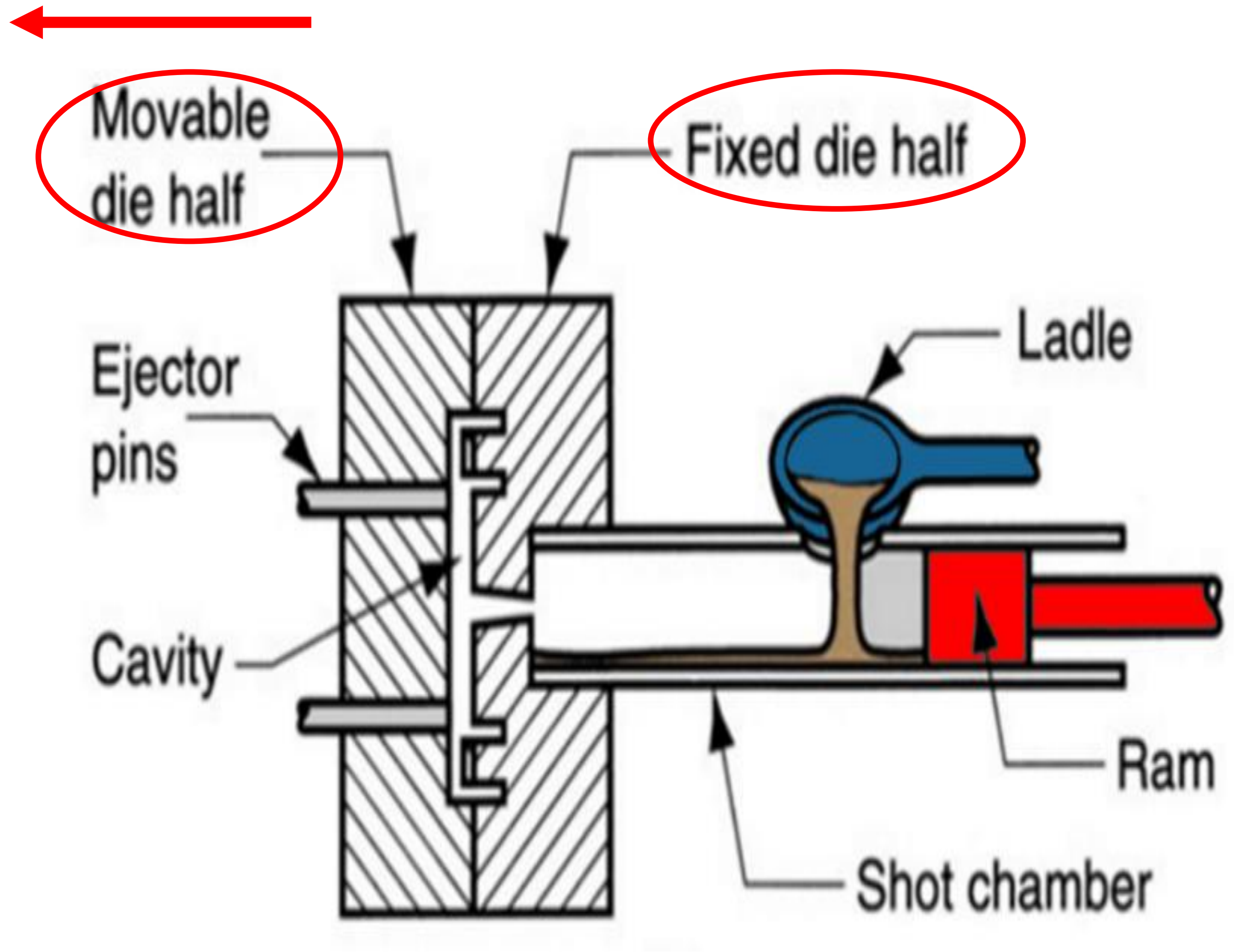

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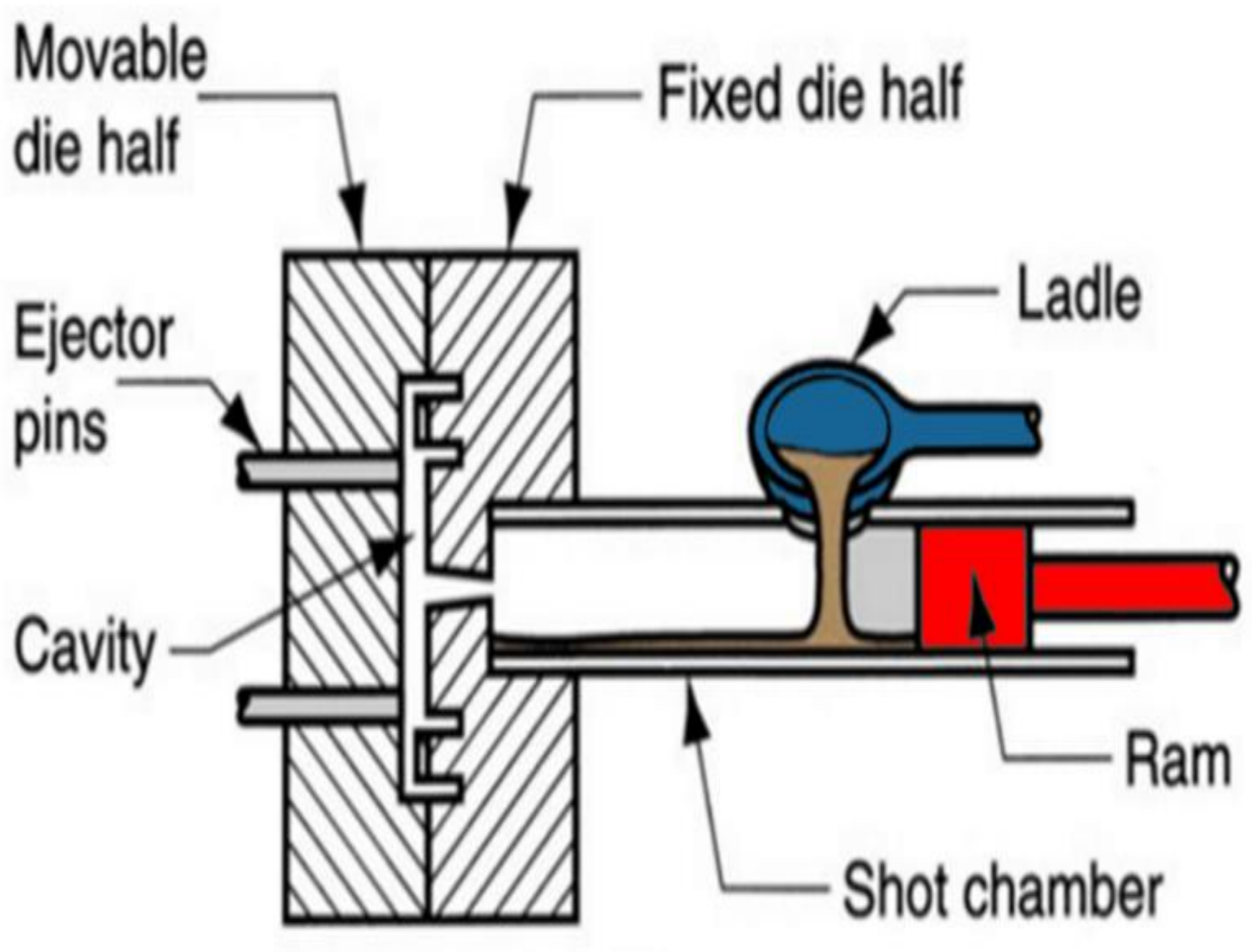

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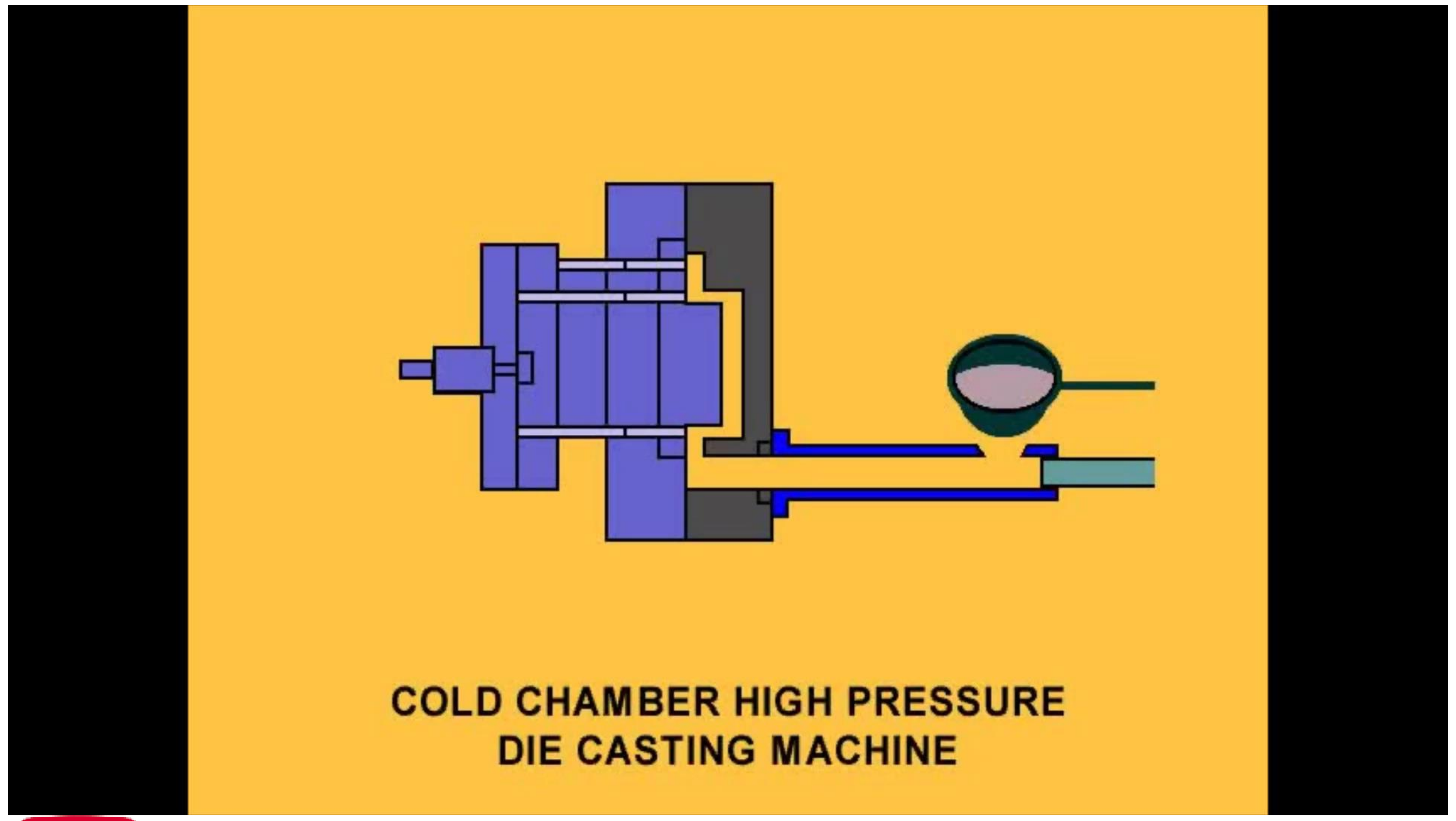

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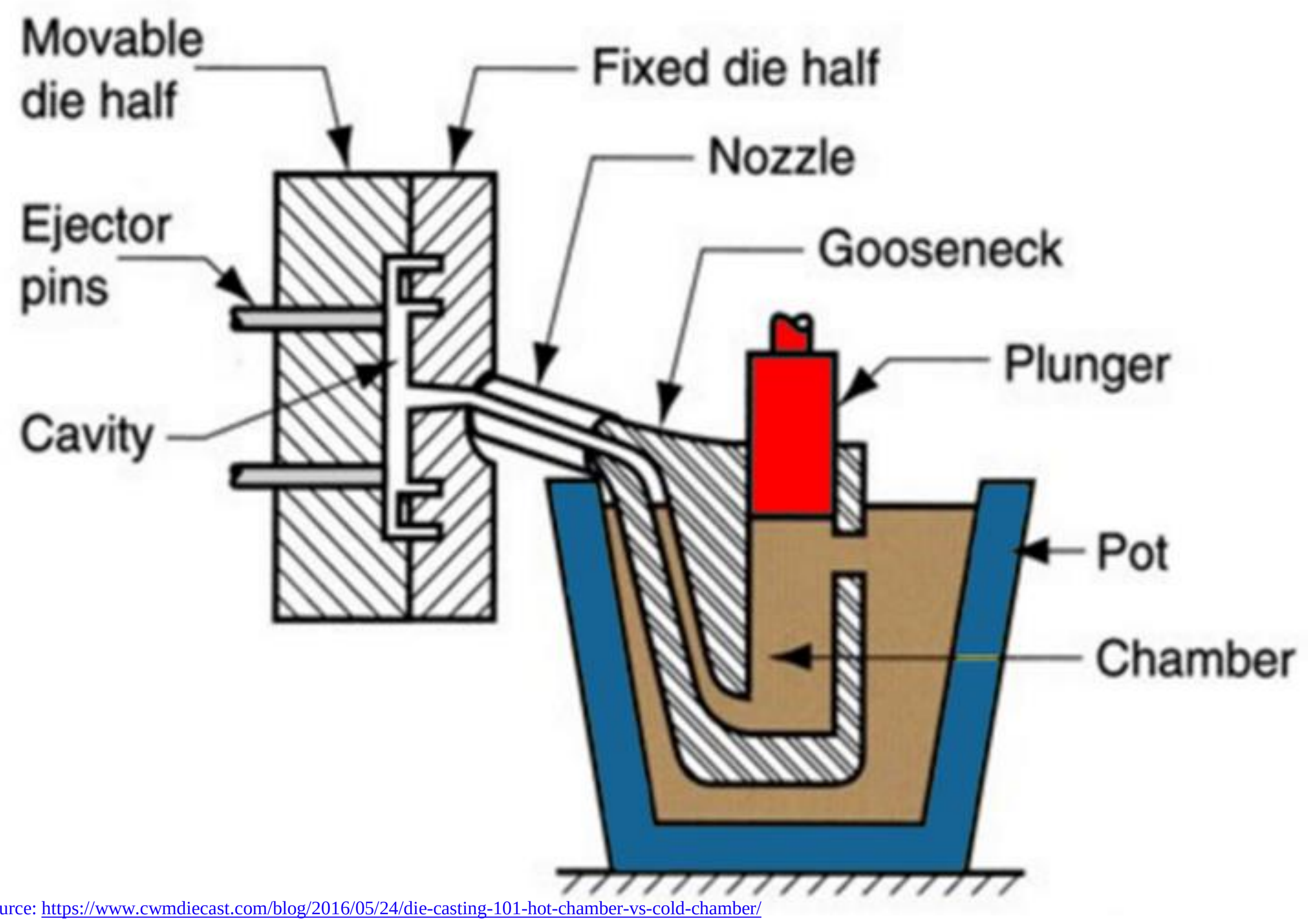

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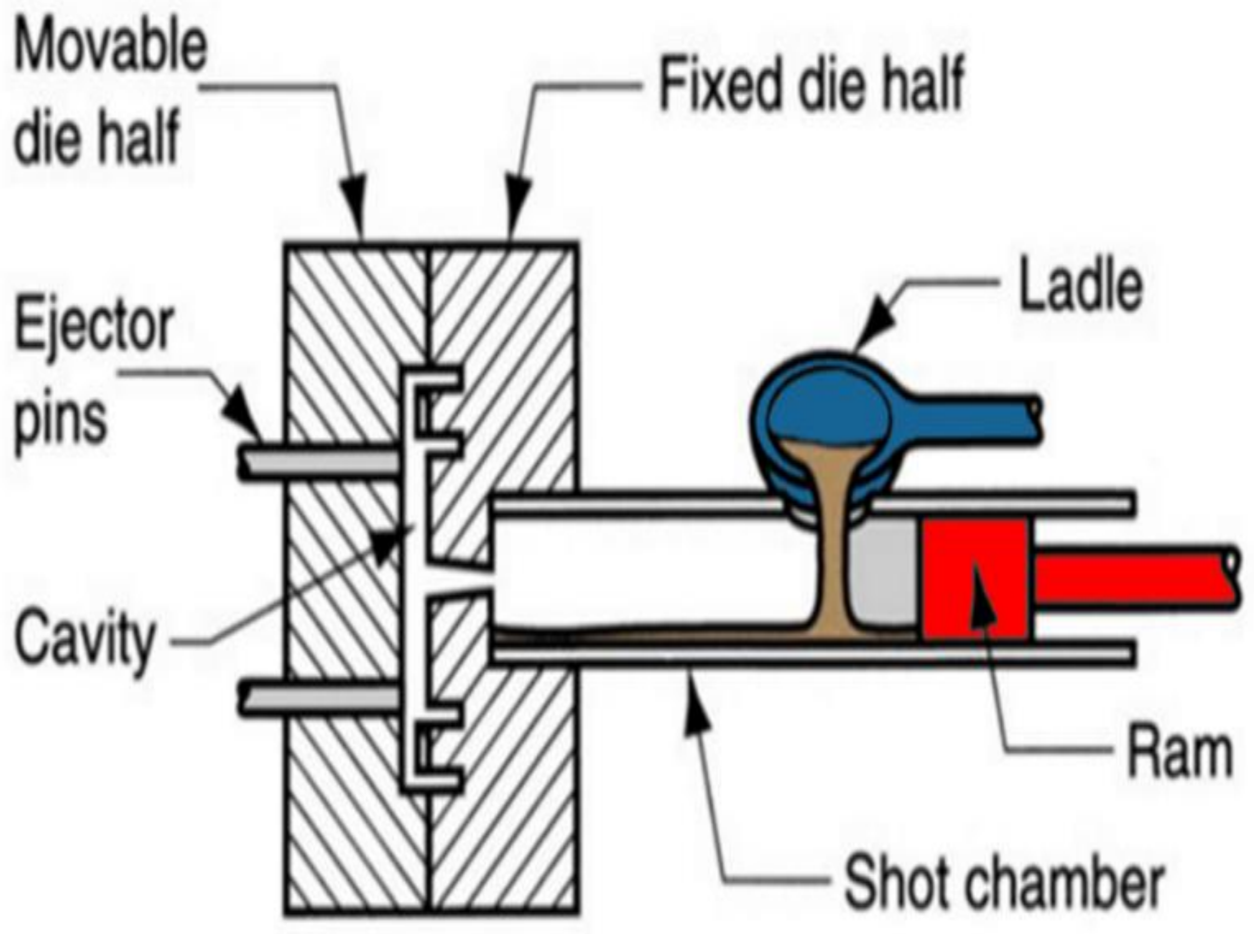

Which one is better?

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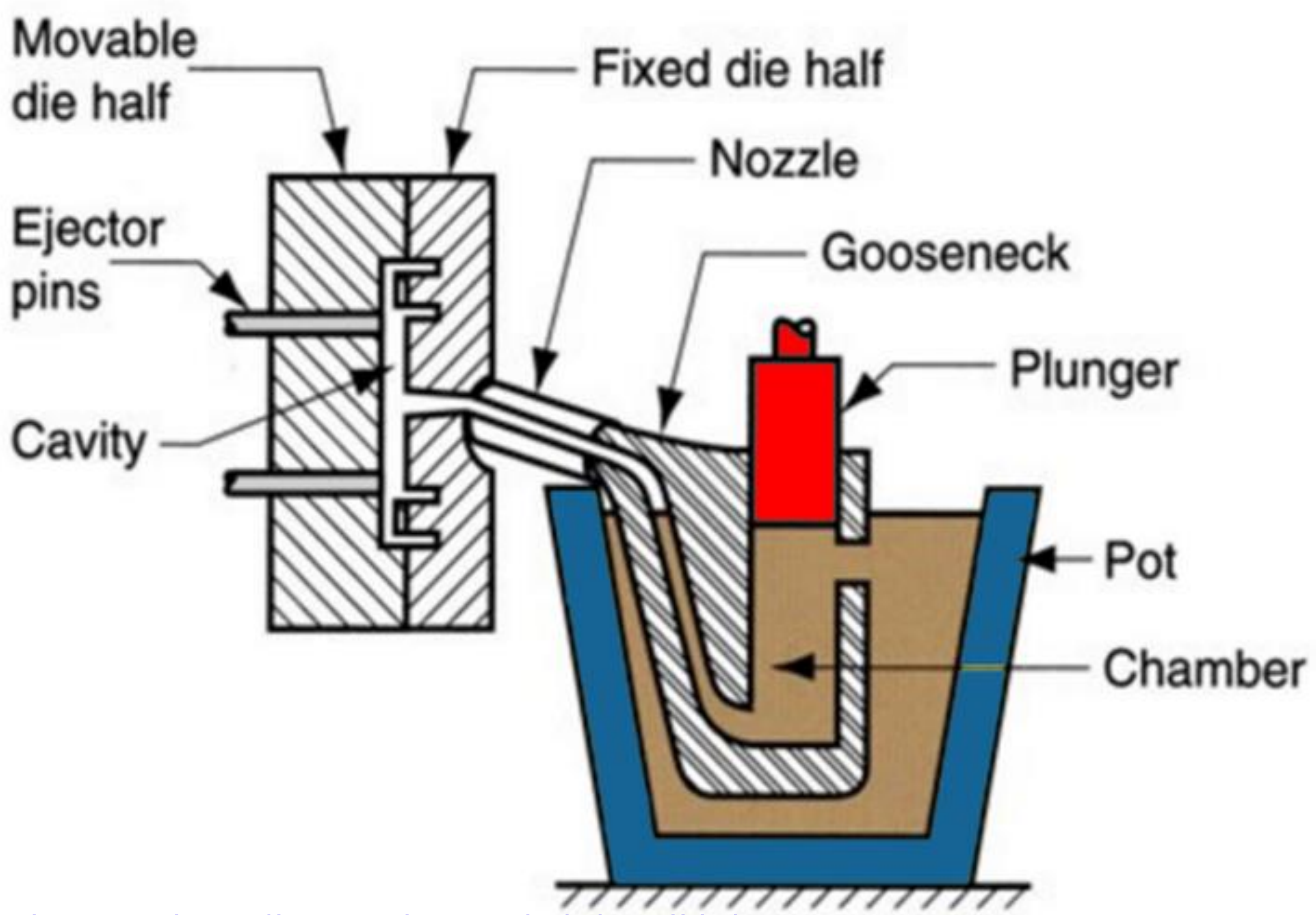

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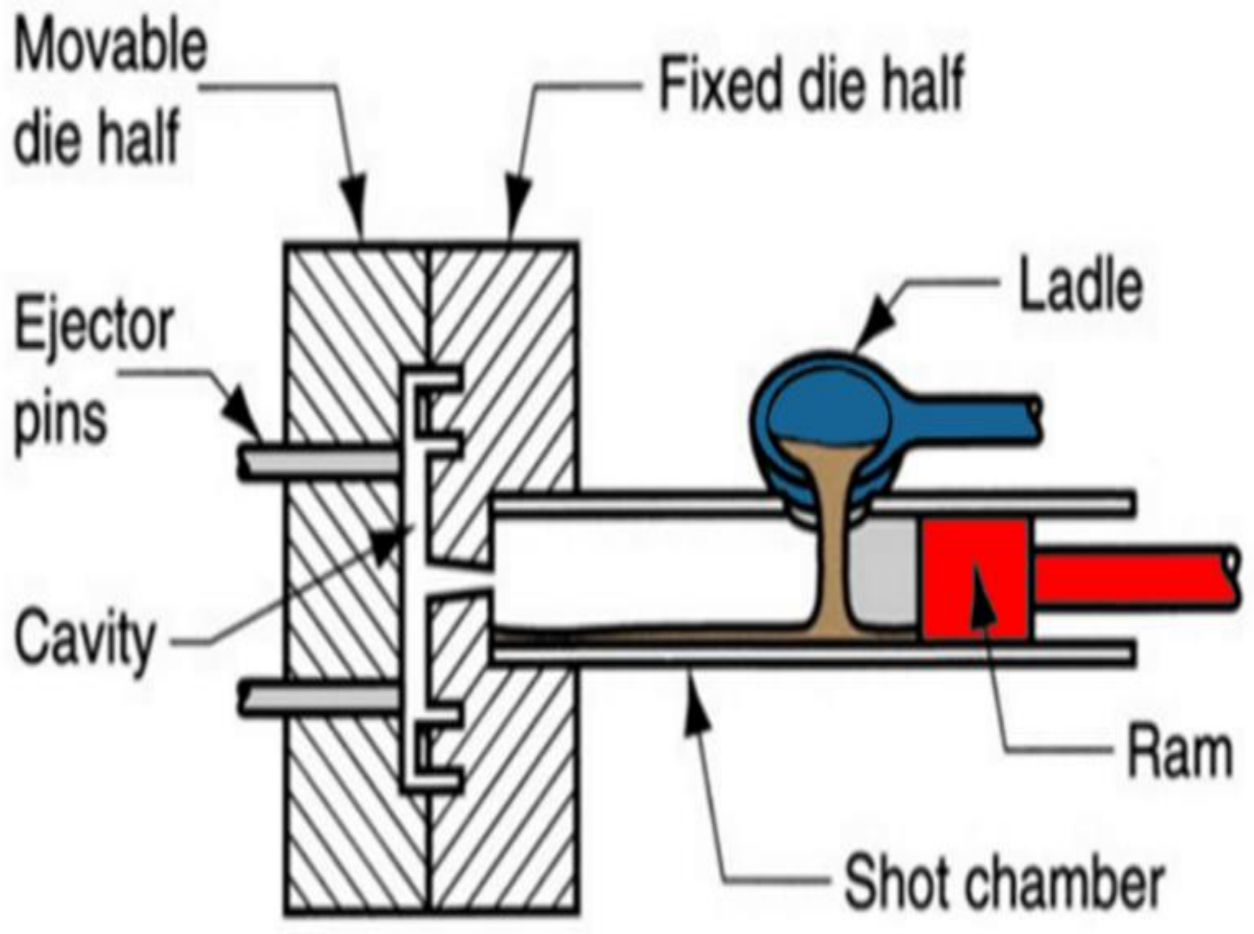

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Note that cycle time determine up to 60% of your final part cost!

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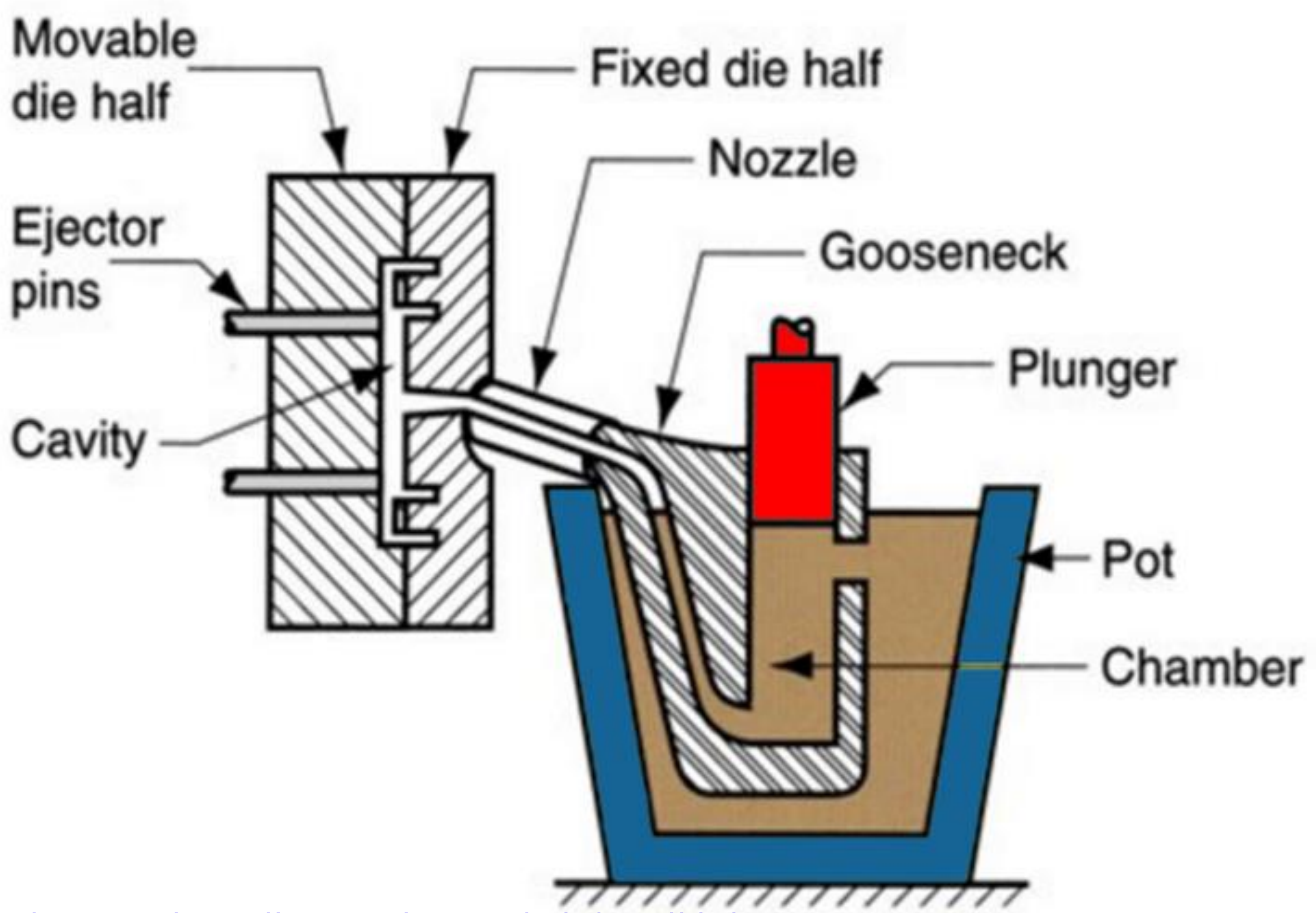

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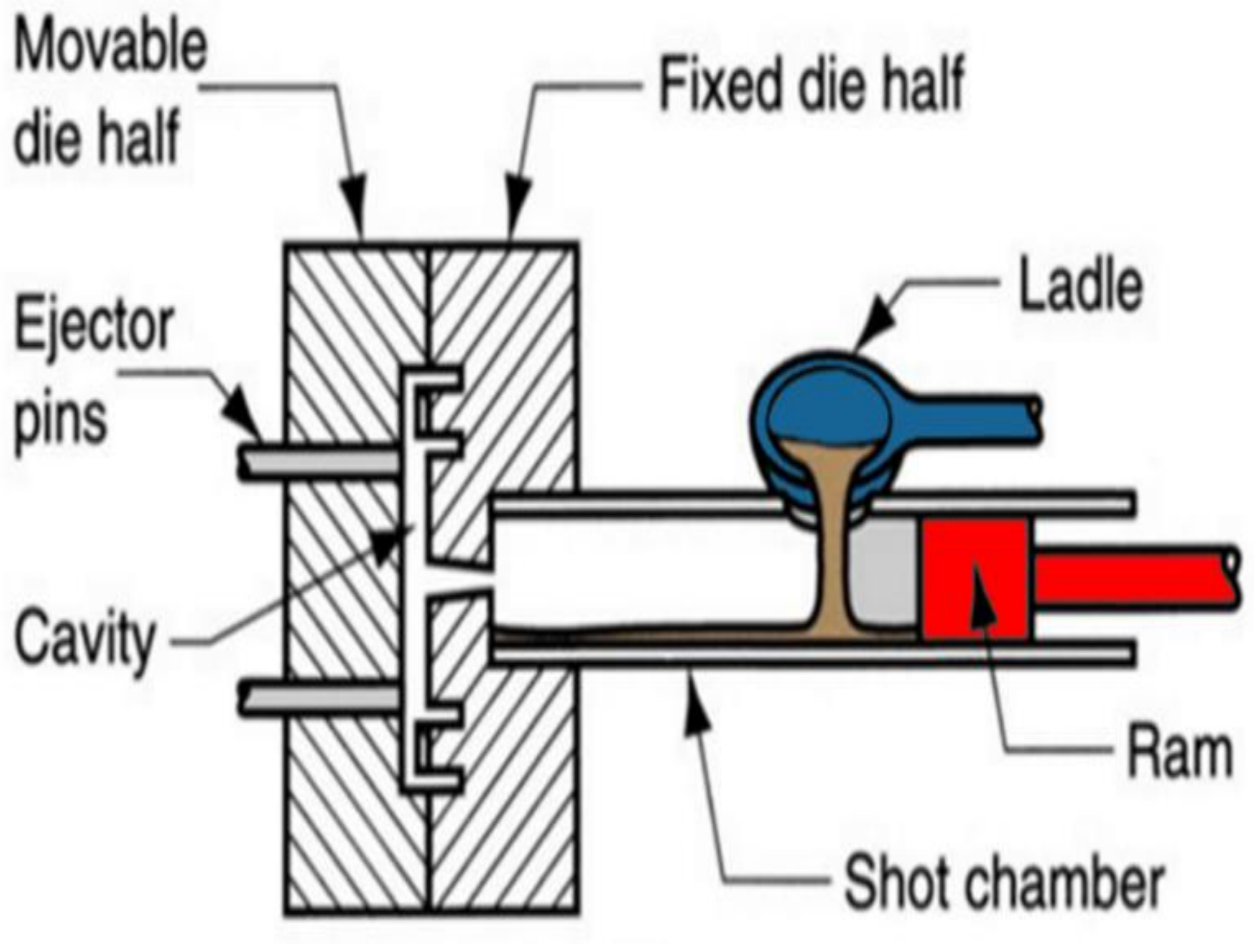

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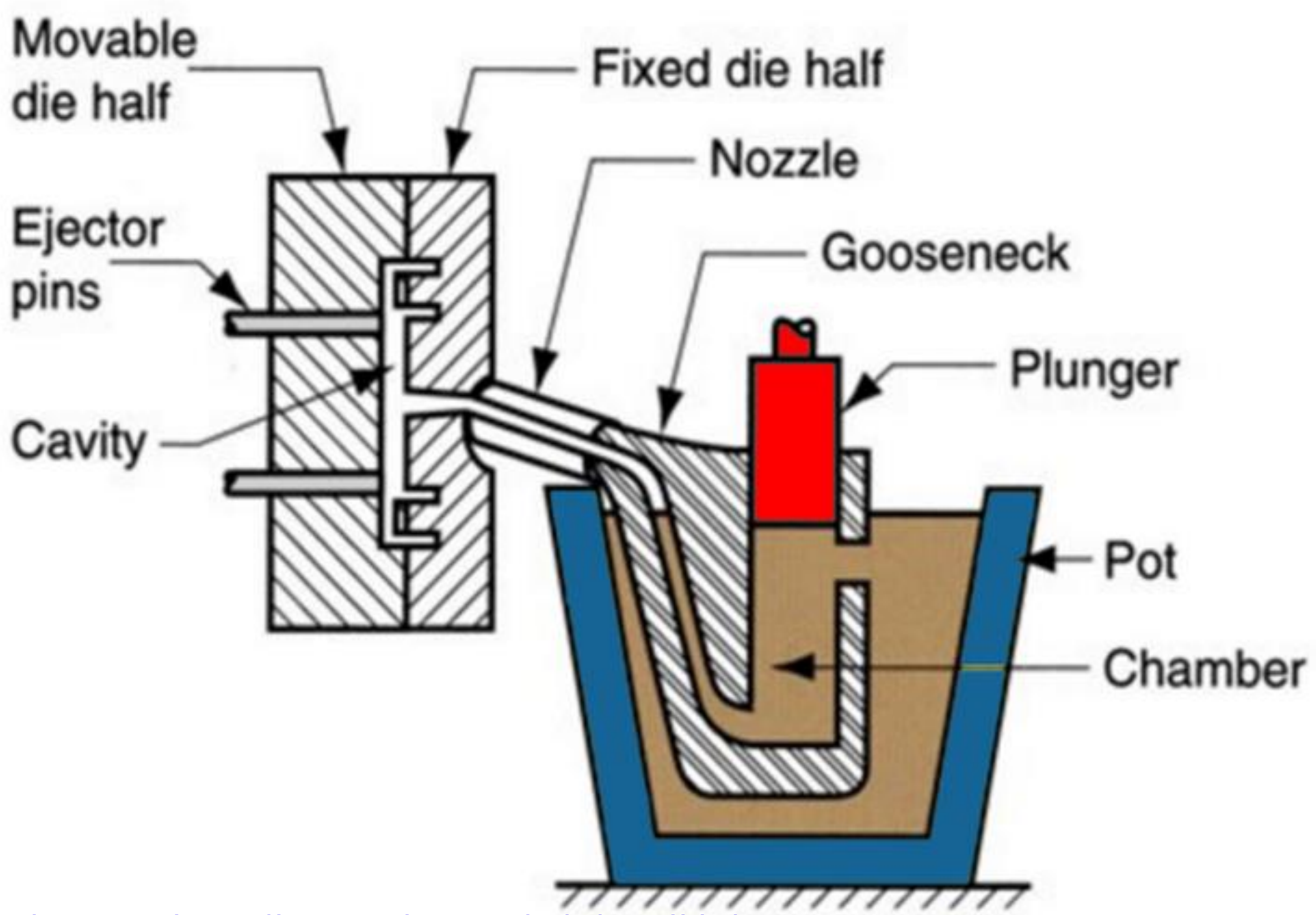

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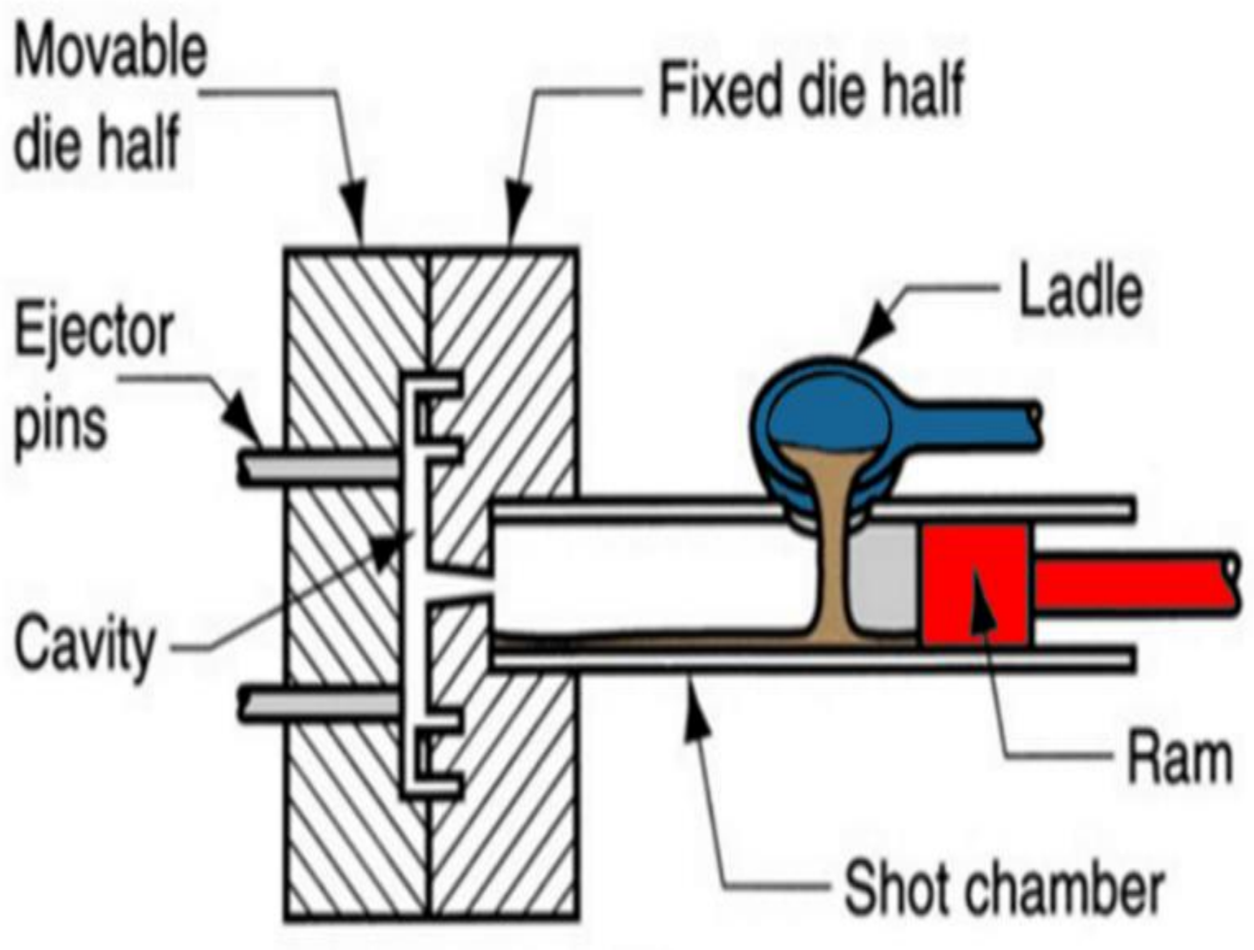

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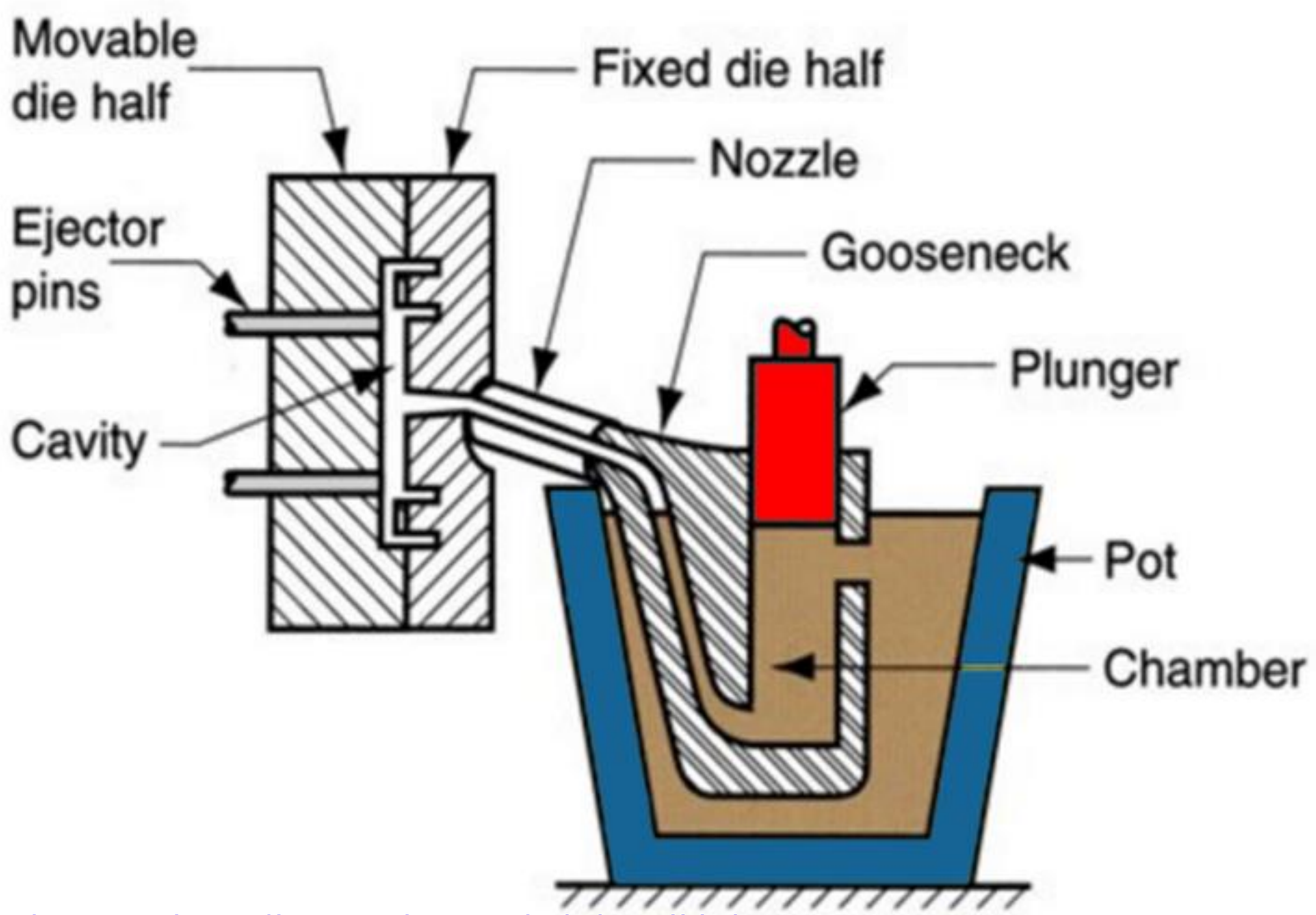

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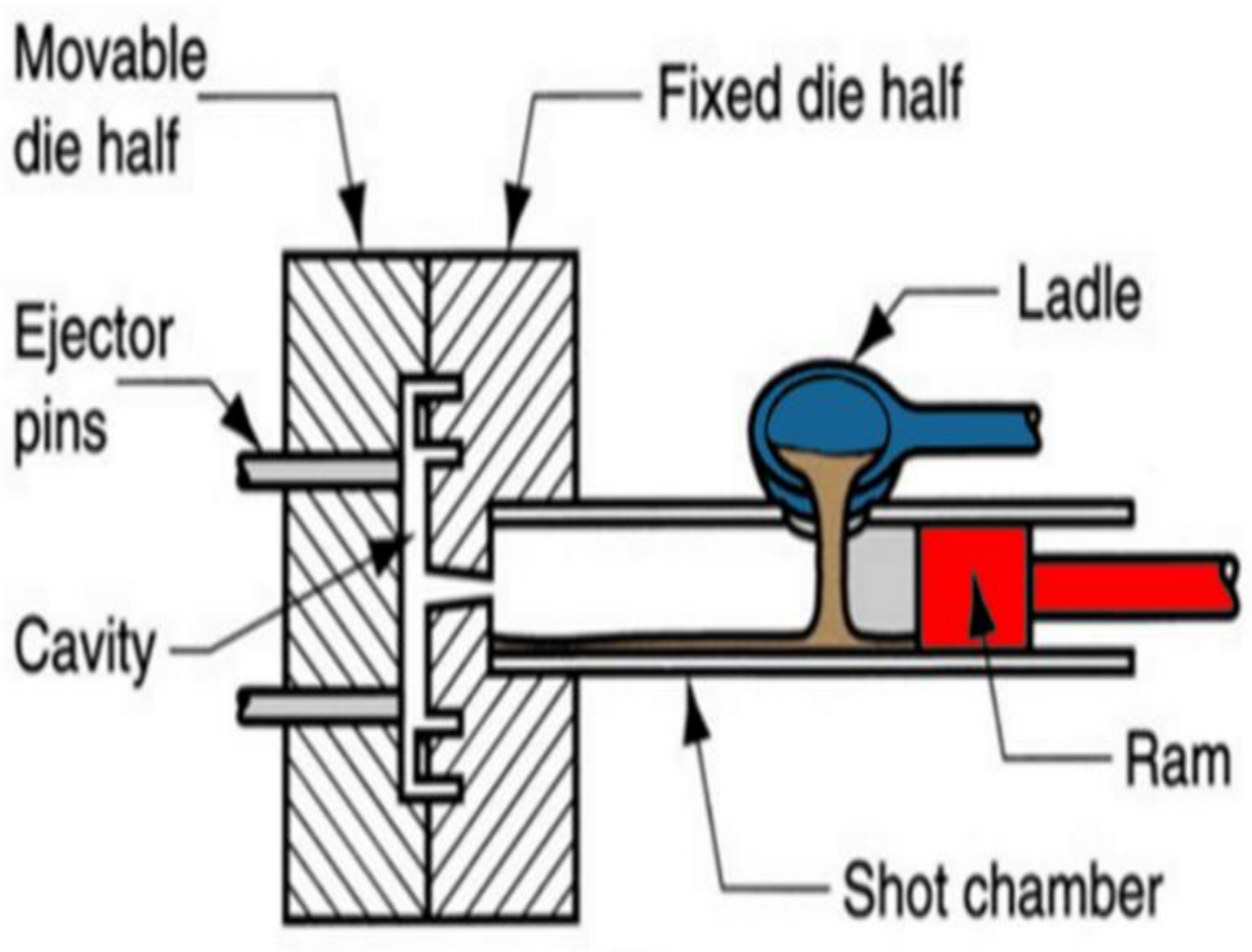

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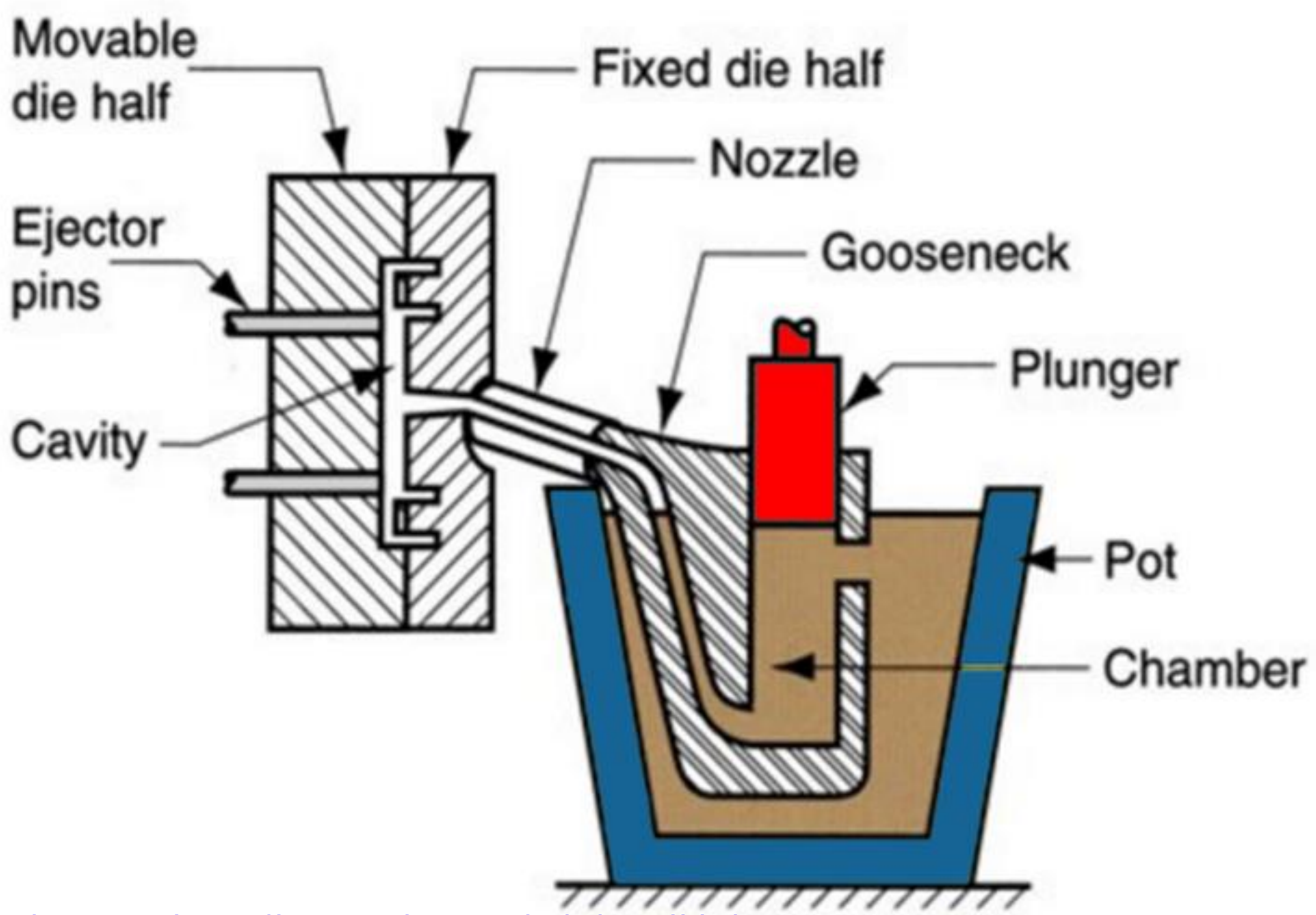

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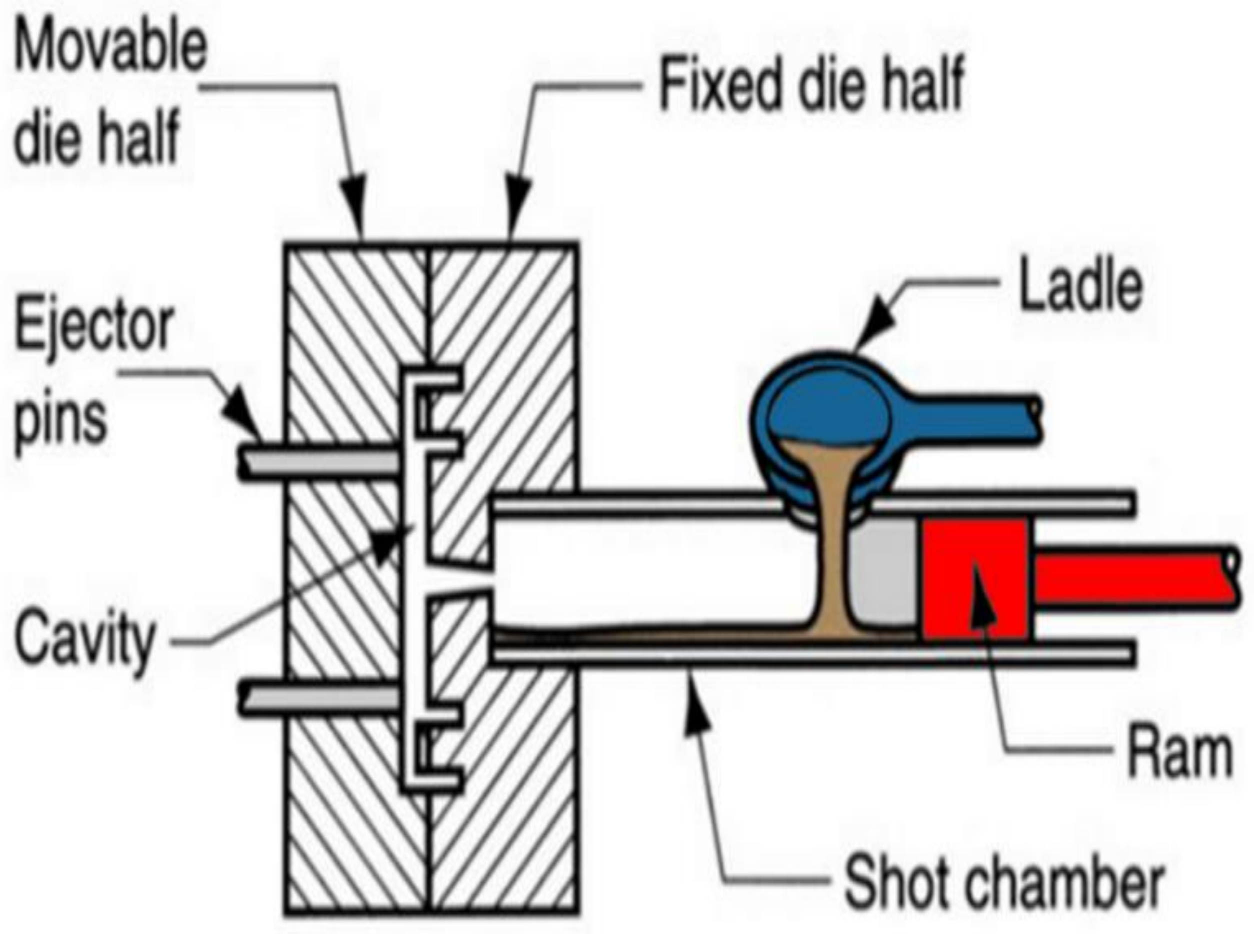

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Ideal for:

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- Steel friendly

Shorter cycle time

Ideal for:

- Alloys with high melting point, Aluminium
- Corrosive properties

Longer cycle time

INVESTMENT CASTING :

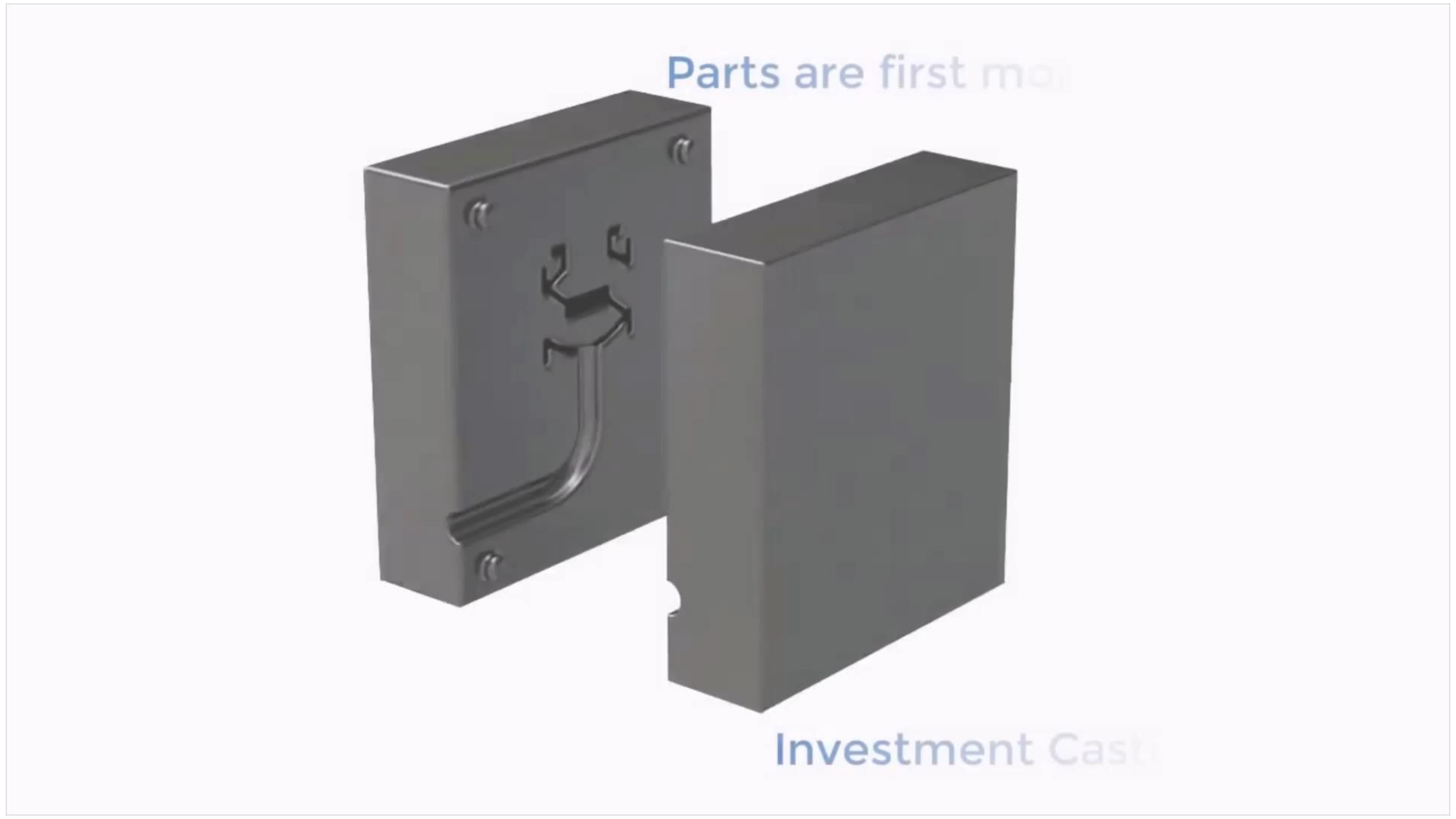
Parts with:

- Complex curves,
- Complex internal cavities,
- Material with high melting point

Rolls-Royce, Single Crystal Turbine Blade

https://www.foundrymag.com/moldscores/rolls-royce-starts-foundry-turbine-blades

INVESTMENT CASTING (LOST WAX CASTING):



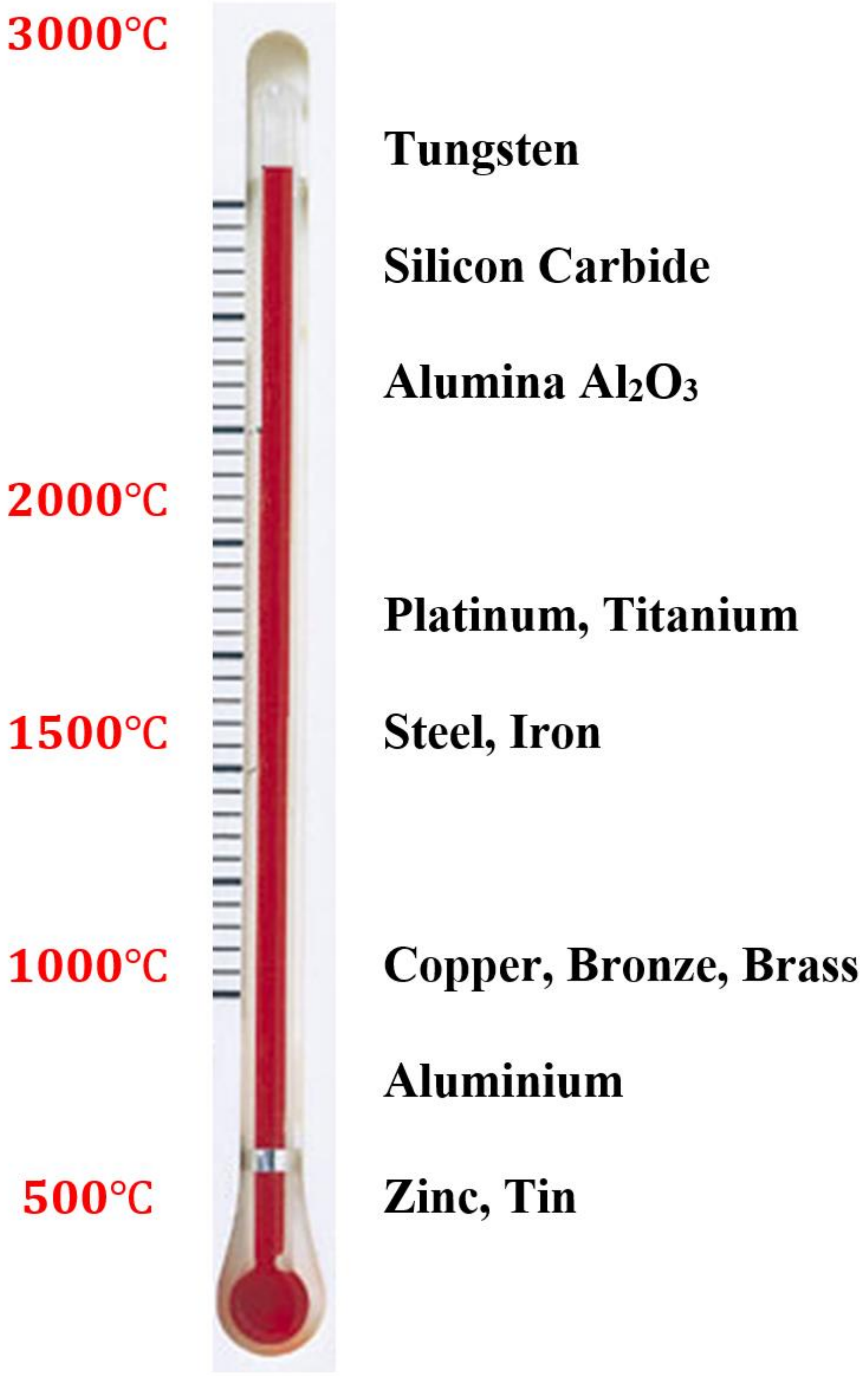
COMPARING THE 3 METHODS OF CASTING:

	Cost	Rate	Quality	Flexibility
Sand Casting	Low	Low	Low	Medium
Die Casting	High	High	Medium	Low
Investment Casting	High	Low	High	Medium

ENGINEERING ANALYSIS:

Key Parameters:

- Latent Heat
- Fluidity Index
- Solidification Time
- Shrinkage



ENGINEERING ANALYSIS:

Fluidity is the ability of the molten metal to flow a certain distance and fill the cavity of the mold. The quality of the cast correlate to fluidity index.

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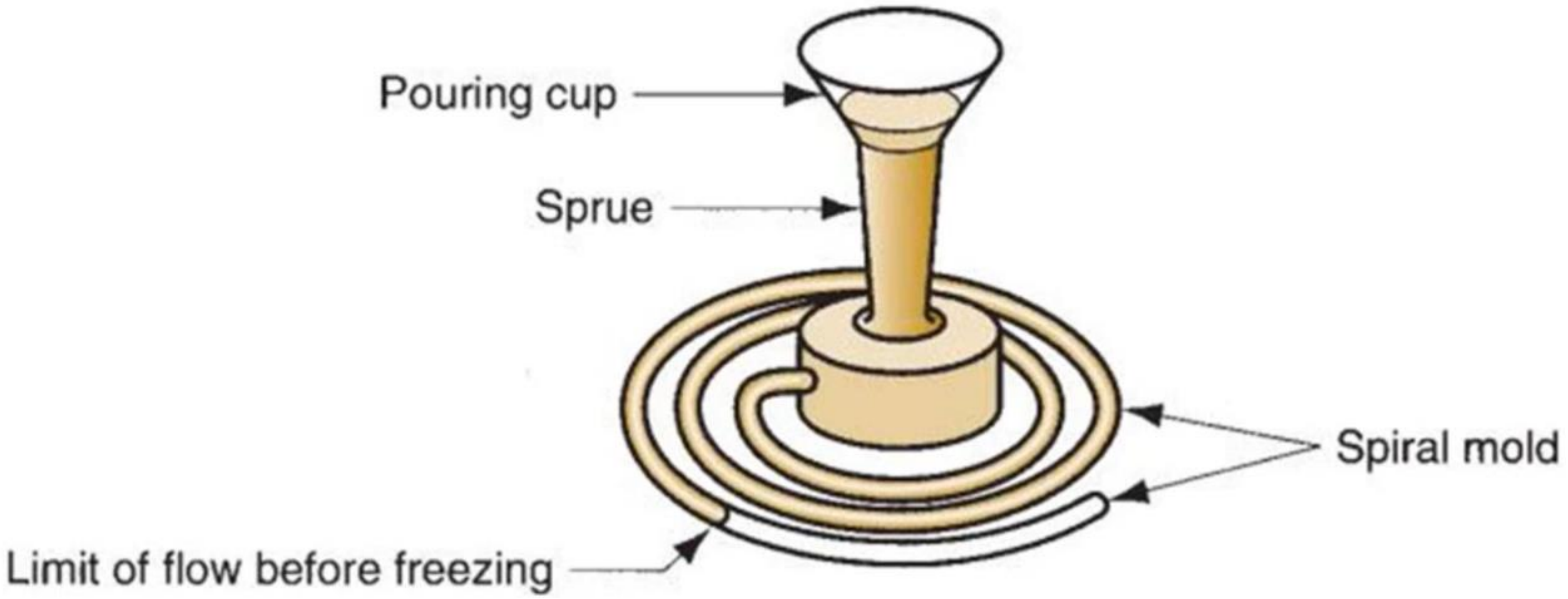

SOLIDIFICATION TIME:

Chvorinov's rule:

Sand: $t_{solidify} = B.(\frac{V}{A})^2$

Die: $t_{solidify} = B.(\frac{V}{A})$

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A: Surface area of the casting
B: mold constant

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Die: $t_{solidify} = B.(\frac{V}{A})$

V: volume of the casting
A: Surface area of the casting
B: mold constant,
For die cast, you can approximate B from:

$$B = \left(\frac{\rho_m L}{T_m - T_0}\right)^2 \left(\frac{\pi}{4k\rho C_p}\right) \left(1 + \left(\frac{C_m (T_{pour} - T_m)}{L}\right)^2\right)^2$$

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For die cast, you can approximate B from:

$$B = \left(\frac{\rho_m L}{T_m - T_0}\right)^2 \left(\frac{\pi}{4k\rho C_p}\right) \left(1 + \left(\frac{C_m(T_{pour} - T_m)}{L}\right)^2\right)^2$$

Mold

SOLIDIFICATION TIME:

Chvorinov’s rule:

Sand: $t_{solidify} = B.(\frac{V}{A})^2$

Die: $t_{solidify} = B.(\frac{V}{A})$

V: volume of the casting
A: Surface area of the casting
B: mold constant

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Molten Metal **Mold** **Molten Metal**

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superheat

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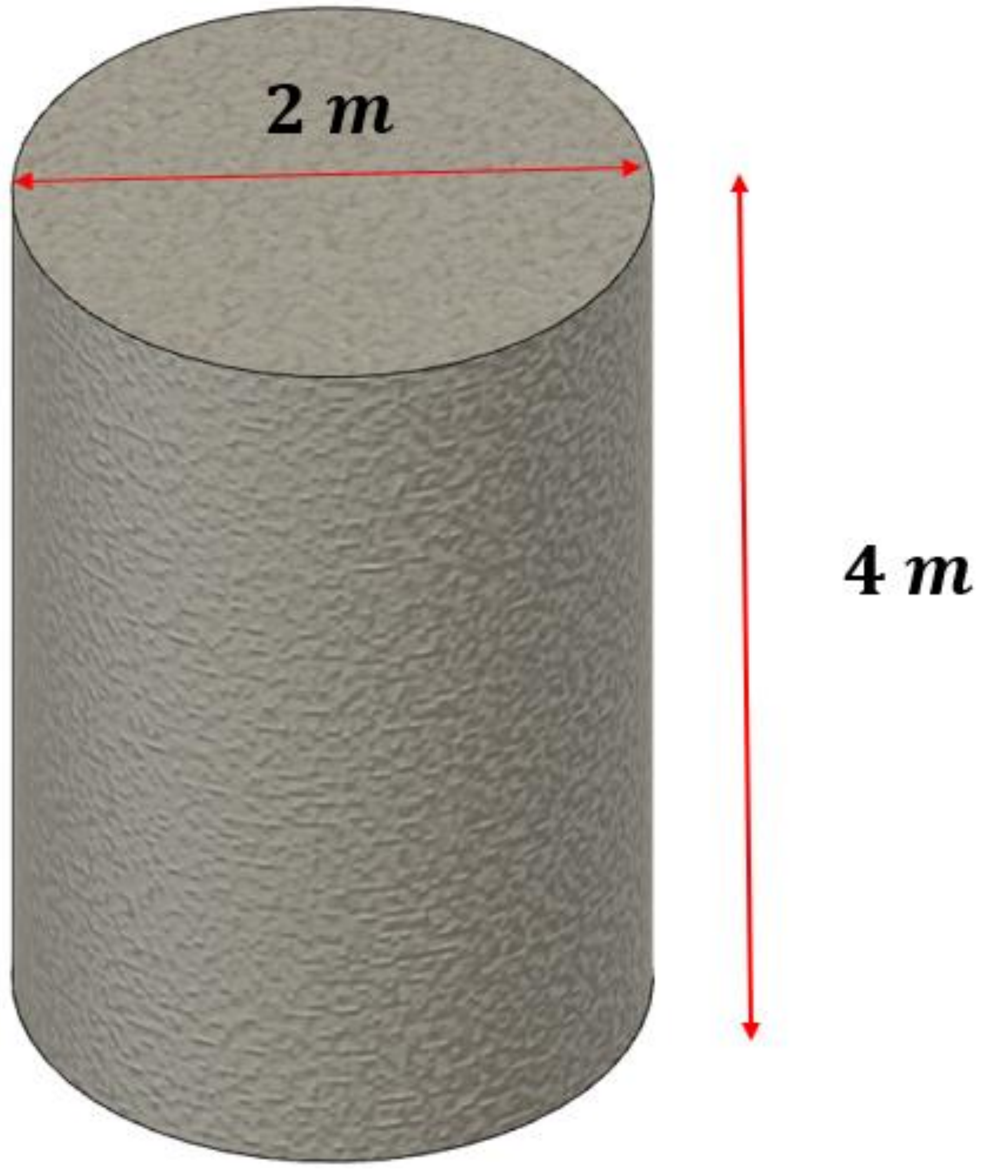
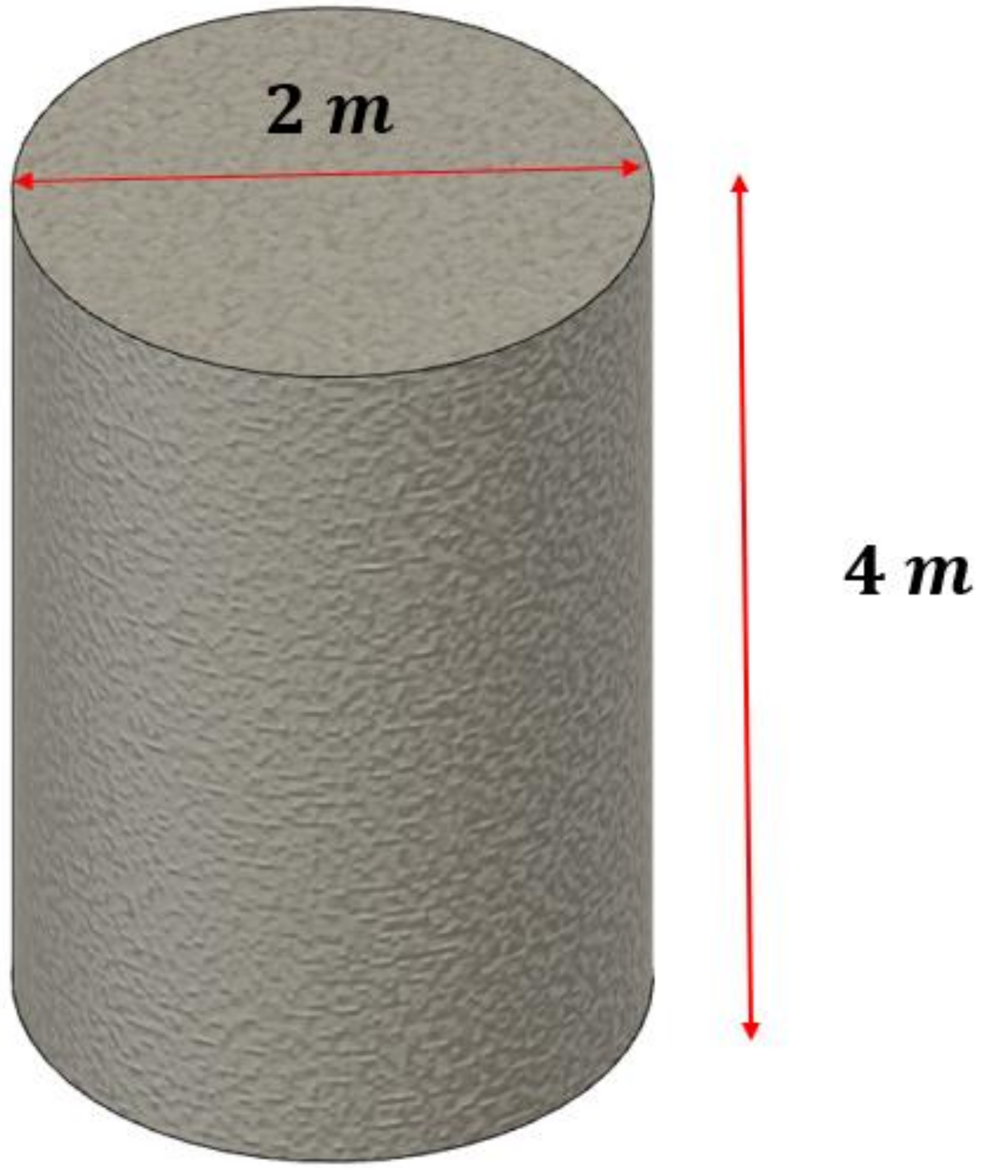
Molten Metal **Mold** **Molten Metal**

EXAMPLE)



EXAMPLE)



$$\frac{V}{A} = 0.4\ \mathrm{m}$$

$$B_{sand} = 1000\,\frac{Sec}{m^2}$$

$$B_{die} = 100\,\frac{Sec}{m}$$

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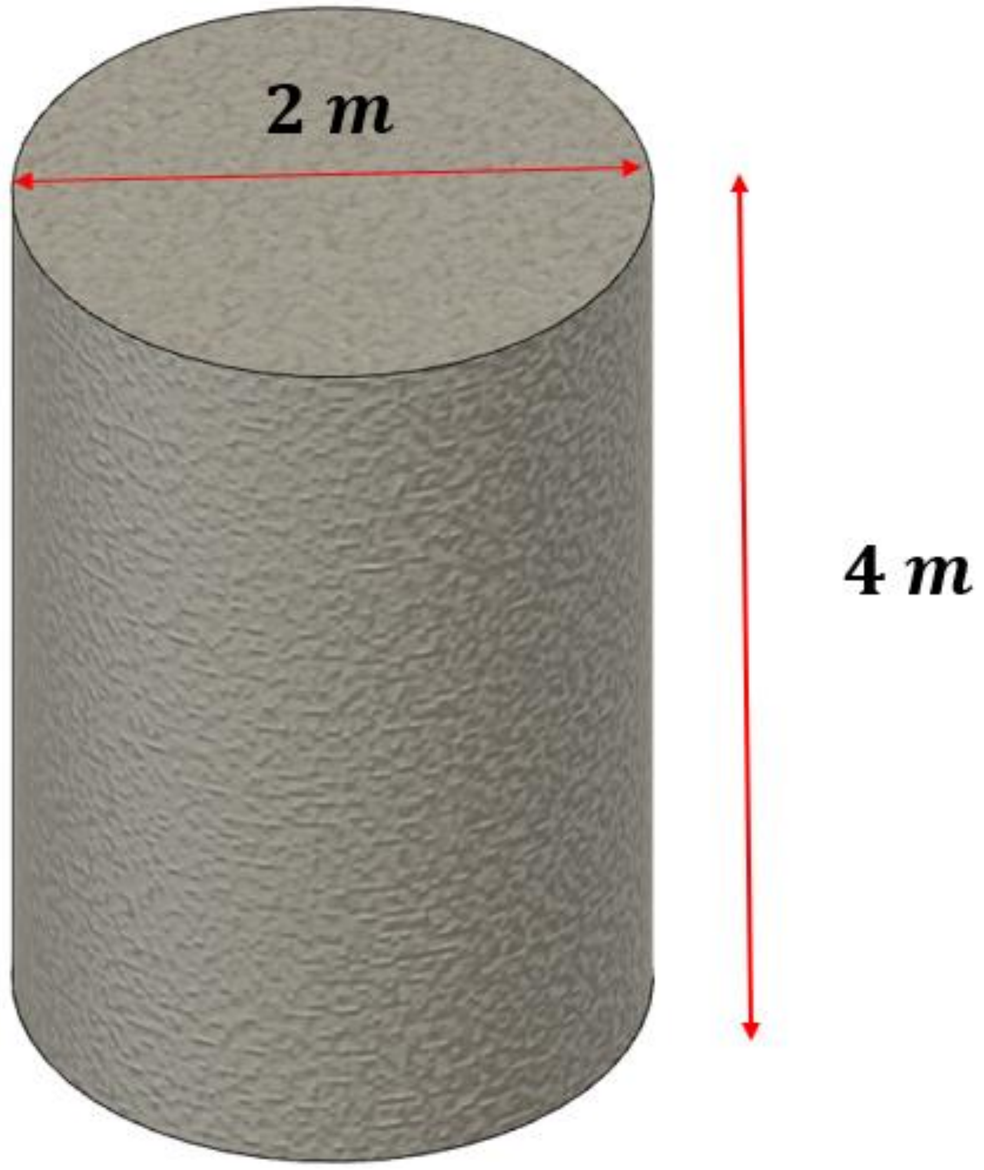

$$\frac{\boldsymbol{V}}{\boldsymbol{A}} = 0.4 \text{ m}$$

$$B_{sand} = 1000\,\frac{Sec}{m^2}$$

$$B_{die} = 100\,\frac{Sec}{m}$$

Sand: $t_{solidify} = B.(\frac{V}{A})^2$=160 Sec

Die: $t_{solidify} = B.(\frac{V}{A})$=4 Sec

SHRINKAGE:

The size and shape of the pattern must take into account the relative amount of shrinkage

No	Metal	Shrinkage (%)
1	Cast iron	1
2	Aluminium Alloys	1.3
3	Brass	1.5
4	Bronze	1.5
5	Steel	2.5

DESIGN CONSIDERATION:

- Thin wall
- Uniform thickness
- Round corner
- Draft angle

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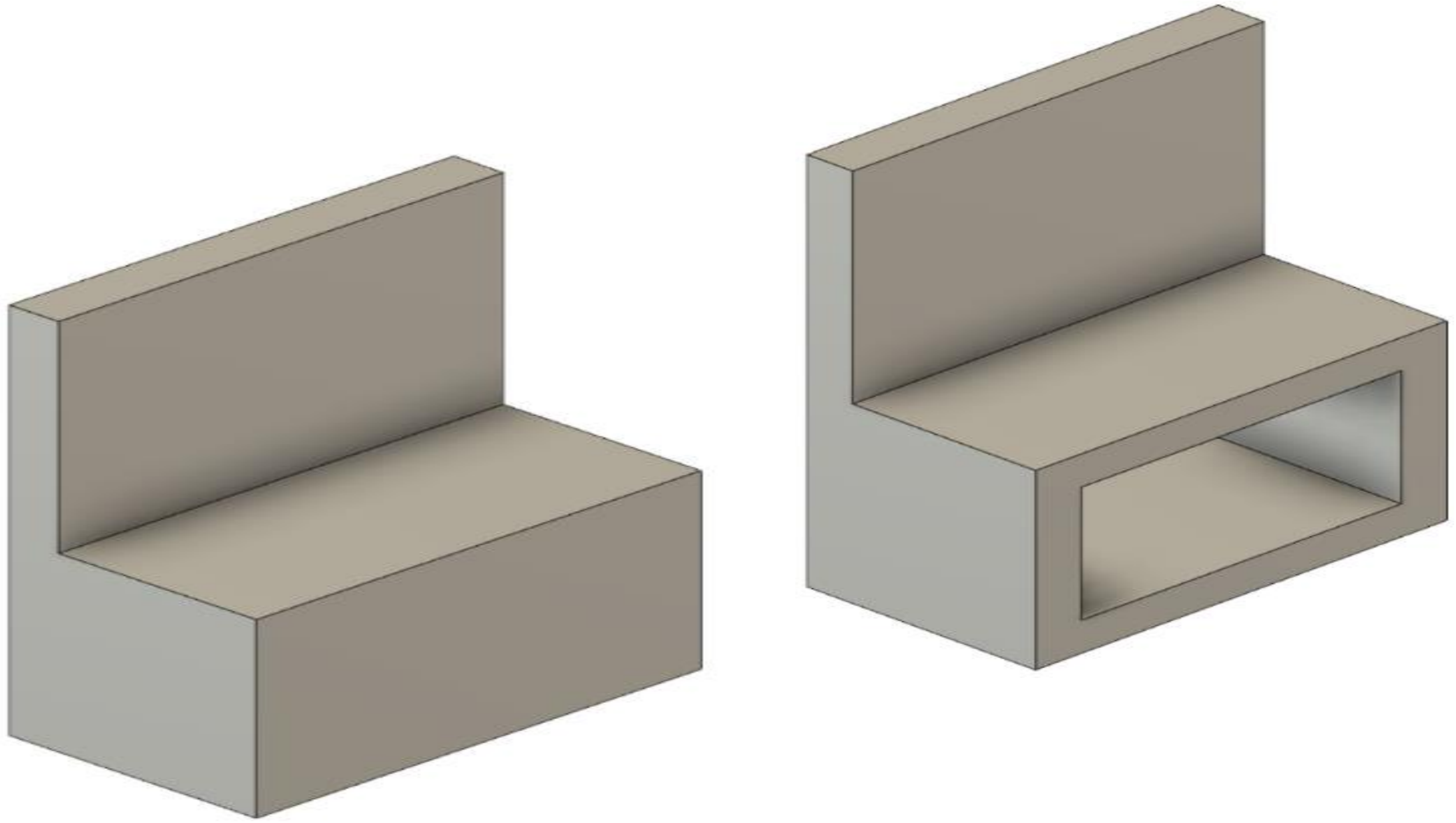

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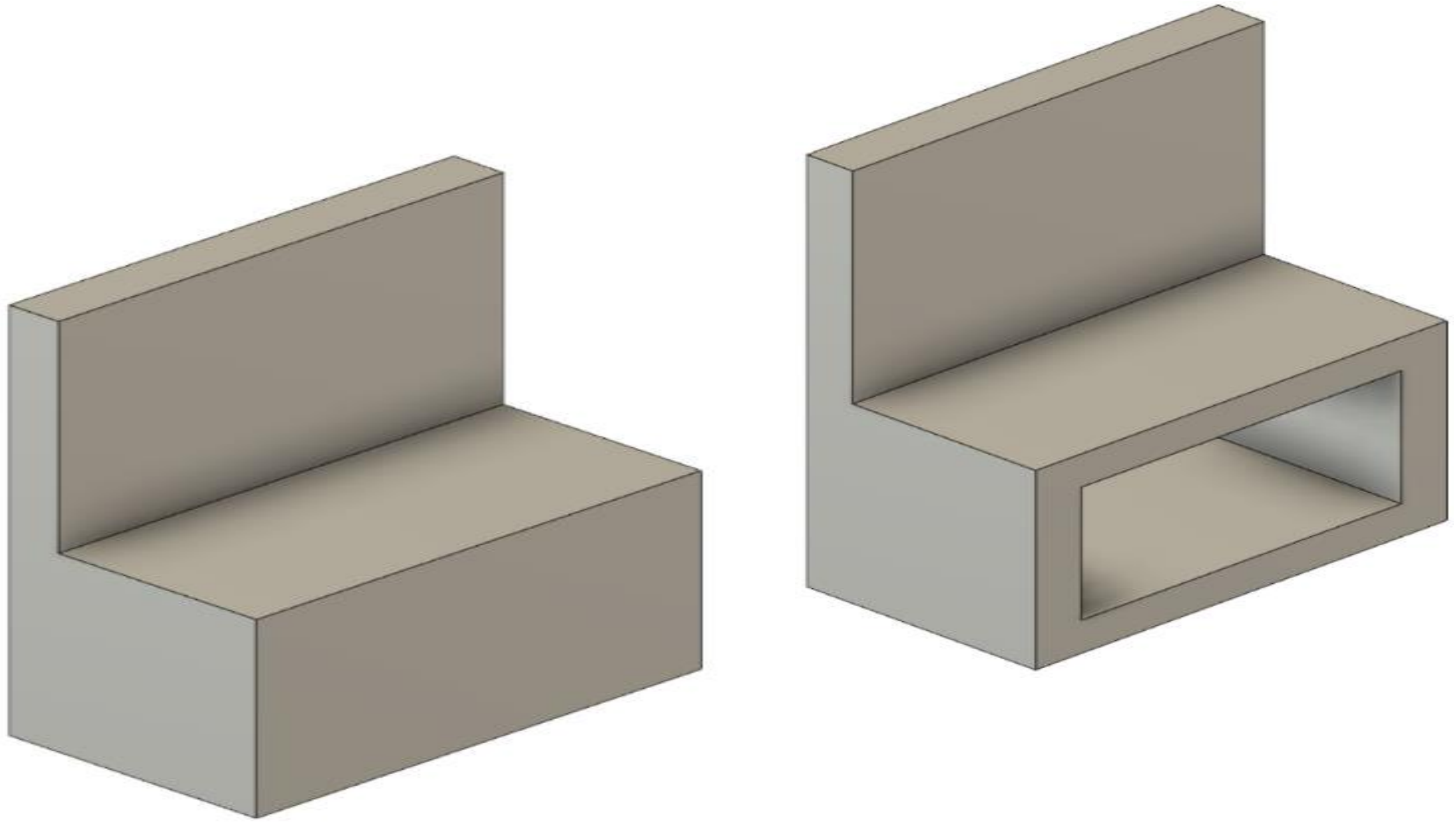

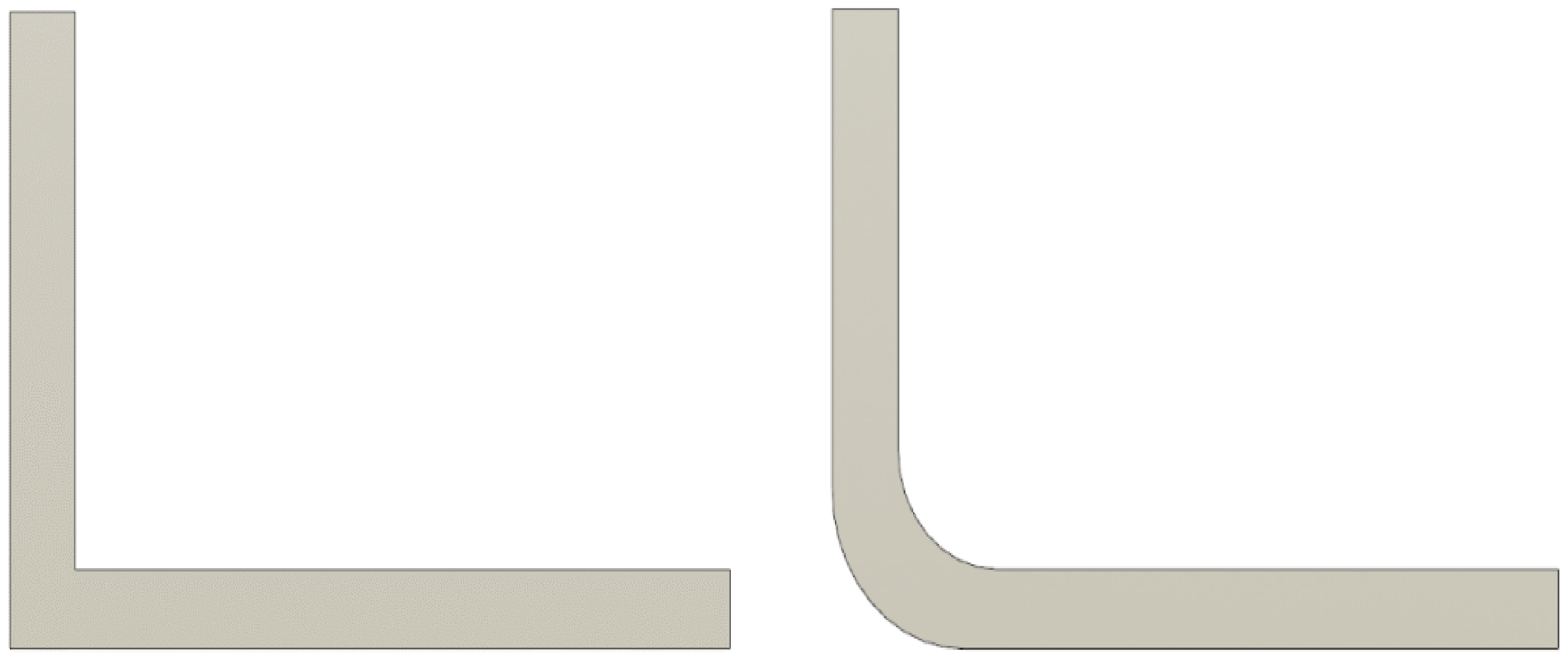

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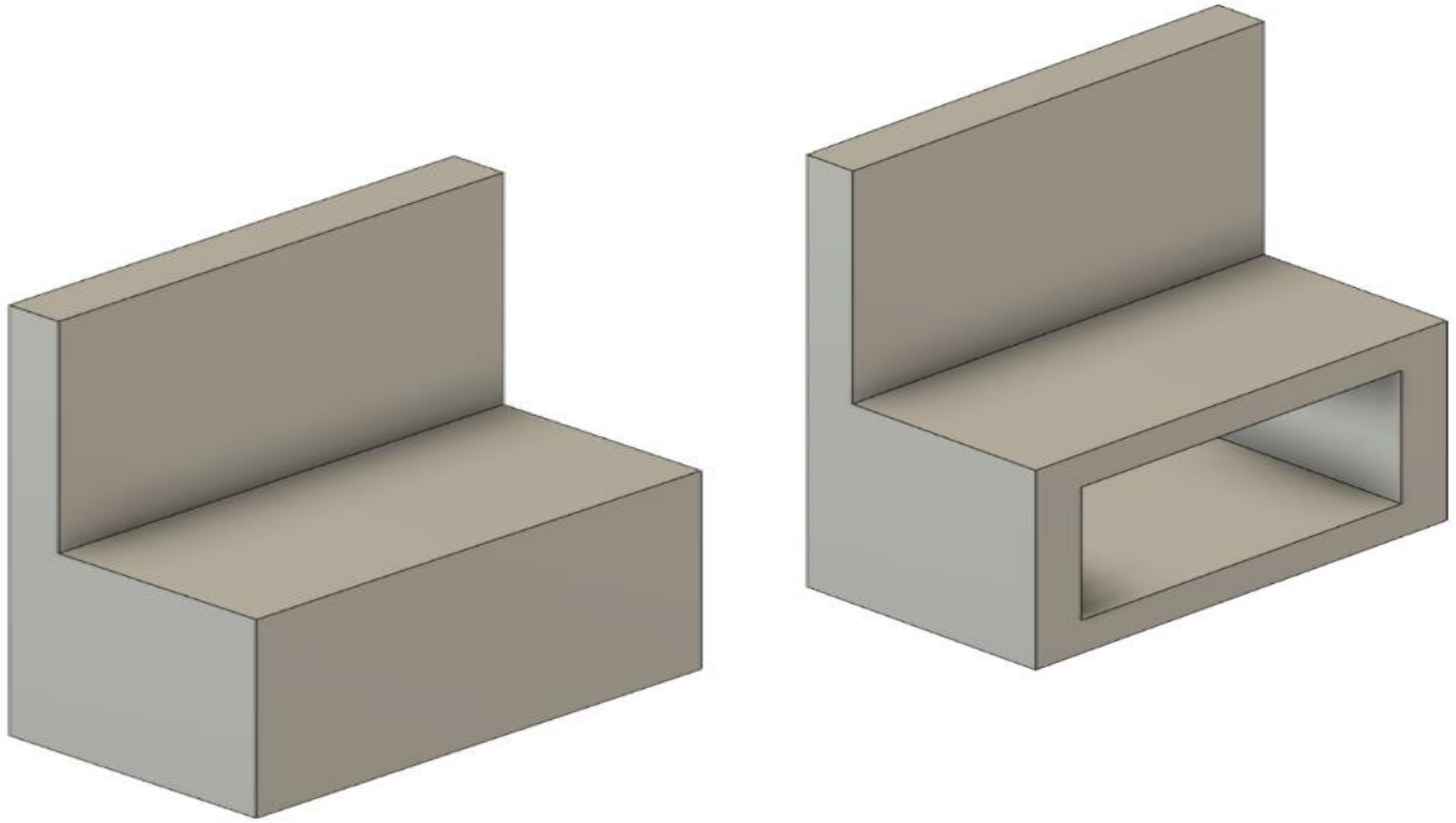

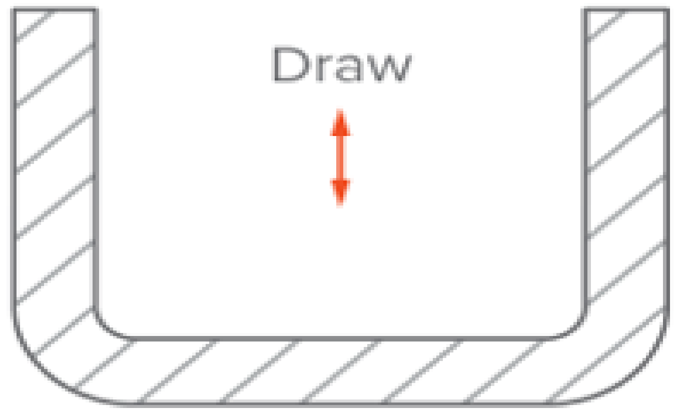

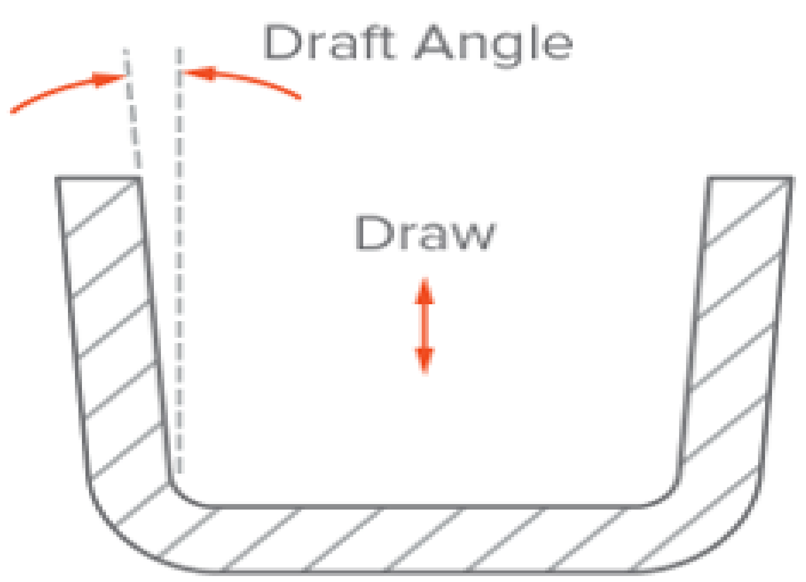

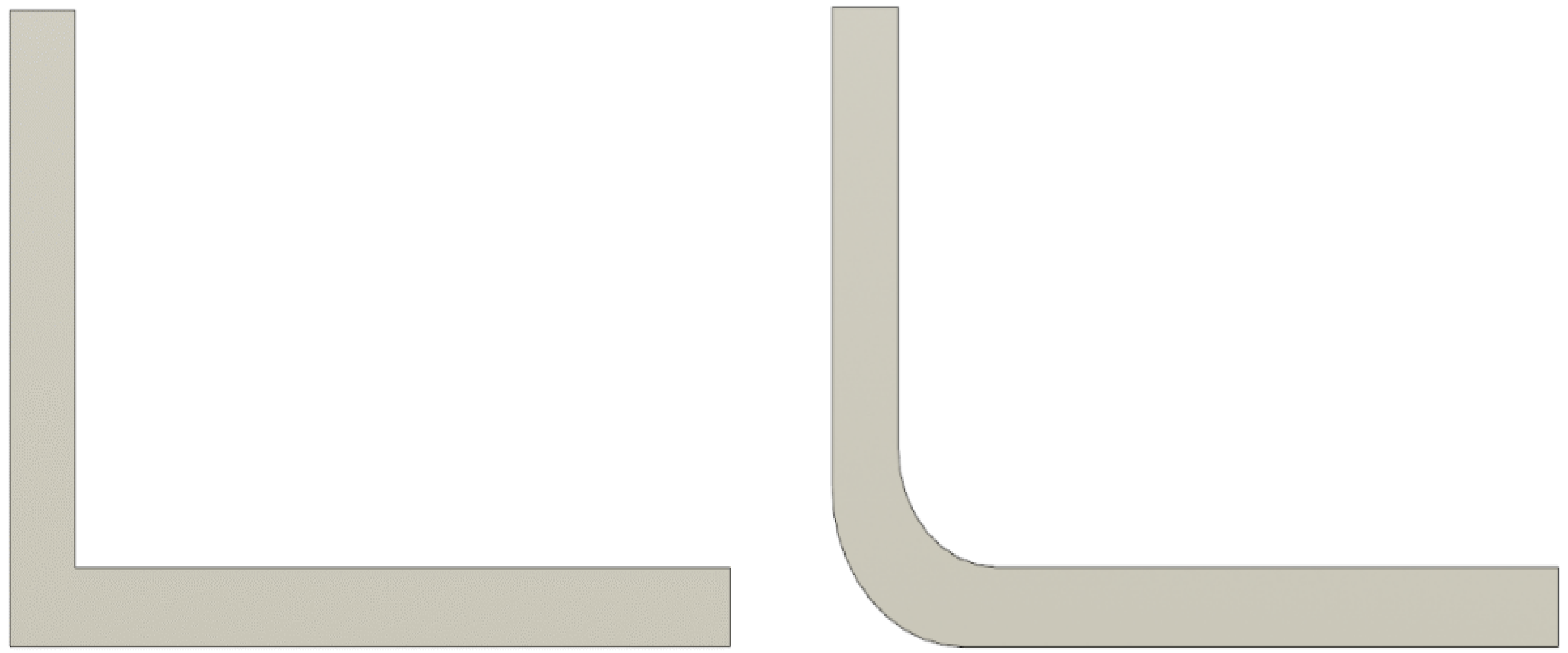

FUTURE OF CASTING:

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Casting more complex parts, obtaining accurate dimension with advance in:

- 3D Printing of Wax
- 3D Printing of Sand