Experimental investigation on a flat heat pipe heat exchanger for waste heat recovery in steel industry

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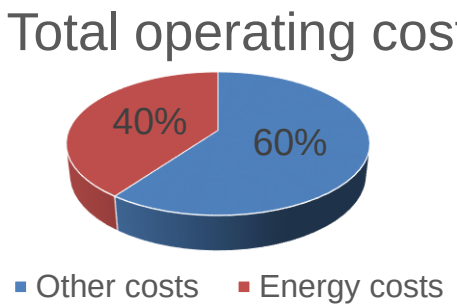
Overview

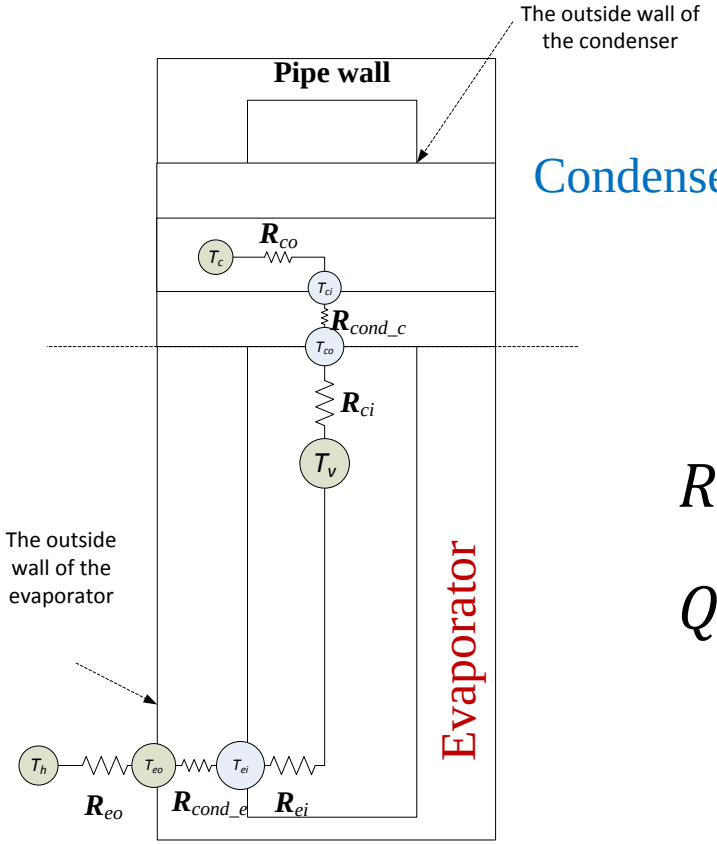
- The Thermal Design of a Flat Heat Pipe (FHP) for waste heat recovery by radiation and forced convection from high temperature sources
- A theoretical model to predict the thermal performance was built
- The Mechanical Design of the FHP
- The Results obtained from testing the unit on site

Introduction



- Energy consumption in steel industry presents 5% world energy consumption
- 40% of total operating cost is for Energy cost
- Challenges:
  - Limited Space, Inaccessibility, Temperature Restrictions
  - Payback periods, Project and investment costs

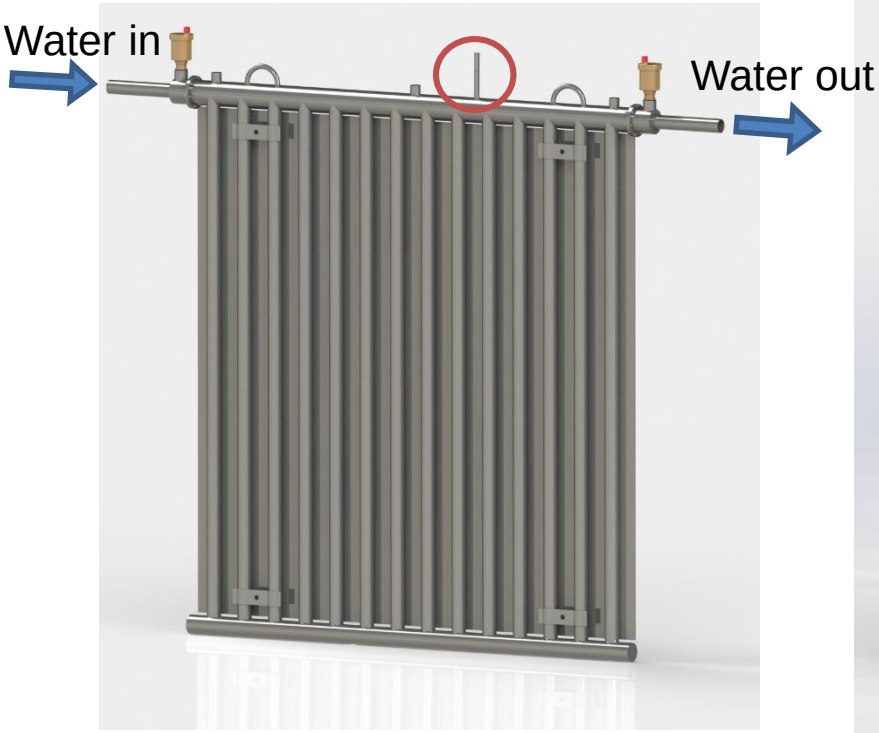
Flat heat pipe Thermal Design



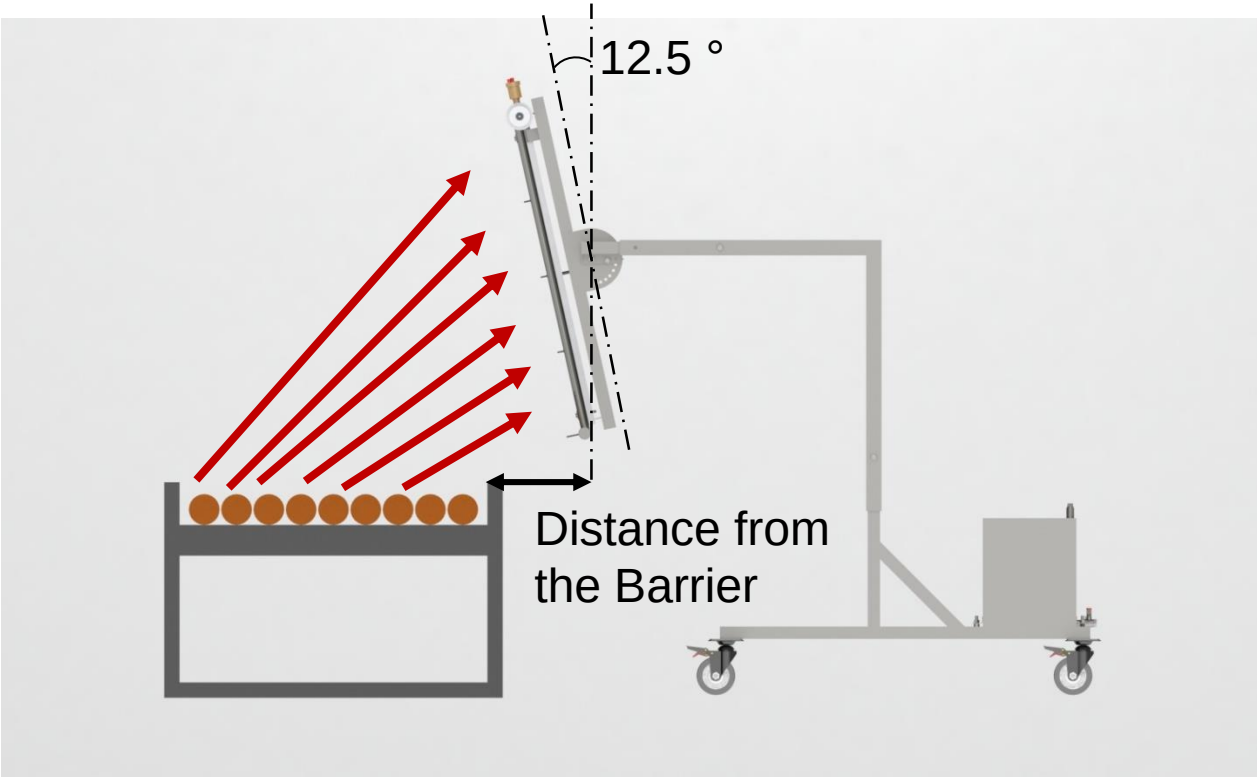
$$R_{hp} = R_{cond\_e} + R_{ei} + R_{co} + R_{cond\_c}$$

$$Q_{hp} = \frac{T_{eo} - T_{ci}}{R_{hp}}$$

FHP Mechanical Design

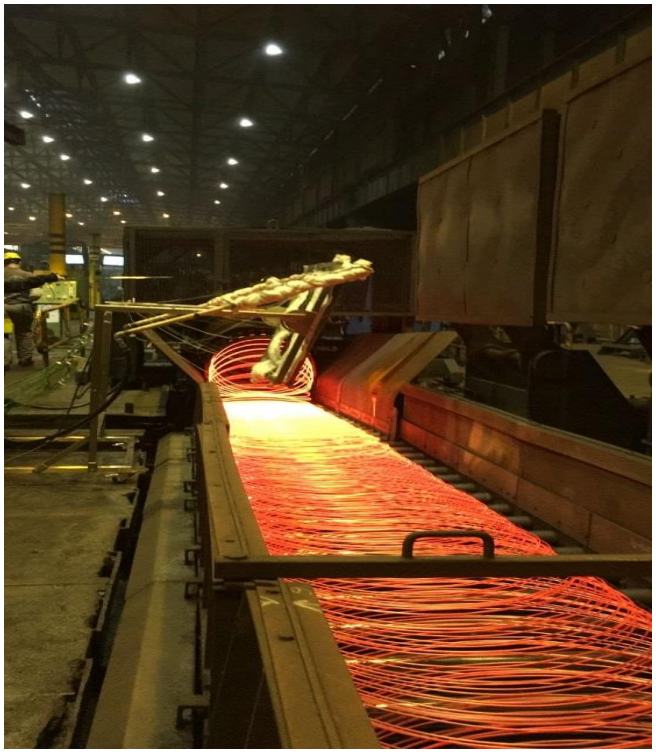


On site Testing

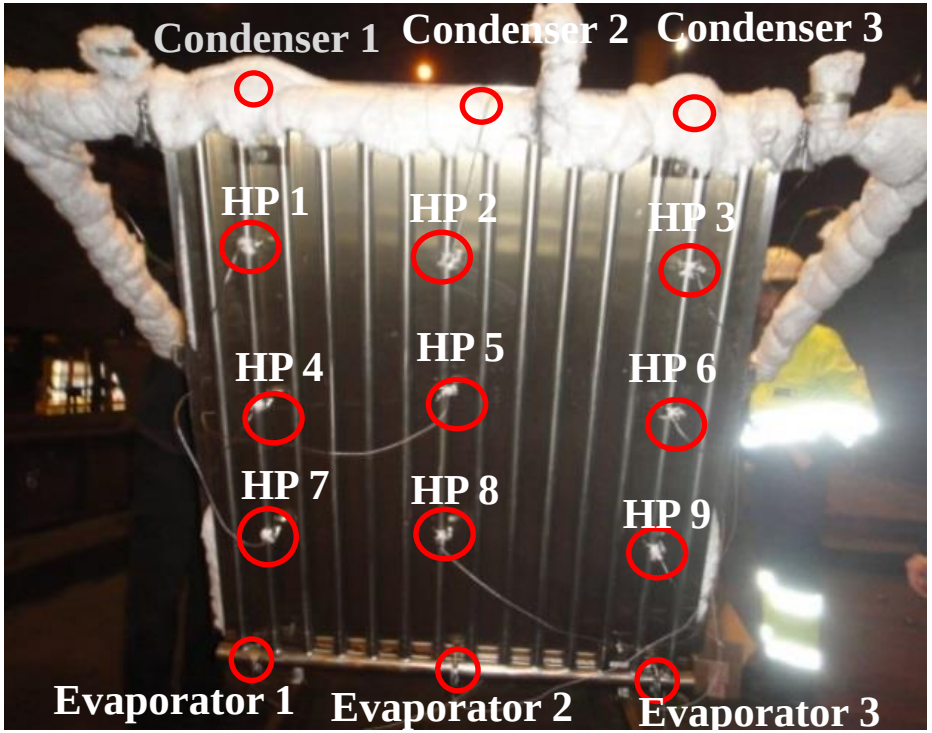


On site Testing

Steel temperature 450 °C, Air flow velocity 6.7-12 m/s, Air temperature 136 °C



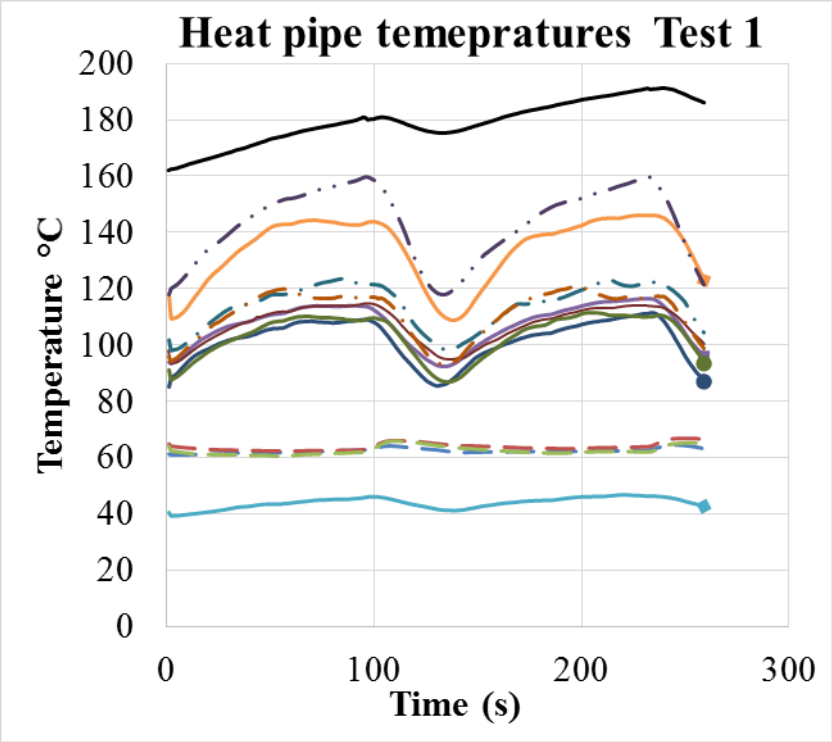
Experimental Setup

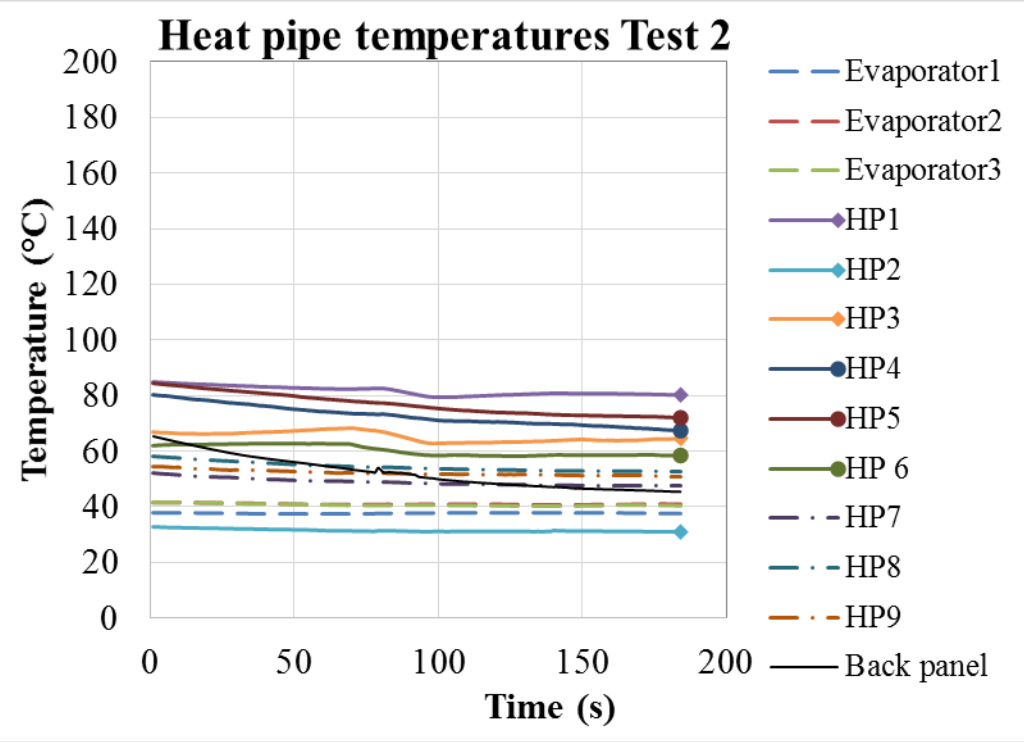


- 3 Thermocouples on the bottom connector
- 9 thermocouples on the surface
- 3 Thermocouples on the condenser
- One thermocouple on the panel

Results

Steel temperature 450 °C, Water flow rate 0.38 kg/s, Air temperature 136 °C
Test **1**: high density of steel wires, Distance from the barrier 65 cm, Air velocity 6.7 m/s
Test **2** : Low density of steel wires, Distance from the barrier 6 cm, Air velocity 12 m/s





Results

Steel temperature 450 °C, Water flow rate 0.38 kg/s
Test **1**: high density of steel wires, Distance from the barrier 65 cm
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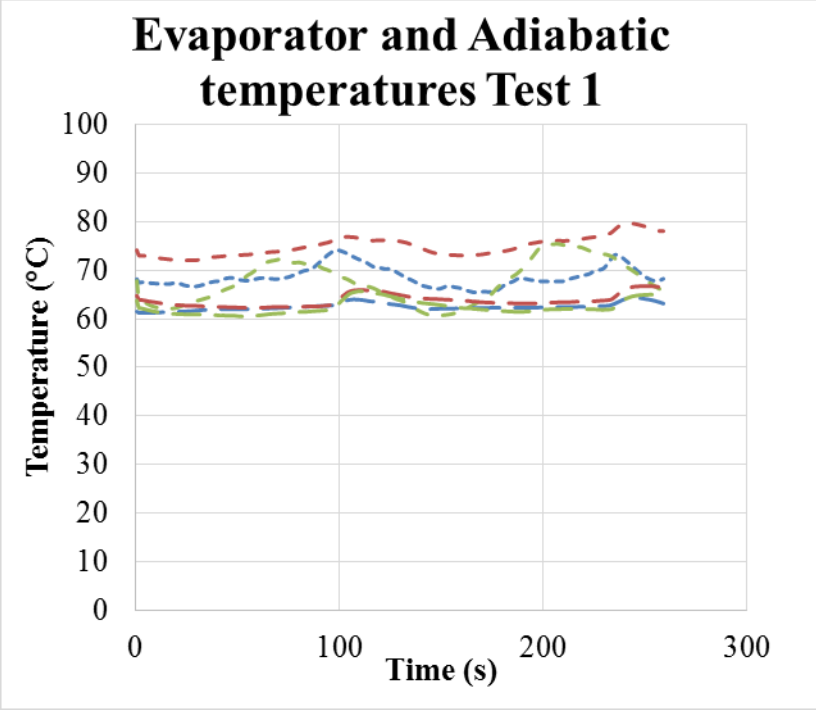
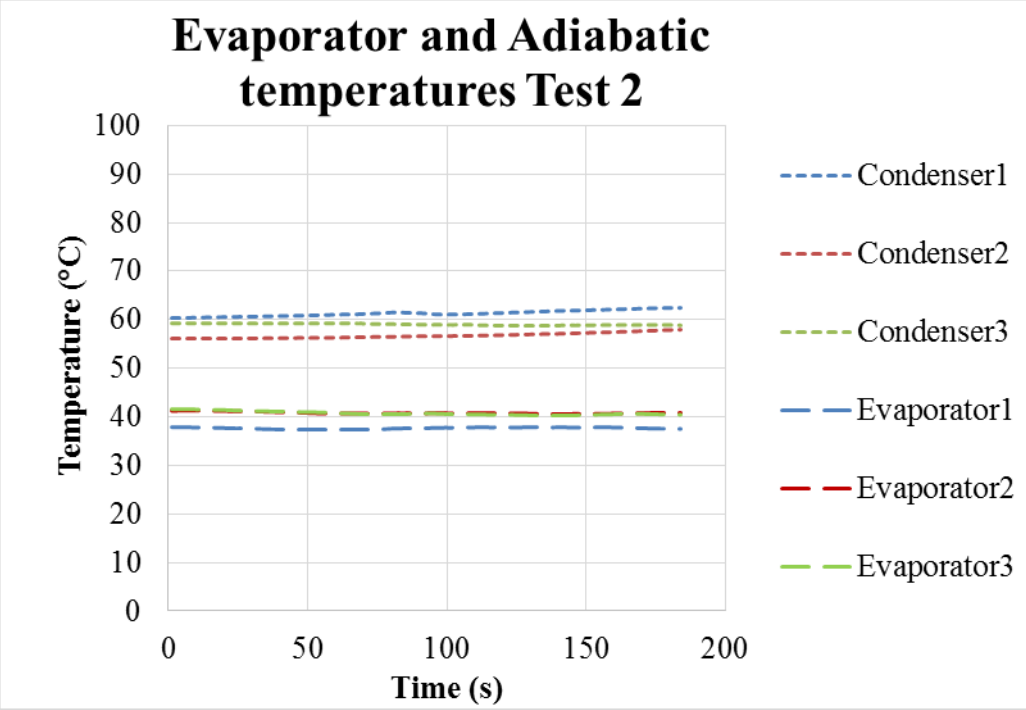
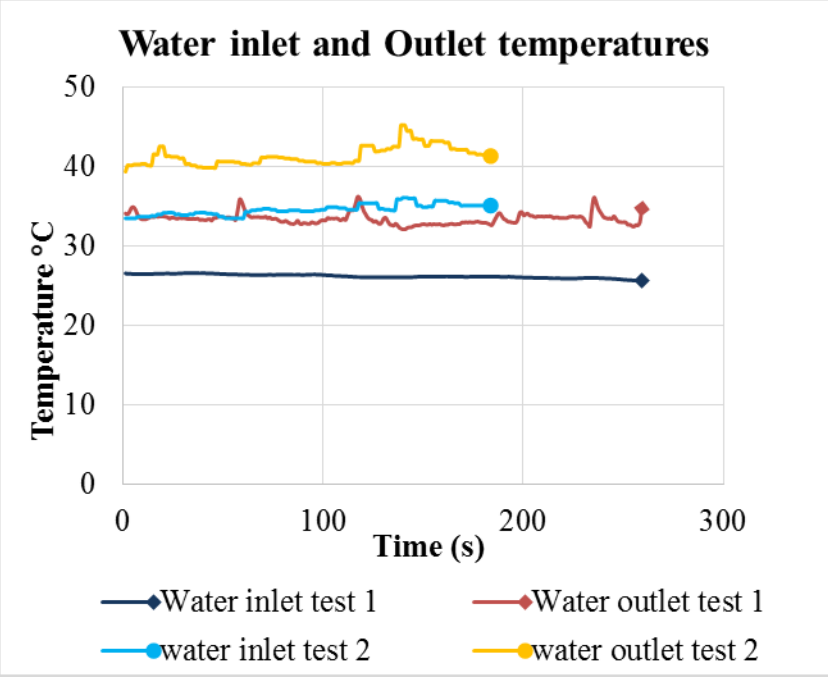
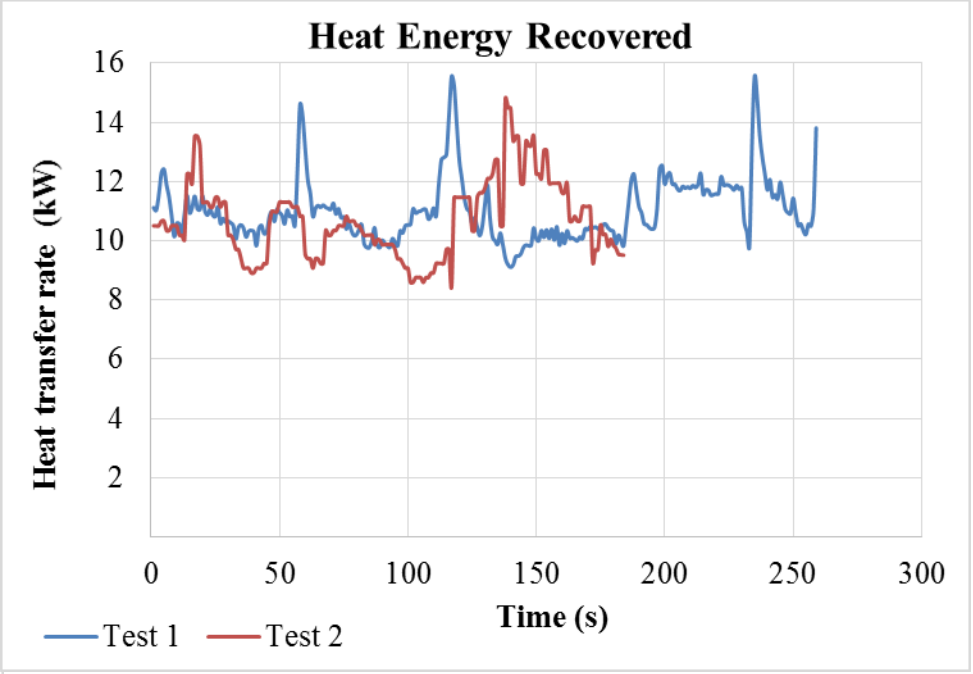




Results

Steel temperature 450 °C, Water flow rate 0.38 kg/s
Test **1**: high density of steel wires, Distance from the barrier 65 cm
Average outlet temperature: 33.4°C, Maximum Heat transfer rate: 15.6 kW
Test **2** : Low density of steel wires, Distance from the barrier 6 cm
Average outlet temperature: 41.4°C, Maximum Heat transfer rate: 14.8 kW





Conclusion

- FHP thermal and mechanical Design and validation on site were preformed
- The average heat recovery amount ranged between 14.8 kW and 15.6 kW
- Future work: Study the FHP performance in different conditions

Acknowledgments

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