Radiative Heat Pipes based Waste Heat Recovery Solution

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 680599.

Summary

- The Application
- End user
- The systems' design
- Lab validation
- Factory validation

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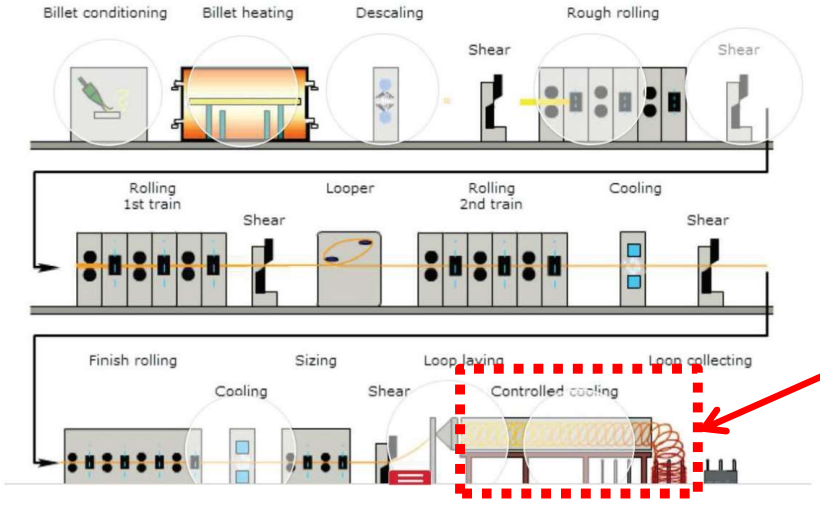
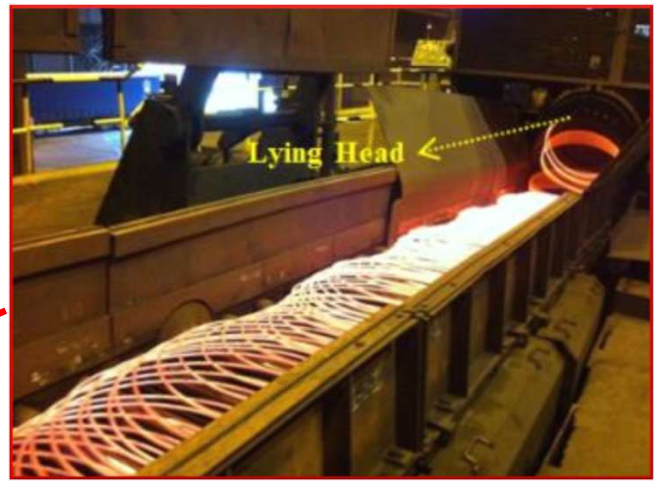
The application

Wire Rod Mill

- Along the line there are a total of 29 fans located below the conveyor length in order to supply a controlled air flow for the material cooling.
- The fans usually cool the wire from 920 °C to 250 °C. Other materials cool down at room temperature, so all the fans are stopped.





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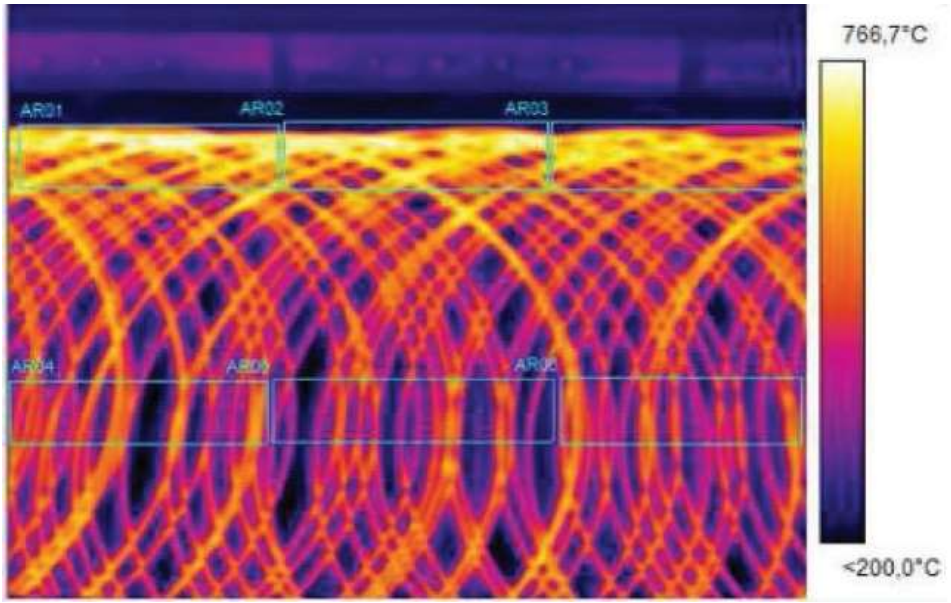
Factory Facility

- **Facility: Wire Rod Mill**
- **Product: Wire Rod**
- **Average T: 500 – 600 ºC**



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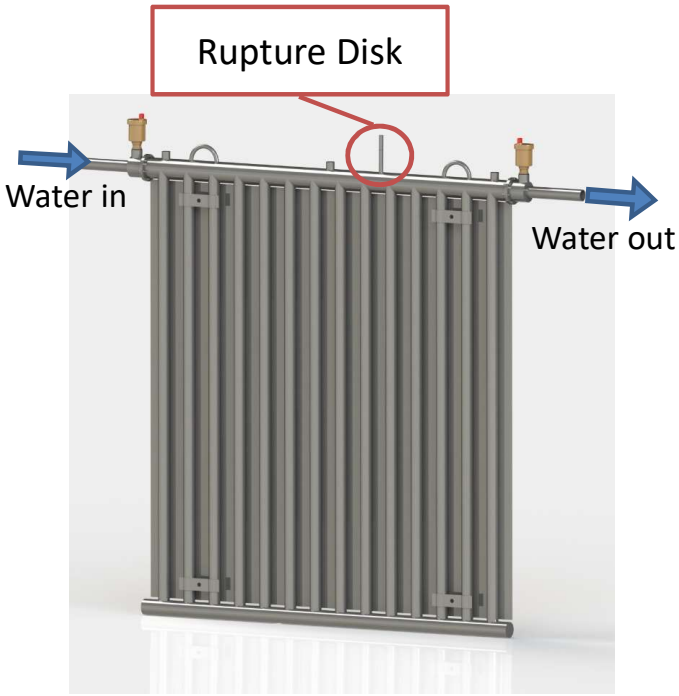
FHP Design



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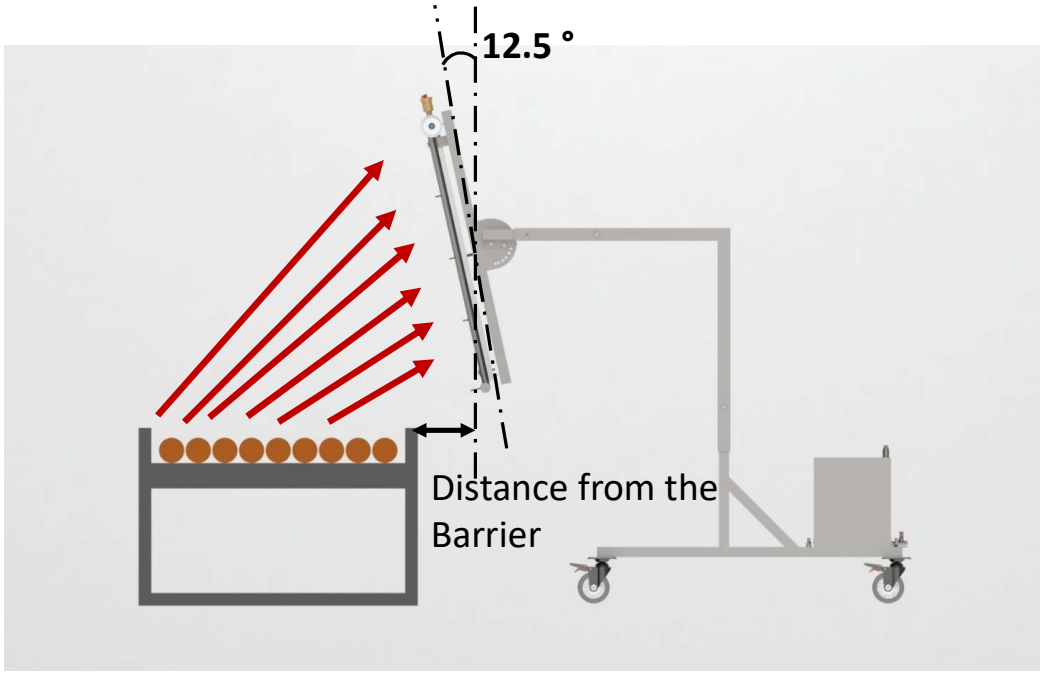
On site Testing Setup



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Flat Heat Pipe Design

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Summary Of Trials

Test conditions

Test	With/Without Panel	With/Without Paint	Angle
Lab trials 1	Back panel	No Paint	12,5°
Factory trials 1	Back panel	No Paint	12,5°
Factory trials 2	Back panel	No Paint	12,5° & 25°
Lab trials 2	No back panel	No paint	12,5°
Lab trials 3	Back panel	**Black paint**	12,5°
Lab trials 4	No back panel	**Black paint**	12,5°
Factory trials 3	Back panel	**Black paint**	12,5°
Factory trials 4	No back panel	**Black paint**	12,5°

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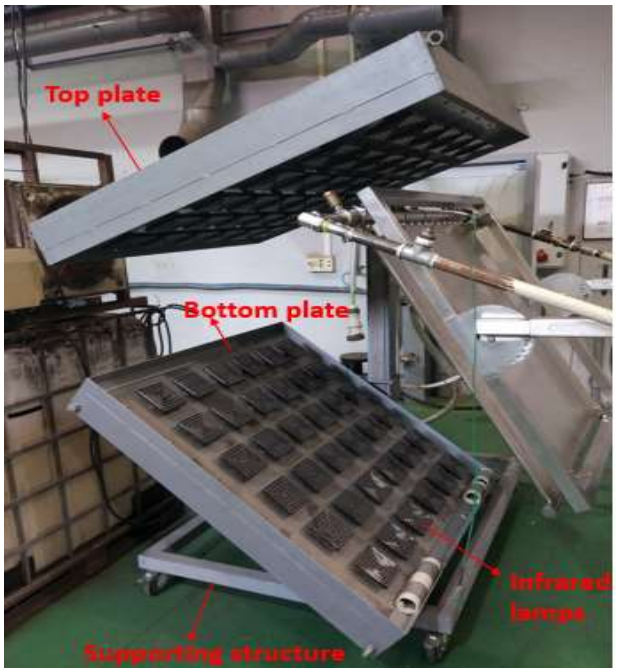
Lab Validation

- The prototype was tested in the lab facilities of ArcelorMittal Global R&D Asturias => Radiant Module
- The impact of the Back panel was evaluated
- The impact of surface absorptivity and emissivity was investigated by applying **black paint**



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Lab Tests Set up

Lab workbench:

- Bottom plate: 1 m²
- Max. Power: 29 kW
- FHP Inclined 12.5° from vertical

Sensors:

- 1 flowmeter
- 2 water thermocouples: for monitoring inlet and outlet temperatures
- Thermocouples on the FHPS surface: evaporator, condenser and heat pipes

Insulation:

- Back panel
- Condenser
- Water connection fittings

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Results at lab

Scenario: Back Panel & **No Paint**

Configuration:

- Temperature of the lamps: 400 – 580 °C
- Water flow rate: 18.5 & 25 l/min
- Inlet water temperature: 10.6 °C
- Heater power: 15-29 kW

Results:

- Max recovered heat energy: 11.5 kW @ 580 °C of lamps temperature

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Results at Lab

Scenario: No Back Panel

Configuration:

- Temperature of the lamps: 400 – 580 °C
- Water flow rate: 15 l/min
- Inlet water temperature: 20 °C
- Heater power: 15-29 kW

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Results at lab scale

Scenario: Back Panel & **Black Painted**

Configuration:

- Temperature of the lamps: 400 – 580 °C
- Water flow rate: 18 l/min
- Inlet water temperature: 21 °C
- Heater power: 15-29 kW

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Results at lab scale

Scenario: No Back Panel & **Black Painted**

Configuration:

- Temperature of the lamps: 400 – 580 °C
- Water flow rate: 15 l/min
- Inlet water temperature: 21 °C
- Heater power: 15-29 kW

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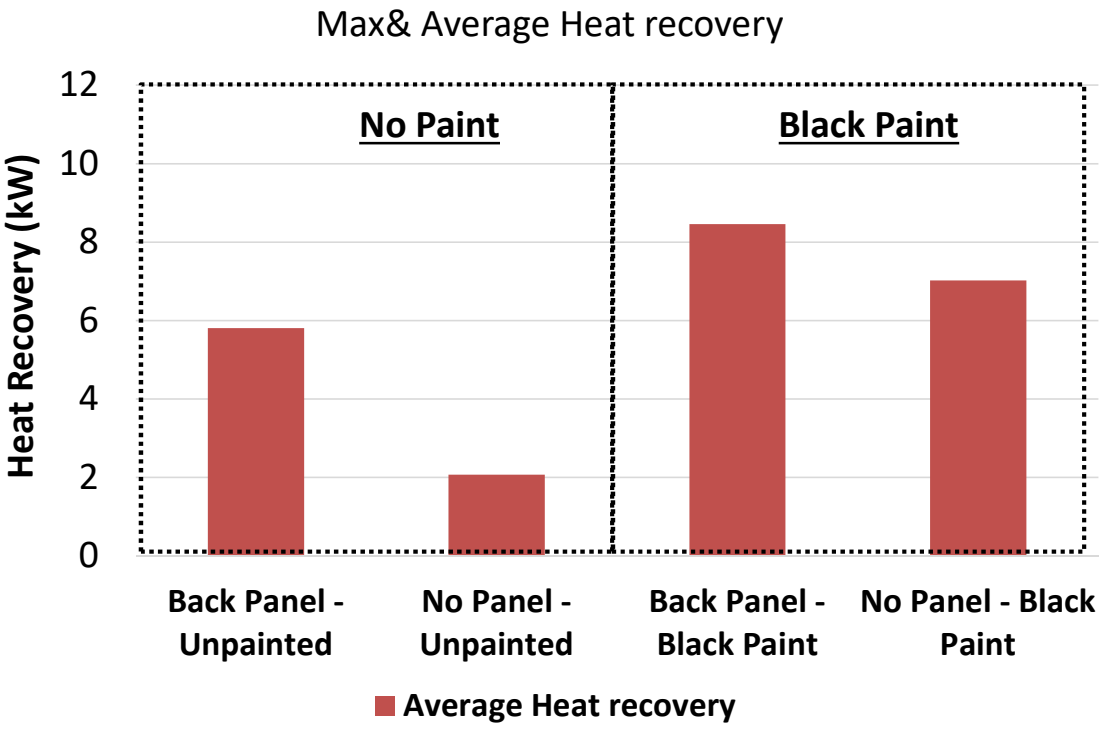
Comparison of Results at lab scale



Best Results: Back Panel & **Black Painted**

- Max. recovered heat energy: **9.3 kW**
- Average Heat recovered: **8.4 kW**
  The average of heat recovery is close to the peak. This shows the improvement of the performance of the FHP.

Test conditions of Back Panel & Black Painted

- Temperature of the lamps: 580 °C
- Water flow rate: 18 L/min
- Heater power: 29 kW

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Factory Tests

Test conditions

- **Best performance:** near the lying head (radiant surface T ~ **600 °C**)
- **Wire Diameter** of produced wires affects the performance
- **Best angle** FHPS for the recovery: 2nd hole (12,50 °)
- **Best position:** Bottom collector 5 cm from the wall of the wire rod mill, inside of the table.

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Factory Validation

Different positioning of the FHP

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Factory Validation

✓ **Different conditions and positions of the FHP**

Testing the FHP prototype **black painted** with and without back panel

Best Result

Max Heat recovered: **16.9 kW**
Average Heat recovered: 12 kW




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Factory Tests

Results : Heat Recovery

Max Heat recovered: **16.9 kW**
Average Heat recovered: 12 kW

Conditions:

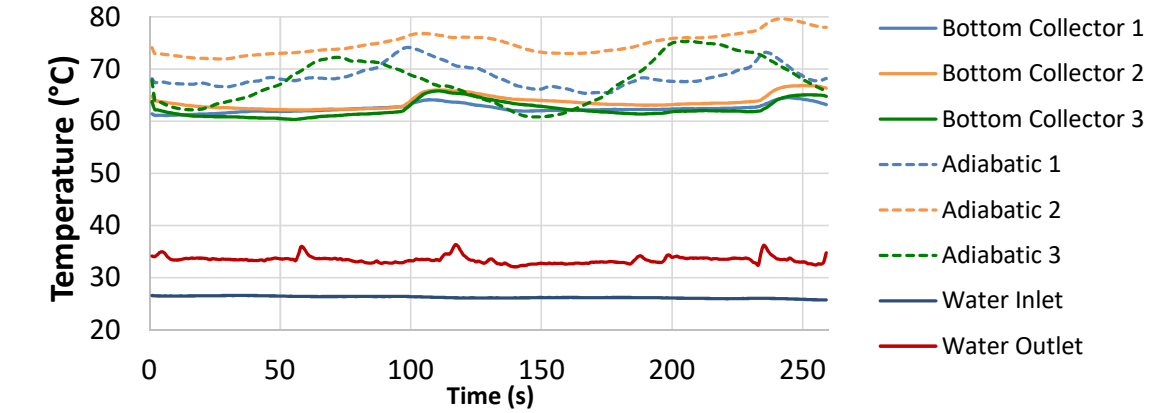
The steel was cooled by the fans

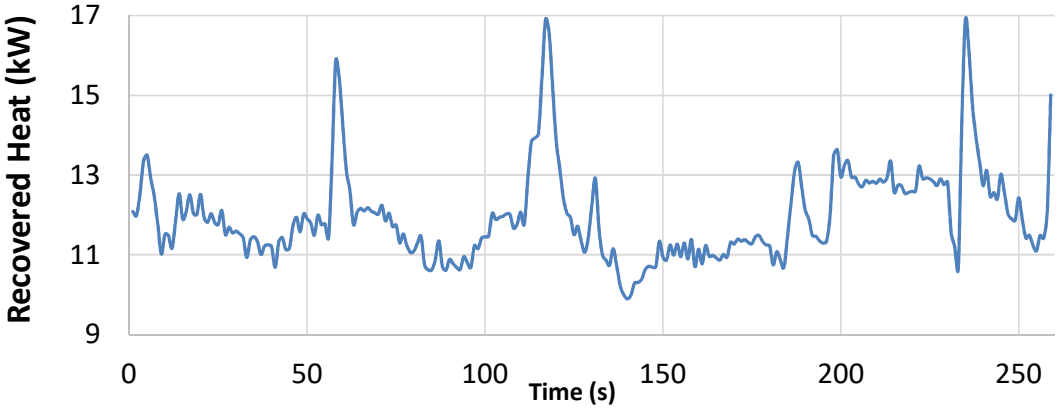
Distance from Laying head: 0 m

Inclination Angle: 12.5 °C from vertical

Wire production: <u>High density</u>

<u>No Paint</u>





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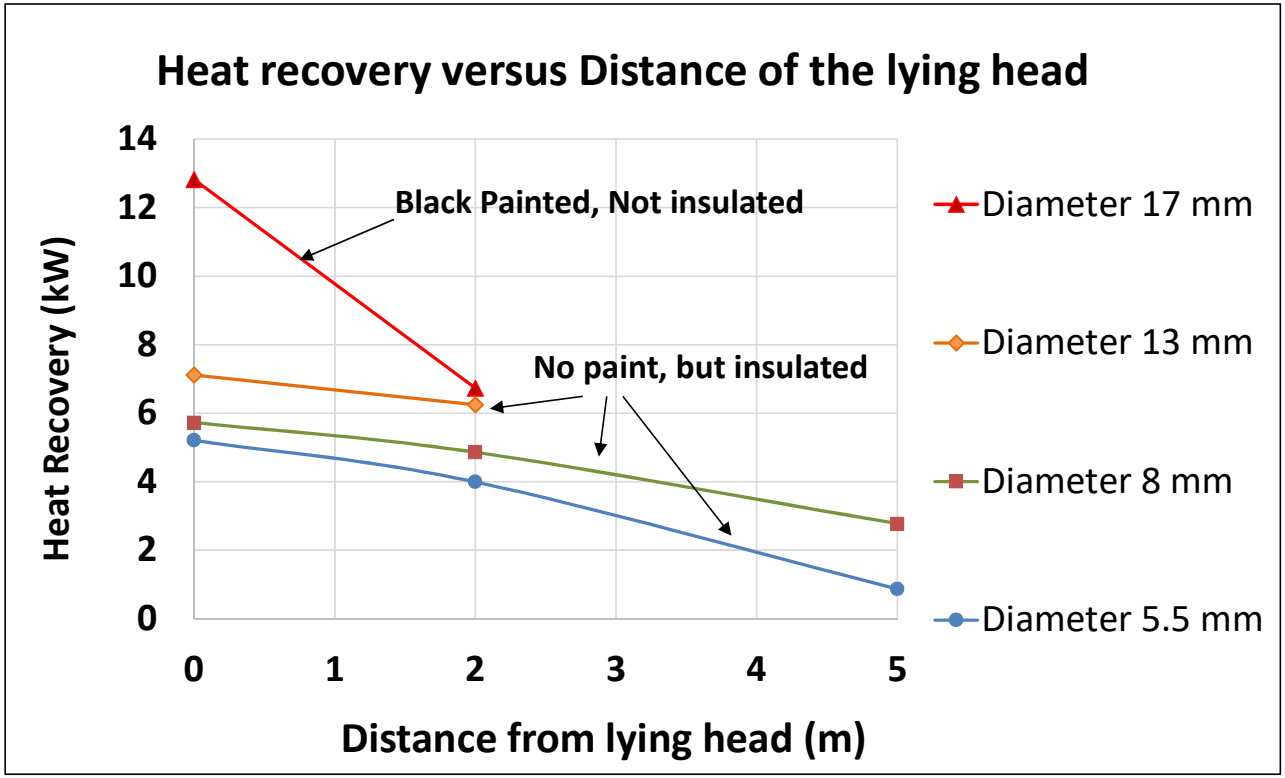
Factory Test

Impact of the steel diameter and the distance from the beginning of the production line

Result observations
The heat recovered increases with the increment of wire diameter
The recovered heat decreases with the distance from the laying head

Conditions:

The steel was cooled by the fans
Rolling speed: Slow
Inclination Angle: 12.5 °C from vertical



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Developed Model

- Number of Pipes : Increased from 14 to be 23 pipes

FHP Prototype (**14 pipes)**

Developed FHP (**23 pipes**) with no Back panel

FHP Developed (**23 pipes**) with Back panel

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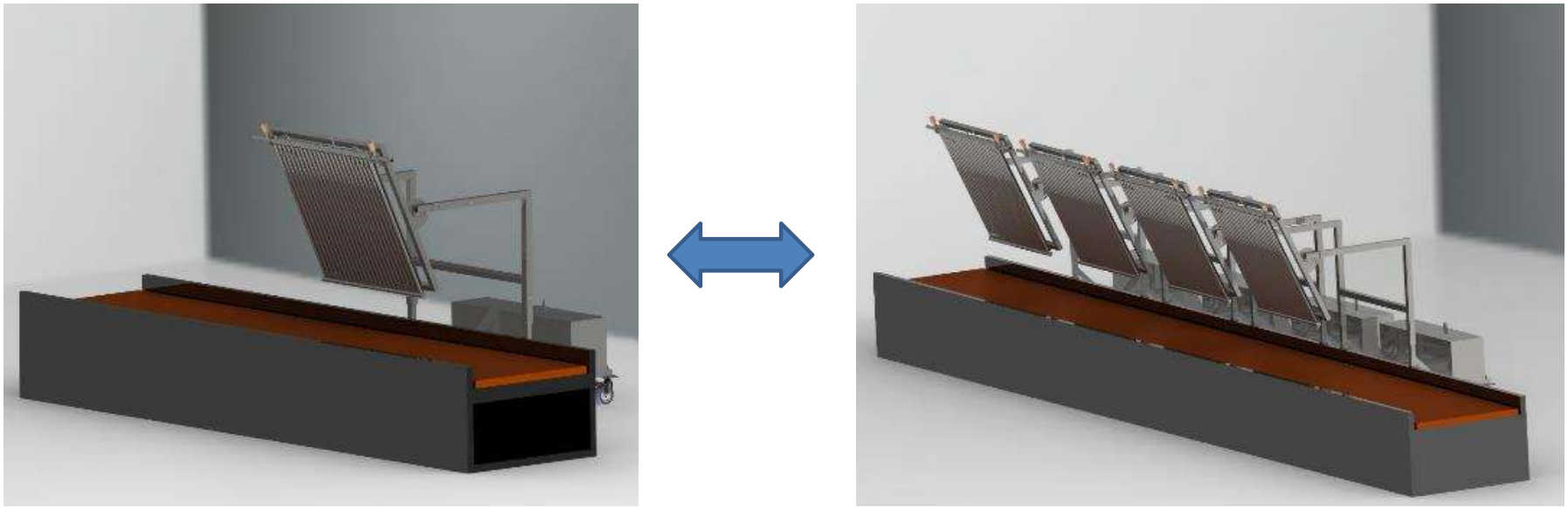
Modular Design of the Developed Model

- Sizing Up & Down the capacity of heat recovery



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