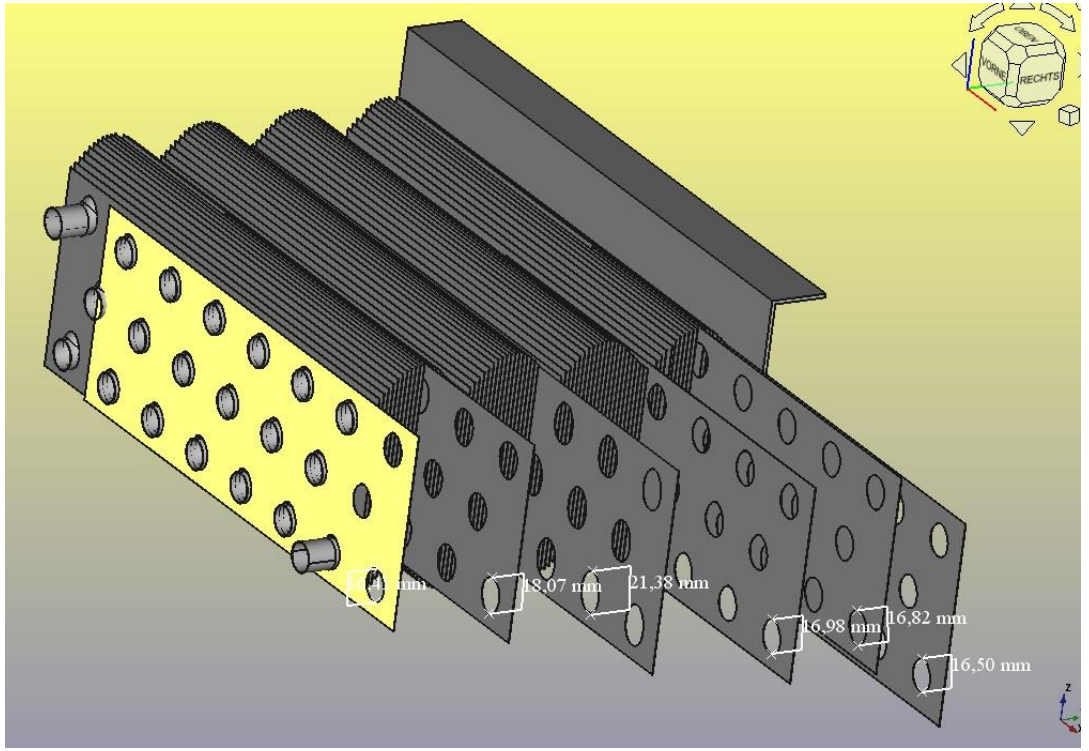
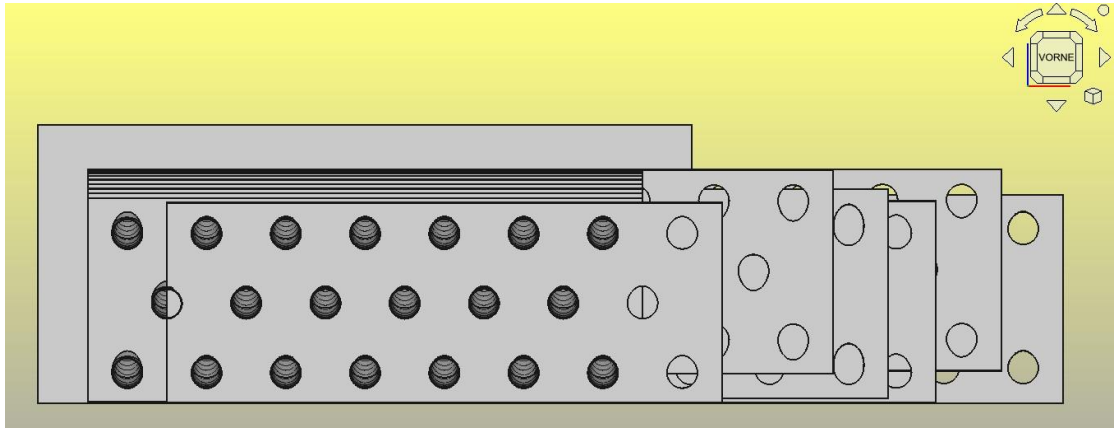
# Production of zigzag-shaped heat exchangers using robots

- Manufacturing process and precise cutting of holes using computer
- Assembly of fins using robots: push individual fin in pipe bundles

- An examination of the zigzag shape in CAD shows different sizes for the contact between fins and pipes.
- Contact shapes are circular and elliptical shape.

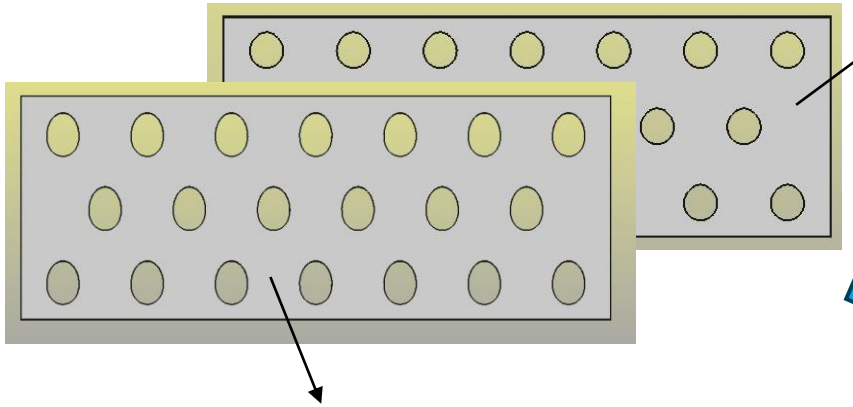


All information about holes‘ sizes and their orders come from CAD files

Cutting the fins

1

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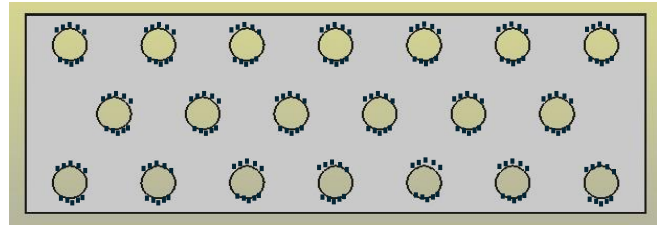

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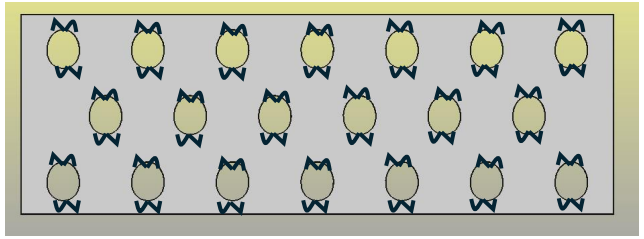

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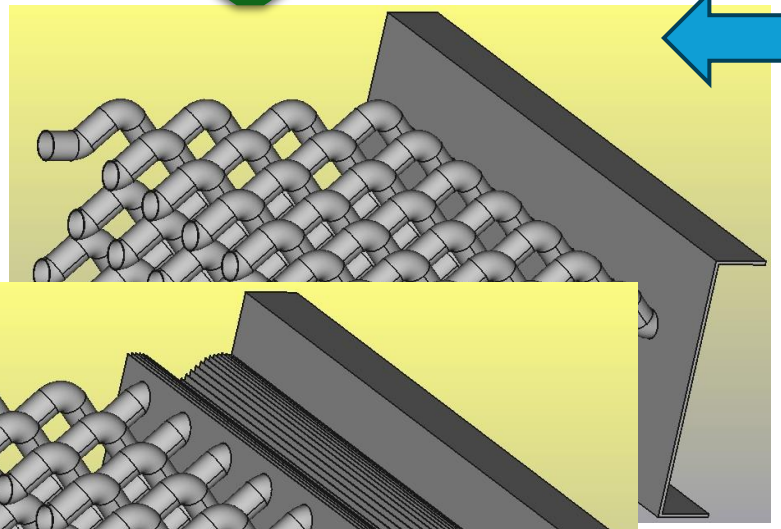
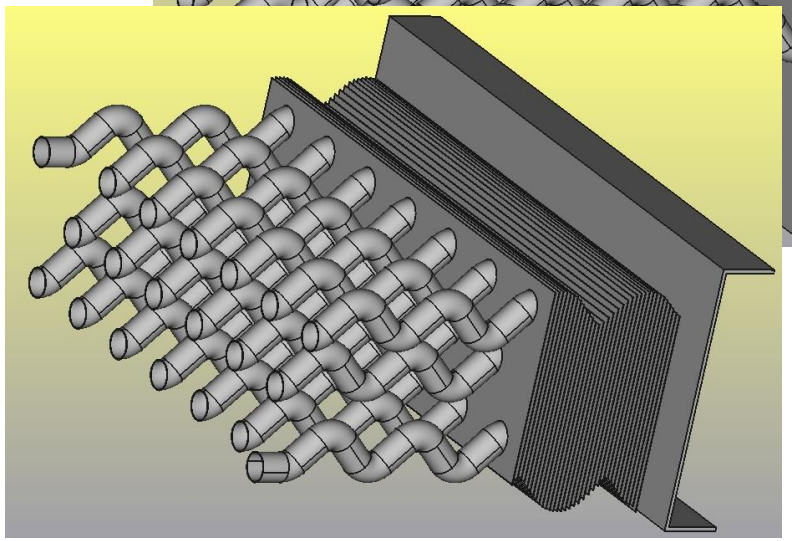




If the fins do not have a maximum elliptical circumference, the holes must first be slit and then given an elliptical shape using a hydraulic press (two steps using "one" hydraulic press).

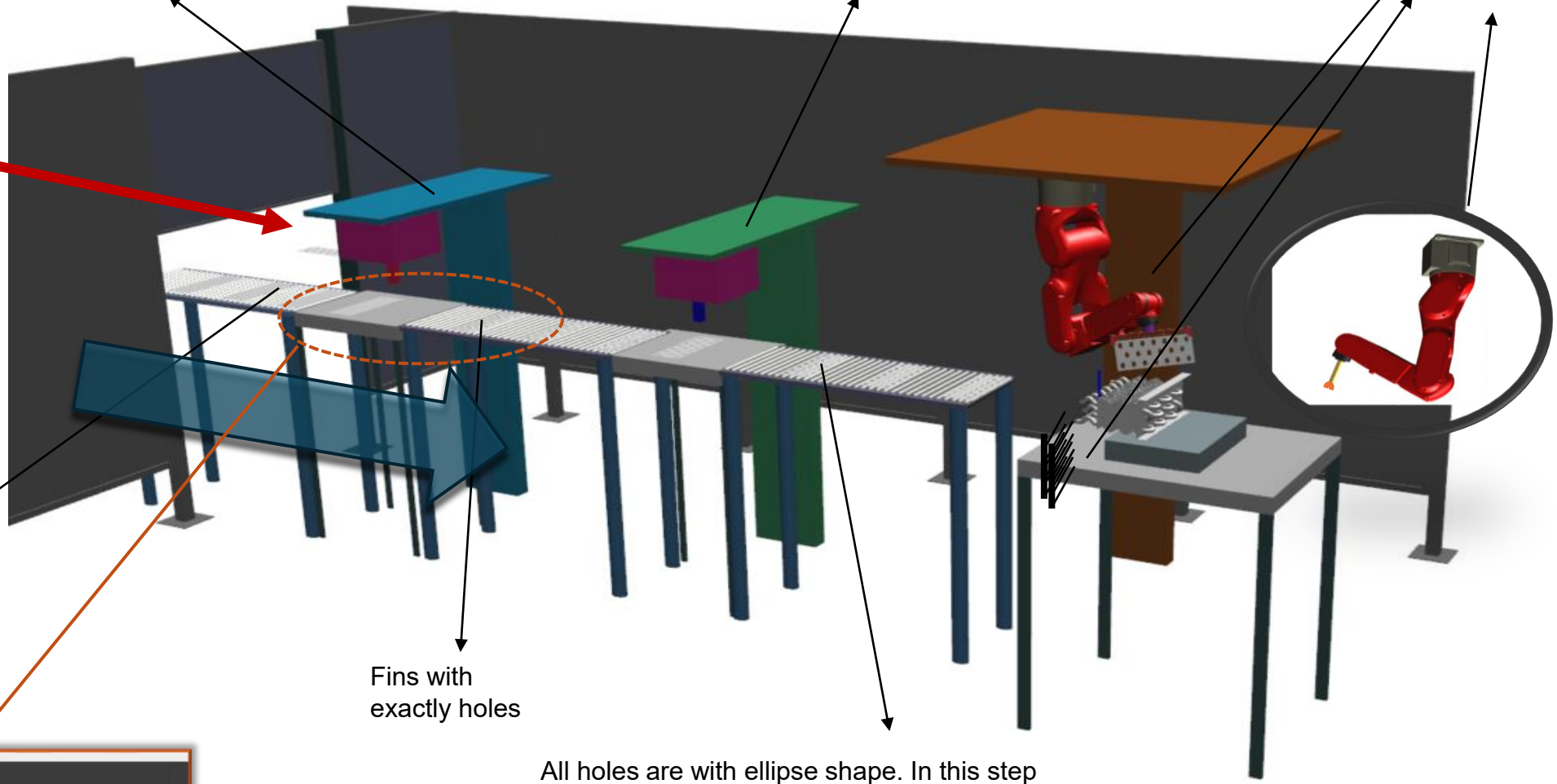
Assembly fins and pipes

Laser cutting:
exactly the hole sizes in the CAD in the correct order

Making slots, which allows the holes to be ellipsonic shape using **a hydraulic press.** Also, the fins are mounted vertically.

Installation of fins + closing slots

Information about the hole measurements and the order of fins comes directly from CAD

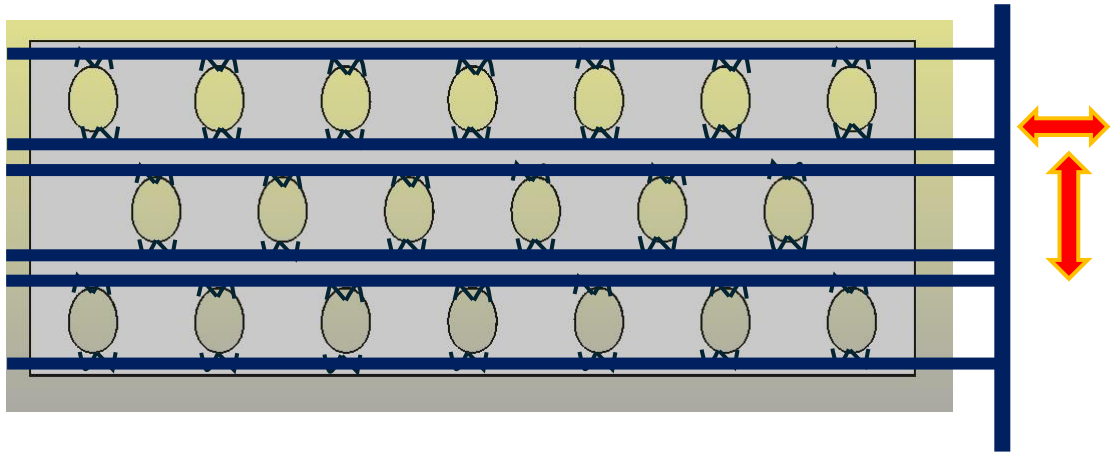


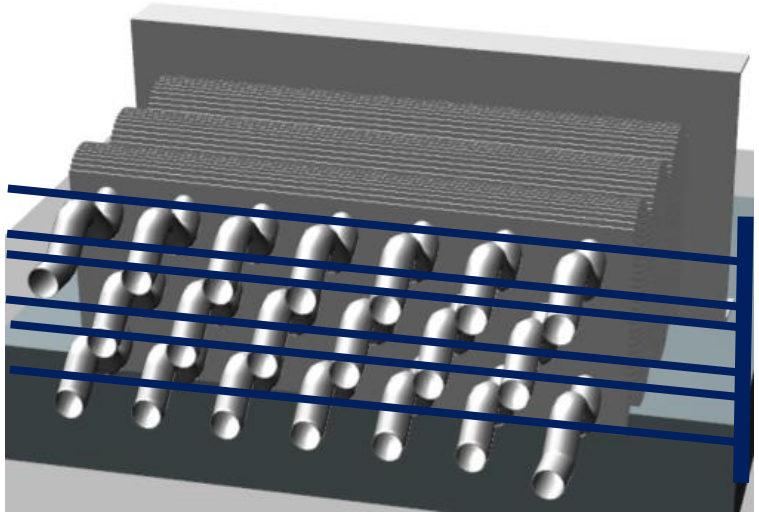
Fins without holes

Fins with exactly holes

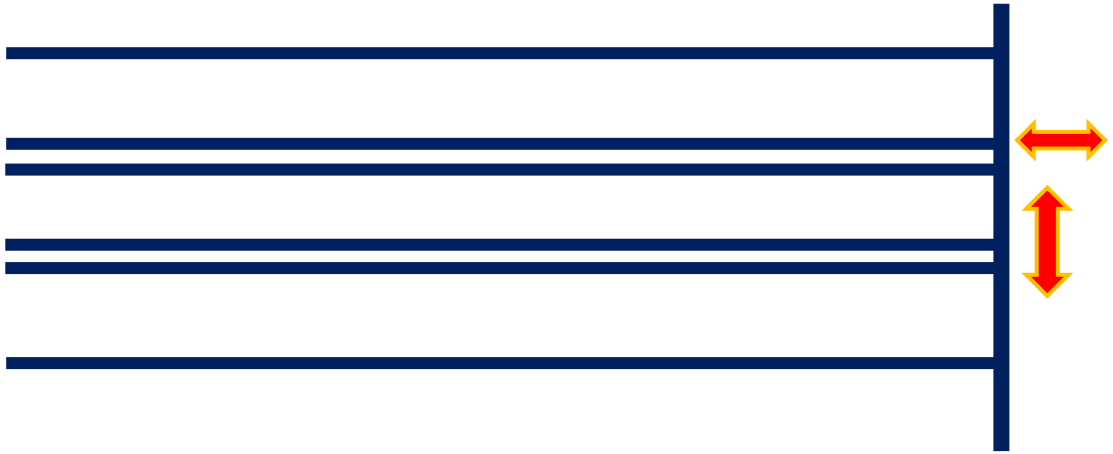
All holes are with ellipse shape. In this step the material is not removed because of the ellipse

How to close the slots? Example1



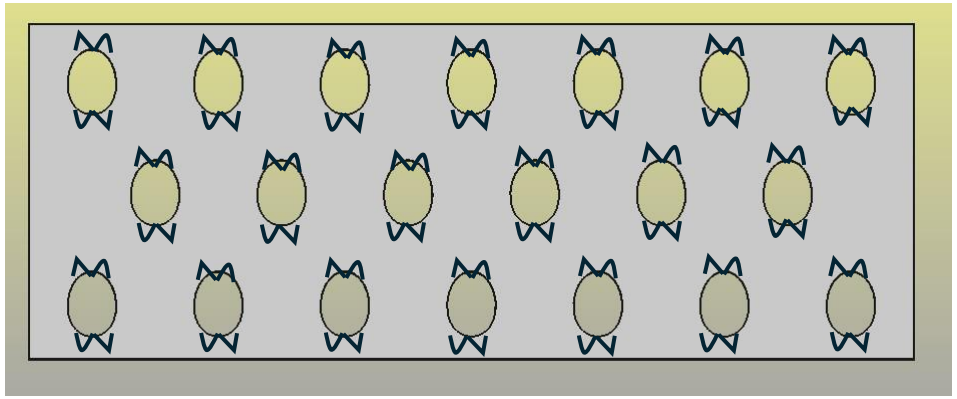


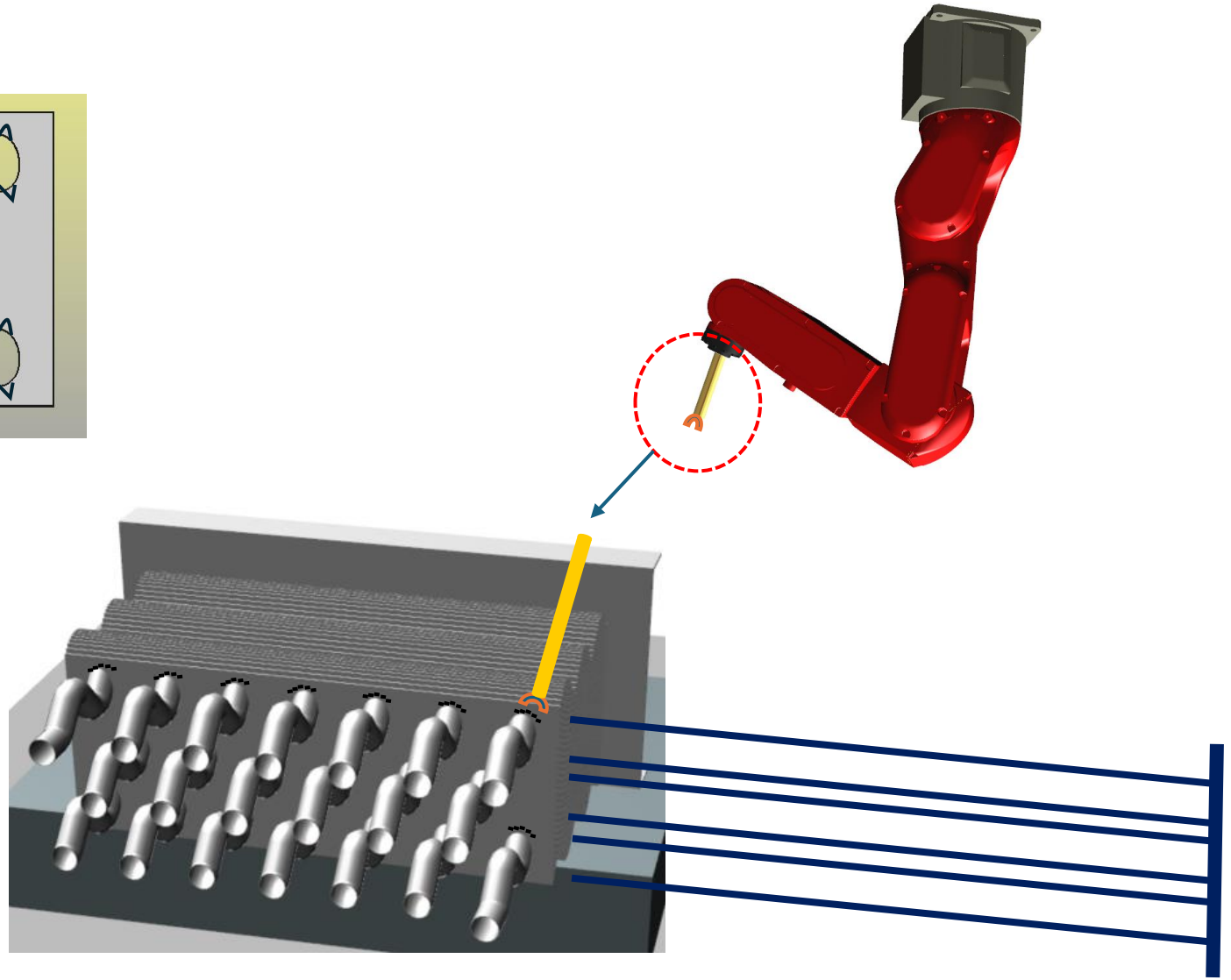
Mechanical pressure to close the slots and allow maximum contact between fins and pipes.



After each fin insertion, the slots are closed by a lateral mechanical pusher. This device resembles a "fork" and acts as a pusher and filler between the fins. It stays in place and helps maintain the spacing between the fins. The forks “can” remain between each tow fins at the end. They remain there until the pipes expand and firm contact is established between the fins and the pipes.
You can imagine, with the help of additional small clamps, that only one fork is to be used (behind the last mounted fin).

How to close the slots?  Example2





Mechanical pressure to close the slots and allow maximum contact between fins and pipes.

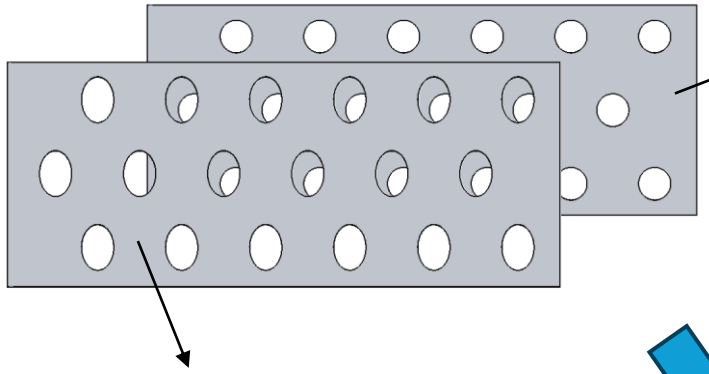
The fork is located behind the fin. A precise robotic arm with an e.g. elliptical (or semicircle) gripper closes the slots. Only one fork would be used.

# Production of zigzag-shaped heat exchangers using hydraulic press

All information about holes' sizes and their orders come from CAD files

Cutting the fins

1

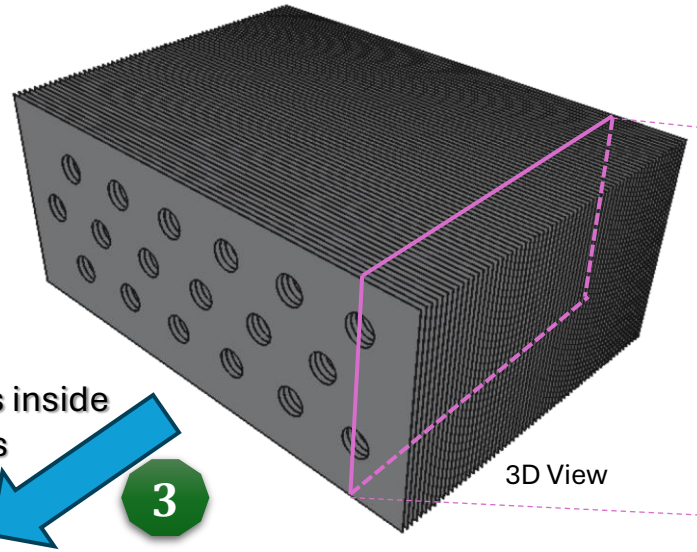


fin with circular holes

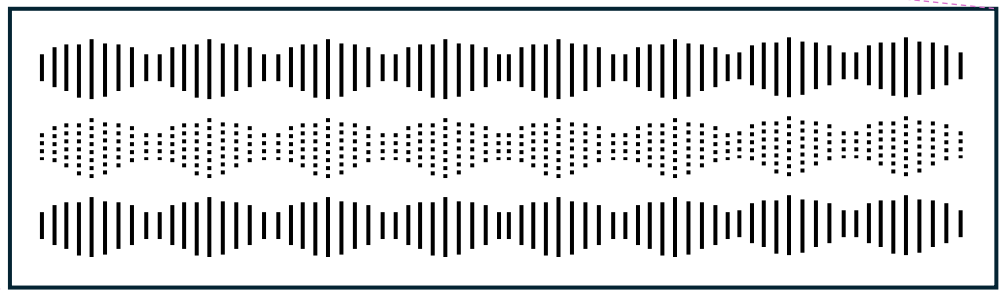
fin with elliptical holes

2

Arranging/Stacking the fins with defined distance according to the information from CAD



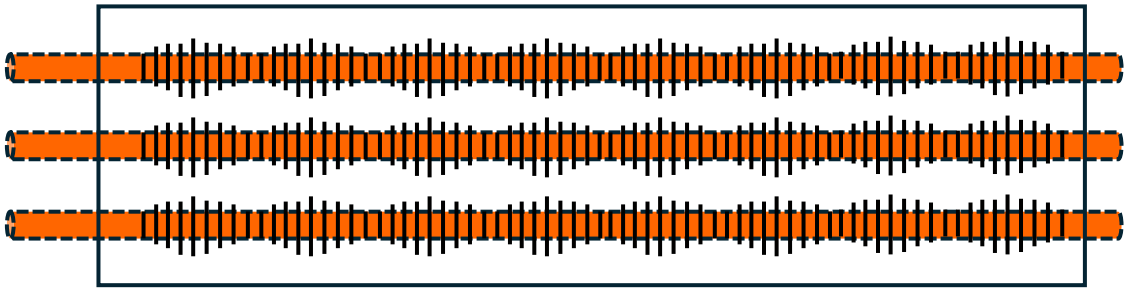
3D View



2D View
(side view)

Inserting the pipes inside the centered holes

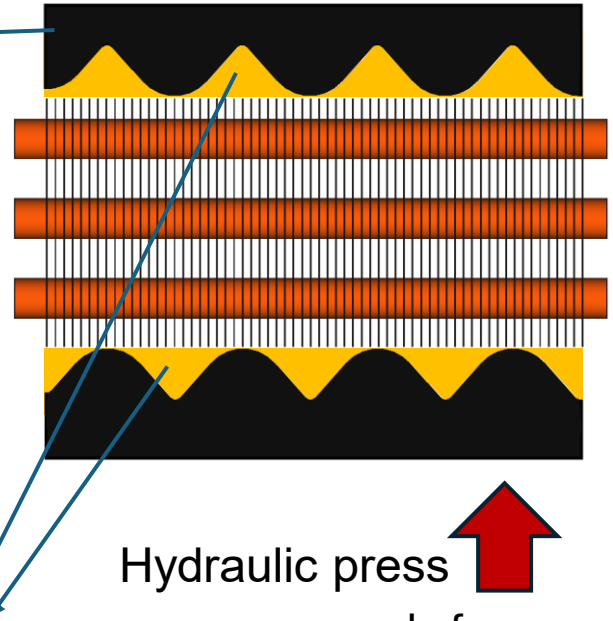
3



**At this stage, all fins are aligned together as a cubic box.**

**Alternative step: The holes between the fins can be later filled with fine sand or hydraulic fluid.**

How is the zigzag shape made with the help of the hydraulic press? Example1

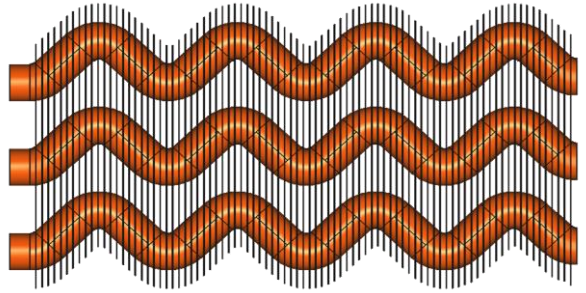


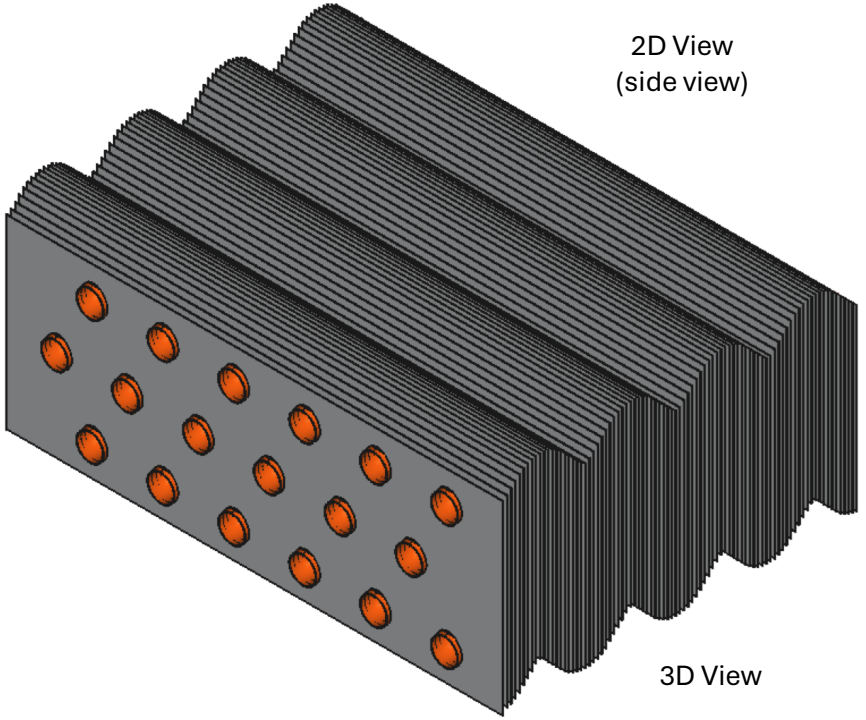

Hydraulic press

press only from one side (it can be imagined from two sides, as in the next Example )

4

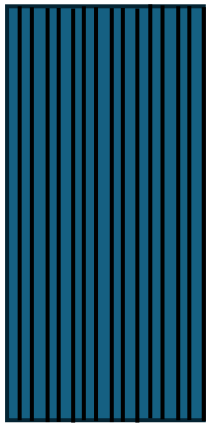
Using accurate positioning of the hydraulic press






- **The pipes can be filled with a hot liquid (e.g. >200 degrees) to soften the pipe material.**
- **The rubber material can be integrated on the hydraulic press**
- **The final stage should include cleaning the filled hollow between the fins from the fine sand or the hydraulic fluid, if exist.**

how is the zigzag shape made with the help of the hydraulic? Example2



Rubber sheet possibly with a profile

Rubber sheet possibly with a profile

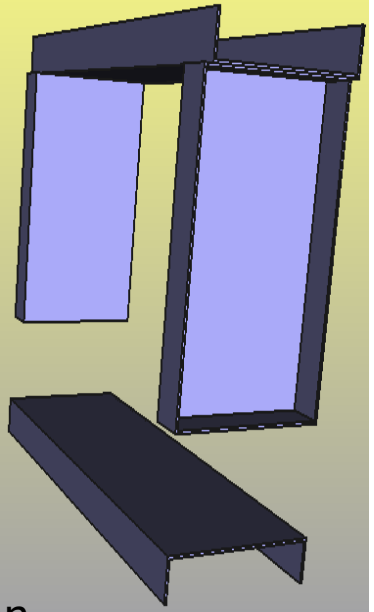
soft rubber material or hard sponge

hard demarcation

hydraulic press



hydraulic press

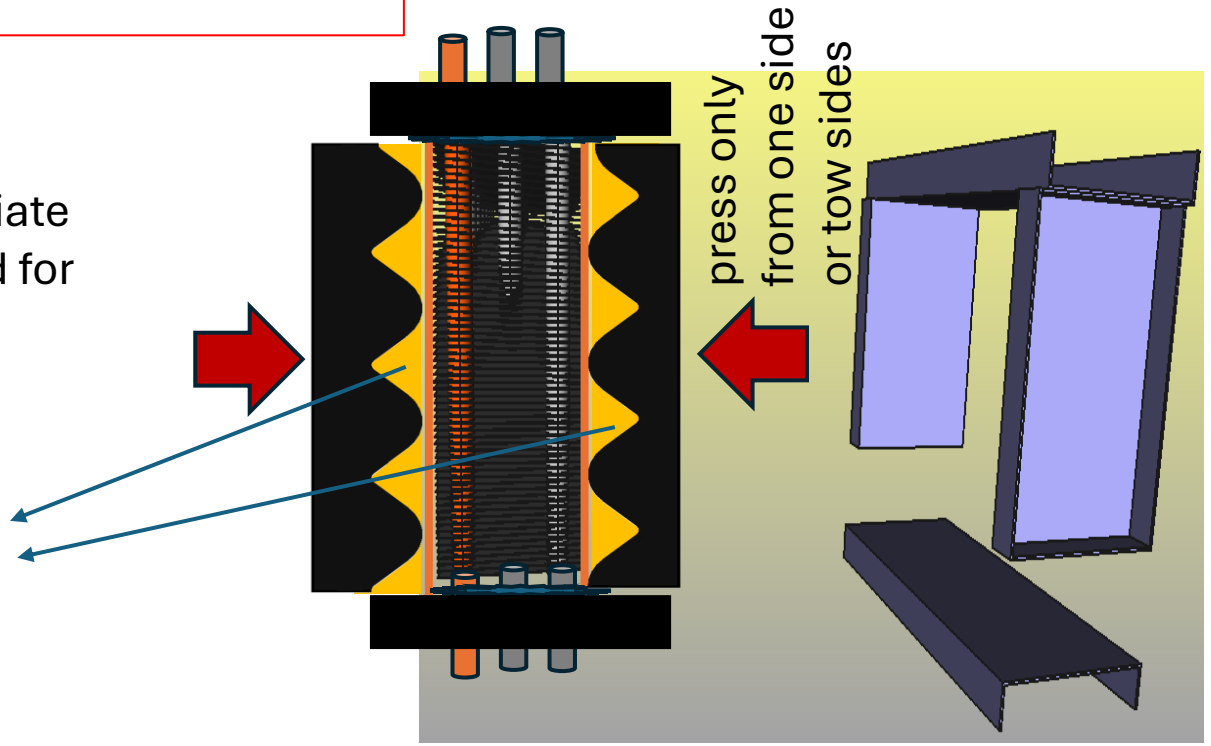


hard demarcation

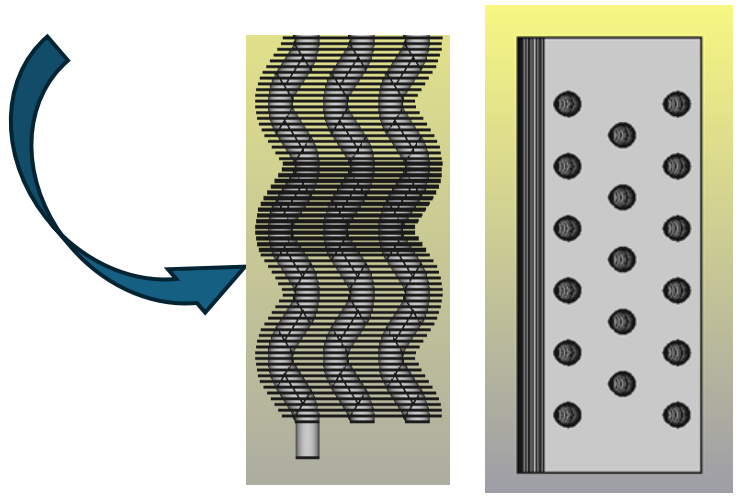
how is the zigzag shape made with the help of the hydraulic?
Example2

Between the fins can also be filled with appropriate material or liquid (if necessary) that can be used for further

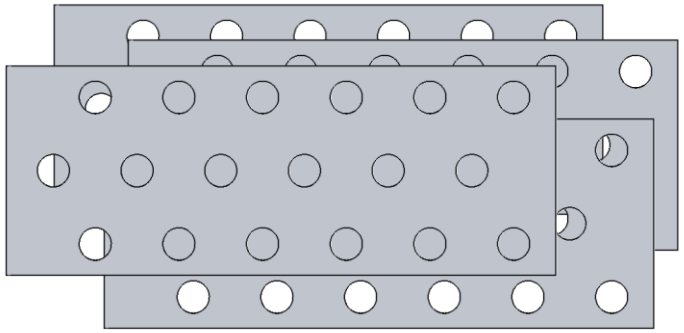
In this area, the appropriate material (soft rubber) can also be filled, just like in the last Example. The aim is to increase the friction between the fins and the hydraulic press and to prevent the fins from slipping or being damaged.




- **The pipes can be filled with a hot liquid (e.g. >200 degrees) to soften the pipe material.**
- **The rubber material can be integrated on the hydraulic press (no additional automation steps)**
- The final stage should include cleaning the filled holes between the fins from the fine sand or the hydraulic fluid, if used or exist.



# Innovative Manufacturing of Zigzag Heat Exchangers Matching Conventional Process



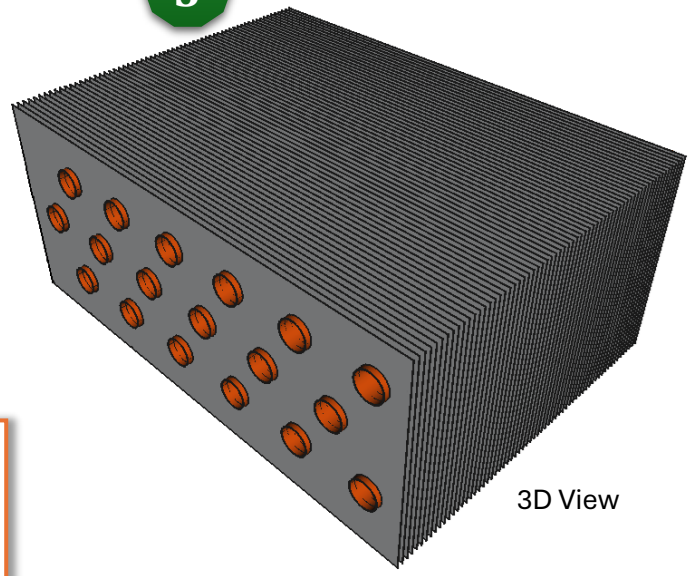
All fins have circular holes

1

Stacking fins together

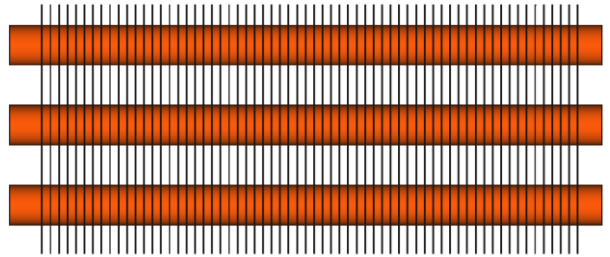
2

Inserting the pipes into the holes



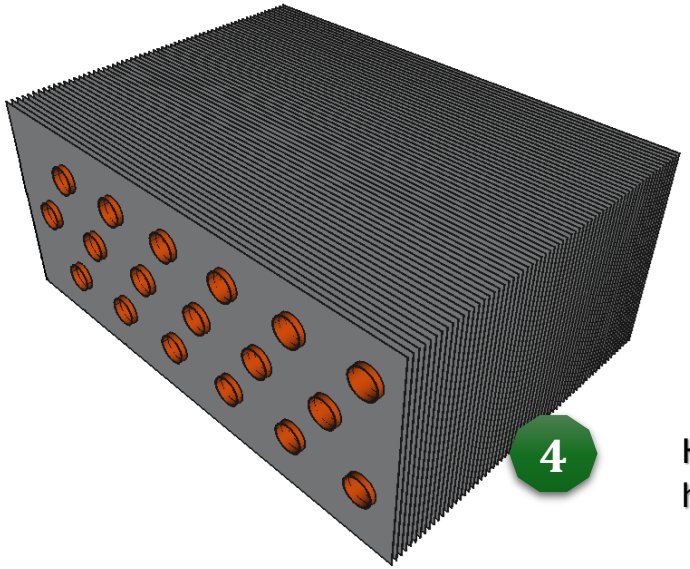
3

3D View



2D View (side view)

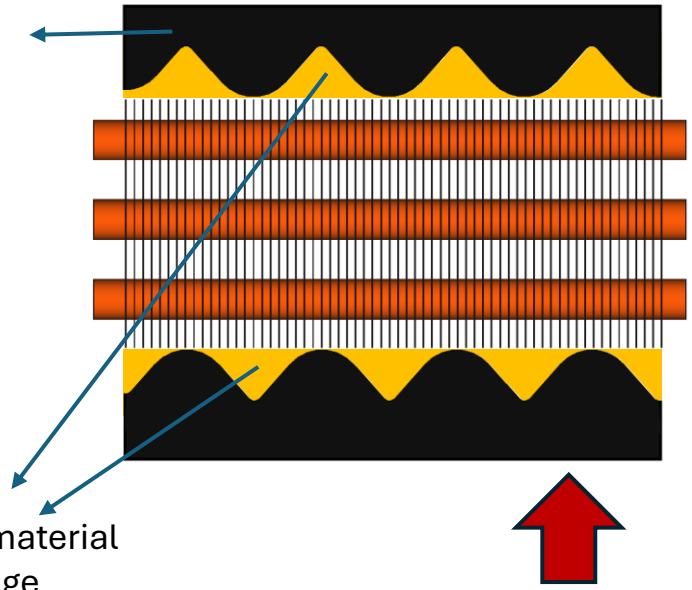
Heating up the pipes via e.g hot sand inserted in the pipes



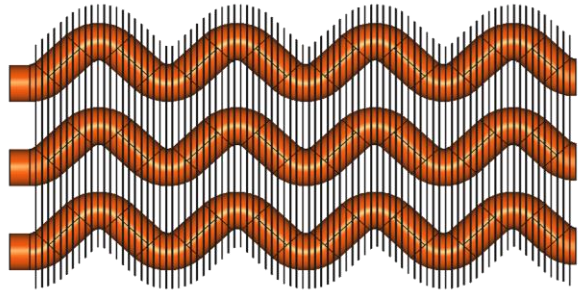
4

**Advantage:**
**Up to this stage the conventional process is carried out.**

5

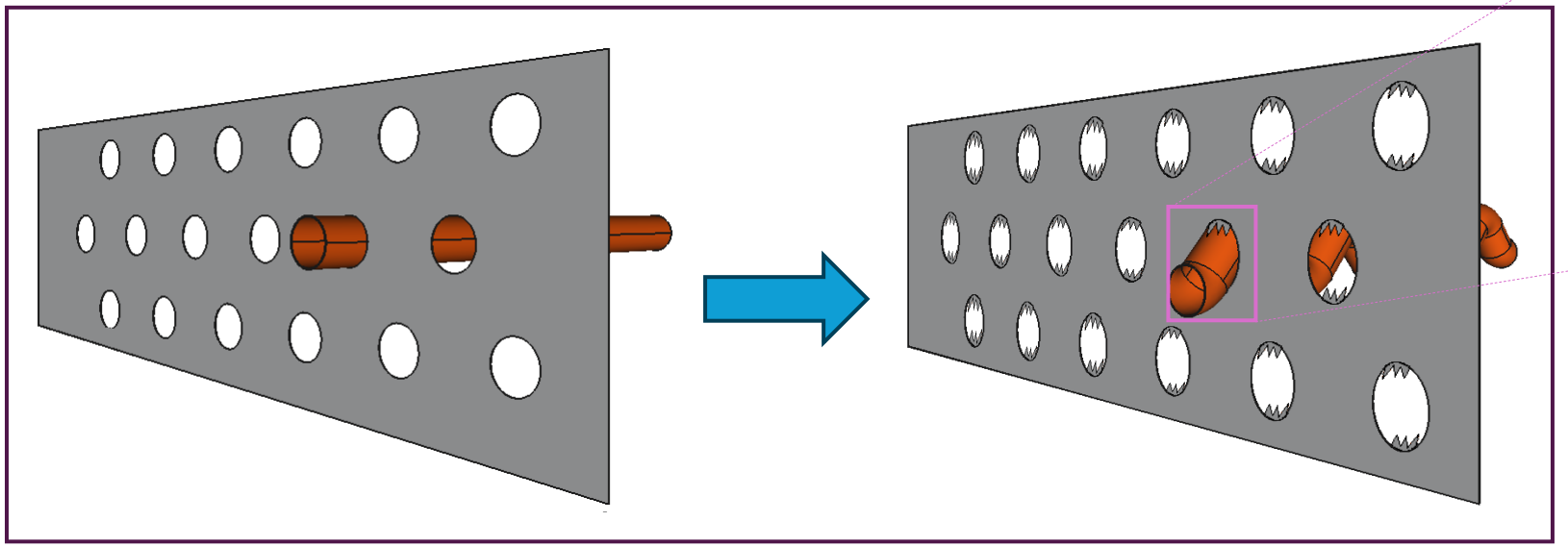


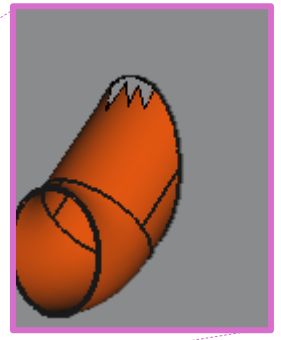

1. Heating up the copper pipes to a **defined temperature** to soften the materials.
2. Using the hydraulic press will cause the targeted deformation of both the pipes and the holes in the fins as well.



Note the melting temperature of the used materials:

- Sand 1700 °C (may used inside the pipes to heat them up)
- Copper 1085 °C (pipes)
- Aluminum 660 °C (fins)





The deformation of the circular holes at that defined temperature follows the copper pipes (Hydraulic press pattern)

At a further optional stage, the temperature can be increased. This allows the deformations of the fins to melt. The fins then bond to the pipes.