Case study – use of innovative heat exchangers for natural fluid heat pumps - Project NxtHPG

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ATMO sphere EUROPE
solutions for europe
natural refrigerants
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Next Heat Pump Generation NxtHPG

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"This project has received funding from the European Union's Seventh Programme for research, technological development and demonstration under grant agreement No [307169]".

LU-VE has posed many effort in the development of a new geometry, the «**Minichannel**», a very efficient heat exchanger fit with a **5mm tube**.

This presentation focus on the following themes:

- **5 mm tubes geometry**

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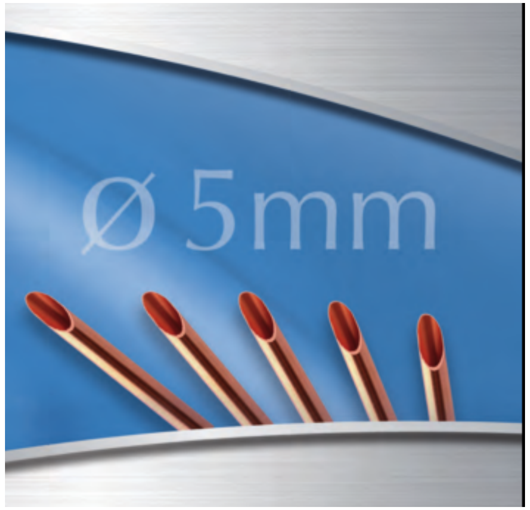

- **Application of R&D to NXTHPG - Project**

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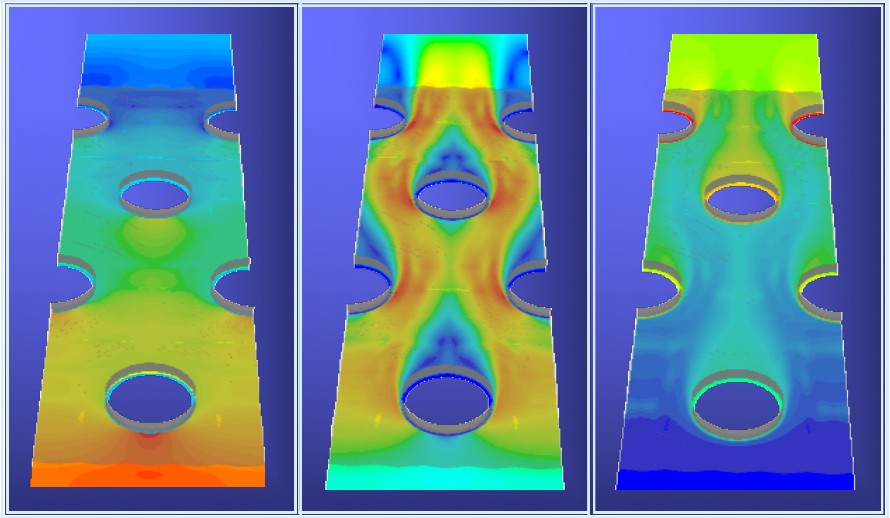
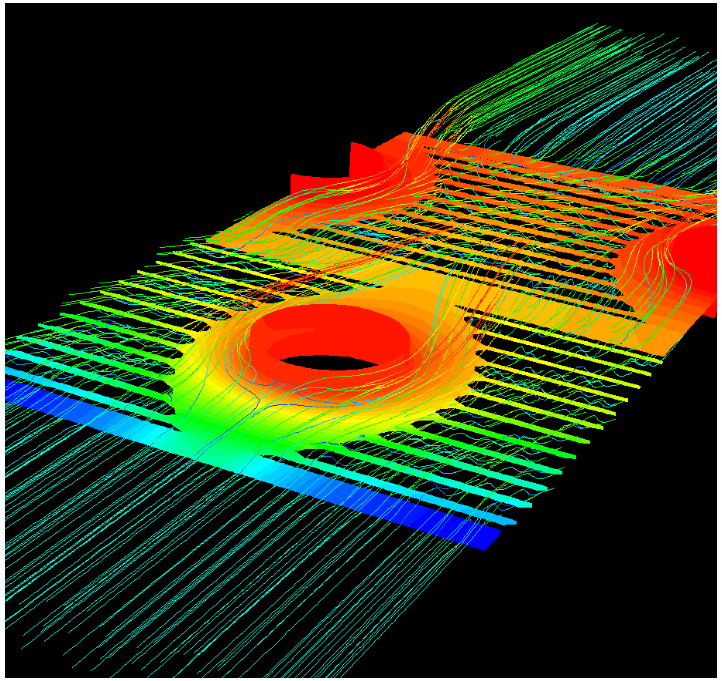
R&D activity: C.F.D. analysis

- New coil geometry definition
- Turbolators improvements
- Best matching fans-coils

Thermo-Fluidodynamics Distributions



Pressure – Velocity - Temperature



Line path for new geometry
Turbofin 5

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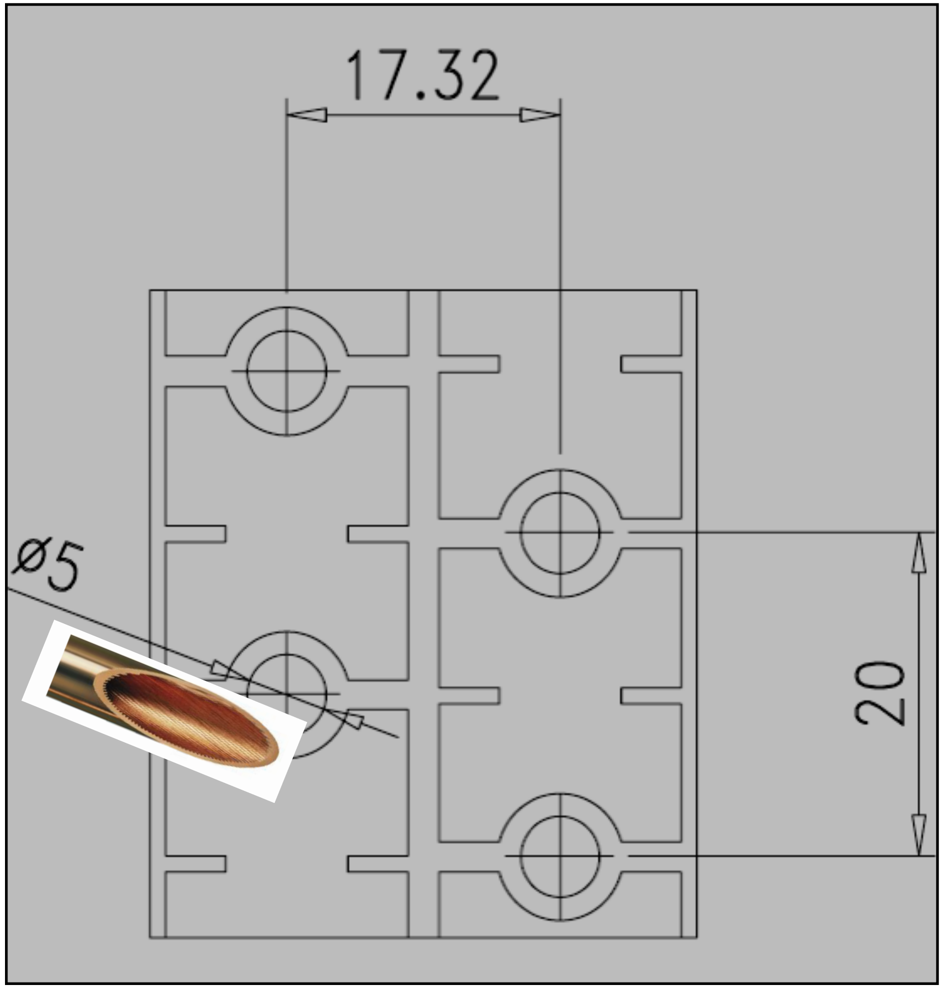
Performance evaluation of coil geometry and fins in the air tunnel – LUVE laboratory

- Analysis of fin side heat exchange coefficients
- Fin efficiency
- Fin pressure loss

New coil geometry Minichannel®



- Geometry 20 x 17,32 mm
- tube diameter **5mm**
- Standard max pressure 45bar
- Best matching with low pressure drop fluids (R410A)
- Very interesting with flammable refrigerants (HC)
- Available special version for CO_2 gas cooler (120 bar)

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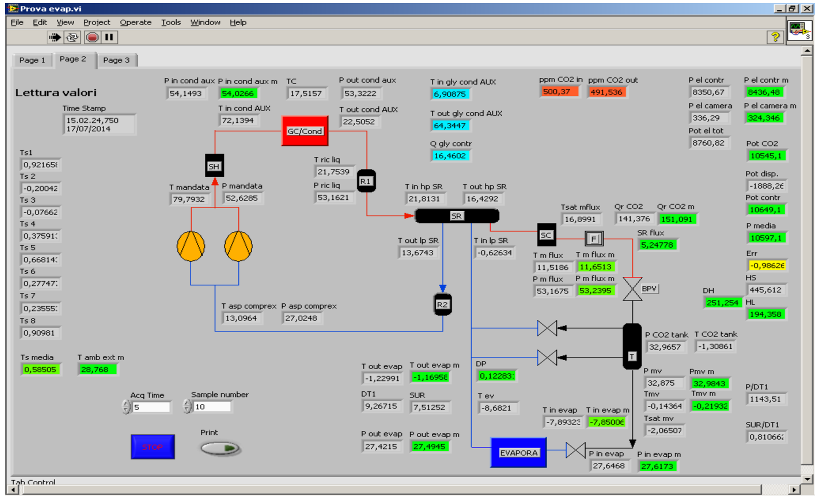
LU-VE CO_2 test ring



•The test equipment is made up of a climatic room operating at a constant temperature. **It is the only plant with such characteristics available in Europe dedicated to heat exchangers.**

•The exchanger to be tested is set inside the room.

•An auxiliary exchanger (counter effect) is also present in the room to ensure perfectly stationary conditions. **Balance between capacity measured on test unit and auxiliary exchanger.**

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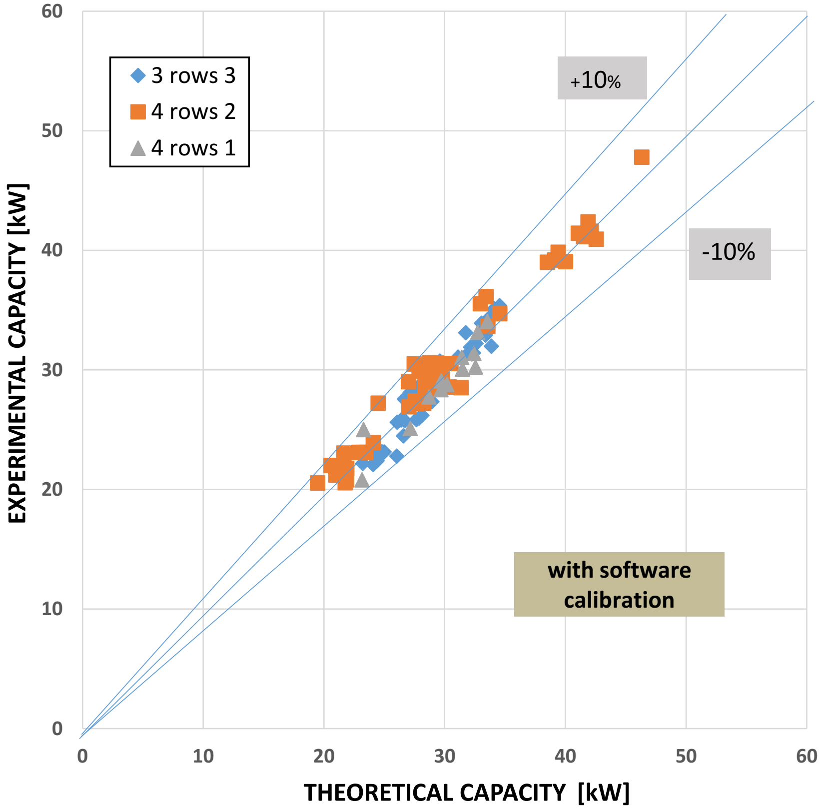
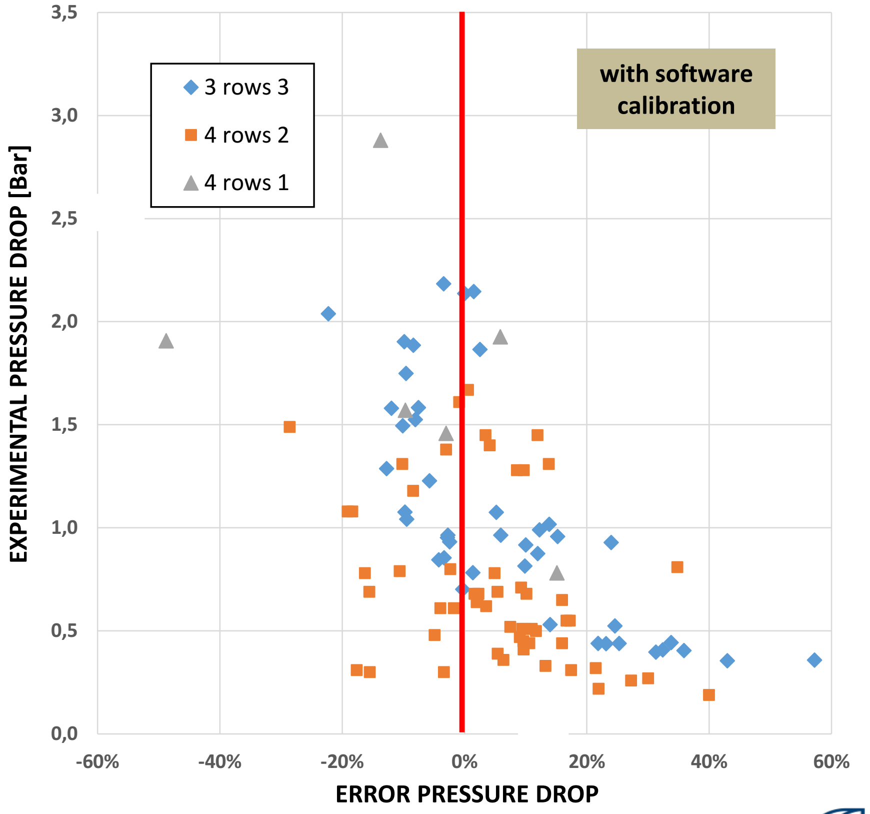
Gas coolers: test results in transcritical operation

Software prediction

Capacity



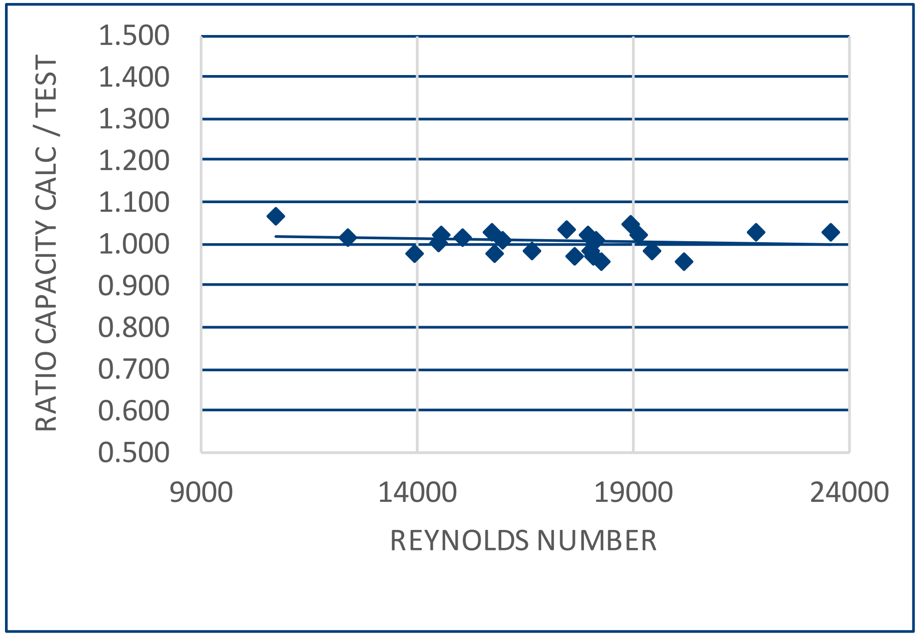
Pressure drop

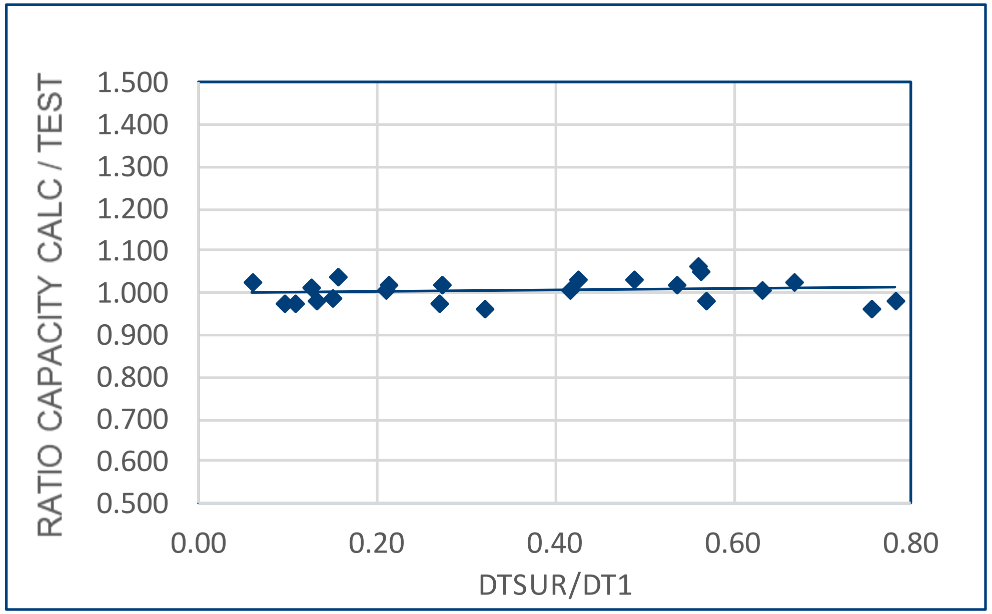


Deviation between measured and predicted value is limited.

Evaporator: test results

Result of test campaign dedicated to CO2 evaporators





DTsur: DT superheating
DT1: Air inlet temperature – evaporating temperature

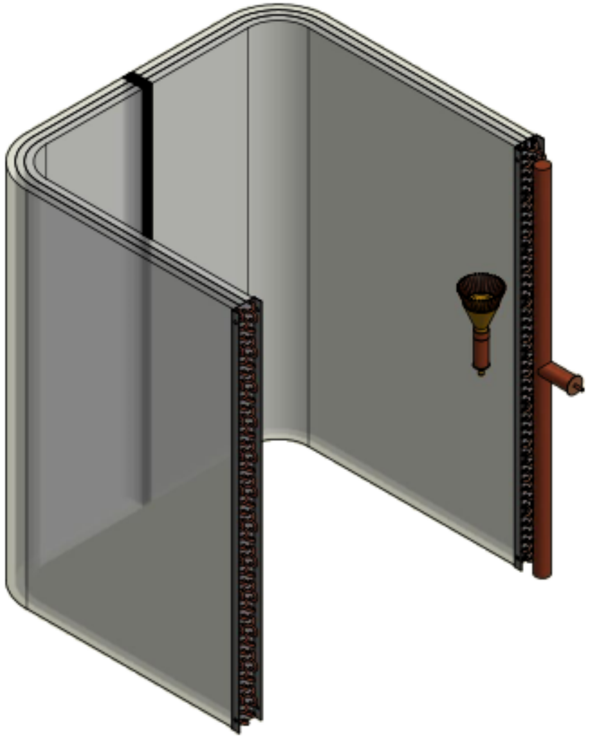
NXTHPG project

LU-VE is partecipating as industrial partner in the **NXTHPG** project.

Three finned heat exchangers have been provided:

- **Propane coil** for Case 1 (reversible air to water heat pump for space heating; 40kW)
- **CO_2 coil** for Case 4 (air to water heat pump for space heating; 30kW)
- **CO_2 coil** for Case 5 (air to water heat pump for space heating as boiler replacement – Tw 80/40°C; 50kW)

NXTHPG project: Case 1



COIL TYPE:

- Refrigerant: Propane
- Fin pack dimensions: 2400x1000x87
- Tube diameter: 7,0 mm
- Numbers of tubes: 40
- Numbers of rows: 4
- Numbers of circuits: 40
- Fin spacing: 3,0 mm

Figure 23. CAD design of prototype 1.

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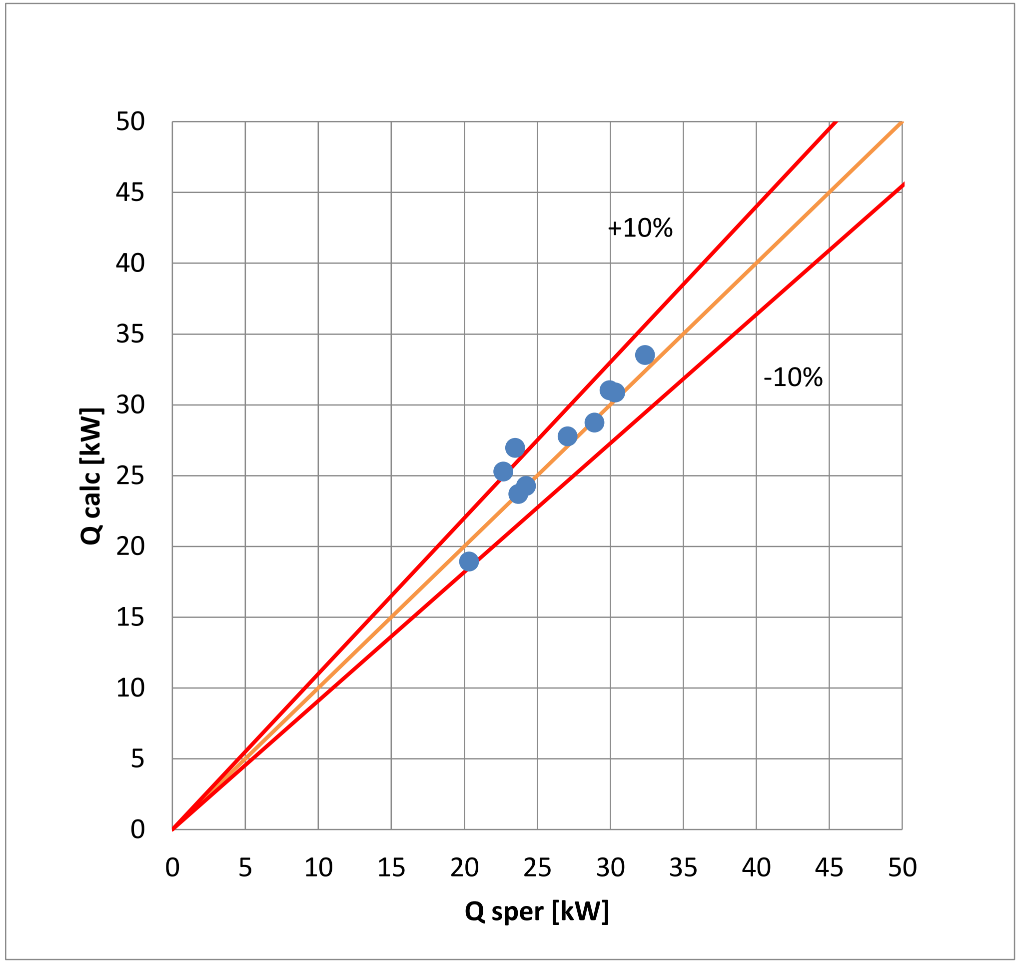
Case 1: Comparison with expected results

Performance of the heat exchanger is generally in line with the power calculated with our in-house software.

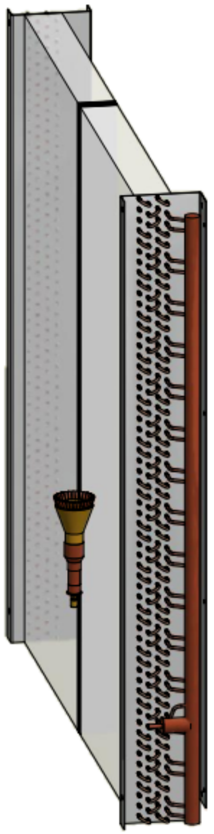
Q calc: Capacity calculated with LU-VE software

Q sper: Capacity measured



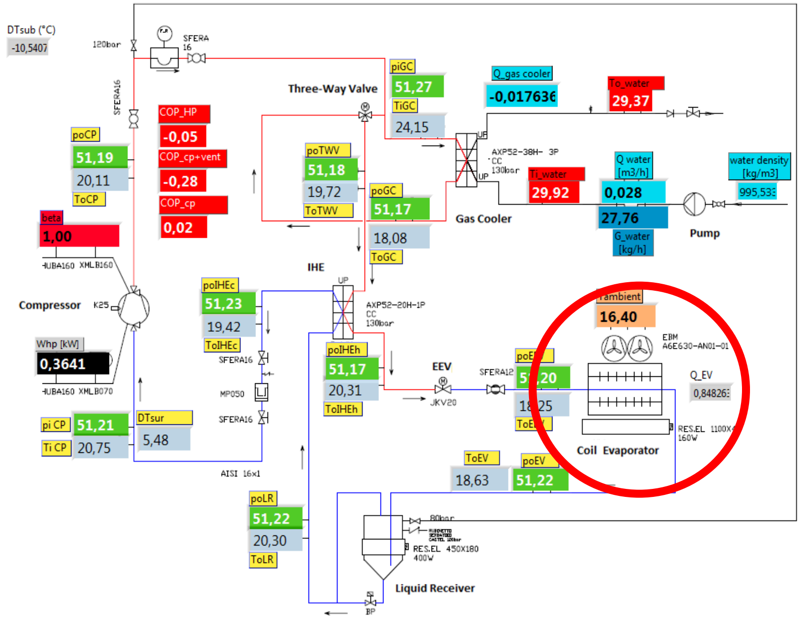
** in the evaluation of evaporating pressure we introduced a simulation of pressure drops due to 4 way valve.

NXTHPG project: Case 4

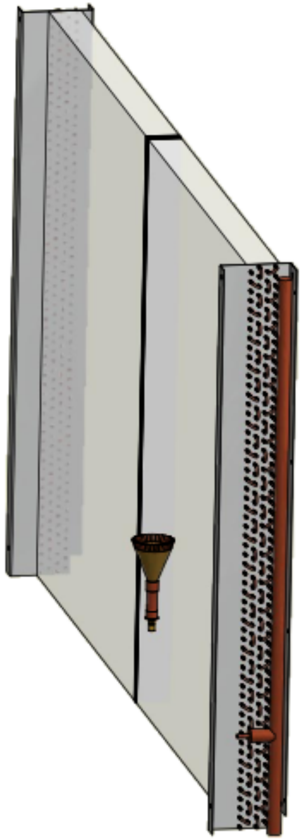


COIL TYPE:

- Refrigerant: CO_2
- Fin pack dimensions: 1200x1200x69
- Tube diameter: 5,0 mm
- Numbers of tubes: 60
- Numbers of rows: 4
- Numbers of circuits: 30
- Fin spacing: 3,0 mm

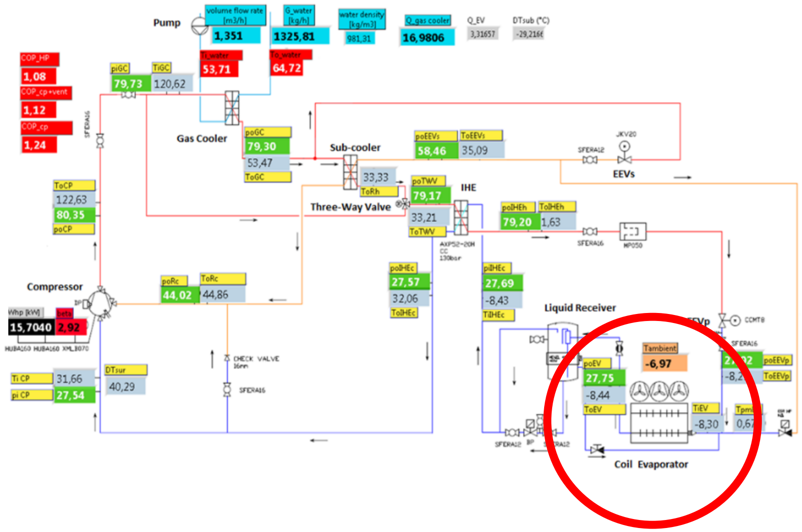


NXTHPG project: Case 5



COIL TYPE:

- Refrigerant: CO_2
- Fin pack dimensions: 2000x1200x69
- Tube diameter: 5,0 mm
- Numbers of tubes: 60
- Numbers of rows: 4
- Numbers of circuits: 40
- Fin spacing: 3,0 mm



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Advantage of 5mm geometry - Case 5

	Geometry 25x21,65 tube Ø9,52	Geometry 20x17,32 tube Ø5
Capacity [kW]	33,40	33,17
Tube diameter [mm]	10,12	5,00
Header volume [dm3]	0,74	0,74
Header diameter [mm]	28	28
Tubes volume [dm3]	25,08	7,13
Total coil internal volume [dm3]	25,82	7,87
Internal volume difference		**-69,5%**
Coil weight [kg]	78,06	45,71
Coil weight difference		**-41,4%**
Air pressure loss [Pa]	66,53	62,70
Air pressure loss difference		**-5,8%**

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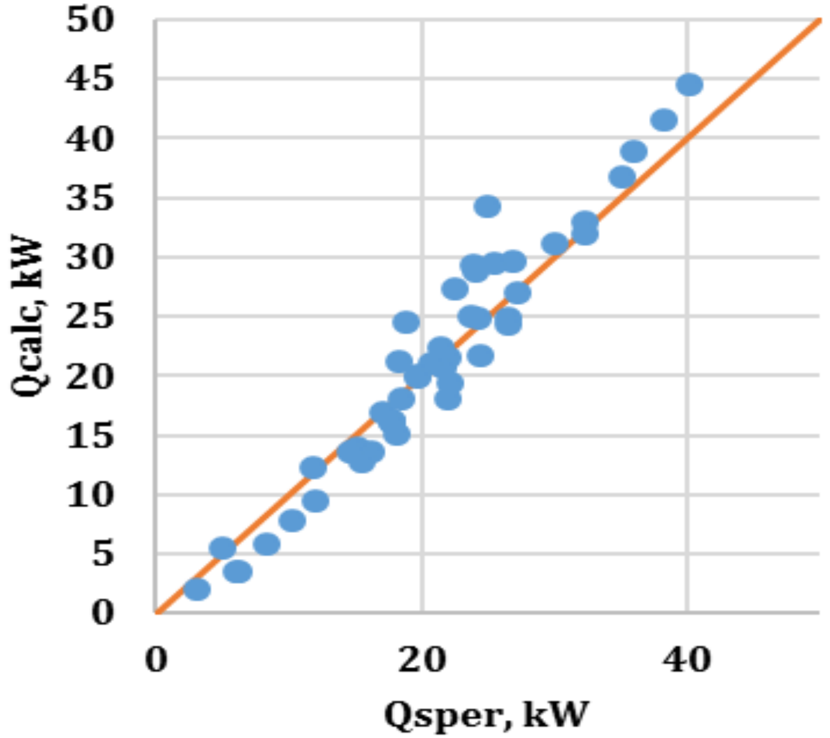
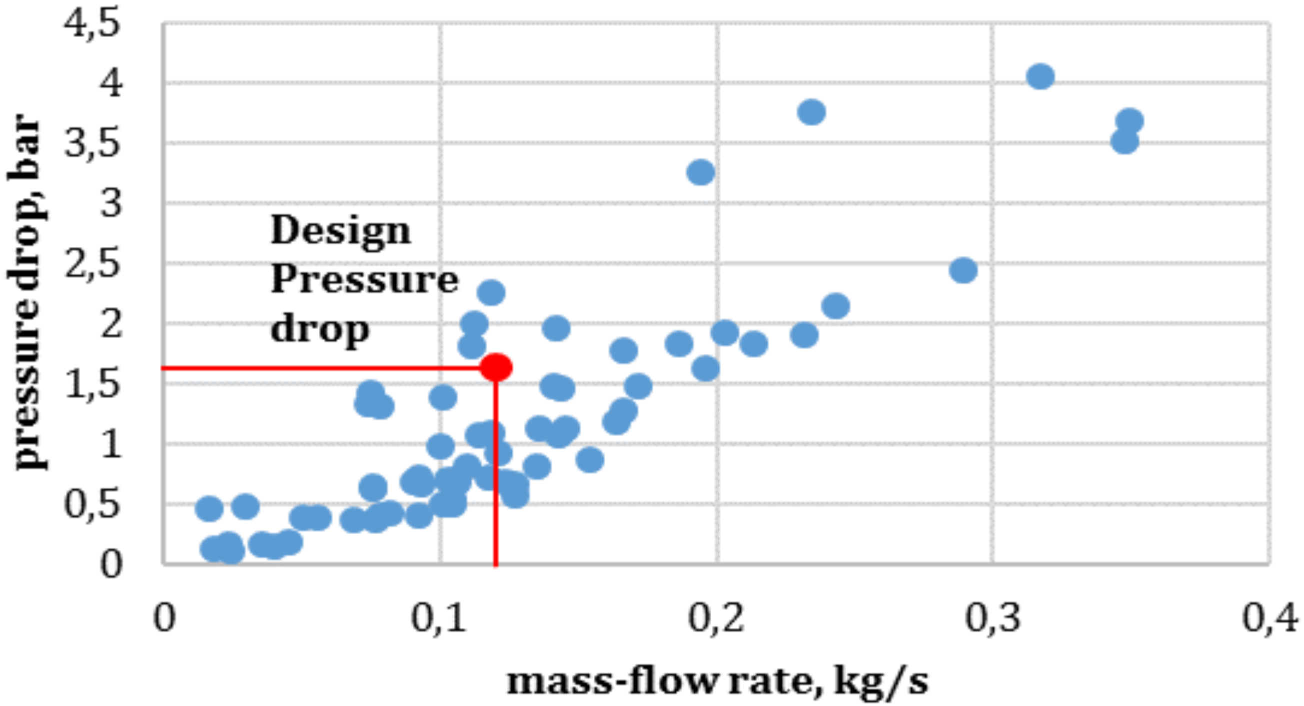
Case 5: Comparison with expected results

Q calc: Capacity calculated with LU-VE software
Q sper: Capacity measured





Performance of the heat exchanger is generally in line with the power calculated with our in-house software.

It seems that the unit performs as we expect.

Data are greatly dispersed, this is due to experimental uncertainties (outlet quality for instance).

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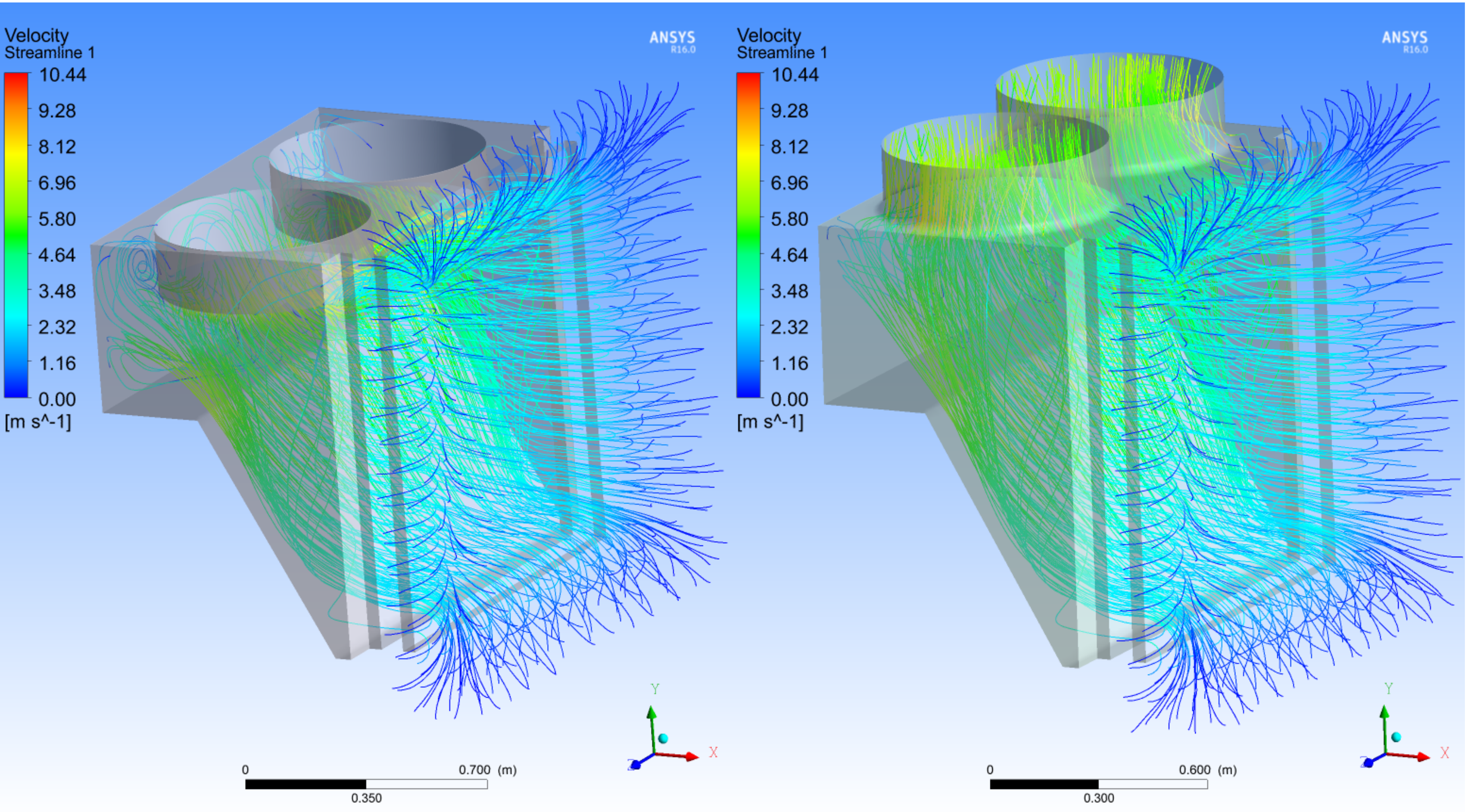
CFD simulation of the behavior of the heat pump's plenum, Case 4 and 5 NXTHPG



The study analyzes both the solution with a **facing downward plenum** (standard solution) and a **facing upward plenum** (modified solution).

The modified solution is characterized by the greatest dissipations leading to a **increase (11%)** in the mass flow rate.

The total value of mass flow-rate for the original solution is 4,0 kg/s and 4,44 kg/s for the modified solution.

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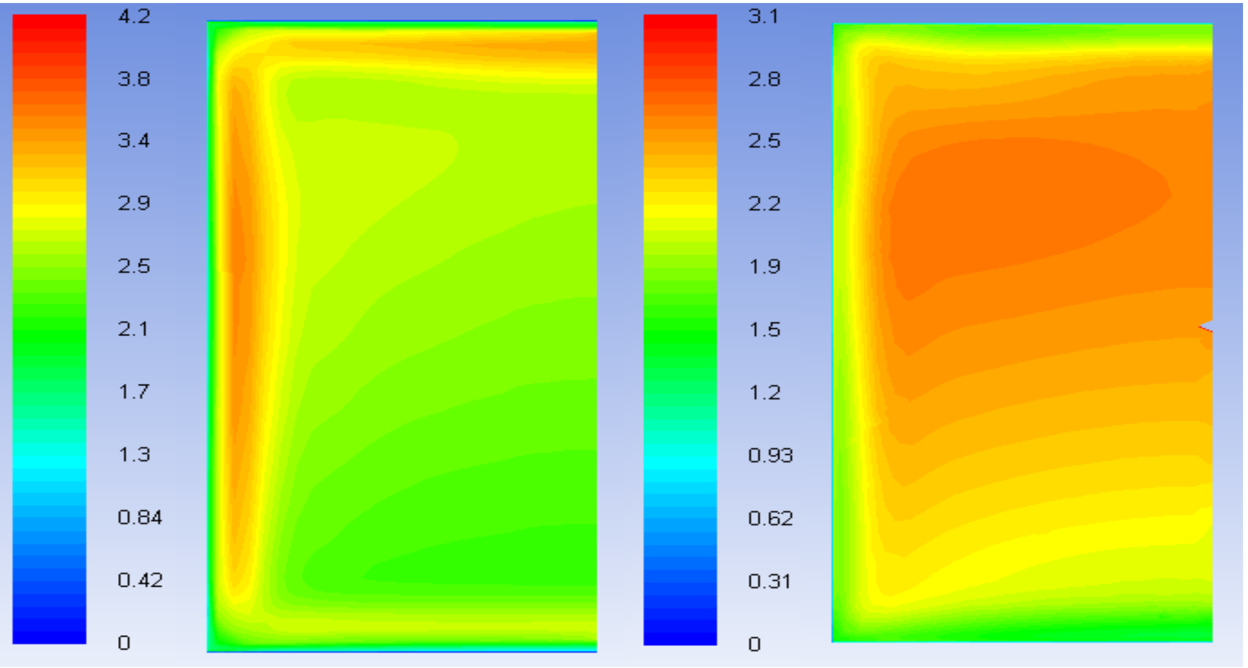
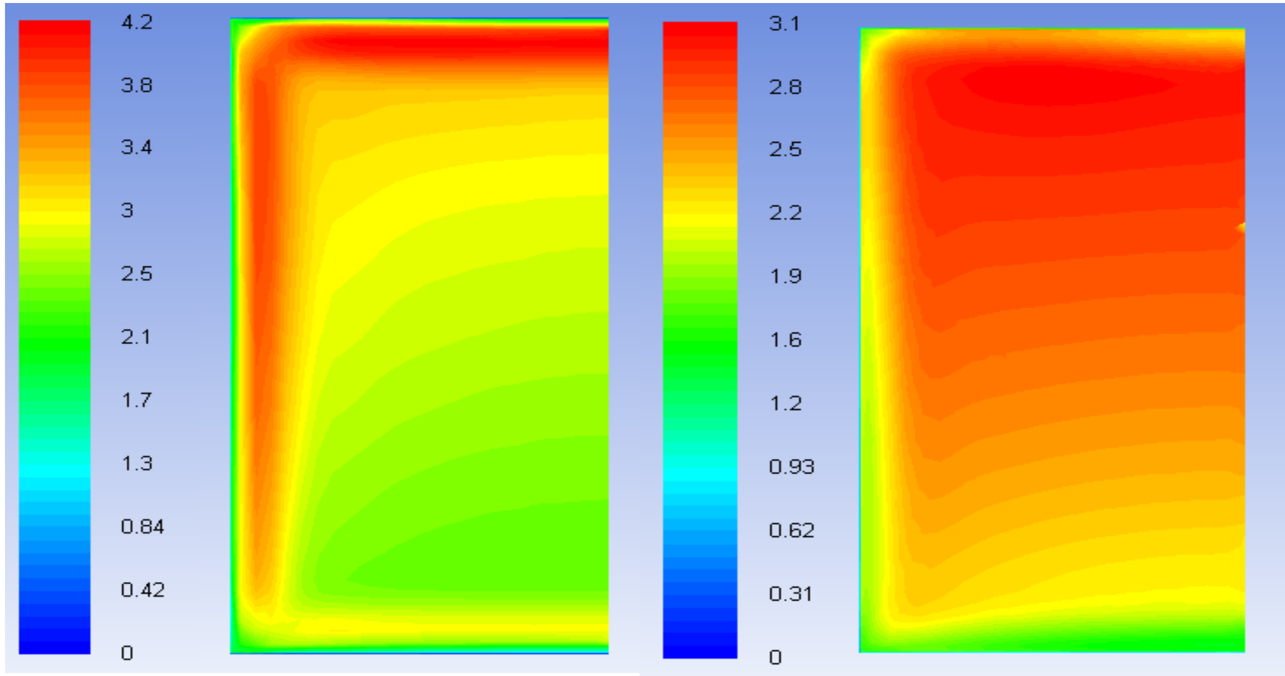
Velocity field at the inlet and at the outlet of the heat exchanger, Case 4 and 5 NXTHPG

Standard solution: inlet (sx) – outlet (dx)



Modified solution: inlet (sx) – outlet (dx)



These pictures give an evaluation of **air distribution** on the whole surface. There is an acceleration near the edges due to the curvature of the fluid coming from the ambient. The average velocities are higher for the modified solution, moreover the zones where the highest velocities are achieved for the two solutions (at the discharge of the heat exchanger) are quite different: (i) for the improved solution this zone is located at the top, (ii) for the standard solution is located just above the lower half of the surface.

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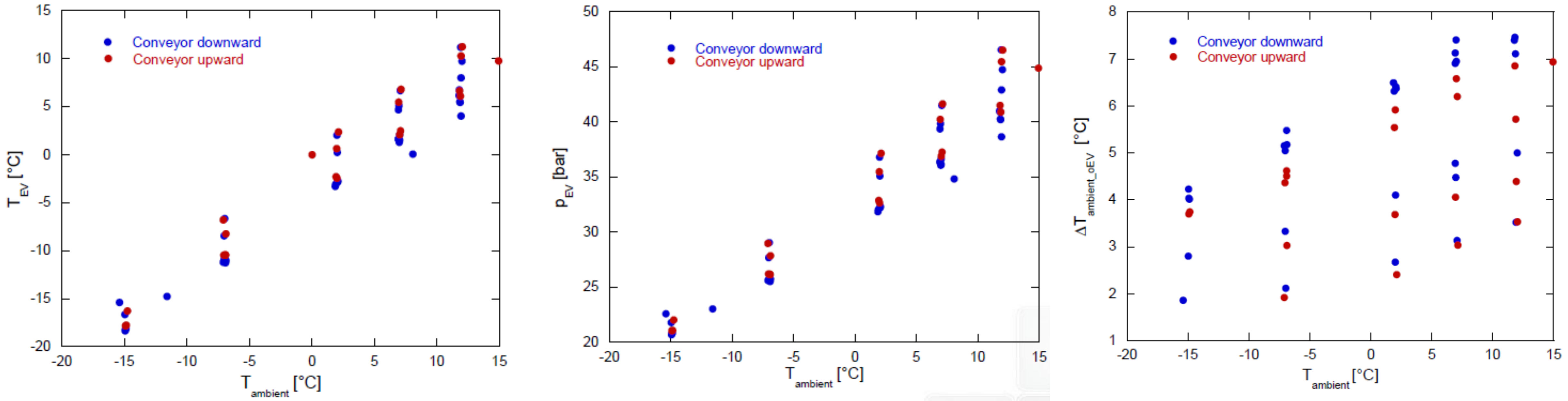
Fan conveyor modifications, NXTHPG Case 5

CASE 5

As suggested by CFD analysis, in second experimental campaign test with conveyor downward and upward were performed

Conveyor **upward** show performance improvement

Fan conveyor modifications, NXTHPG Case 5



- the evaporation pressure increases

Tamb [°C]	-15	-7	2	7	12
COP First Exp. Campaing	1,10	1,73	1,89	1,93	2,35
Improvements Mechanical Modifications	55,3%	7,6%	11,3%	17,3%	2,2%
Reduction of fan velocity	7,2%	6,4%	3,2%	3,3%	3,5%
With FAN upwards	-0,4%	1,9%	1,99%	2,0%	1,99%
FINAL COP	***1,82***	***2,02***	***2,22***	***2,39***	***2,53***
Total improvement	65,83%	16,64%	17,14%	23,65%	7,80%

New conveyor configuration gives 2% COP increase

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Conclusion

1. After intensive R&D activity new coil geometry Minichannel® with 5mm tube Ø has been developed

2. Measured data of coil performances confirm the predicted data

3. CFD approach allows to improve in general product efficiency, specially concerning air distribution

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THANK YOU !!!!!

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