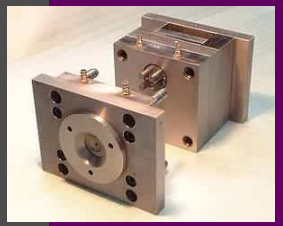
plastic injection molding

part 1

process, mold and machine

erik de lange



plastic injection molding =

+

+

Kč 40 / kg	Kč 56000	Kč 56000 – Kč 1120000
€ 1,50 / kg	€ 2000	€ 2000 – € 40000
	(for an old one)	

Whose property you think a mold is?

In most cases, it's

them →

who own the mold!

industrial	***product***	***tool (=mold)***
design	design of injection-molded products	mold engineering
manufacture	injection molding process	mold manufacturing

Today

- Process, mold and machine
- Getting your product out of the mold

Tomorrow

- Guidelines for designing plastic products

concept design

drawings, CAD-files, production plans

designer

mechanical engineer

mold engineer

molds

parts

assembly department

parts production department

For product designers, having a thorough knowledge in the field of of mold engineering and injection molding is extremely useful!

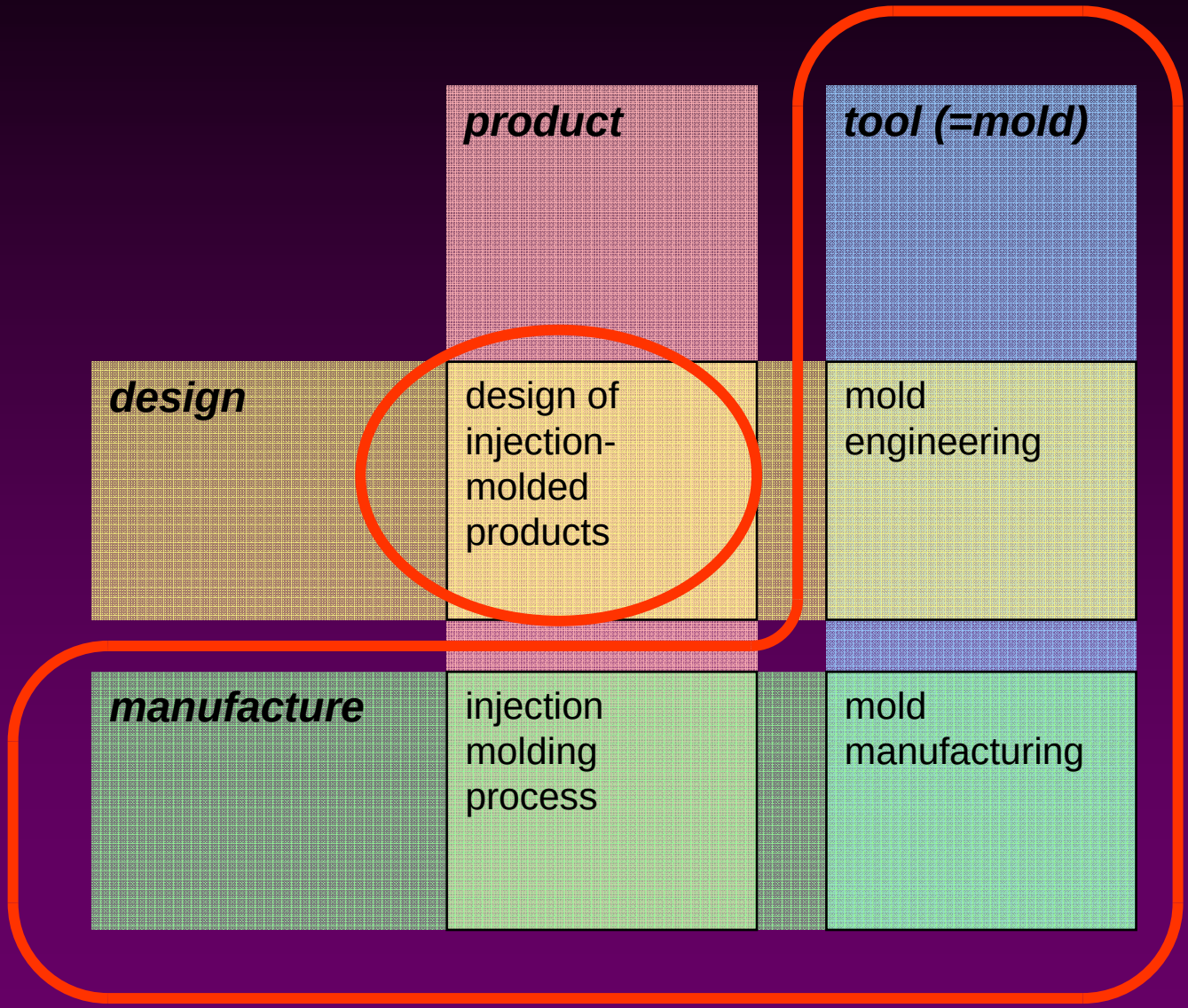
- it prevents “throwing over the wall” work flow

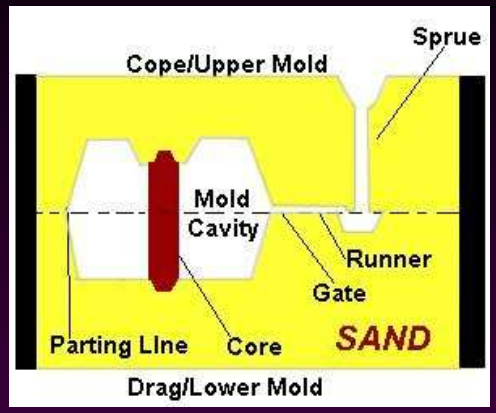
- it helps to design parts with the mold in mind, saving time and money

it enables them to:

- speak the language of the mold engineer

- negotiate with the mold engineer


product
tool (=mold)
design
design of injection-molded products
mold engineering
manufacture
injection molding process
mold manufacturing



giant cast-iron ball joints of storm surge barrier in waterway near Rotterdam, cast by Škoda foundries, Plzeň

> 3 million/year

> 12 million/year

> 500 *million/year*

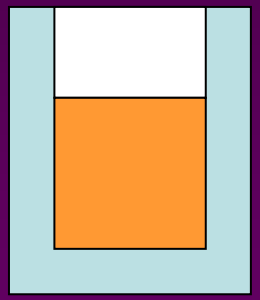
> 1 billion/year

- Metal **melts** and becomes liquid: low viscosity
- Plastic becomes plastic, not liquid: high viscosity

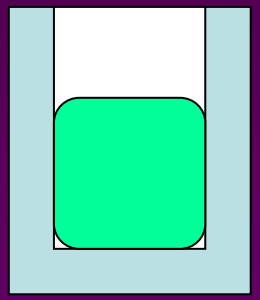
Consequently:

A. Casting will take too much time

B. Plastic won't fill the corners and small details



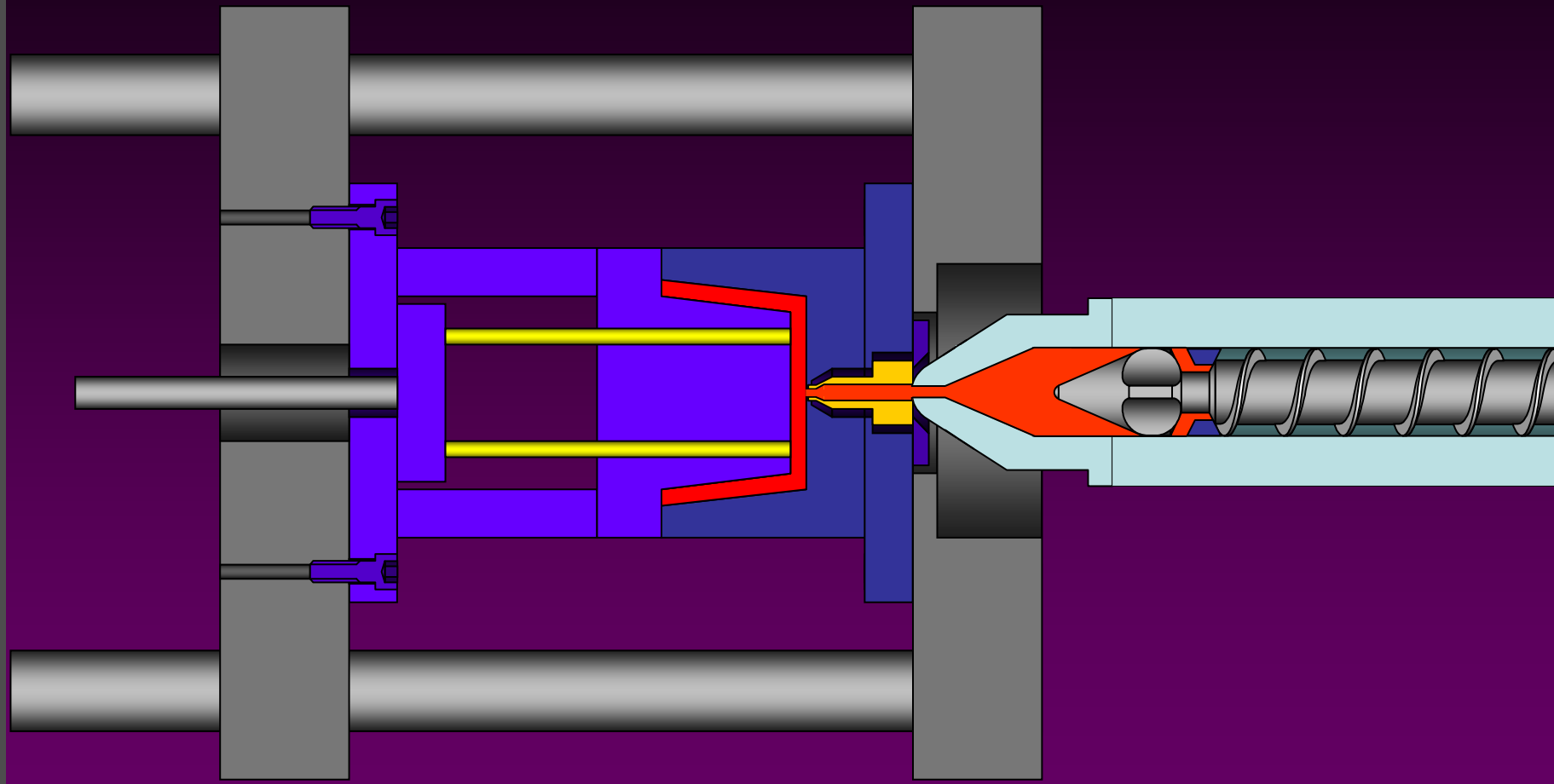
molten metal

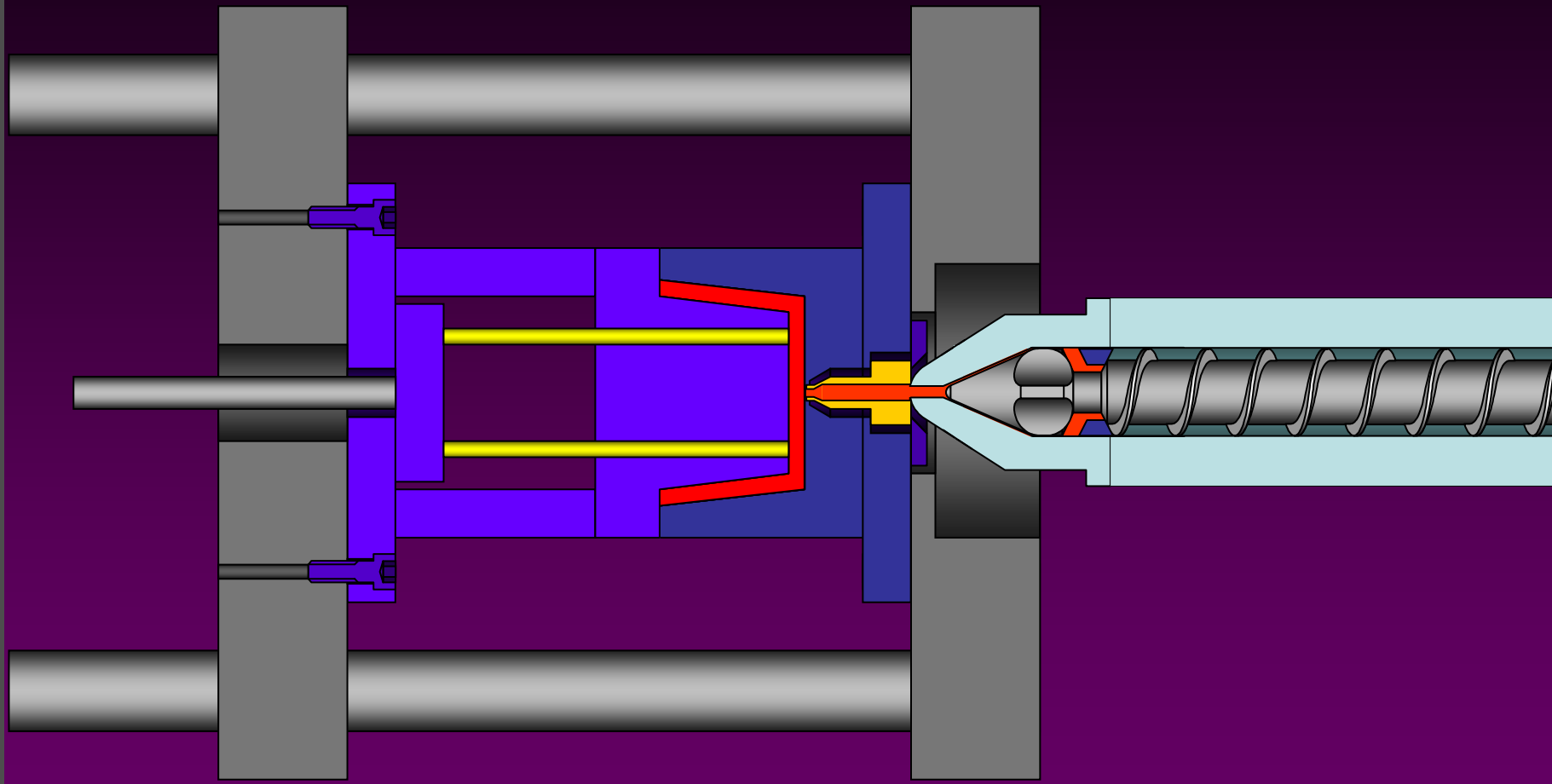


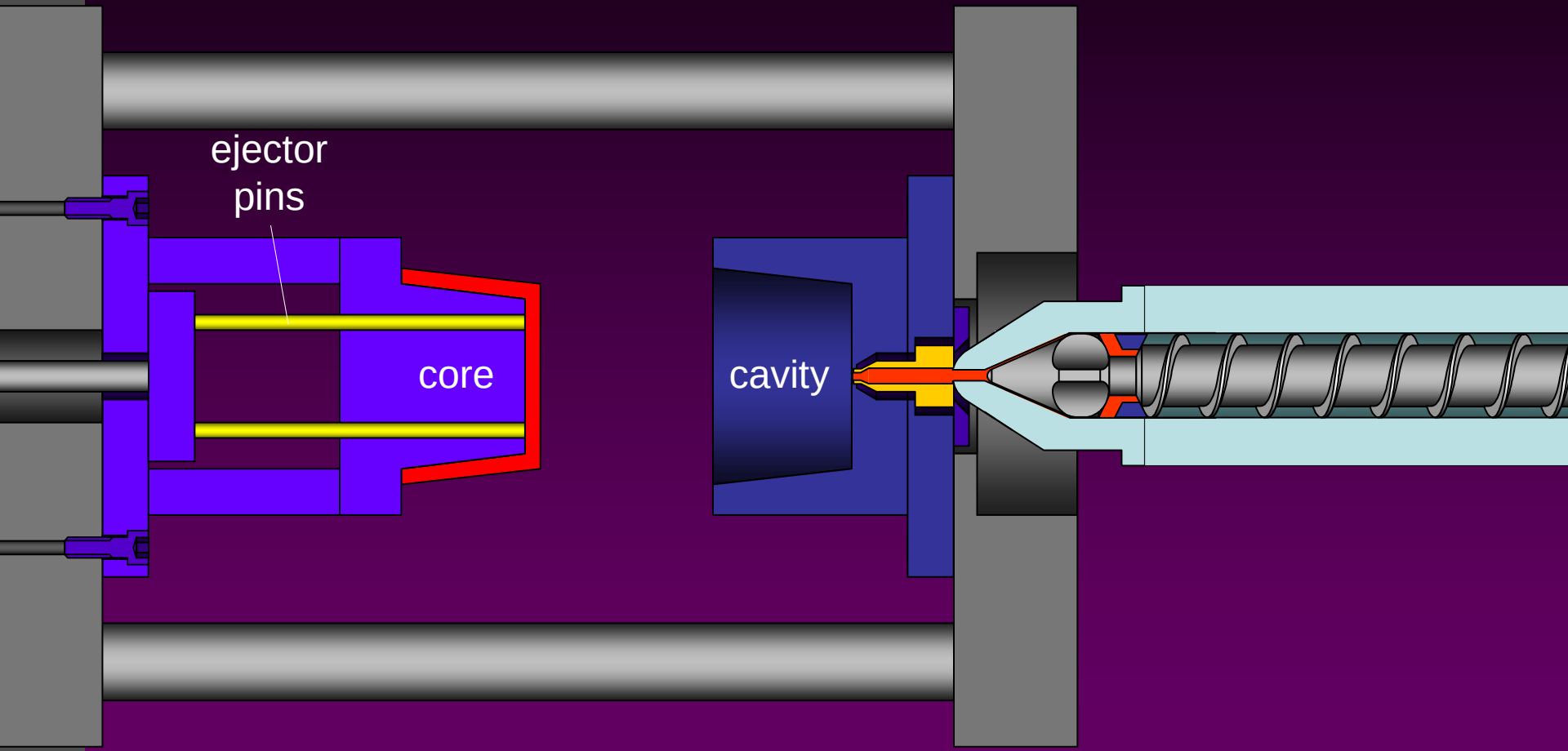
plastic

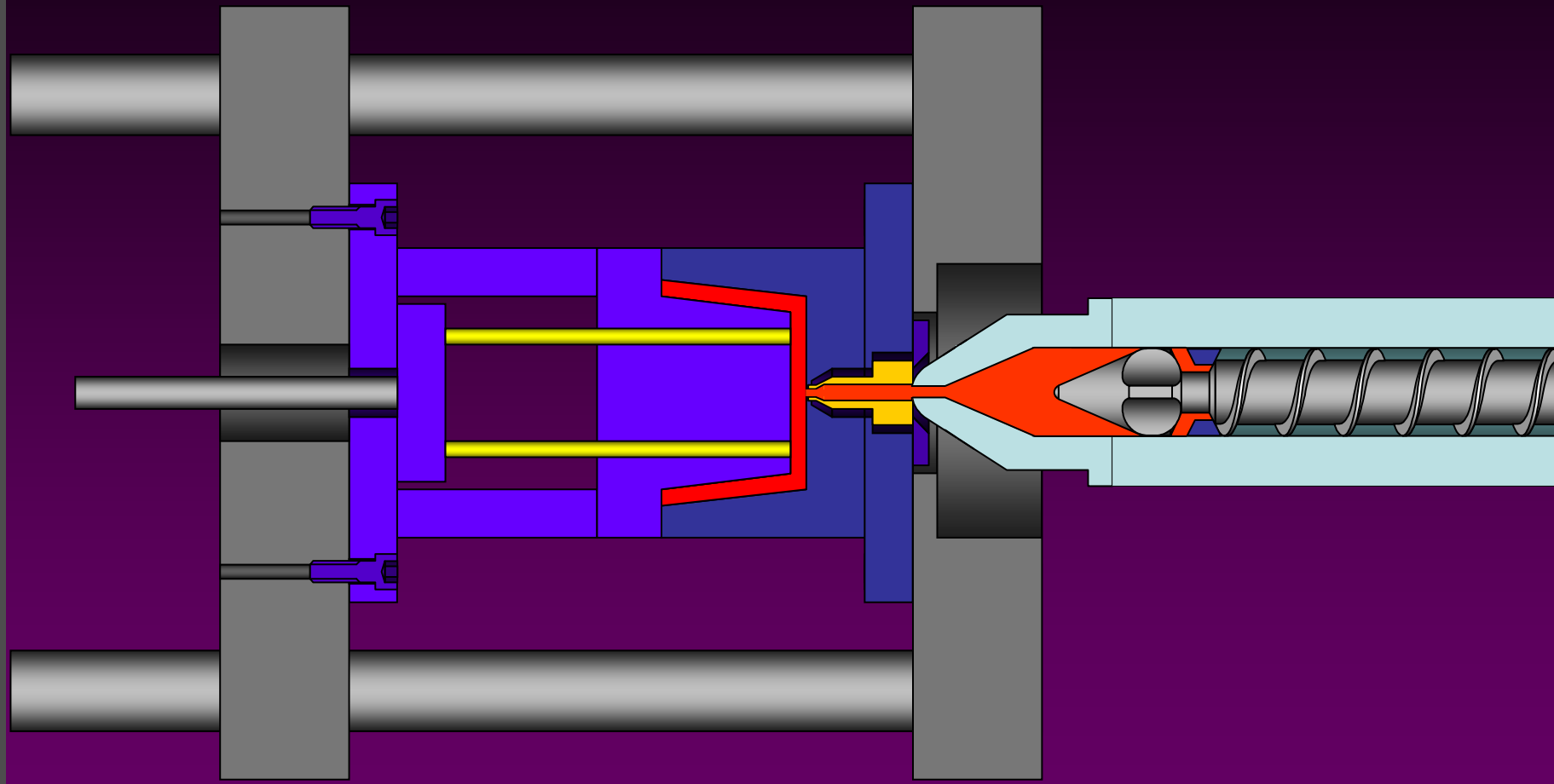
To speed up the filling process, the plastic is forced into the mold under high pressure.

(10 – 150 MPa)






ejector
pins
core
cavity



granulate funnel

“hopper”

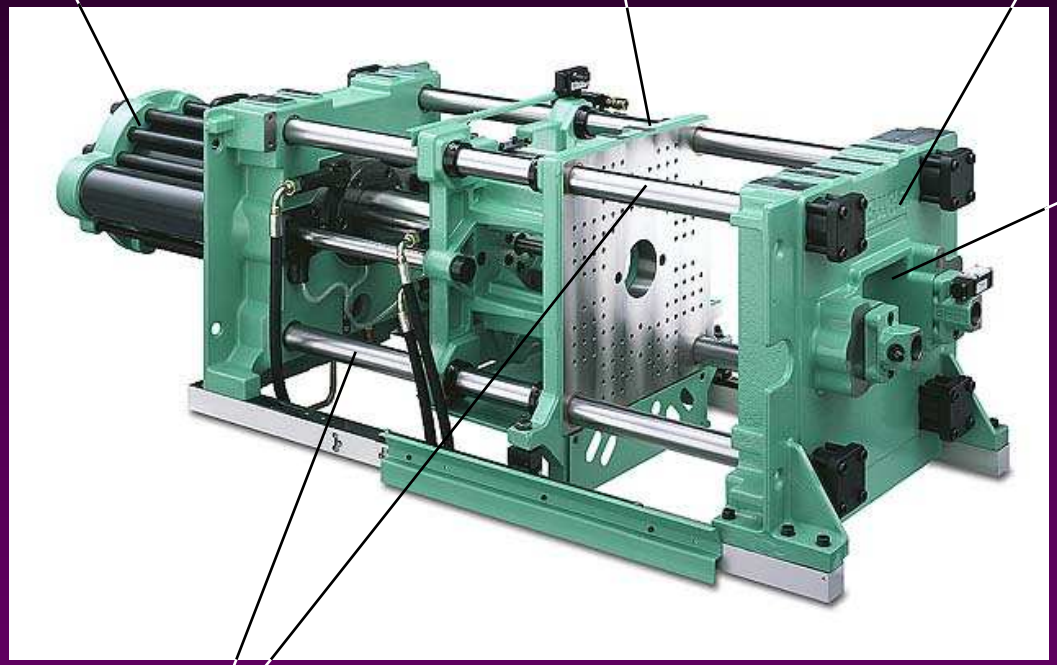
clamping mechanism

plasticizing and injection unit, “melts” the granulate and injects it

hydraulic cylinder, providing the clamping force

movable platen

fixed platen



hole for injection unit

tiebars, guiding the movable platen

the molding cycle:

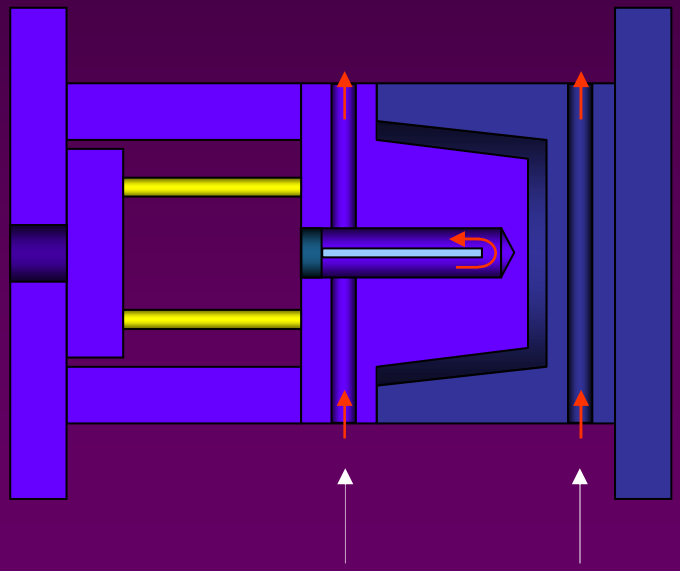
- close the mold
- inject the plastic into the cavity
- keep the mold closed until the plastic is cooled and ready for ejection
- open the mold
- eject the product

the cycle time depends on the wall thickness:

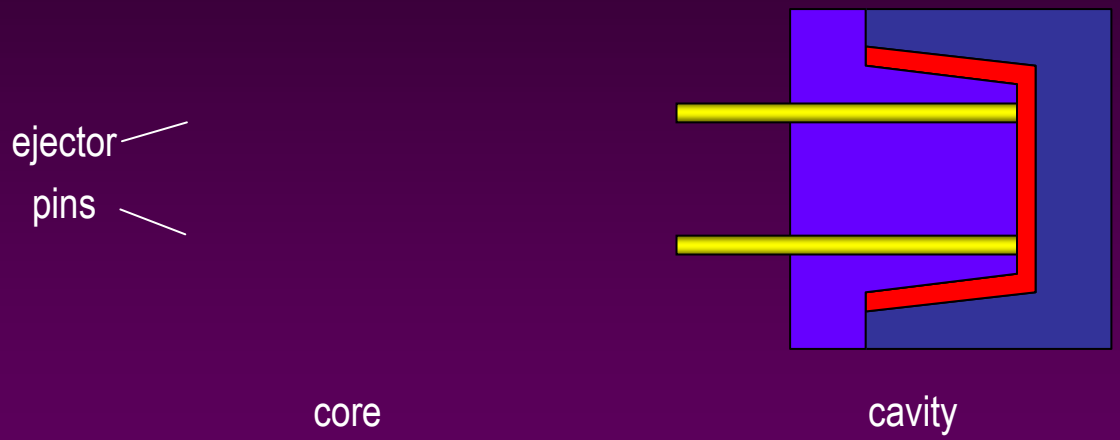
- thin part (for instance 2,5 mm): 5 secs
- thick part (for instance 10 mm): 1 min

Due to the hot plastic (for example, 220 ℃), the mold will get hotter every shot. The time to solidify will become longer and longer; and so will the cycle time.

That’s why cooling is necessary.



The simplest type of mold has only two product-shaping parts, often called “core” and “cavity”. This is called a *straight pull mold*.



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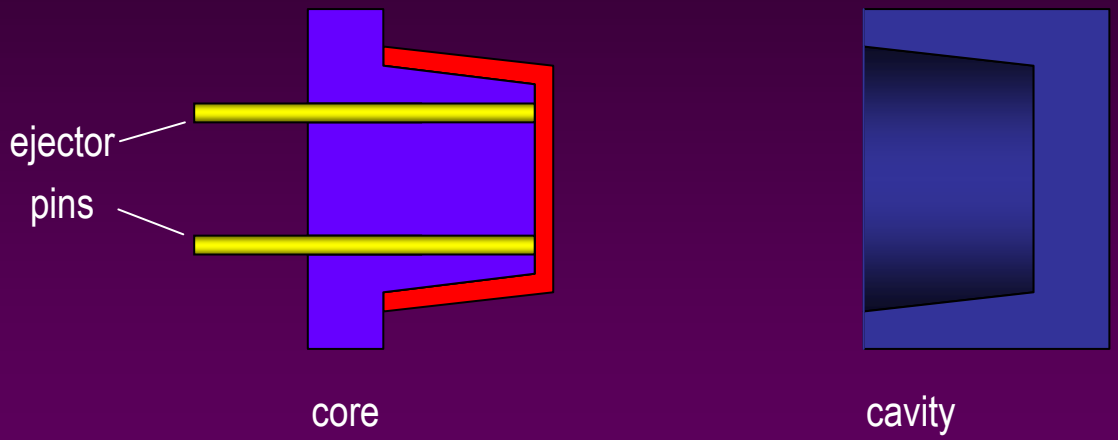

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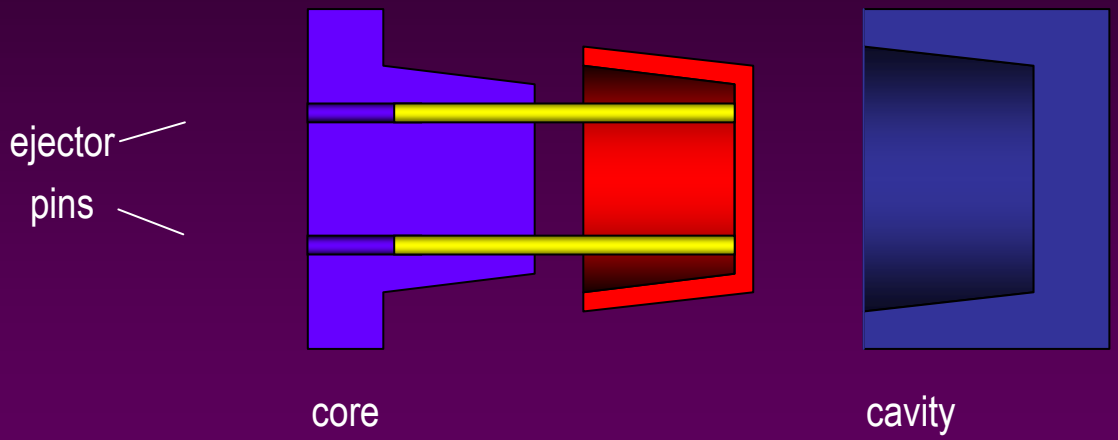
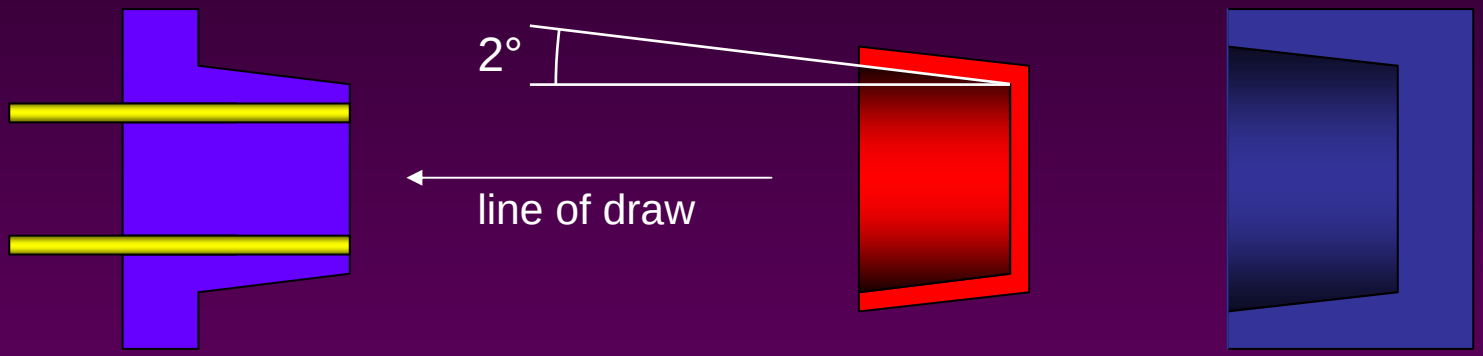
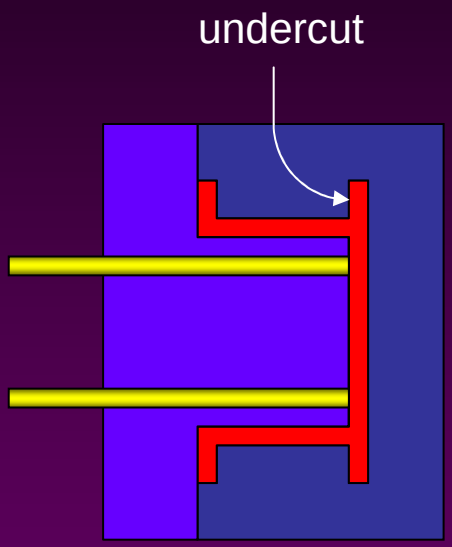


During solidification, the product shrinks by a few percent. To facilitate the product's ejection from the core, the walls should make an angle of at least 2° with the line of draw.

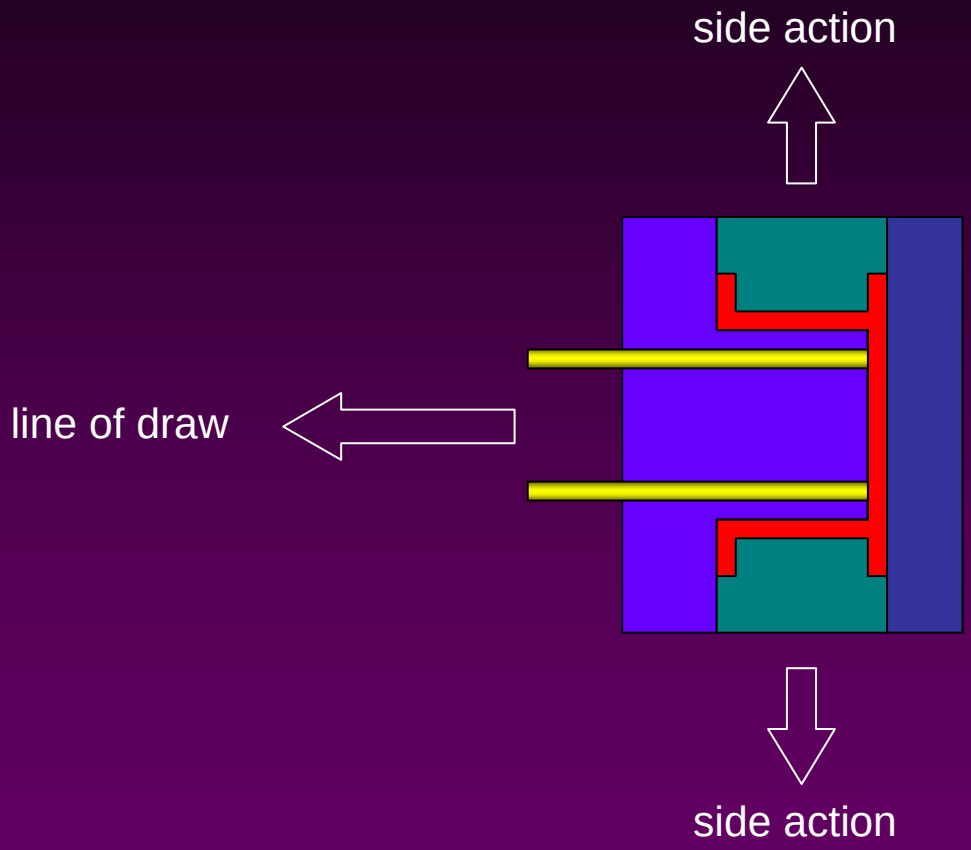


Many shapes would get “locked” in a straight pull mold:

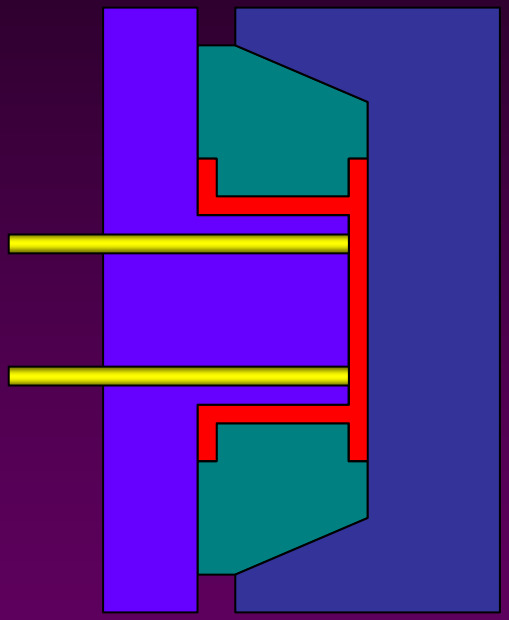


This part will draw from the core, but won’t draw from the cavity, due to undercuts.

This product requires a mold with “side actions”.



Schematic of a side-action mold.



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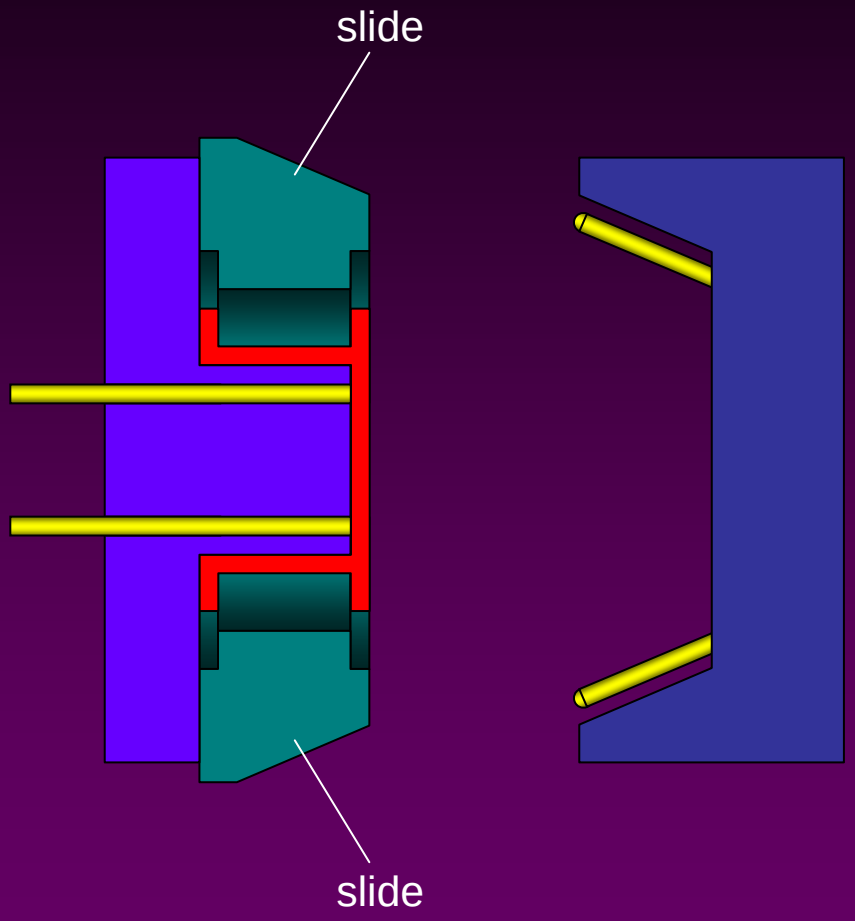
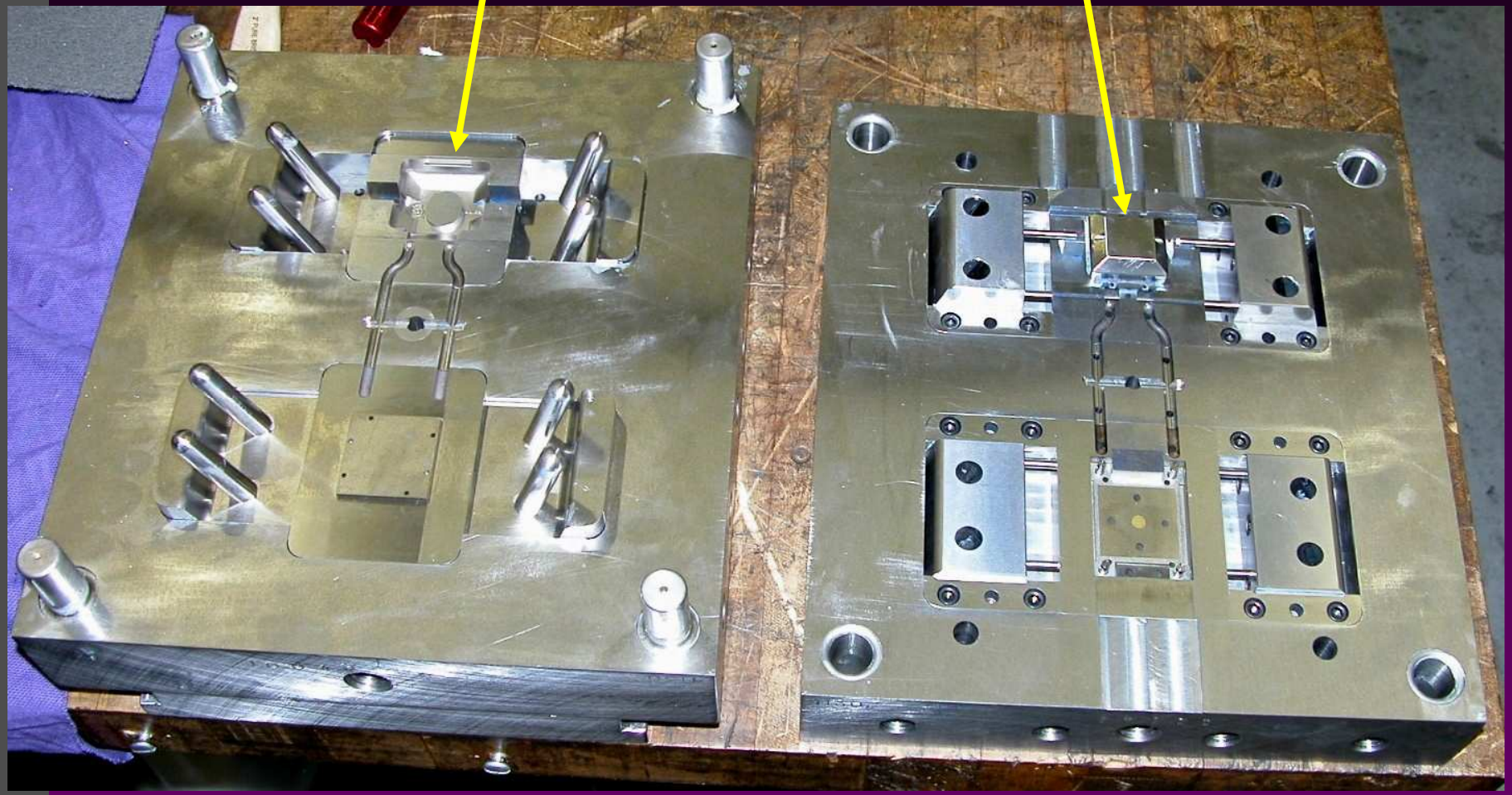
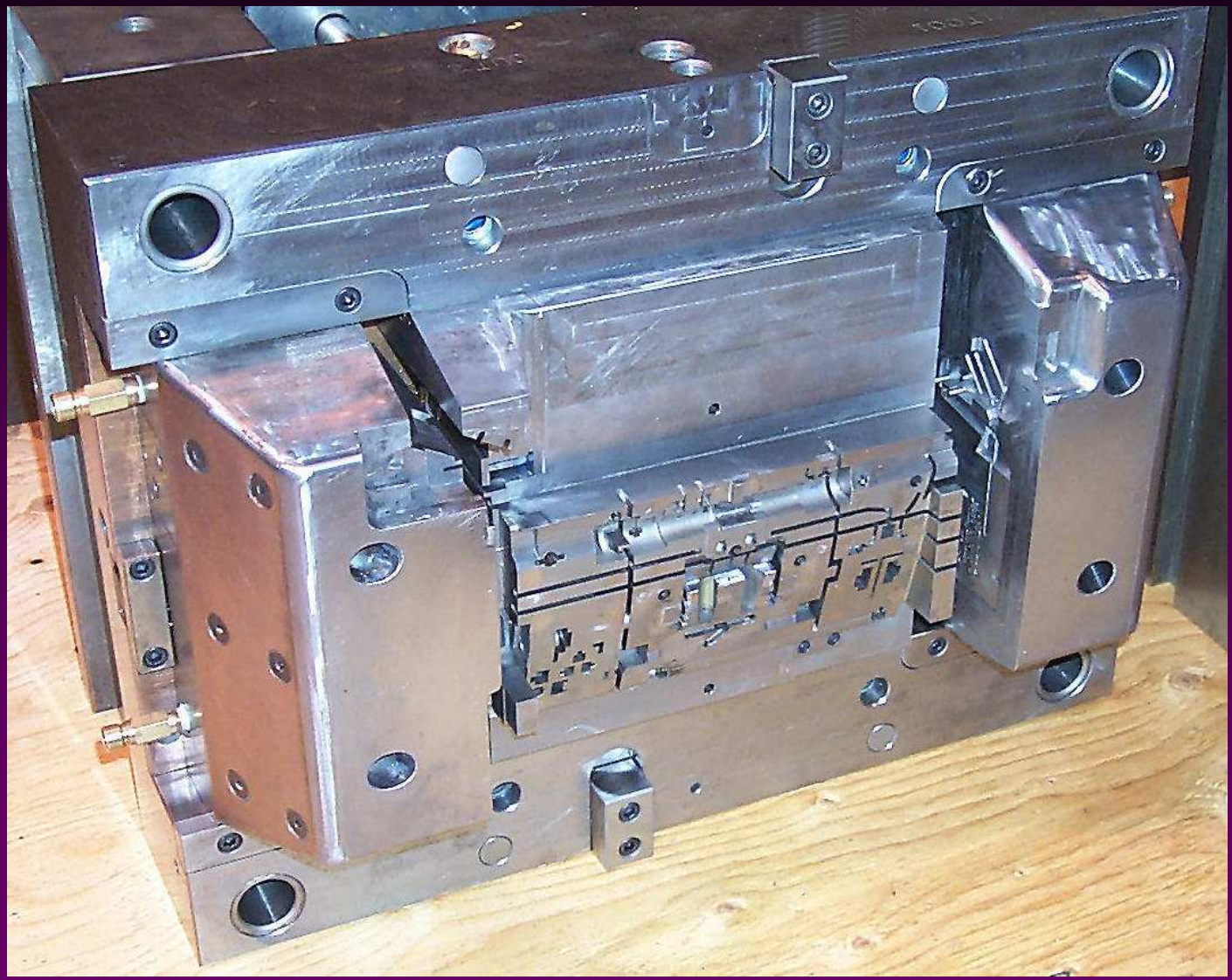


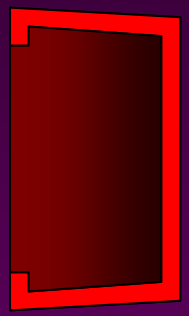
K2010.exe


cavity
core

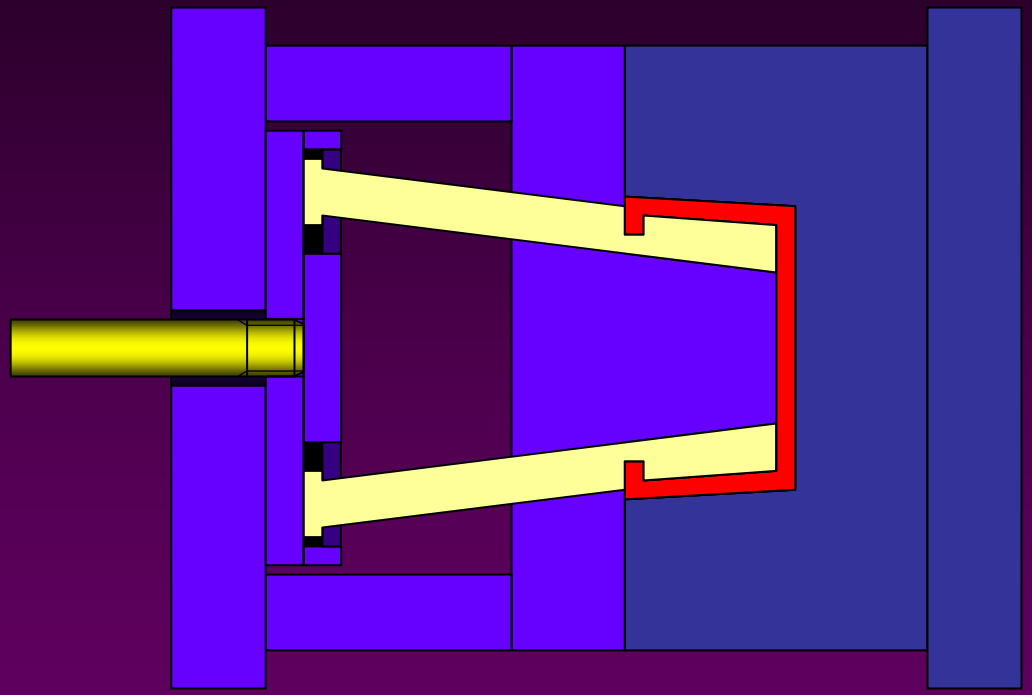


What if the part has *internal* undercuts?

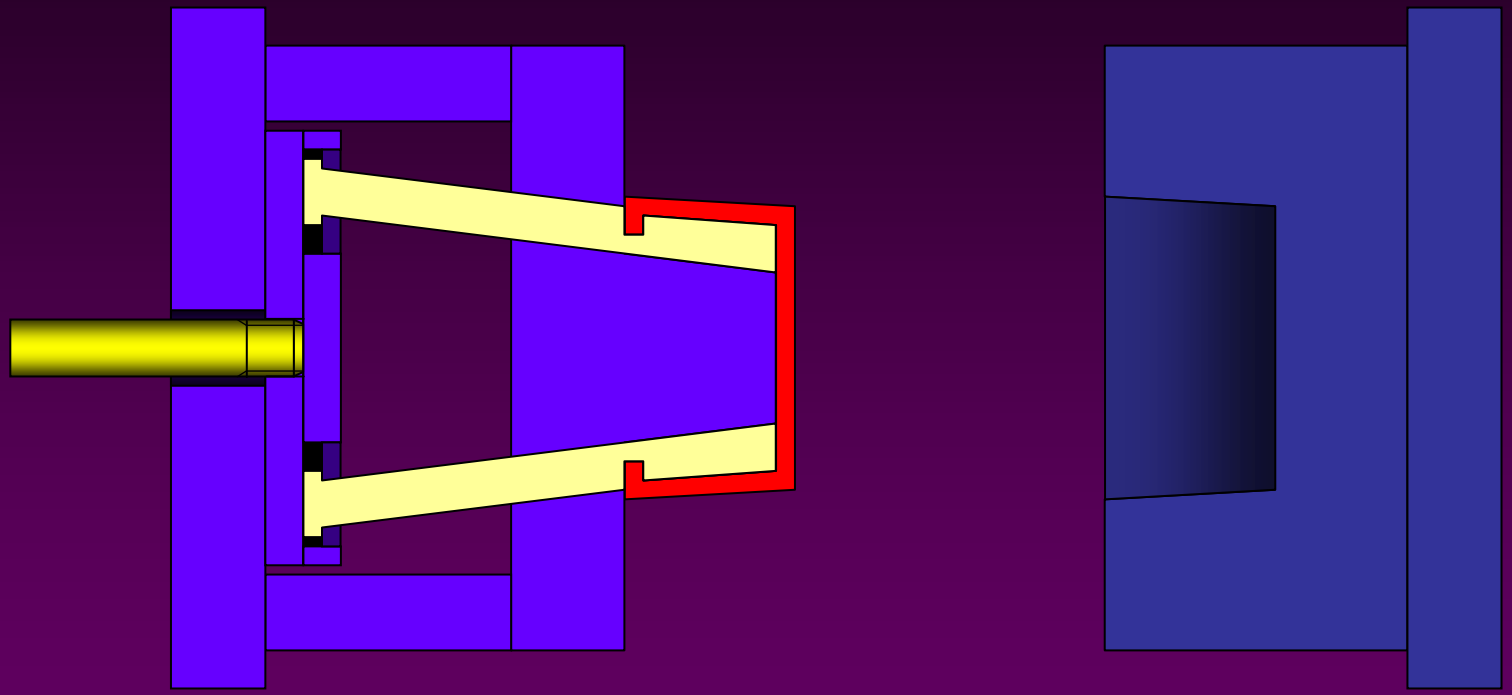
Exercise: try to make a sketch of a mold from which the part will release.



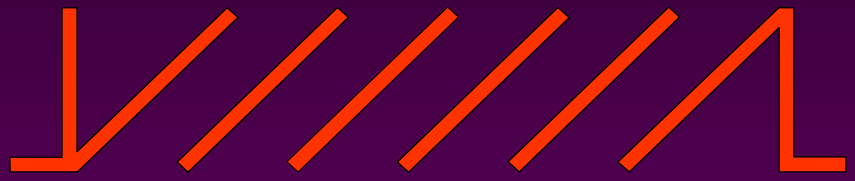
Angled ejection pins

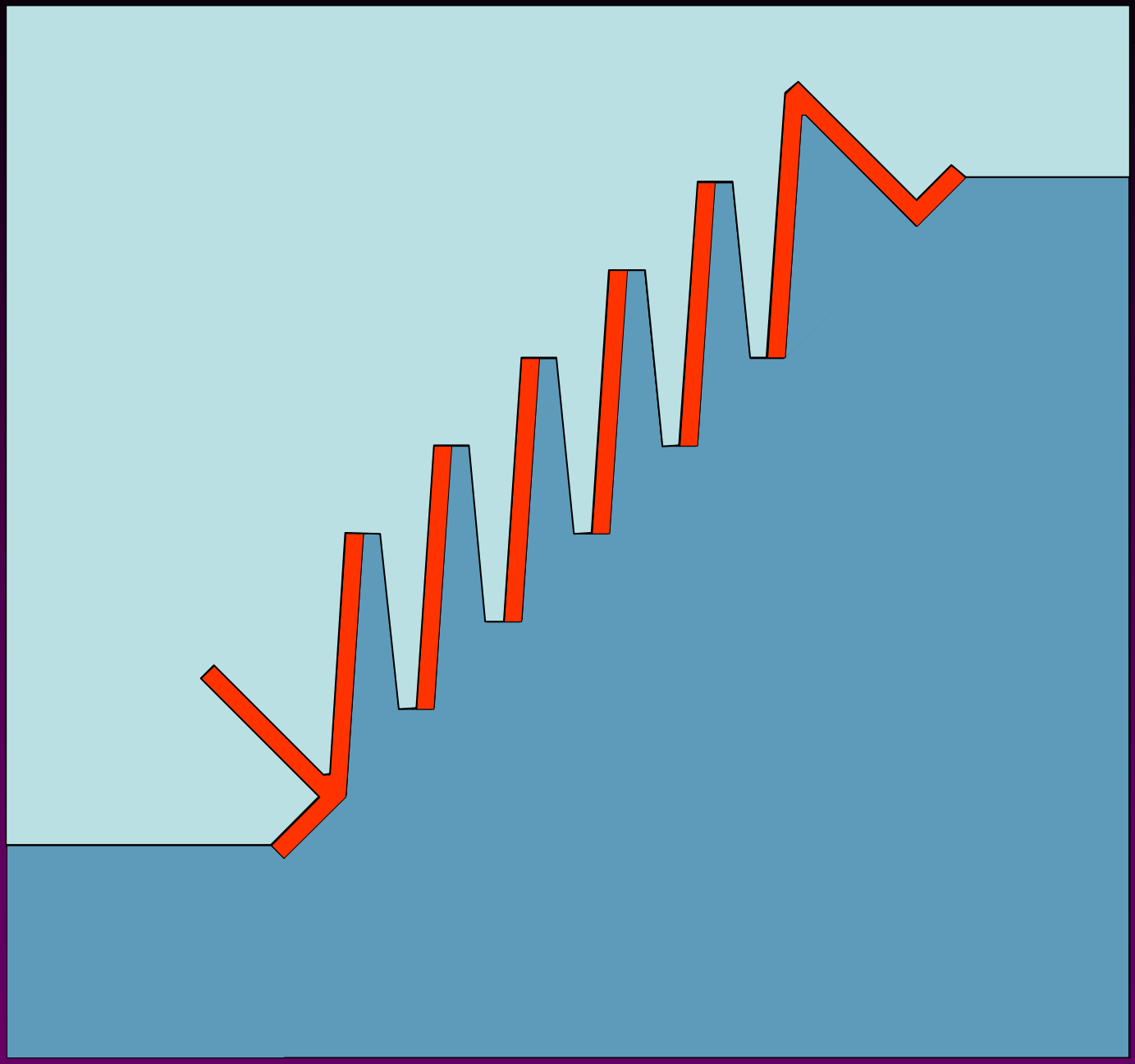


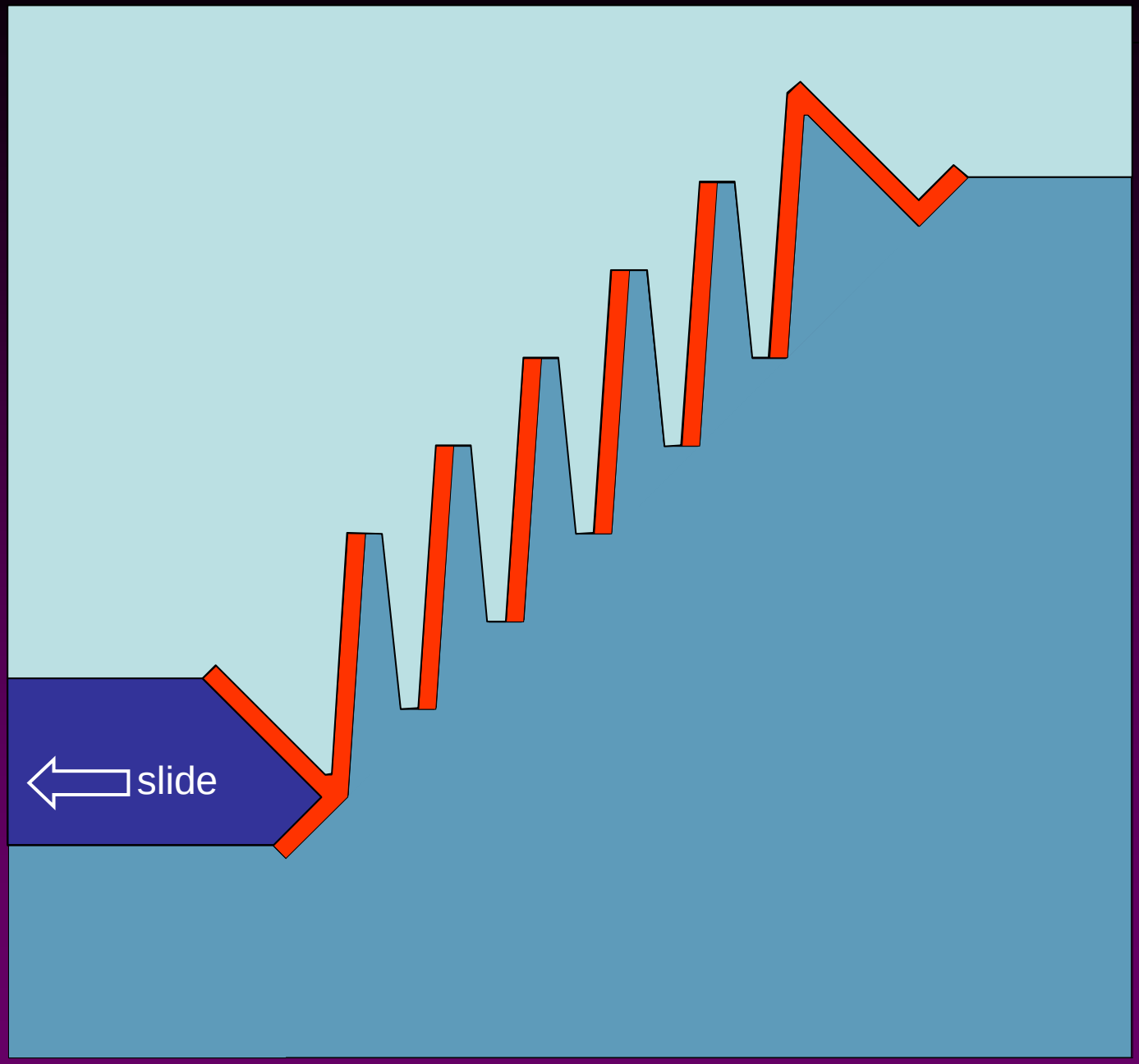
Angled ejection pins

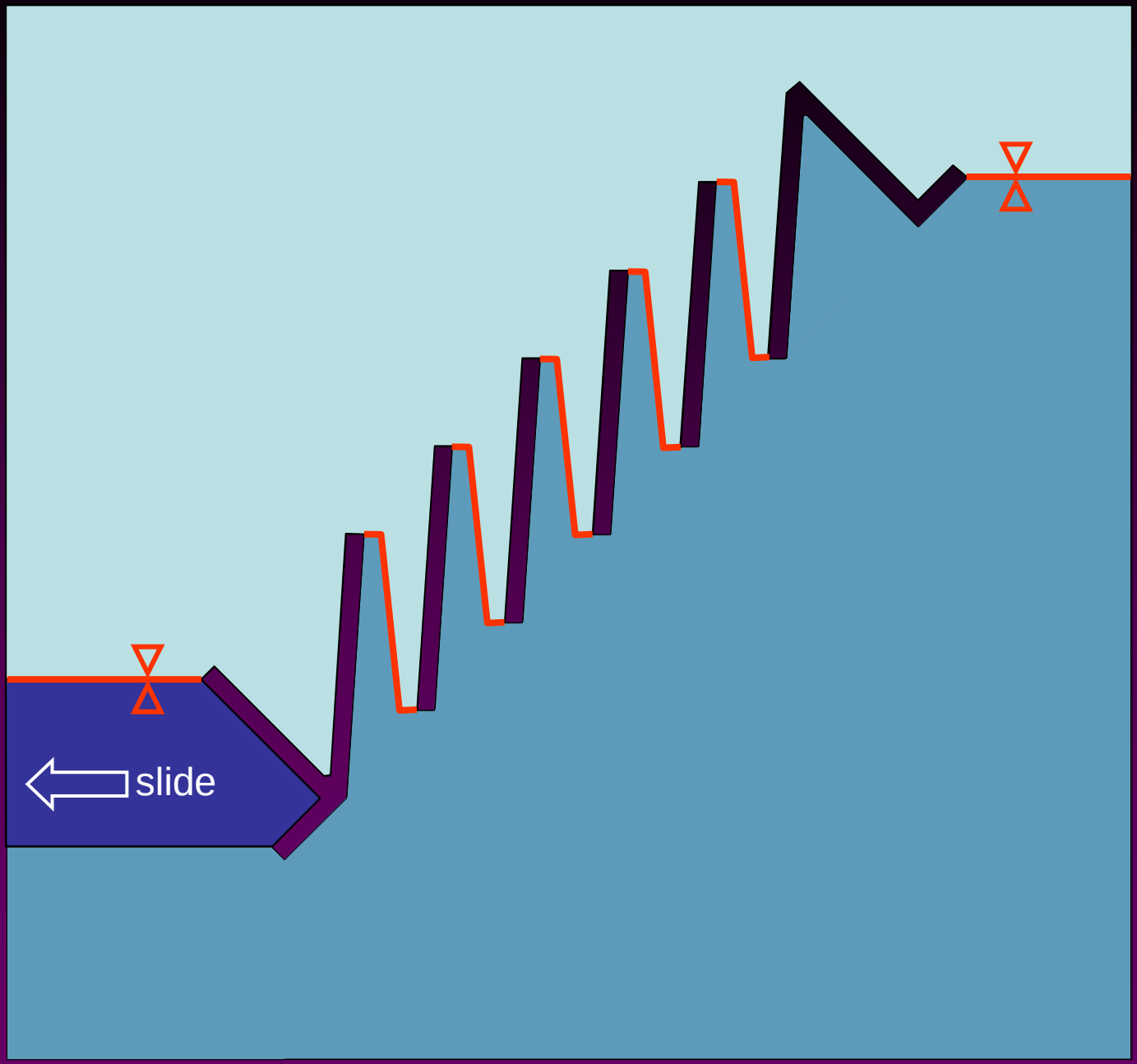


cross section of louvered vent



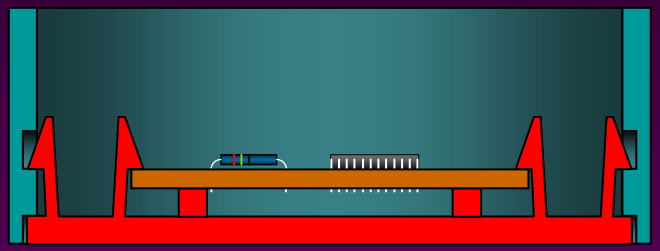



slide

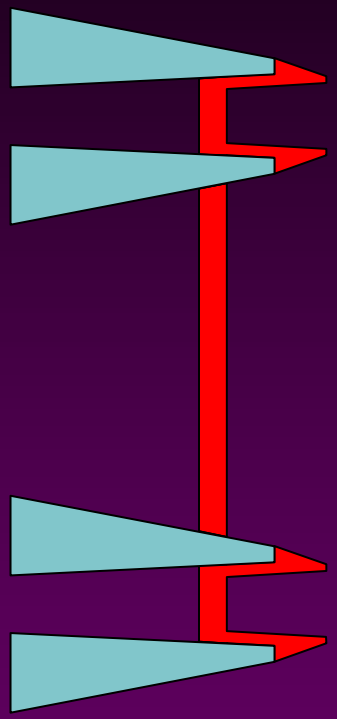

parting
line (PL)
slide

The parting line is visible on the product. As a designer, you might have certain ideas where you would like to locate this line.

Parting lines can also be curved. This makes the mould more expensive. ⟶



A side action mold is far more expensive than a single draw mold. How can the costs be kept low?



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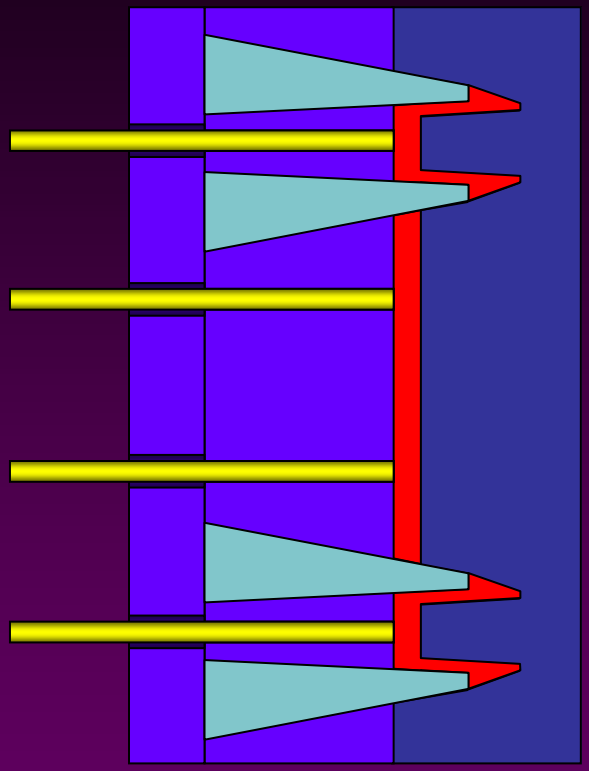

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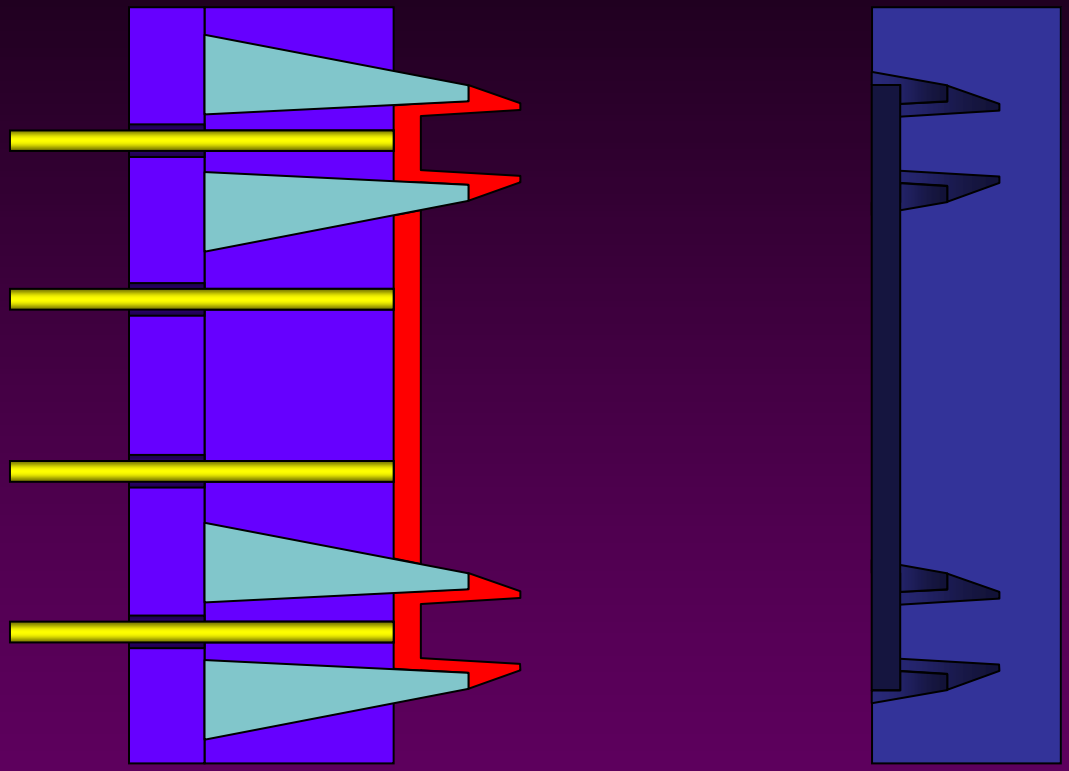

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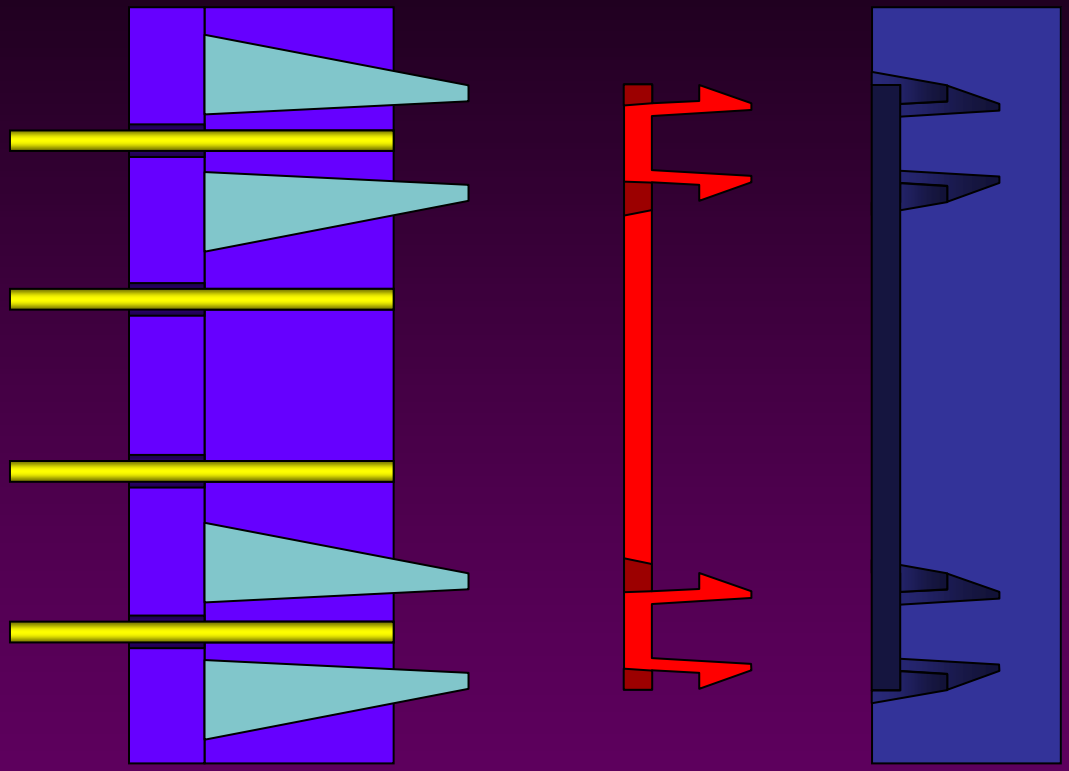
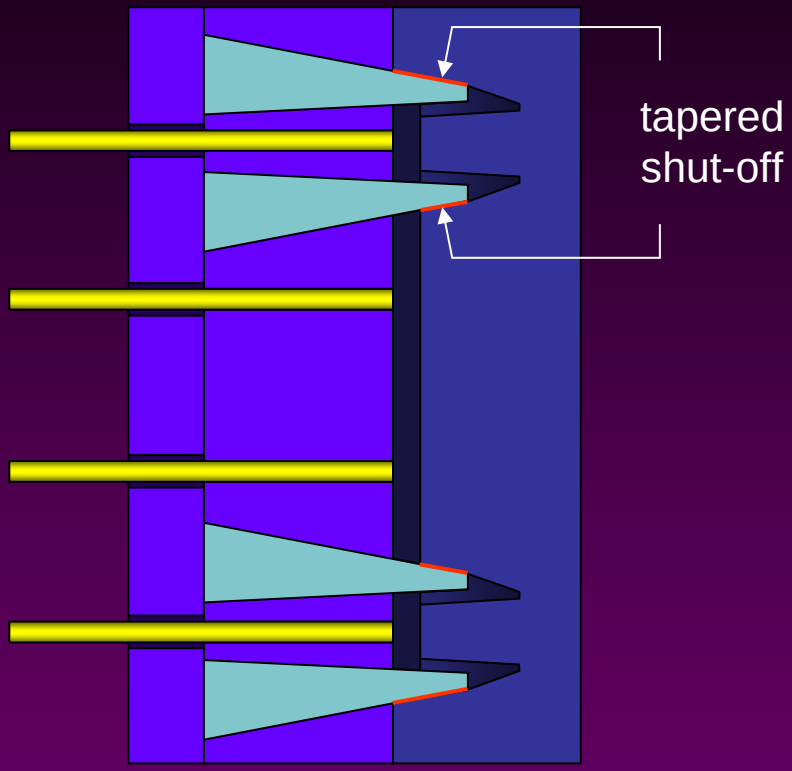


A side action mold is far more expensive. How can the costs be kept low?

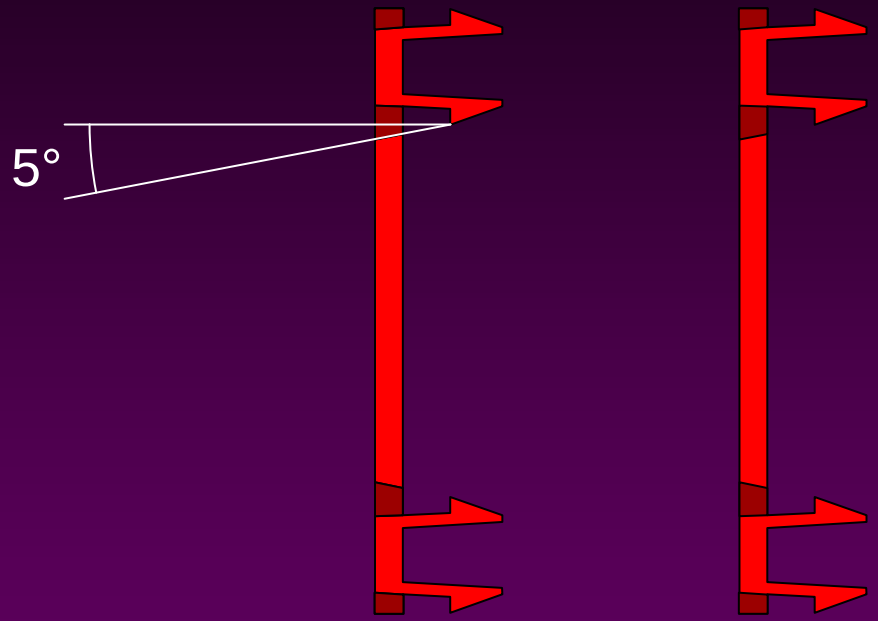
Tapered shut-offs should make an angle of at least 5° with the line of draw, for two reasons:

- to avoid collision
- to avoid clearance, which would cause flash



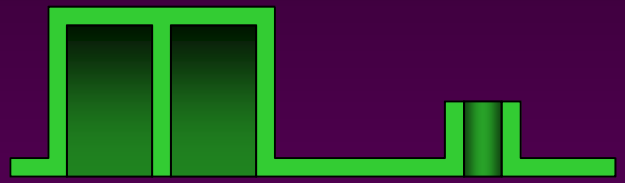
The minimum angle of shut-off planes impacts the shape of your product.

In our case, it influences the size of the holes.

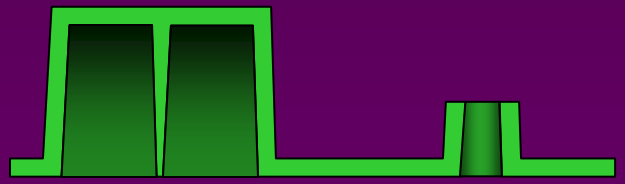


Draft may “spoil” the perfect shape you had in mind as a designer.

Which factors determine the required draft angle?



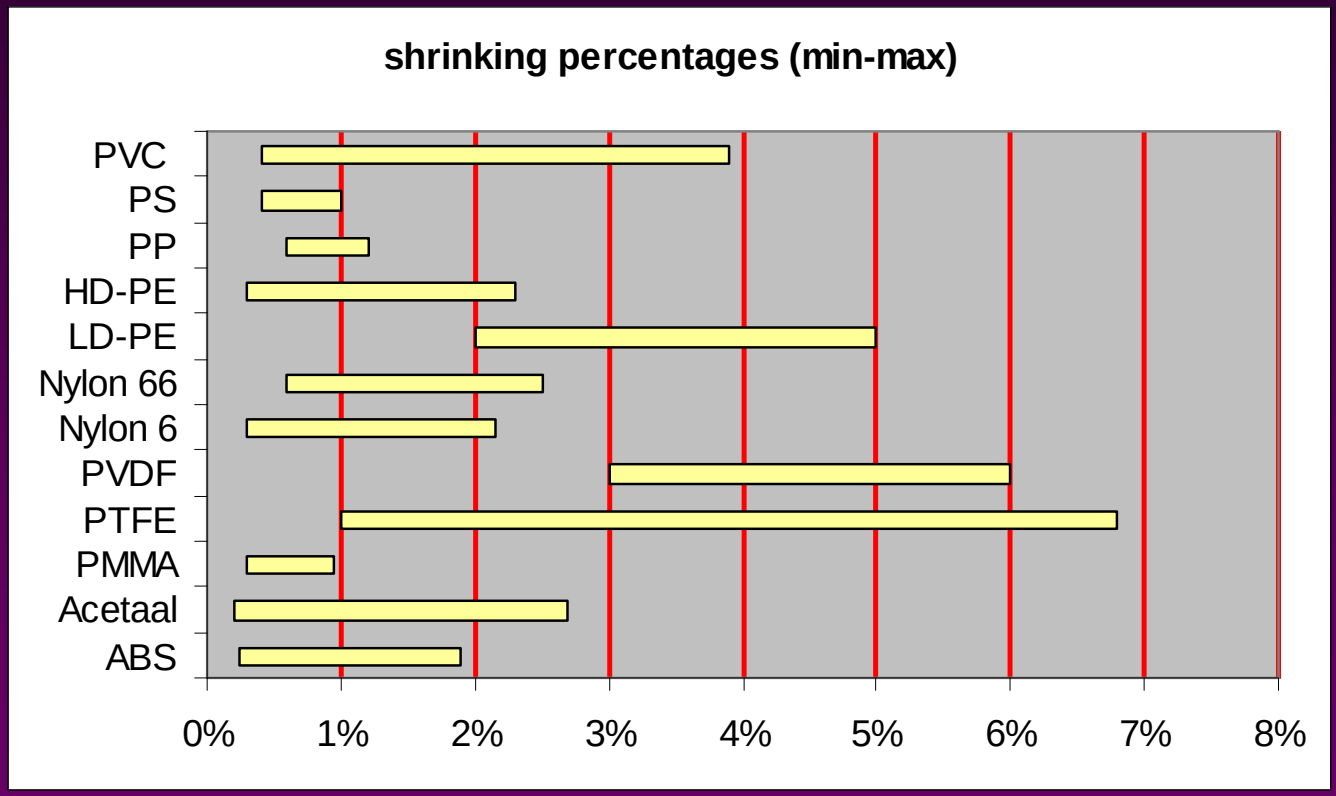
0,2º



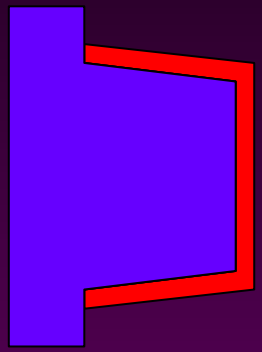
4º

Materials having a large shrinkage percentage need a larger draft angle.

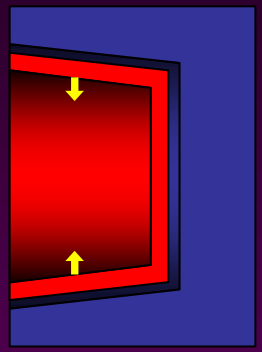
Also, “stickier” materials, having a larger coefficient of friction, need a larger draft angle.



Surfaces that are being shaped bij the core, need a larger angle than ones being shaped by the cavity.



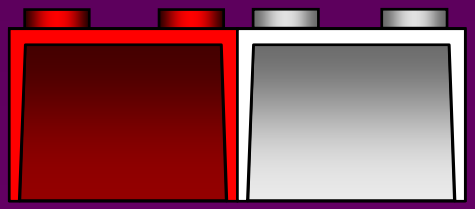
core

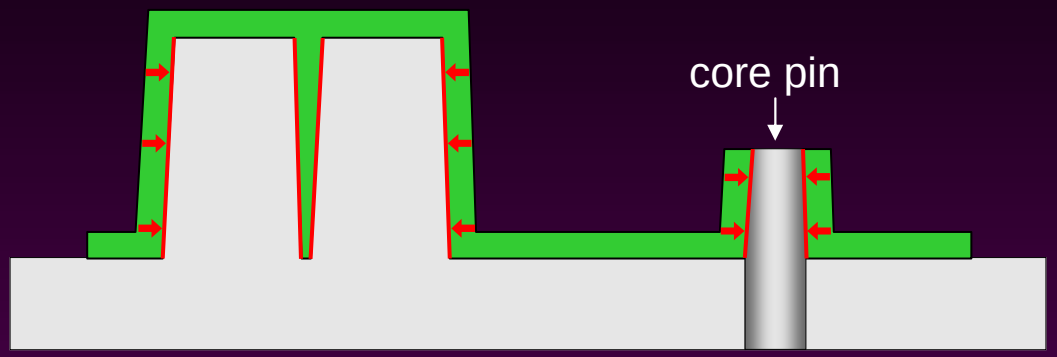


cavity

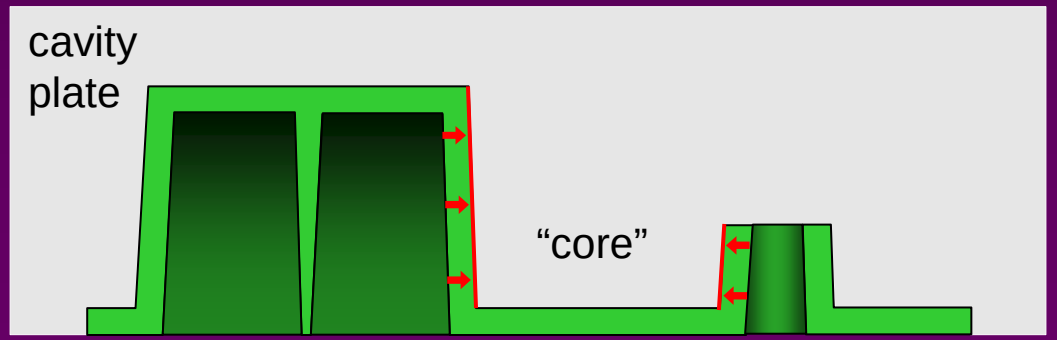
example: Lego blocks

(exaggerated)





Products may even have “cores” on the cavity side of the mold, around which the plastic will shrink:



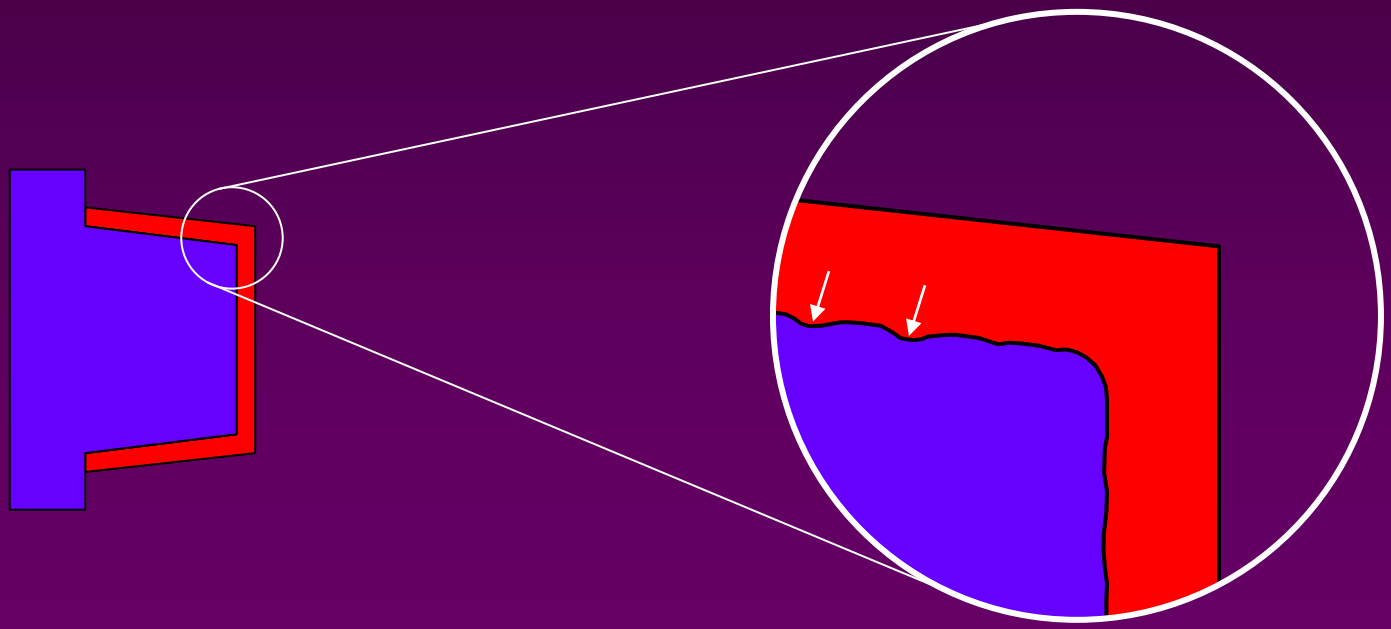
Some other factors are:

- product texture and mold roughness;

  → the deeper the roughness “valleys” are, the larger the draft angle must be

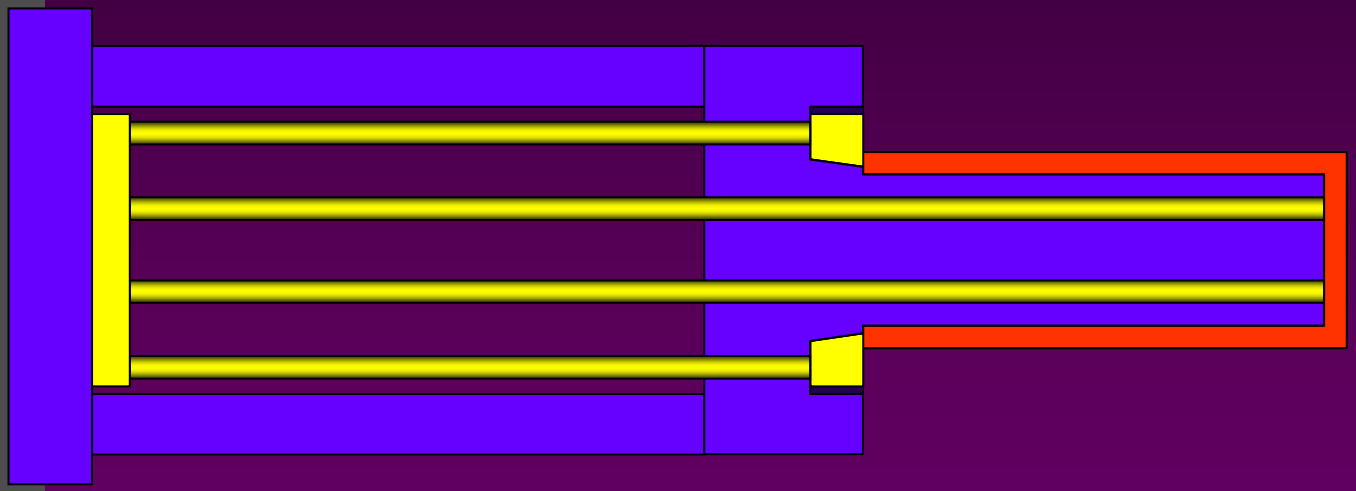
- whether or not you are willing to accept scratches on the product;

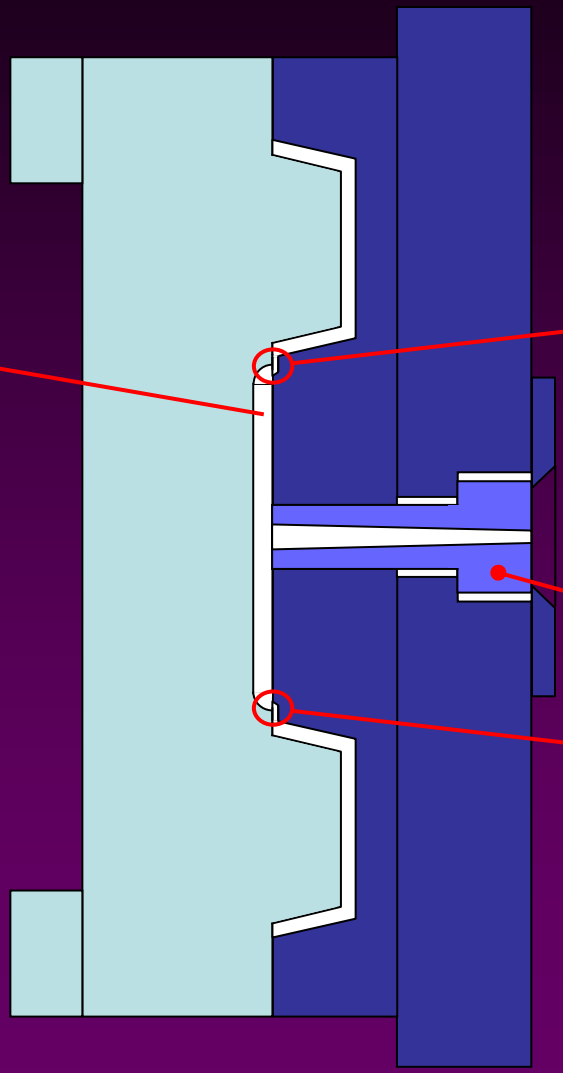
- how many ejector pins you want to use.



You can negotiate (sjednávat) with mold makers about the draft angle. With special measures very small draft angles are possible.

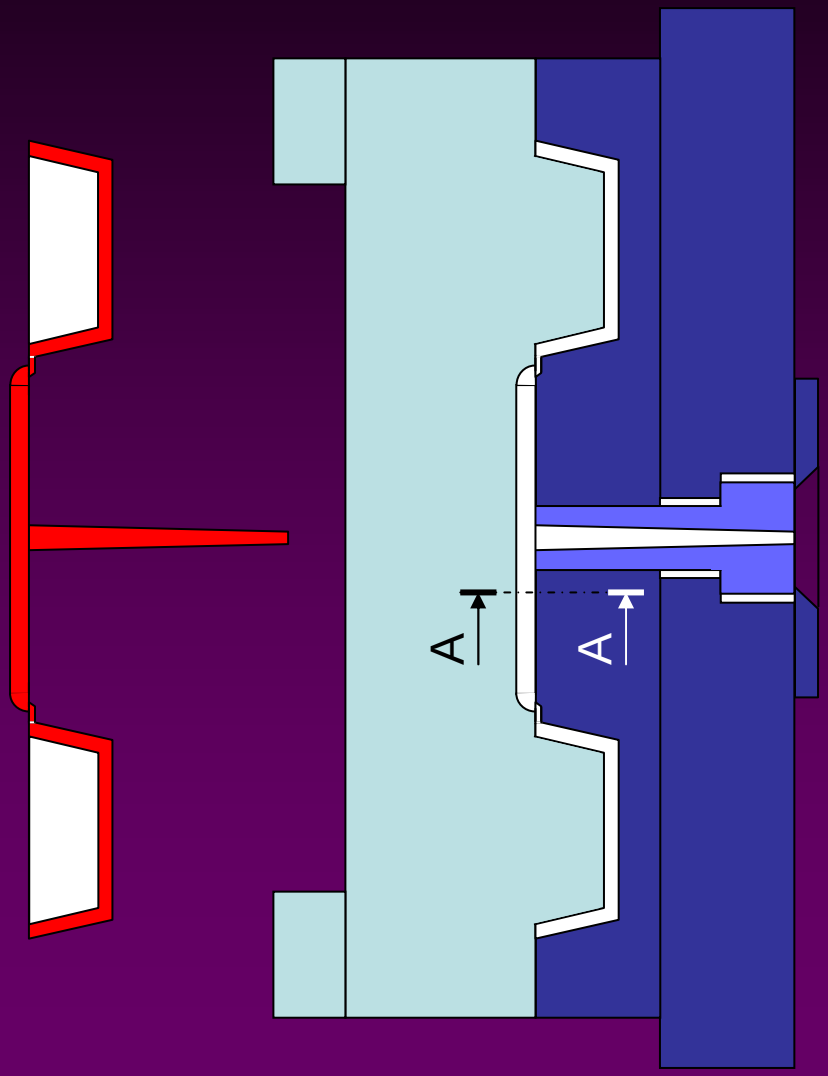
“special measures” can be a stripper ring and additional ejection pins.





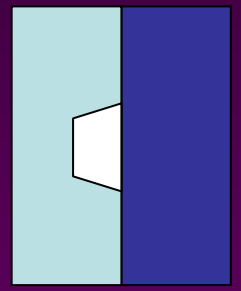
sprue
bushing

The runner has been milled in the core plate, or alternatively, in both plates.

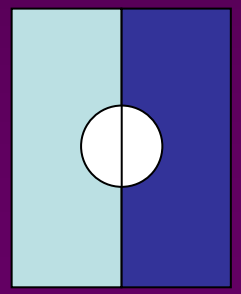


A-A

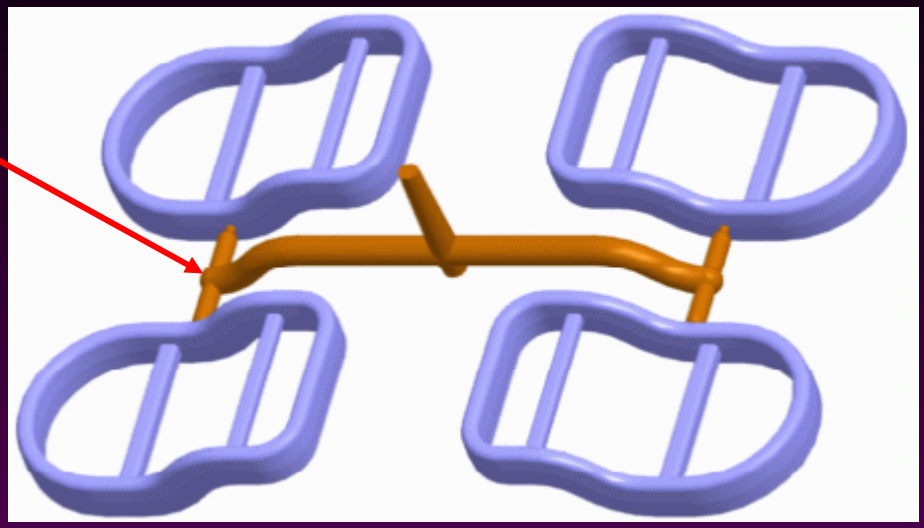
runner in core plate only

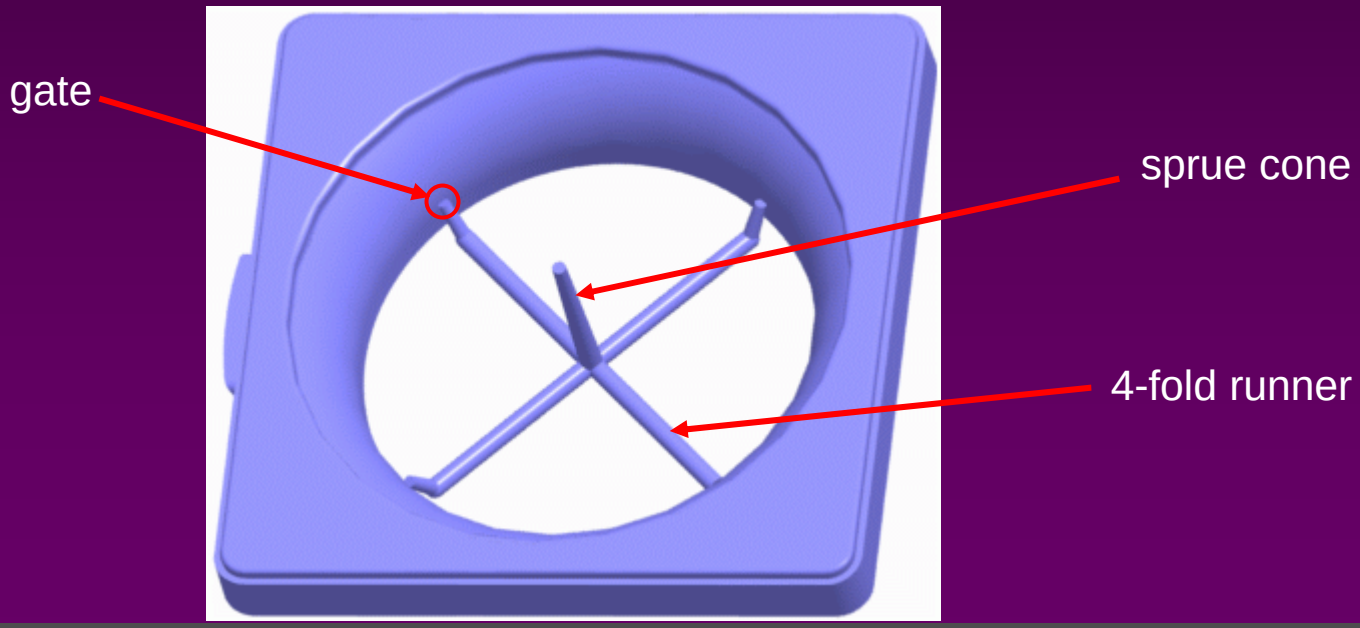


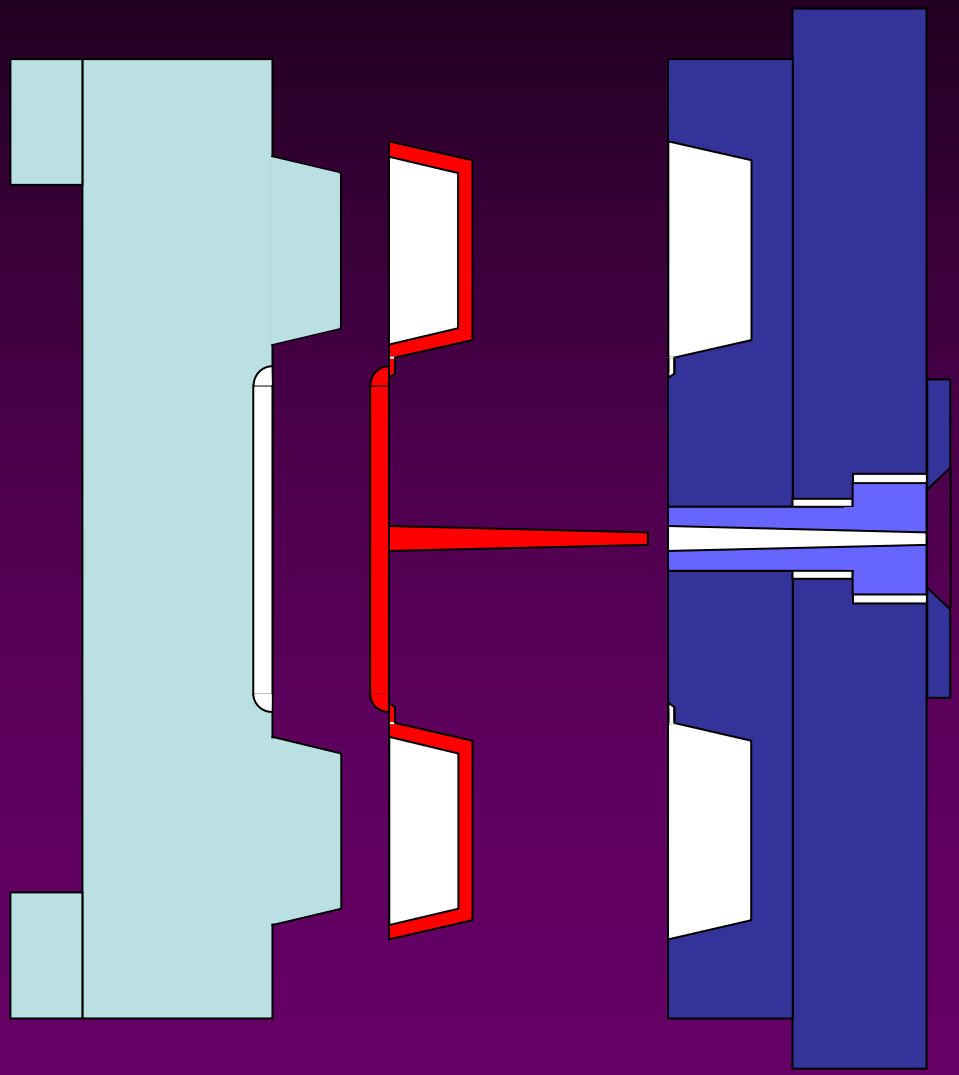
runner in both plates; better, more expensive



A fraction of the plastic solidifies in the filling sytem. In some cases it can be ground and re-used.







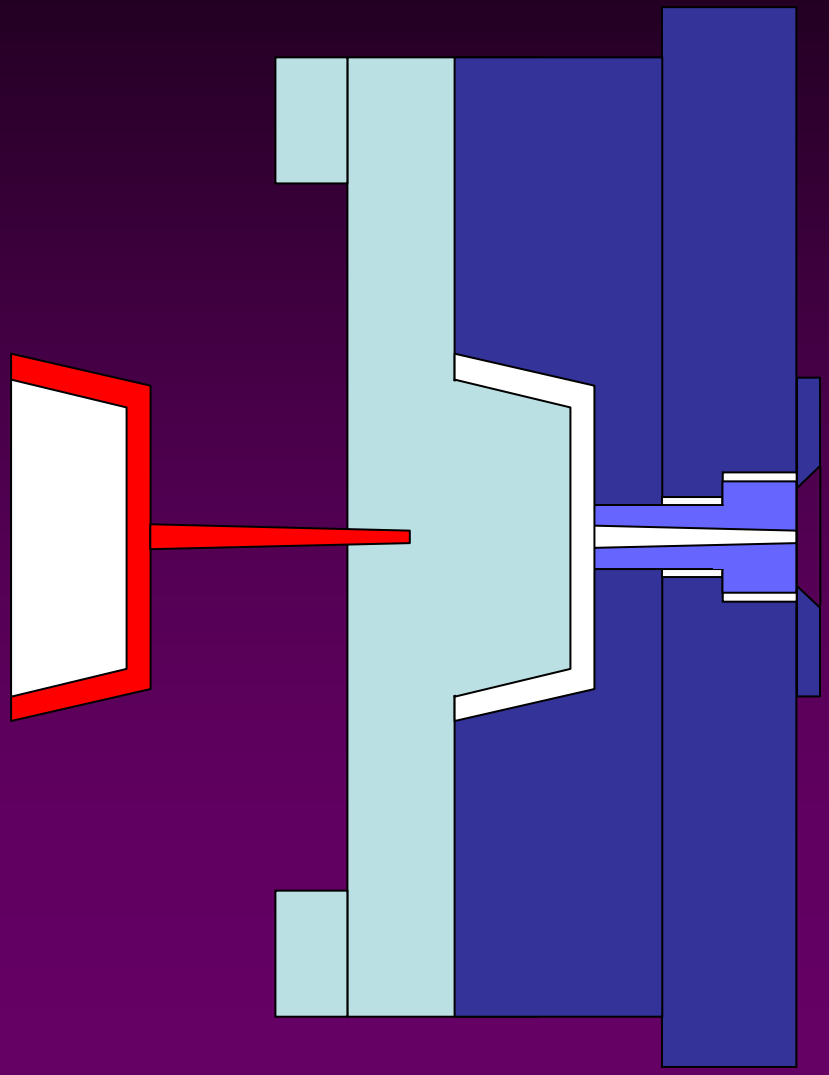
Advantages:

- multiple cavities possible
- gating on the parting line causes a modest vestige

Disadvantages:

- manual separation of parts and runner
- loss of plastic due to the runner
- hard to make perfectly round products in this way

Spuitneus komt rechtstreeks in de holte uit

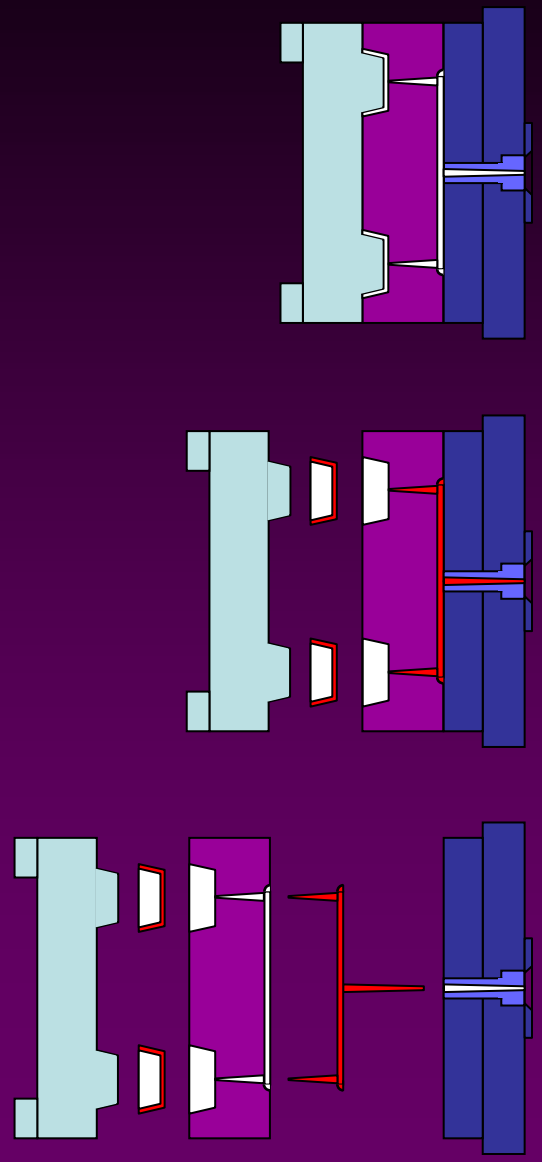


Advantages:

- simple and low-cost
- central gating ensures round products to stay perfectly round

Disadvantages:

- only one cavity
- sprue cone needs to be manually removed
- leaves a clearly visible vestige on the product

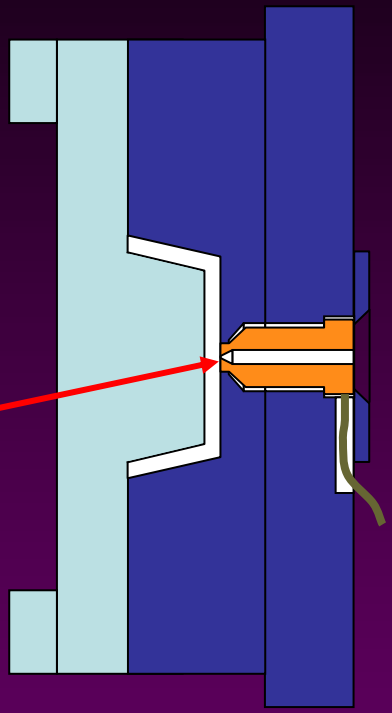


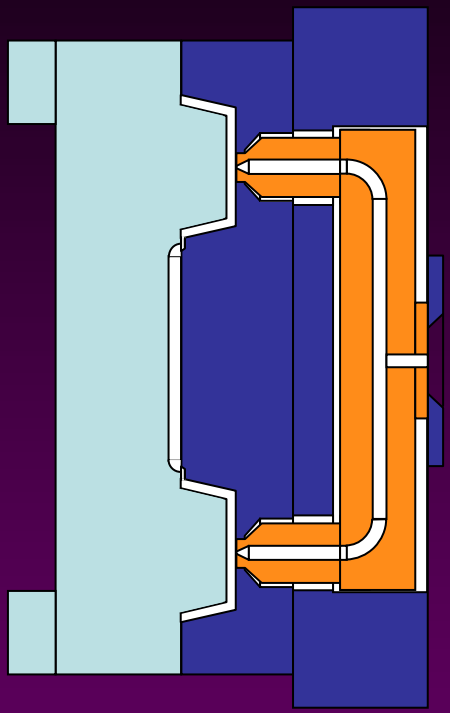
Spuitneus komt rechtstreeks in de holte uit

If you would like to have central gating AND multiple cavities, a three plate mold is necessary.

This has two parting planes, the second one serving to release the runner.

Spuitneus komt rechtstreeks in de holte uit





heated sprue

heated runner

“hot runner”

Spuitneus komt rechtstreeks in de holte uit

heated filling systems have numerous advantages:

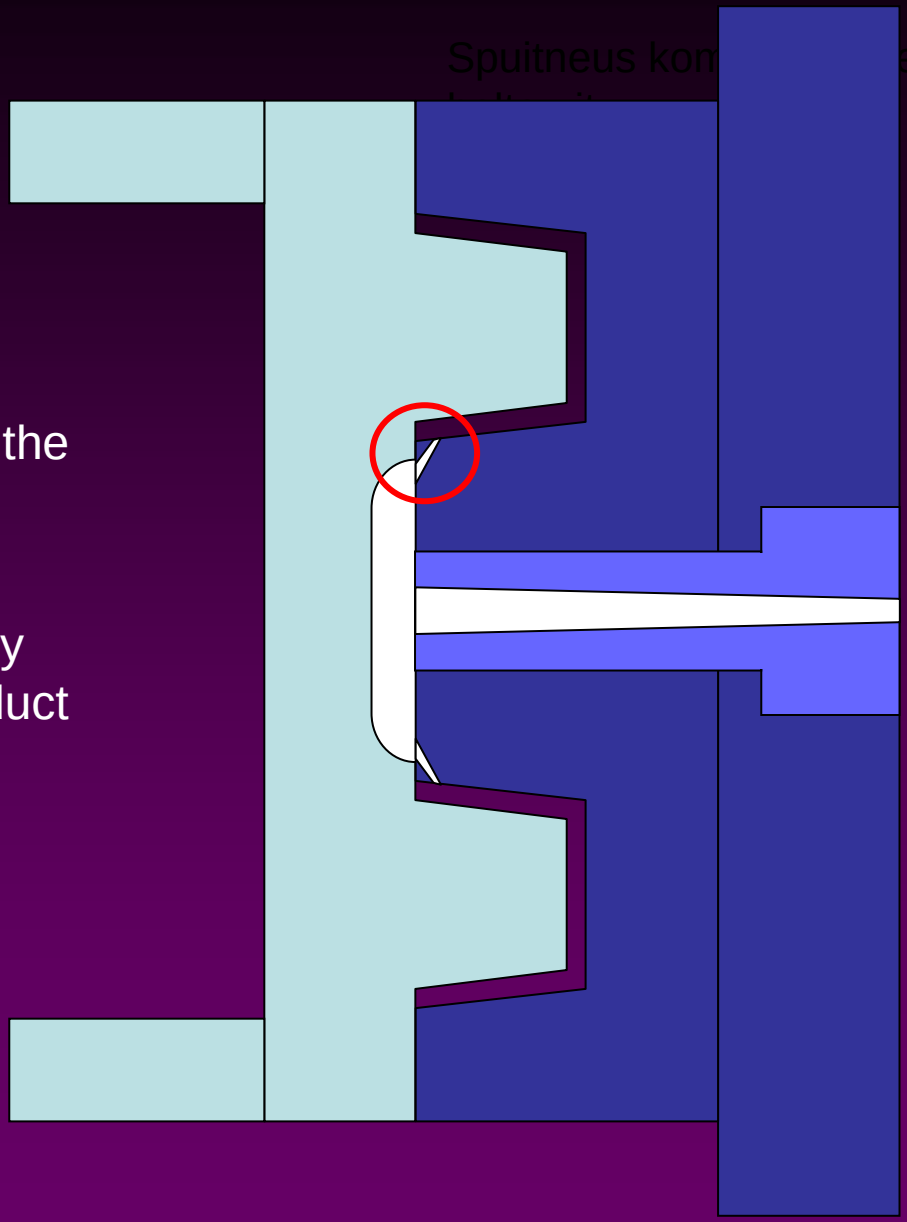
- only a pinpoint vestige
- no loss of material
- central gating possible also in multiple-cavity molds

Disadvantages

- costly (hot runner manifold

> 150000 Kč / € 5000)

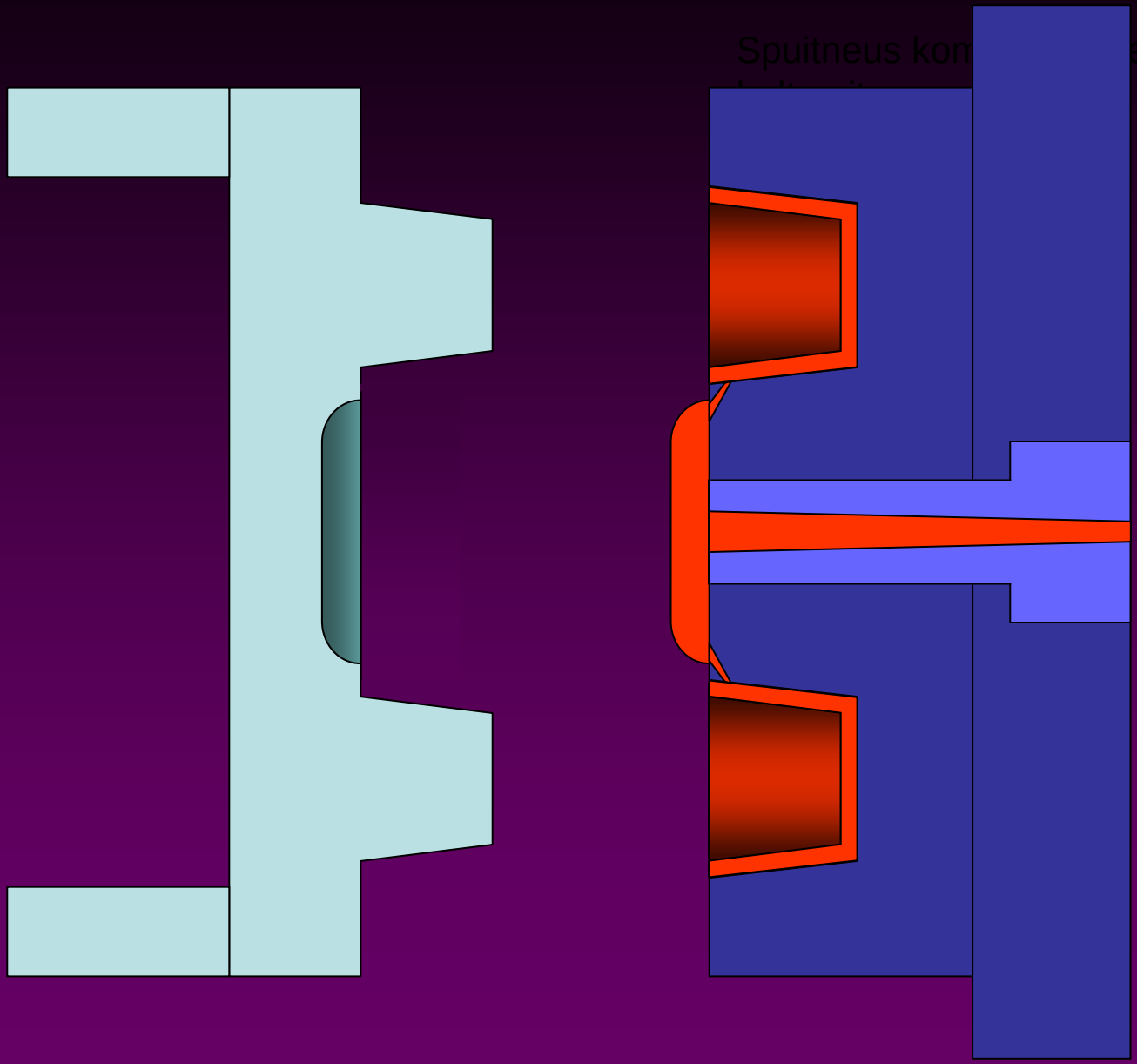
- will clog if granulate contains impurities

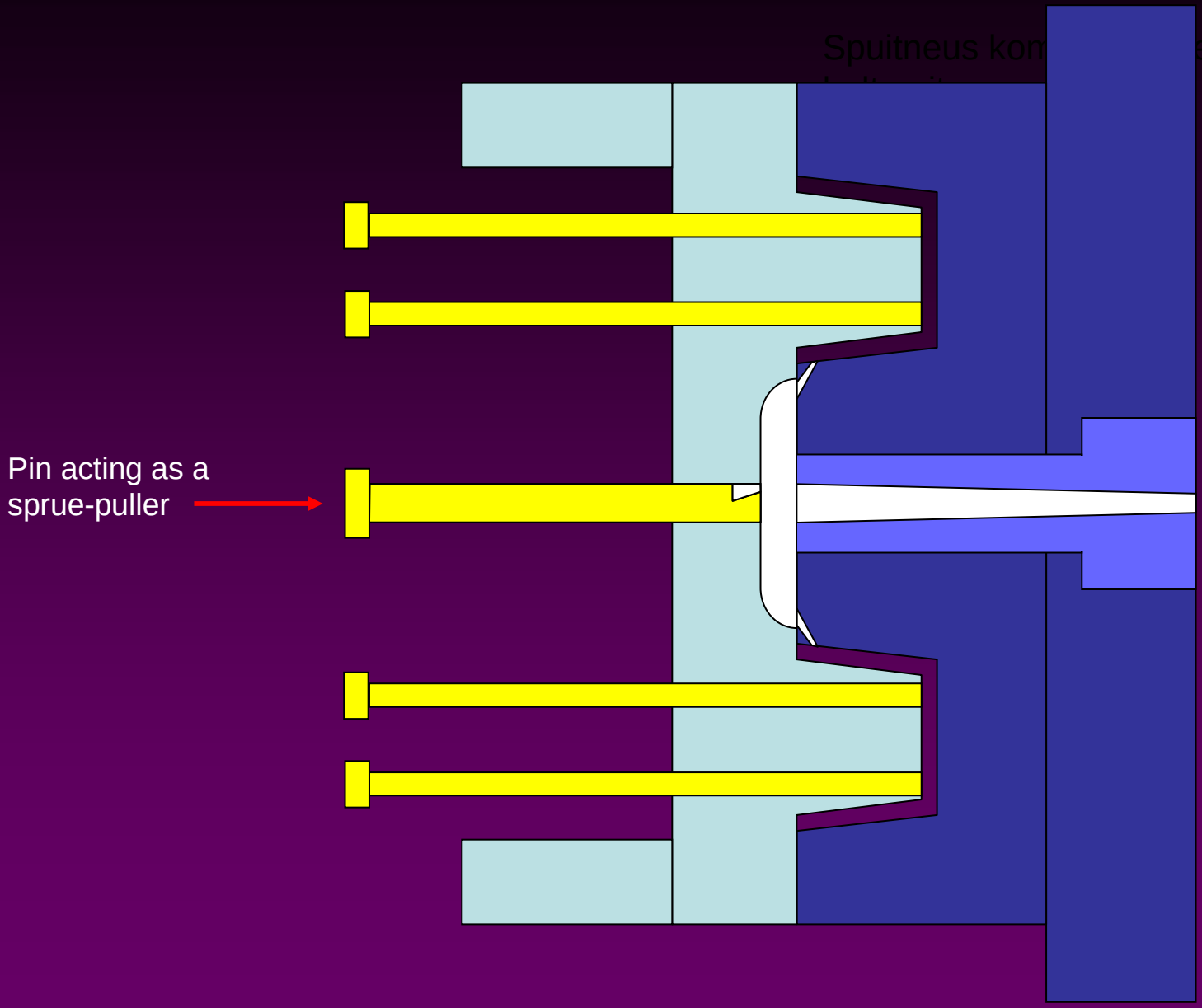


idea

When the mold opens:

- the product will stay on the core (goes to the left)
- the small steel triangle (which is part of the cavity plate) separates the product from the runner, cutting through the small conical gate.




Pin acting as a
sprue-puller