VŠB - Technical University of Ostrava

Faculty of Mechanical Engineering

List of examples for stand-alone solutions

Modeling of heat, mass and momentum transfer

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Ostrava 2020

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CONTENT OF SEMINAR WORK

- Description of the problem, physical properties, boundary conditions
- Definition of mathematical model, theoretical and empirical relations for Re, Pr, Nu, heat transfer coefficient and their estimation (if it makes sense)
- ANSYS DesignModeler - model creation, boundary conditions, areas of flowing media
- ANSYS Meshing - meshing (compression by inflation, sweep method, number of cells less than 500 000), display the mesh and the boundary conditions graphically on the model
- ANSYS Fluent -
- Start ANSYS Fluent, check the following parameters: units and area dimensions, number of cells, negative volumes
- Mesh display including boundary conditions
- Define model, materials, boundary conditions
- Initialization, calculation
- Residual display
- Create auxiliary sections to display results
- Display velocity vectors, contours of static pressure, velocity, temperature, effective viscosity, XY graph of heat flow through the wall into liquid and air
- Set temperature and dimension reference values for liquid, XY plot of heat transfer coefficient and Nusselt number, compute average values of heat transfer coefficient and Nusselt number
- Set temperature and dimension reference values for air, XY plot of heat transfer coefficient and Nusselt number, compute average values of heat transfer coefficient and Nusselt number
- Comparison of CFD simulation results and estimation
- Conclusion

Note: Remember to precisely define the mathematical model, boundary conditions

Examples are simplified in terms of physical properties and geometry for educational purposes. For 3D jobs of this type, the number of cells would surely exceed 500,000.

1 SOLUTION OF FLOW THROUGH HEAT EXCHANGER WITH TUBE BUNDLE IN A CROSS, A (ARGÜELLES CAAMAÑO ÁLVARO) – ENERG - 1

Perform a mathematical simulation of water and air flow in a simplified heat exchanger geometry with the heat transfer from hot water to cold air through the steel pipe wall. Define the individual areas and parameters according to the specified boundary conditions and evaluate the results.

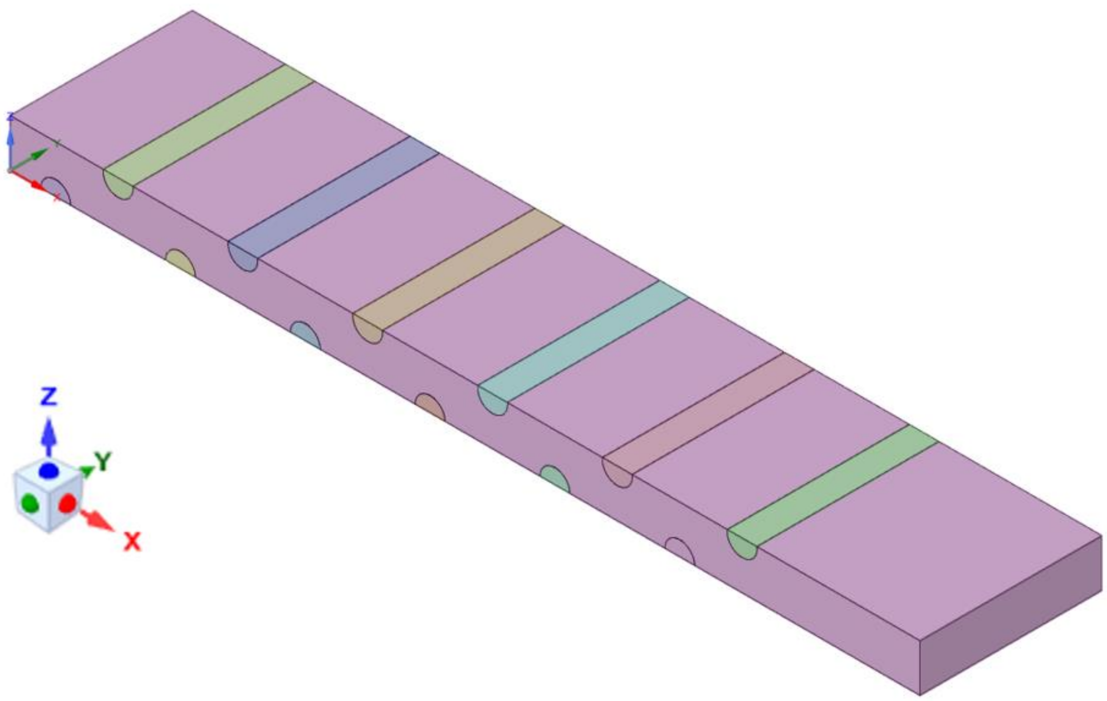

Fig. 1.1 - Simplified geometry of the heat exchanger

The dimensions of this geometry are specified in the following figure.

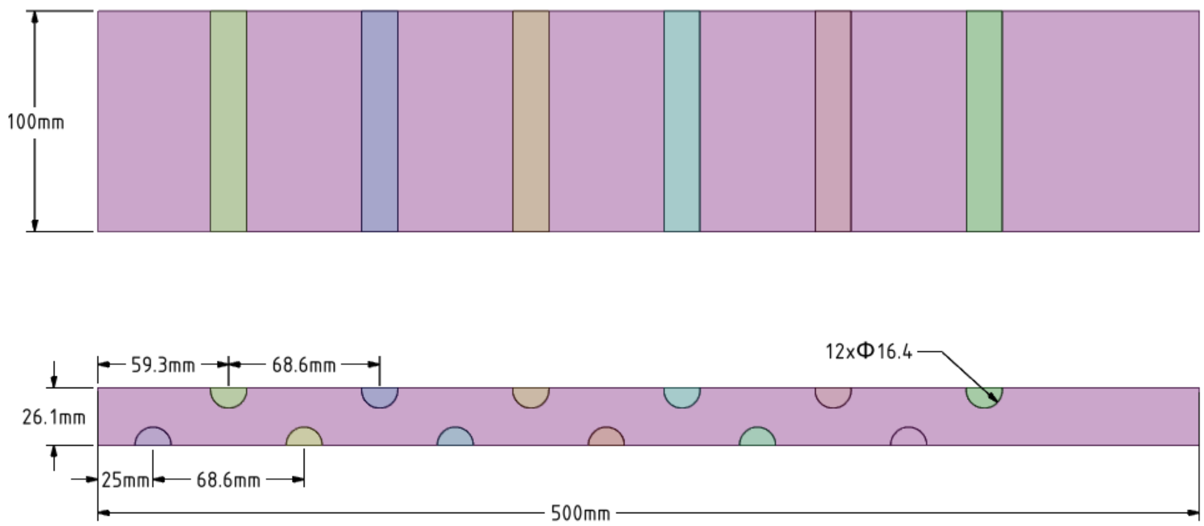

Fig. 1.2 - Dimensions of the heat exchanger area

The boundary conditions of the geometry are shown in Figure 1.3

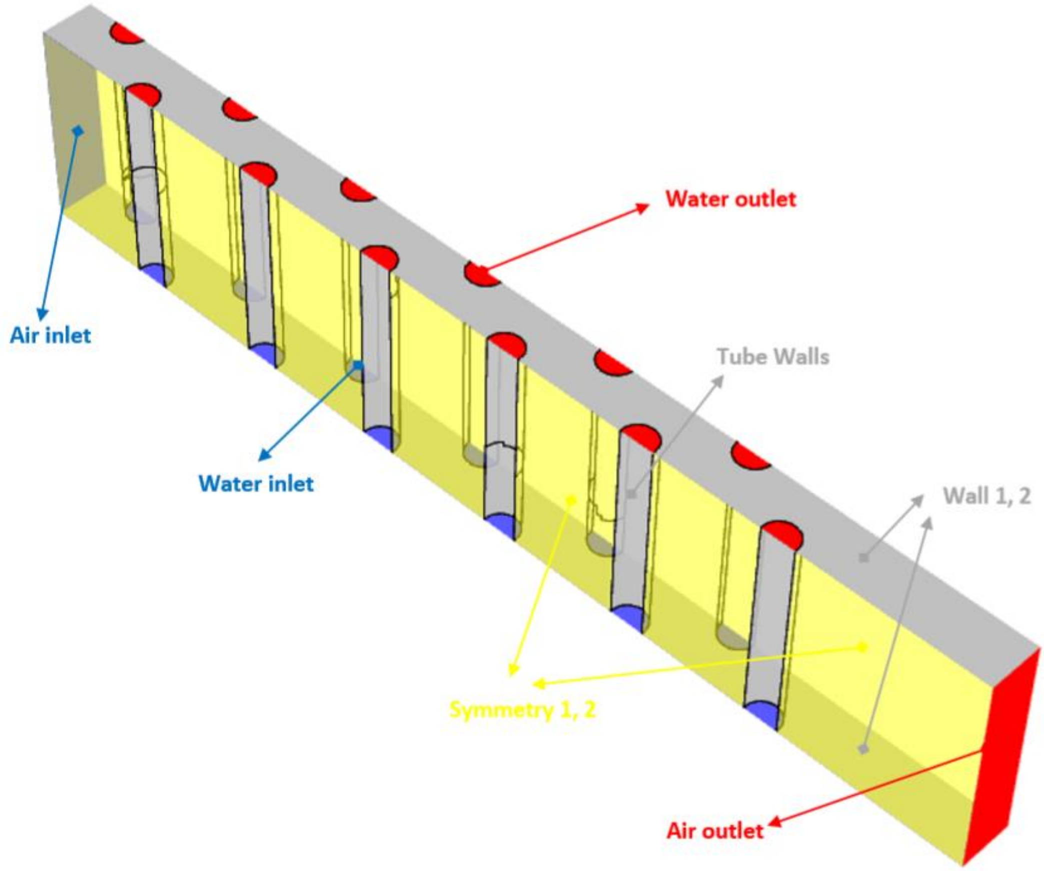

Fig. 1.3 - Boundary conditions of the heat exchanger

In ANSYS Meshing, create a computational mesh with densification at the tube walls and use Inflation and Sweep.

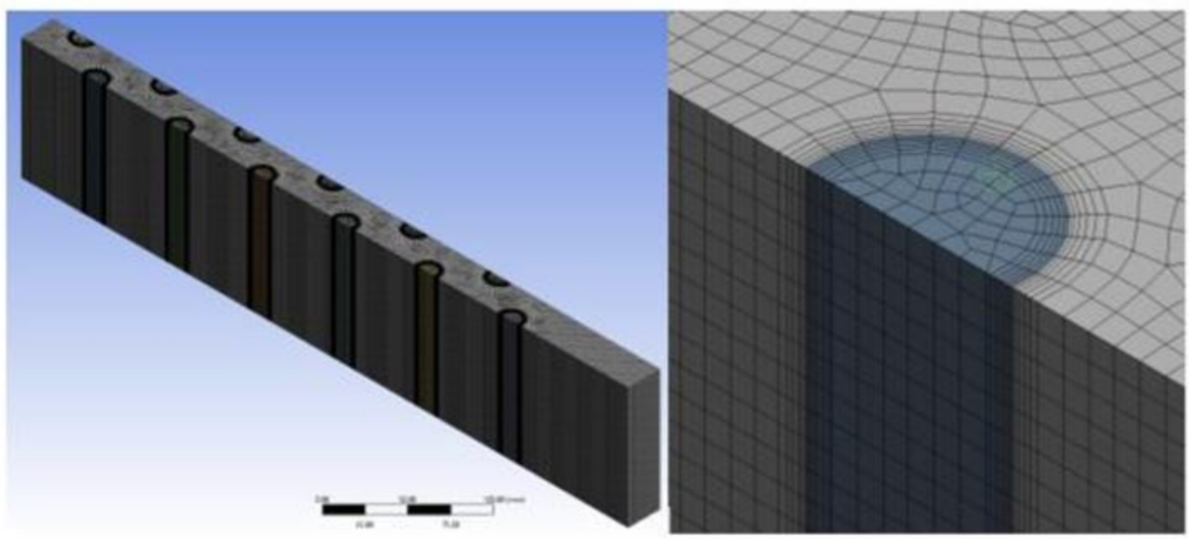

Fig. 1.4 – Cell densification around pipes with flowing water

The physical properties of flowing media and solid material are defined in Tab. 1.1

Tab. 1.1 - Physical properties of the material (steel, air) at 300 K:

Material	**Steel**	**Water**	**Air**	**Unit**
density ρ	8030	998	1.225	[kg.m^{-3}]
specific heat capacity c_p	502.48	4182	1006.43	[J.kg^{-1}K^{-1}]
thermal conductivity λ	16.27	0.6	0.0242	[W.m^{-1}K^{-1}]
viscosity η		0.001	1.7894e-05	[kg.m^{-1}s^{-1}]

The types of boundary conditions are as follows:

- Water inlet ⇒ „Velocity inlet“
- Water outlet ⇒ „Pressure outlet“
- Wall 1,2 ⇒ „Wall“
- Tubes wall ⇒ „Wall“
- Air inlet ⇒ „Velocity inlet“
- Air outlet ⇒ „Pressure outlet“
- Symmetry ⇒ „Symmetry“
- Fluid water ⇒ „Fluid“
- Fluid air ⇒ „Fluid“

The specification of boundary conditions is given in Tab. 1.2.

Tab. 1.2 - Boundary conditions:

	Water inlet	**Water outlet**	**Tubes wall**	**Air inlet**	**Air outlet**	**Wall 1,2**	**Unit**
Temperature T	353	353	coupled	283	283	insulated	[K]
Velocity v	0.2			0.5			[m.s^{-1}]
Pressure p		0			0		[Pa]
Intensity of turbulence I	0.1	0.1		0.1	0.1		[%]
Hydraulic diameter D_h	0.0164	0.0164		0.261	0.261		[m]

Examples of results:

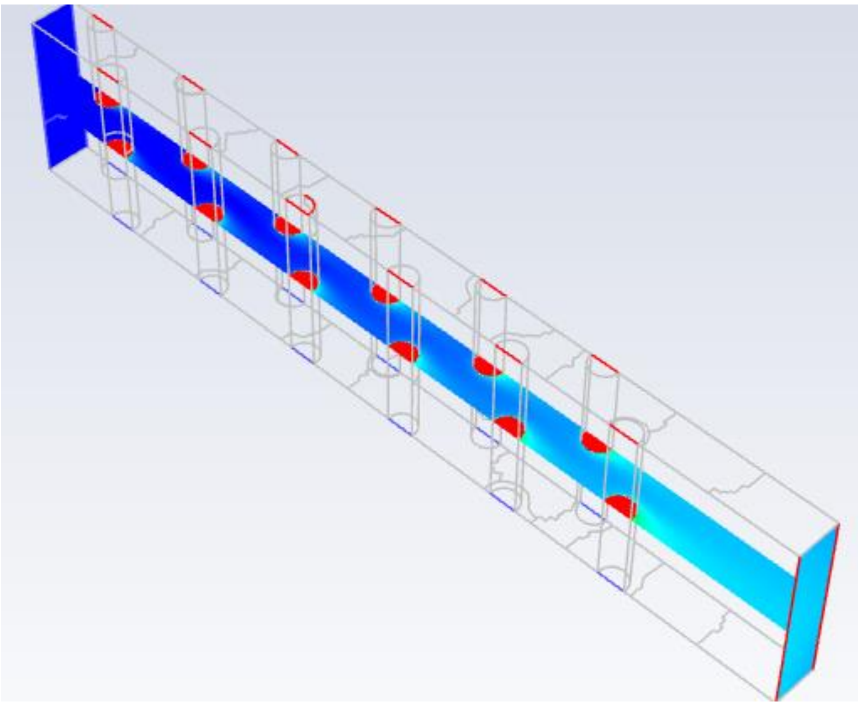

Fig. 1.5 Temperature contours in the evaluation cross section

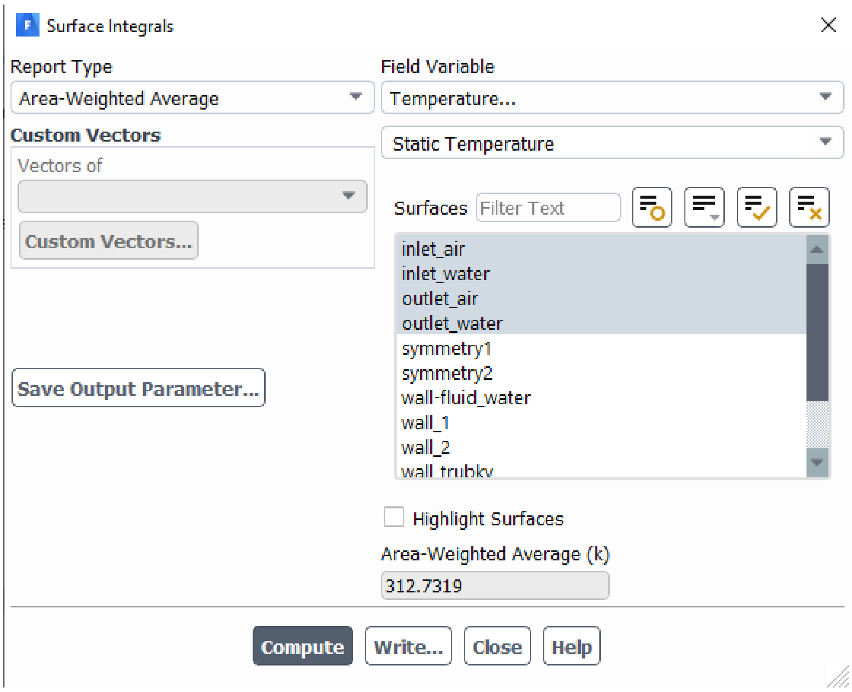

Fig. 1.6 Averaged temperature values at inlet and oulet

2 SOLUTION OF FLOW THROUGH HEAT EXCHANGER WITH TUBE BUNDLE IN A CROSS, B (ARTHANARIESWARAN HEMAMALINI VIKNESH) – ENERG -2

Perform a mathematical simulation of water and air flow in a simplified heat exchanger geometry with the heat transfer from hot water to cold air through the steel pipe wall. Define the individual areas and parameters according to the specified boundary conditions and evaluate the results.

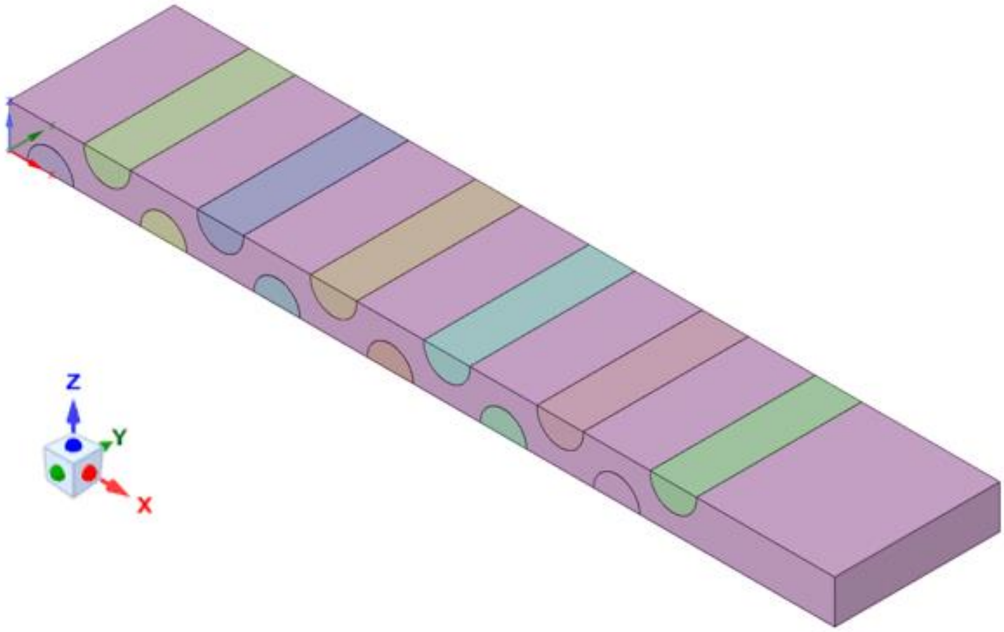

Fig. 2.1 – Simplified geometry of the heat exchanger

The dimensions of this geometry are specified in the following figure.

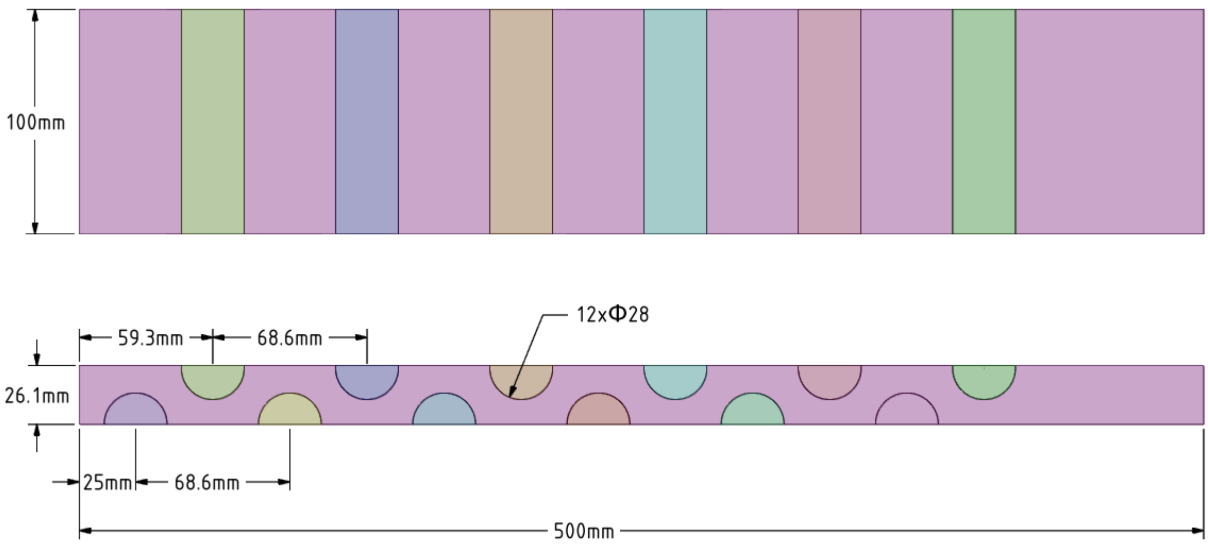

Fig. 2.2 – Dimensions of the heat exchanger area

The boundary conditions of the geometry are shown in Fig. 2.3

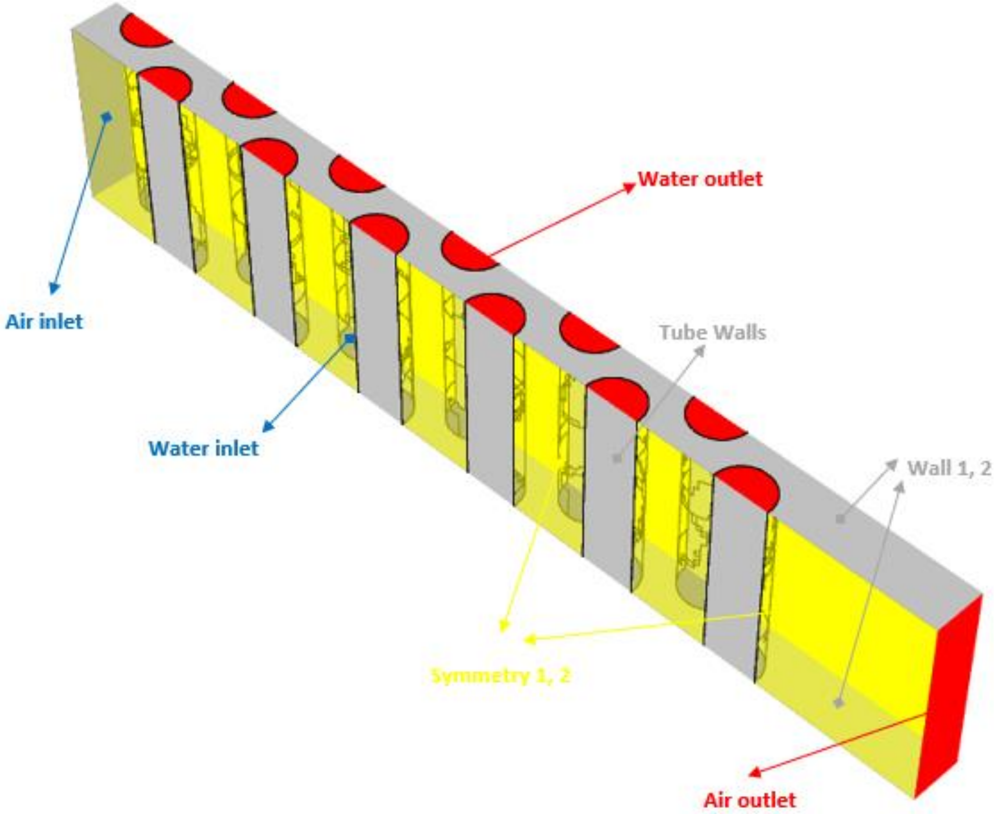

Fig. 2.3– Boundary conditions of the heat exchanger

In ANSYS Meshing, create a computational mesh with densification at the tube walls and use Inflation and Sweep.

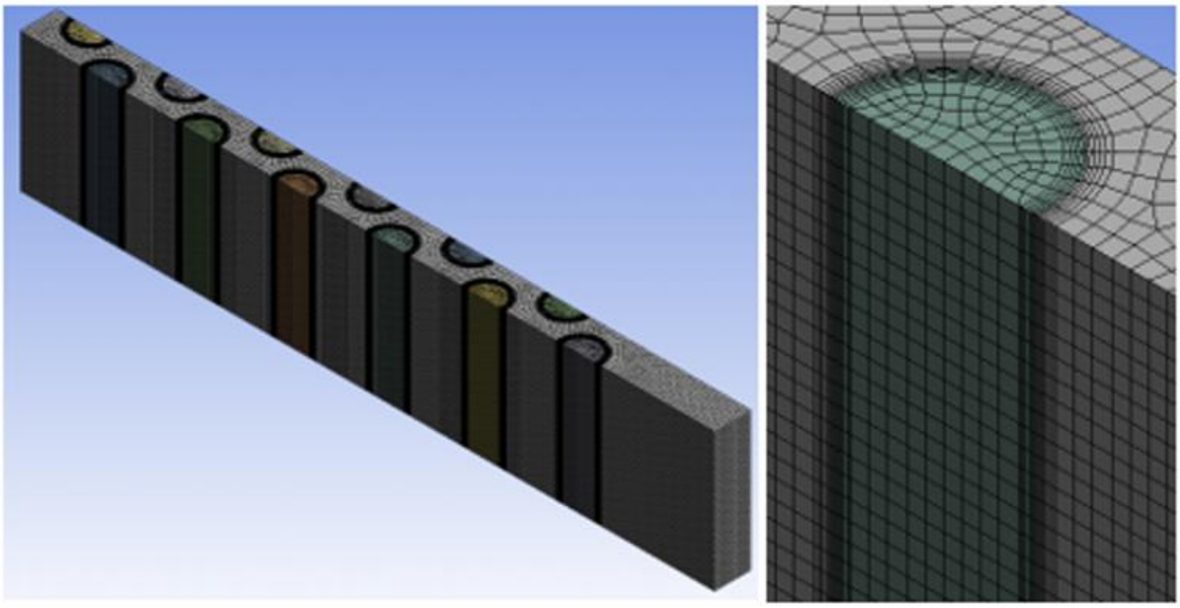

Fig. 2.4 – Cell densification around pipes with flowing water

The physical properties of flowing media and solid material are defined in Tab. 2.1

Tab. 2.1 – Physical properties of the material (steel, air) at 300 K:

Material	Steel	Water	Air	Unit
density ρ	8030	998	1.225	[kg.m^{-3}]
specific heat capacity c_p	502.48	4182	1006.43	[J.kg^{-1}K^{-1}]
thermal conductivity λ	16.27	0.6	0.0242	[W.m^{-1}K^{-1}]
viscosity η		0.001	1.7894e-05	[kg.m^{-1}s^{-1}]

The types of boundary conditions are as follows:

- Water inlet ⇒ „Velocity inlet“
- Water outlet ⇒ „Pressure outlet“
- Wall 1,2 ⇒ „Wall“
- Tubes wall ⇒ „Wall“
- Air inlet ⇒ „Velocity inlet“
- Air outlet ⇒ „Pressure outlet“
- Symmetry ⇒ „Symmetry“
- Fluid water ⇒ „Fluid“
- Fluid air ⇒ „Fluid“

The specification of boundary conditions is given in Tab. 2.2.

Tab. 2.2– Boundary conditions:

	Water inlet	Water outlet	Tubes wall	Air inlet	Air outlet	Wall 1,2	Unit
Temperature T	353	353	coupled	283	283	insulated	[K]
Velocity v	0.2			0.5			[m.s^{-1}]
Pressure p		0			0		[Pa]
Intensity of turbulence I	0.1	0.1		0.1	0.1		[%]
Hydraulic diameter D_h	0.028	0.028		0.261	0.261		[m]

Examples of results:

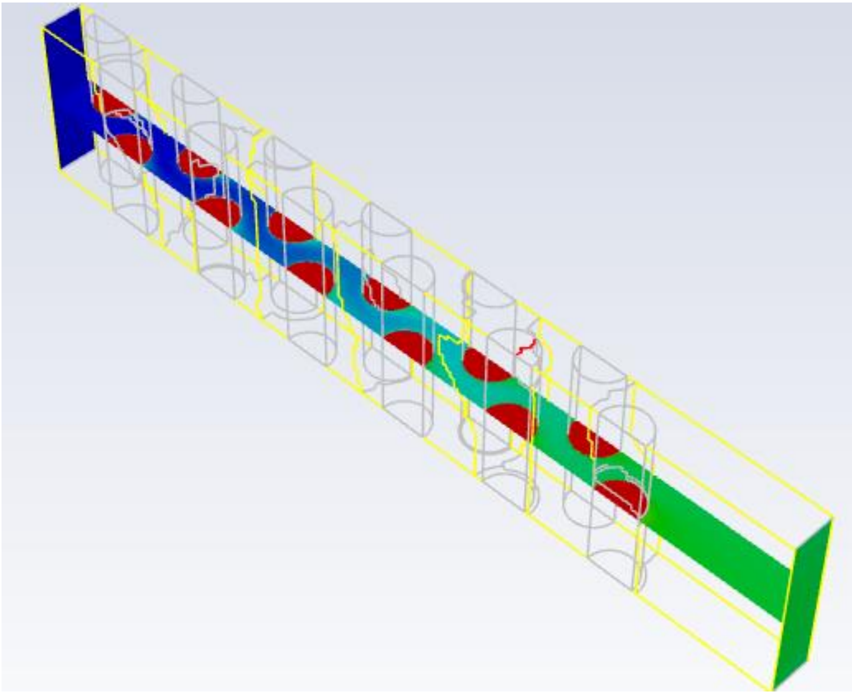

Fig. 2.5 Temperature contours in the evaluation cross section

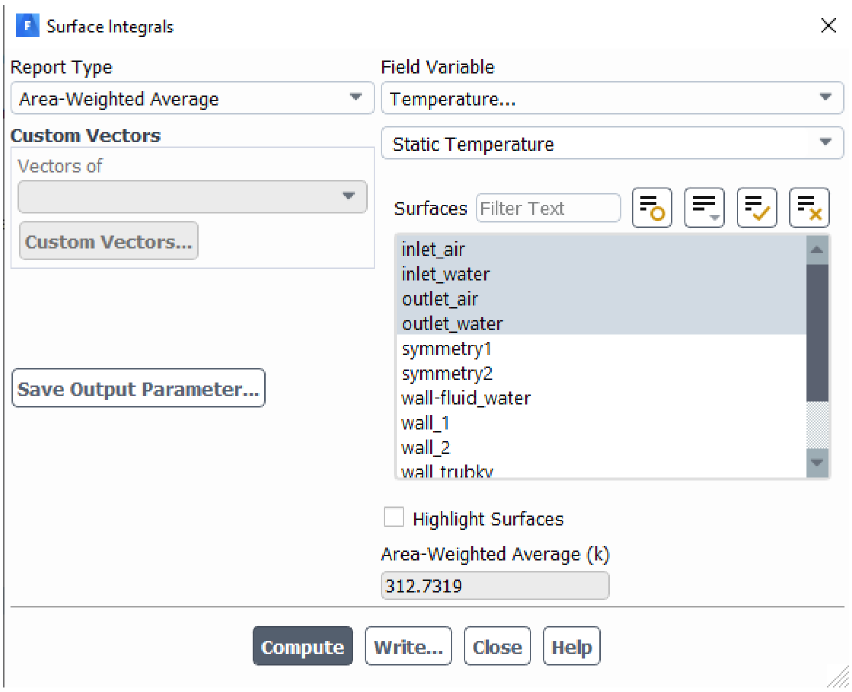

Fig. 2.6 Averaged temperature values at inlet and outlet

3 SOLUTION OF FLOW THROUGH HEAT EXCHANGER WITH THE TUBE BUNDLE IN A ROW, A (BRAÑA BUENO DIEGO) – ENERG - 3

Perform a mathematical simulation of water and air flow in a simplified heat exchanger geometry with the heat transfer from hot water to cold air through the steel pipe wall. Define the individual areas and parameters according to the specified boundary conditions and evaluate the results.

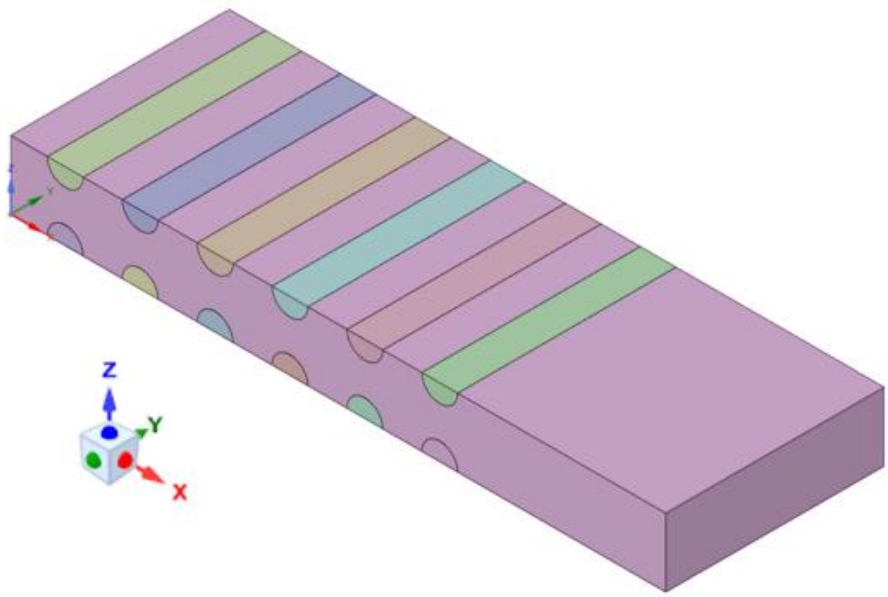

Fig. 3.1 – Simplified geometry of the heat exchanger

The dimensions of this geometry are specified in the following figure.

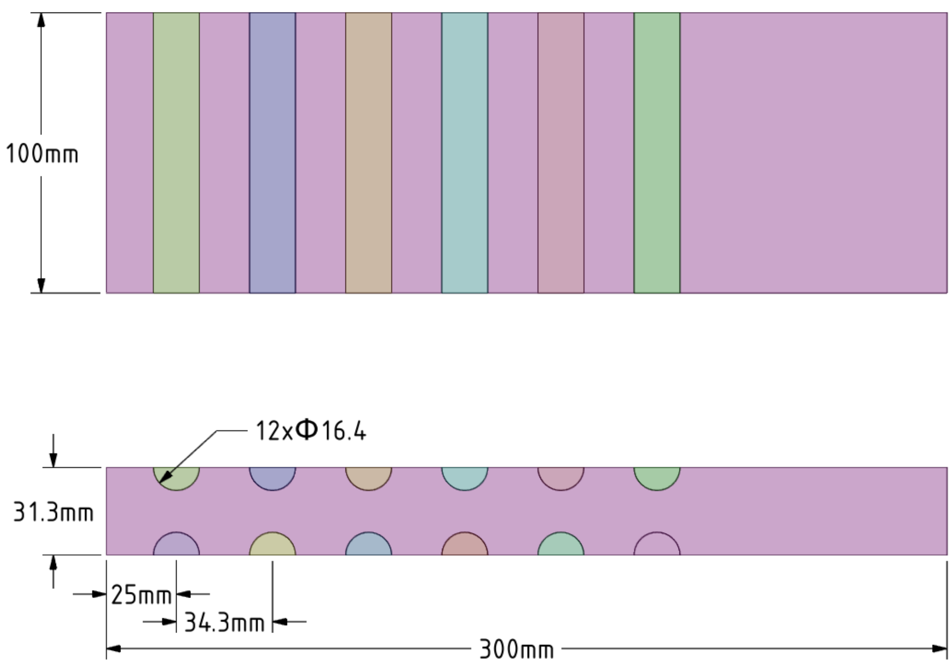

Fig. 3.2 – Dimensions of the heat exchanger area

The boundary conditions of the geometry are shown in Fig. 3.3

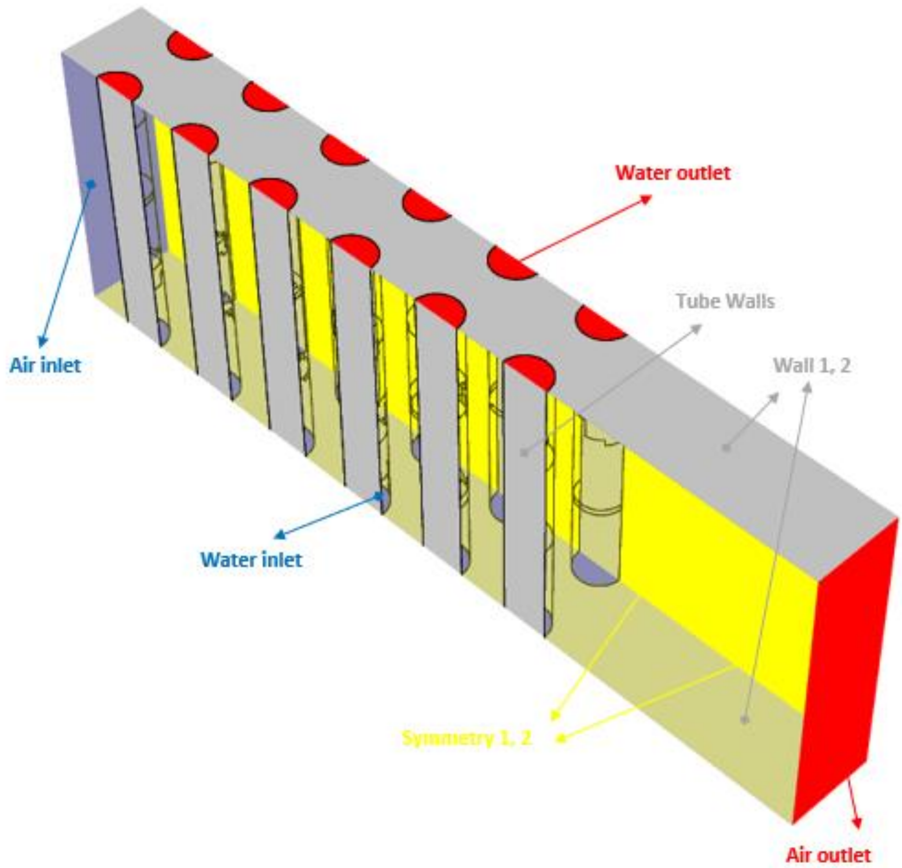

Fig. 3.3– Boundary conditions of the heat exchanger

In ANSYS Meshing, create a computational mesh with densification at the tube walls and use Inflation and Sweep.

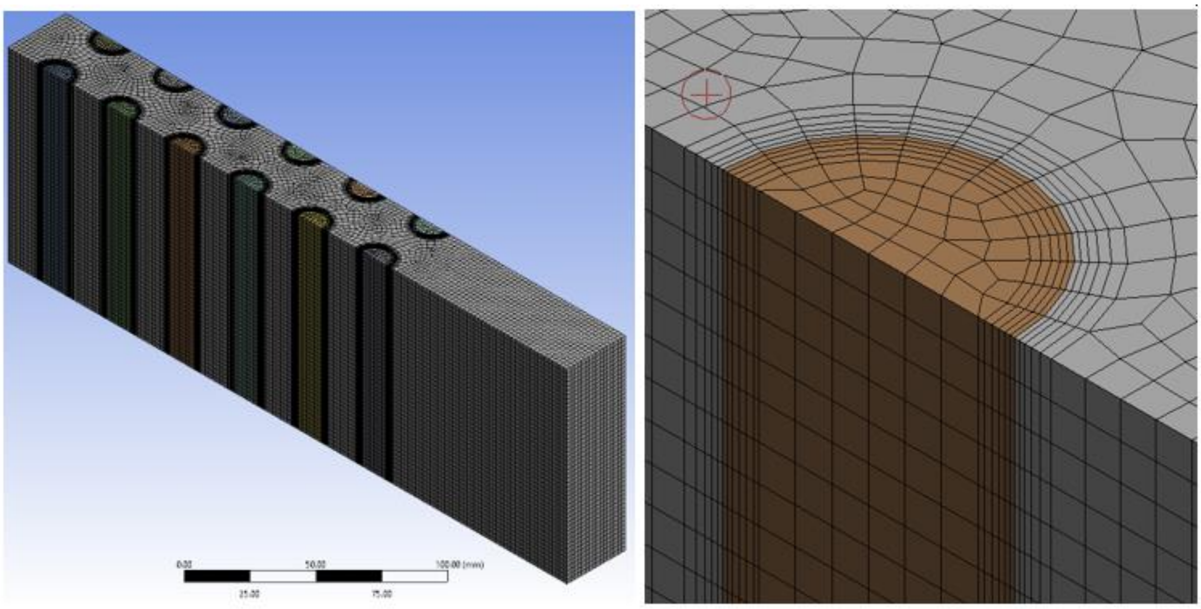

Fig. 3.4 – Cell densification around pipes with flowing water

The physical properties of flowing media and solid material are defined in Tab. 3.1

Tab. 3.1 – Physical properties of the material (steel, air) at 300 K:

Material	Steel	Water	Air	Unit
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specific heat capacity c_p	502.48	4182	1006.43	[J.kg^{-1}K^{-1}]
thermal conductivity λ	16.27	0.6	0.0242	[W.m^{-1}K^{-1}]
viscosity η		0.001	1.7894e-05	[kg.m^{-1}s^{-1}]

The types of boundary conditions are as follows:

- Water inlet ⇒ „Velocity inlet“
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- Tubes wall ⇒ „Wall“
- Air inlet ⇒ „Velocity inlet“
- Air outlet ⇒ „Pressure outlet“
- Symmetry ⇒ „Symmetry“
- Fluid water ⇒ „Fluid“
- Fluid air ⇒ „Fluid“

The specification of boundary conditions is given in Tab. 3.2.

Tab. 3.2– Boundary conditions:

	Water inlet	Water outlet	Tubes wall	Air inlet	Air outlet	Wall 1,2	Unit
Temperature T	353	353	coupled	283	283	insulated	[K]
Velocity v	0.2			0.5			[m.s^{-1}]
Pressure p		0			0		[Pa]
Intensity of turbulence I	0.1	0.1		0.1	0.1		[%]
Hydraulic diameter D_h	0.0164	0.0164		0.313	0.313		[m]

Examples of results:

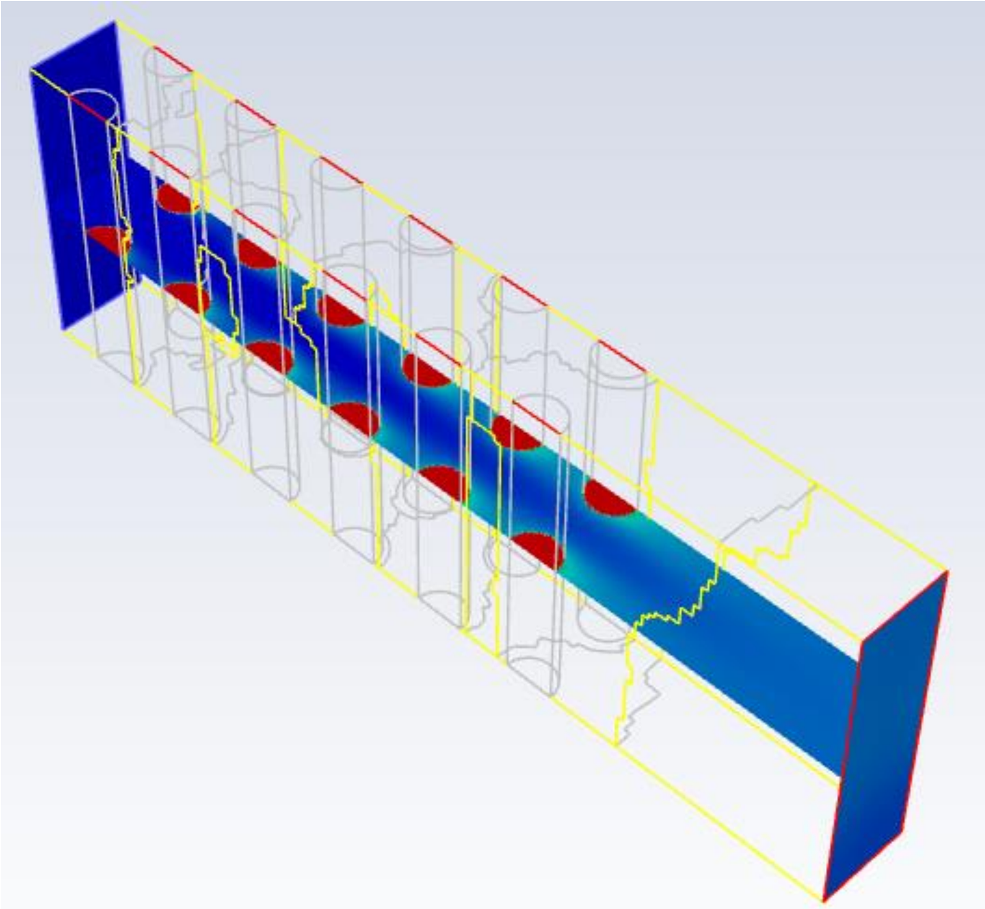

Fig. 3.5 Temperature contours in the evaluation cross section

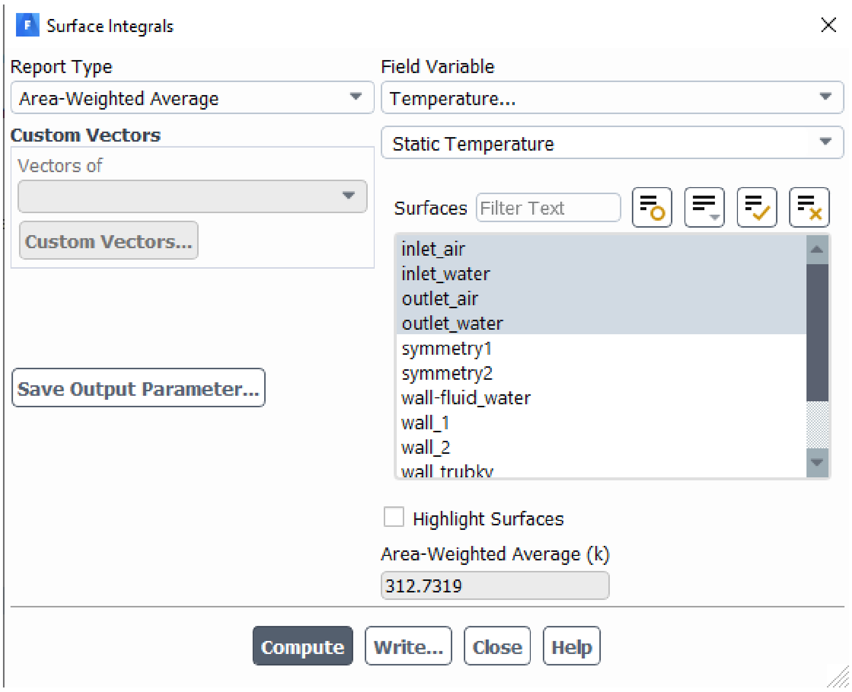

Fig. 3.6 Averaged temperature values at inlet and outlet

4 SOLUTION OF FLOW THROUGH HEAT EXCHANGER WITH THE TUBE BUNDLE IN A ROW, B (JOHN ALBIN) – ENERG -4

Perform a mathematical simulation of water and air flow in a simplified heat exchanger geometry with the heat transfer from hot water to cold air through the steel pipe wall. Define the individual areas and parameters according to the specified boundary conditions and evaluate the results.

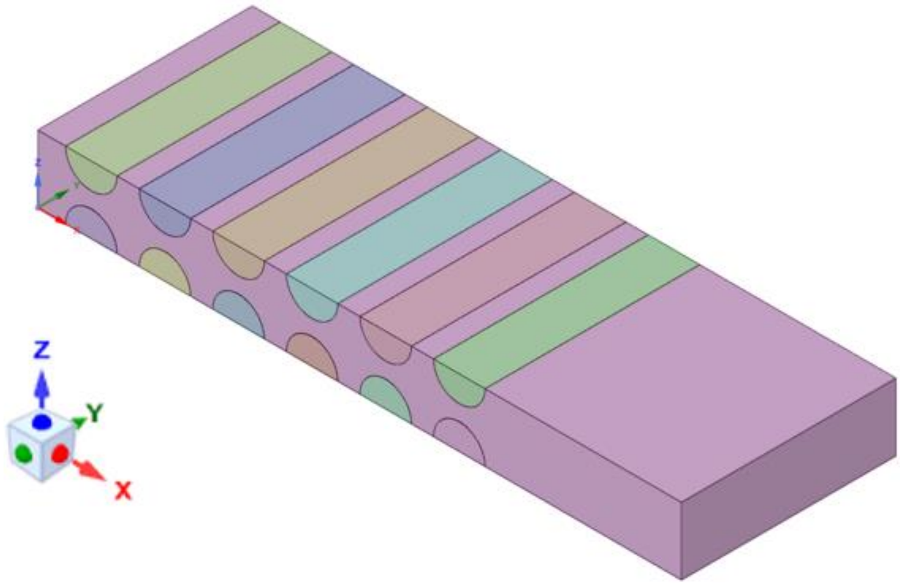

Fig. 4.1 – Simplified geometry of the heat exchanger

The dimensions of this geometry are specified in the following figure.

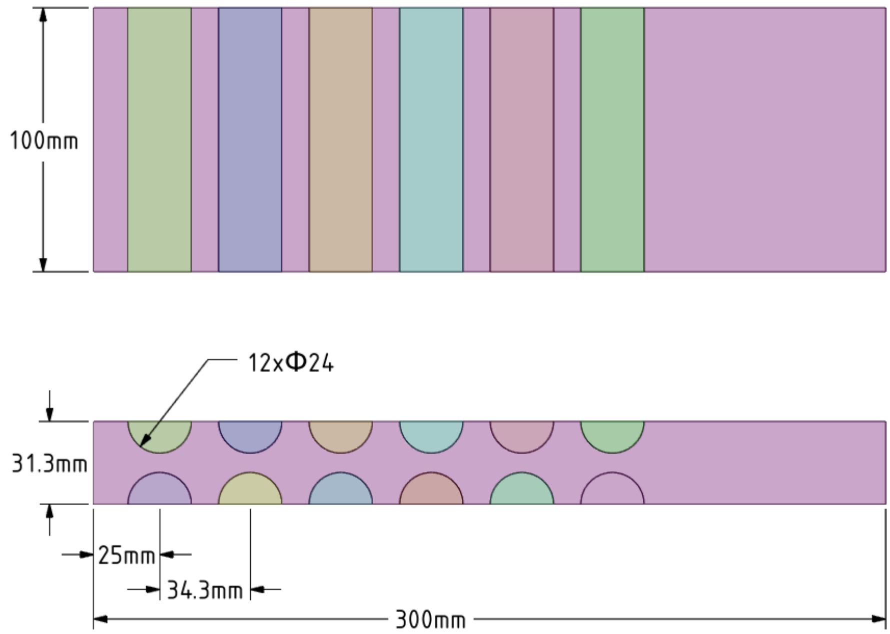

Fig. 4.2 – Dimensions of the heat exchanger area

The boundary conditions of the geometry are shown in Fig. 4.3

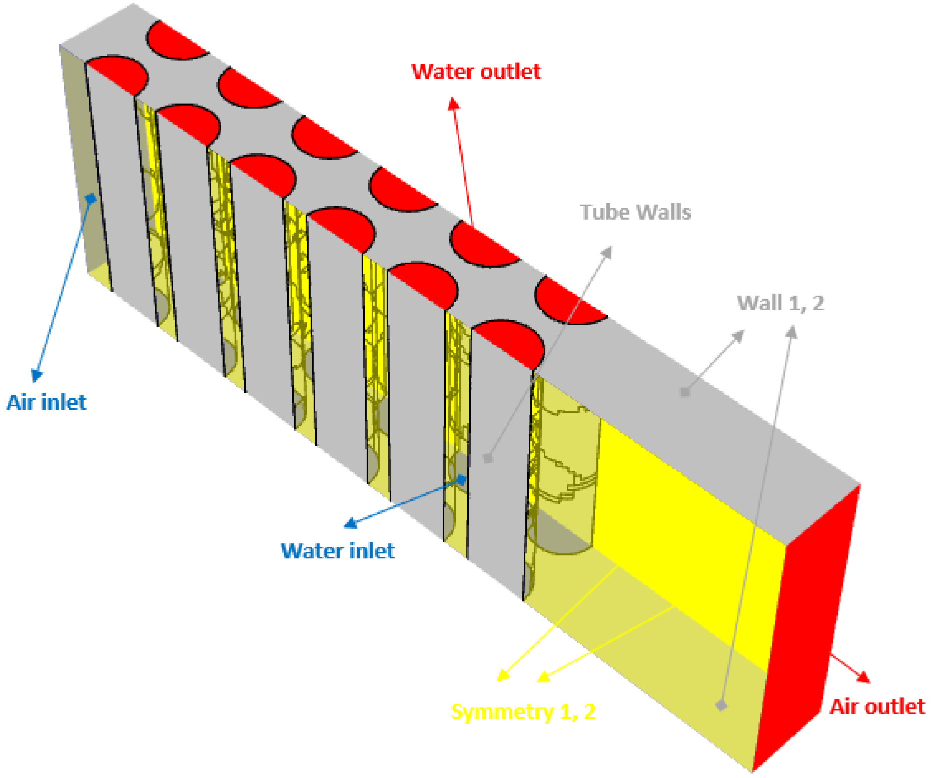

Fig. 4.3– Boundary conditions of the heat exchanger

In ANSYS Meshing, create a computational mesh with densification at the tube walls and use Inflation and Sweep.

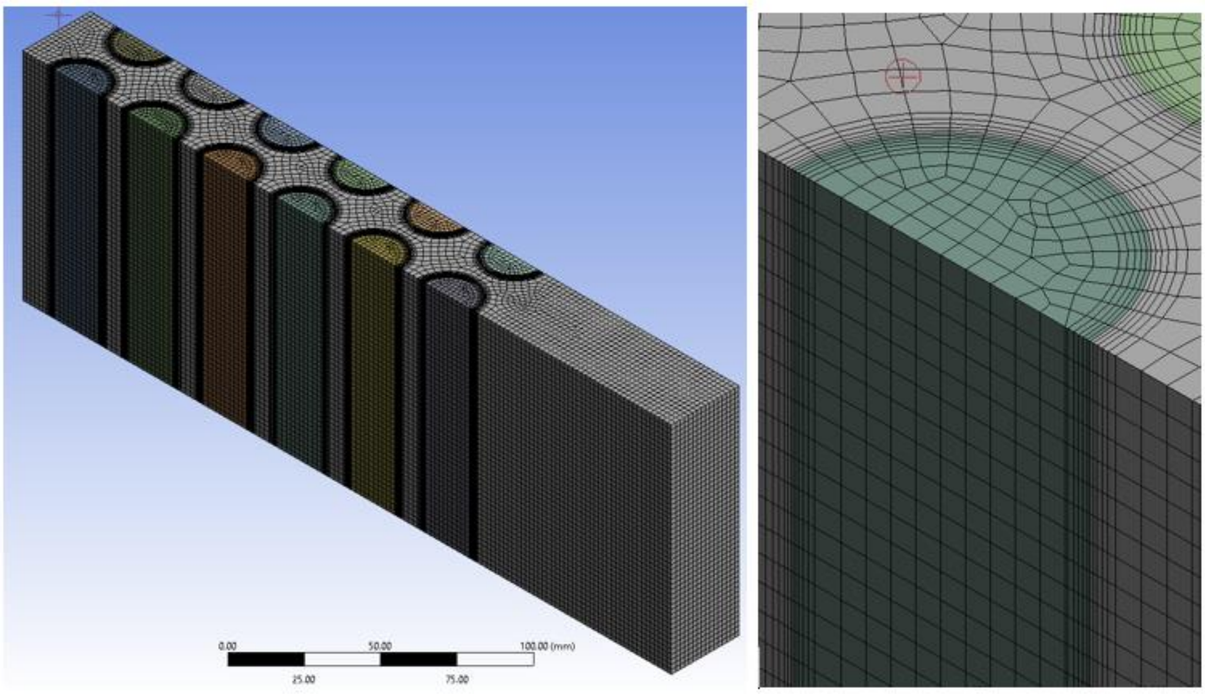

Fig. 4.4 – Densification around pipes with flowing water

The physical properties of flowing media and solid material are defined in Tab. 4.1

Tab. 4.1 – Physical properties of the material (steel, air) at 300 K:

Material	Steel	Water	Air	Unit
density ρ	8030	998	1.225	[kg.m^{-3}]
specific heat capacity c_p	502.48	4182	1006.43	[J.kg^{-1}K^{-1}]
thermal conductivity λ	16.27	0.6	0.0242	[W.m^{-1}K^{-1}]
viscosity η		0.001	1.7894e-05	[kg.m^{-1}s^{-1}]

The types of boundary conditions are as follows:

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- Wall 1,2 ⇒ „Wall“
- Tubes wall ⇒ „Wall“
- Air inlet ⇒ „Velocity inlet“
- Air outlet ⇒ „Pressure outlet“
- Symmetry ⇒ „Symmetry“
- Fluid water ⇒ „Fluid“
- Fluid air ⇒ „Fluid“

The specification of boundary conditions is given in Tab. 4.2.

Tab. 4.2– Boundary conditions:

	Water inlet	Water outlet	Tubes wall	Air inlet	Air outlet	Wall 1,2	Unit
Temperature T	353	353	coupled	283	283	insulated	[K]
Velocity v	0.2			0.5			[m.s^{-1}]
Pressure p		0			0		[Pa]
Intensity of turbulence I	0.1	0.1		0.1	0.1		[%]
Hydraulic diameter D_h	0.024	0.024		0.313	0.313		[m]

Examples of results:

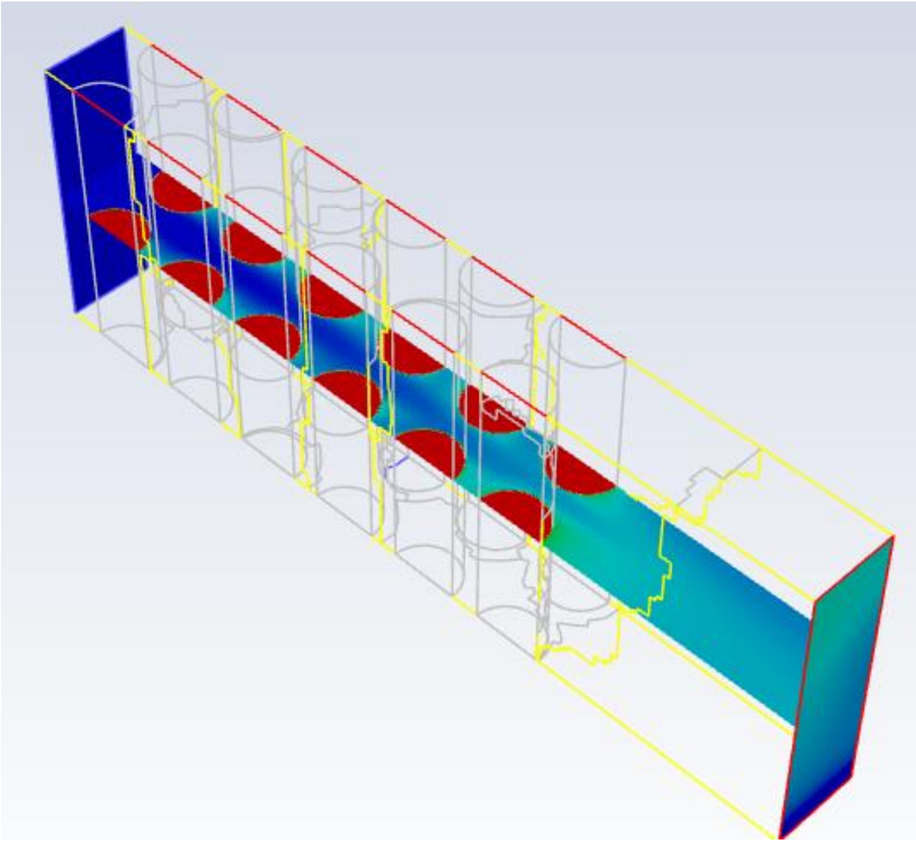

Fig. 4.5 Temperature contours in the evaluation cross section

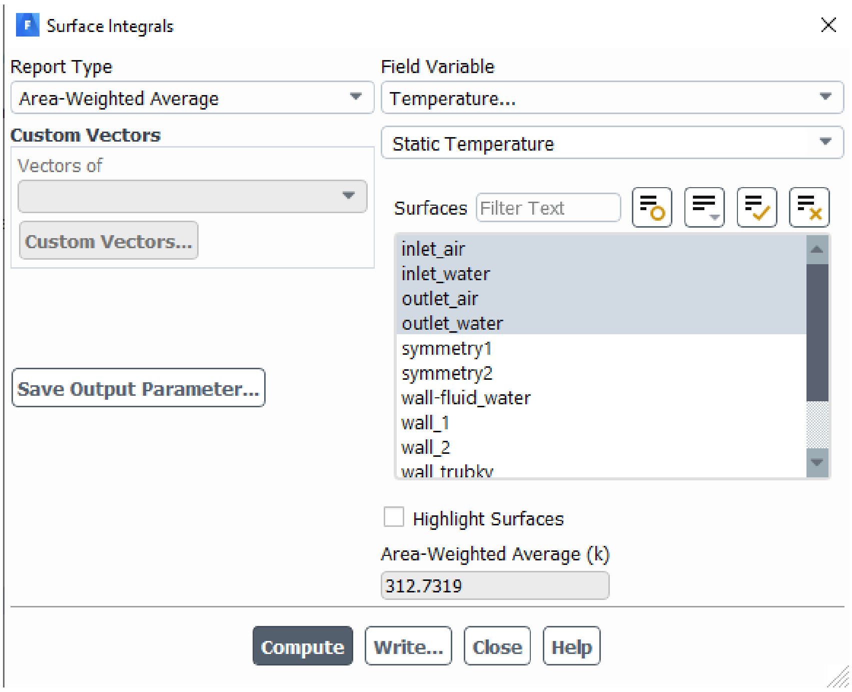

Fig. 4.6 Averaged temperature values at inlet and outlet

5 SOLUTION OF FLOW THROUGH THE STOVE HEAT EXCHANGER WITH THE TUBE BUNDLE IN A ROW, A (PENIEL PAULDOSS JOYSON SAM DEVAPAUL) – ENERG - 5

Perform a mathematical simulation of water and air flow in a simplified heat exchanger geometry with the heat transfer from hot water to cold air through the steel pipe wall. Define the individual areas and parameters according to the specified boundary conditions and evaluate the results.

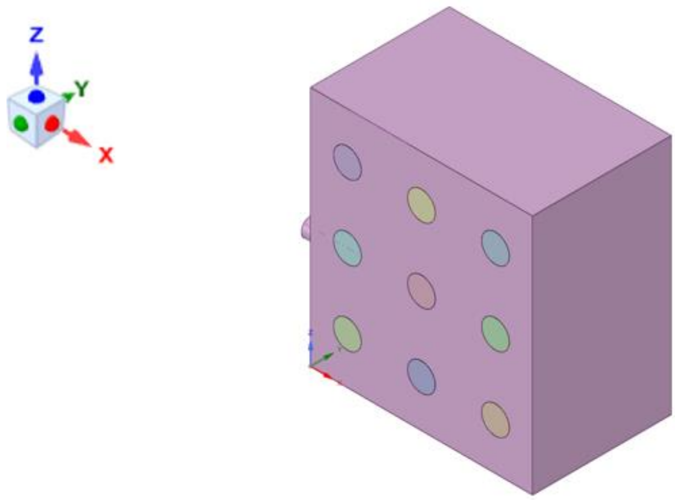

Fig. 5.1 – Simplified geometry of the heat exchanger

The dimensions of this geometry are specified in the following figure.

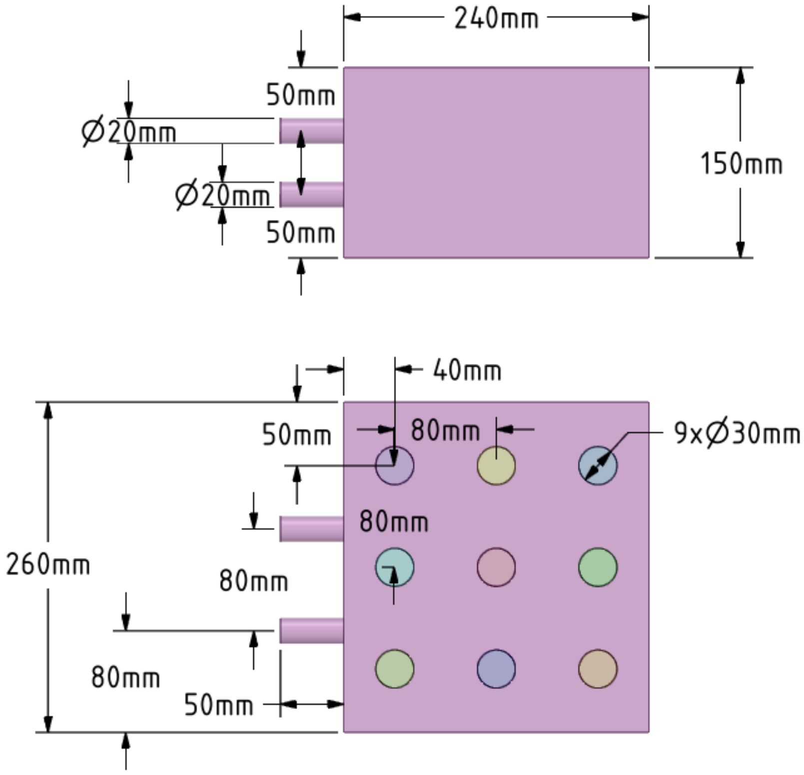

Fig. 5.2 – Dimensions of the heat exchanger area

The boundary conditions of the geometry are displayed on Fig. 5.3

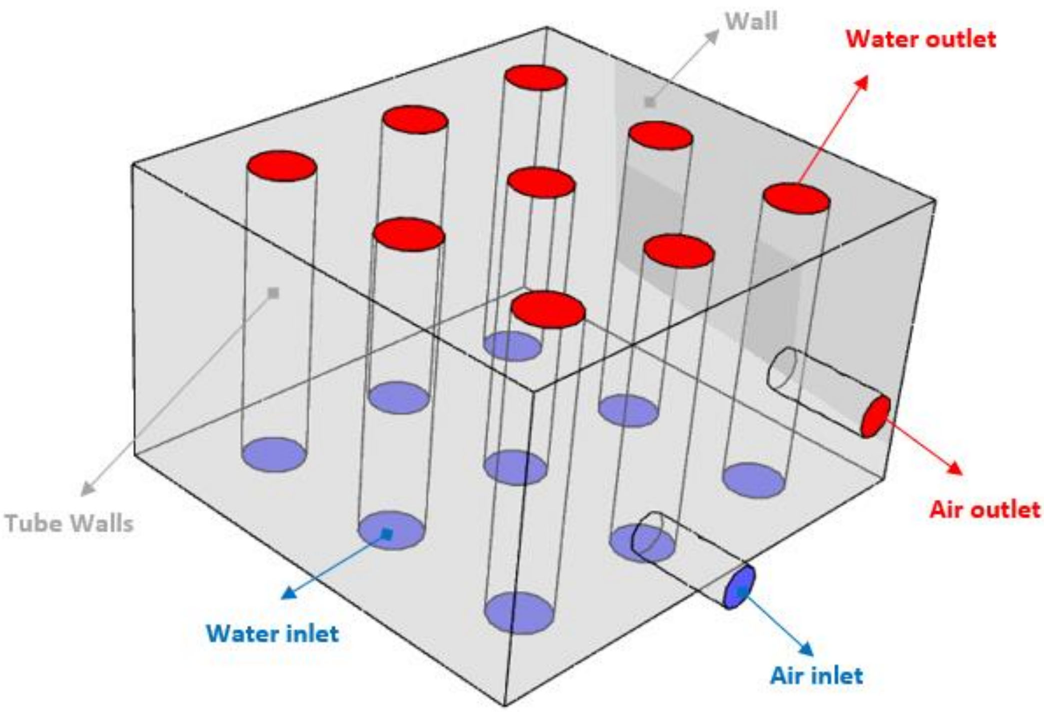

Fig. 5.3– Boundary conditions of the heat exchanger

In ANSYS Meshing, create a computational mesh with densification at the tube walls and use Inflation and Sweep.

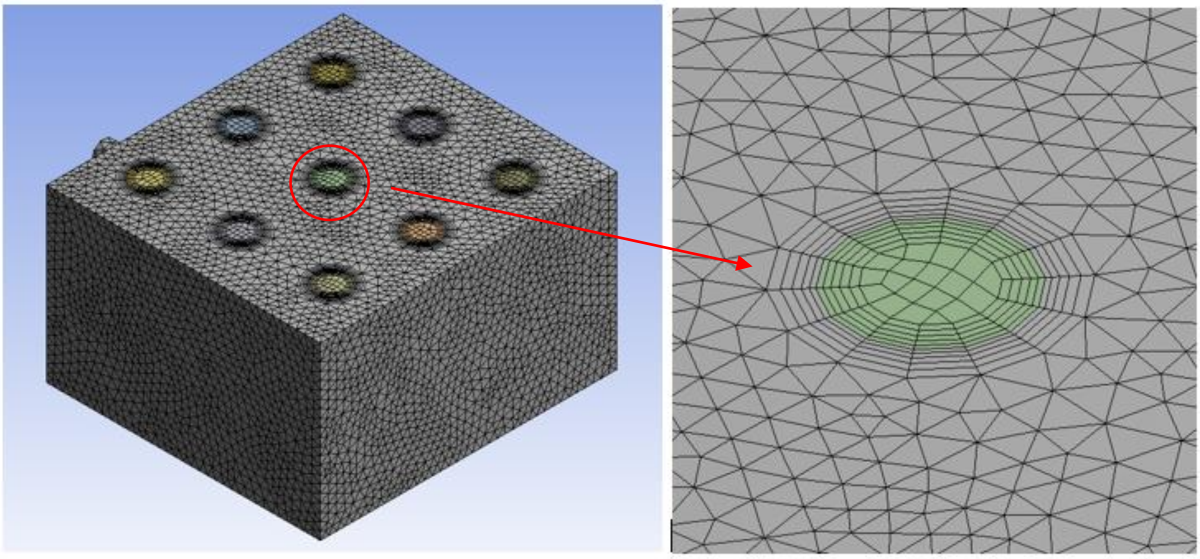

Fig. 5.4 – Cell concentration around pipes with flowing water

The physical properties of flowing media and solid material are defined in Tab. 5.1

Tab. 5.1 – Physical properties of material (steel, air) at 300 K:

Material	Steel	Water	Air	Unit
density ρ	8030	998	1.225	[kg.m^{-3}]
specific heat capacity c_p	502.48	4182	1006.43	[J.kg^{-1}K^{-1}]
thermal conductivity λ	16.27	0.6	0.0242	[W.m^{-1}K^{-1}]
viscosity η		0.001	1.7894e-05	[kg.m^{-1}s^{-1}]

The types of boundary conditions are as follows:

- Water inlet ⇒ „Velocity inlet“
- Water outlet ⇒ „Pressure outlet“
- Wall ⇒ „Wall“
- Tubes wall ⇒ „Wall“
- Air inlet ⇒ „Velocity inlet“
- Air outlet ⇒ „Pressure outlet“
- Water fluid ⇒ „Fluid“
- Air fluid ⇒ „Fluid“

The specification of boundary conditions is given in Tab. 5.2.

Tab. 5.2– Boundary conditions:

	Water inlet	**Water outlet**	**Tubes wall**	**Air inlet**	**Air outlet**	**Wall**	**Unit**
Temperature T	353	353	coupled	283	283	insulated	[K]
Velocity v	0.2			0.5			[m.s^{-1}]
Pressure p		0		0	0		[Pa]
Intensity of turbulence I	0.1	0.1		0.1	0.1		[%]
Hydraulic diameter D_h	0.03	0.03		0.02	0.02		[m]

Examples of results:

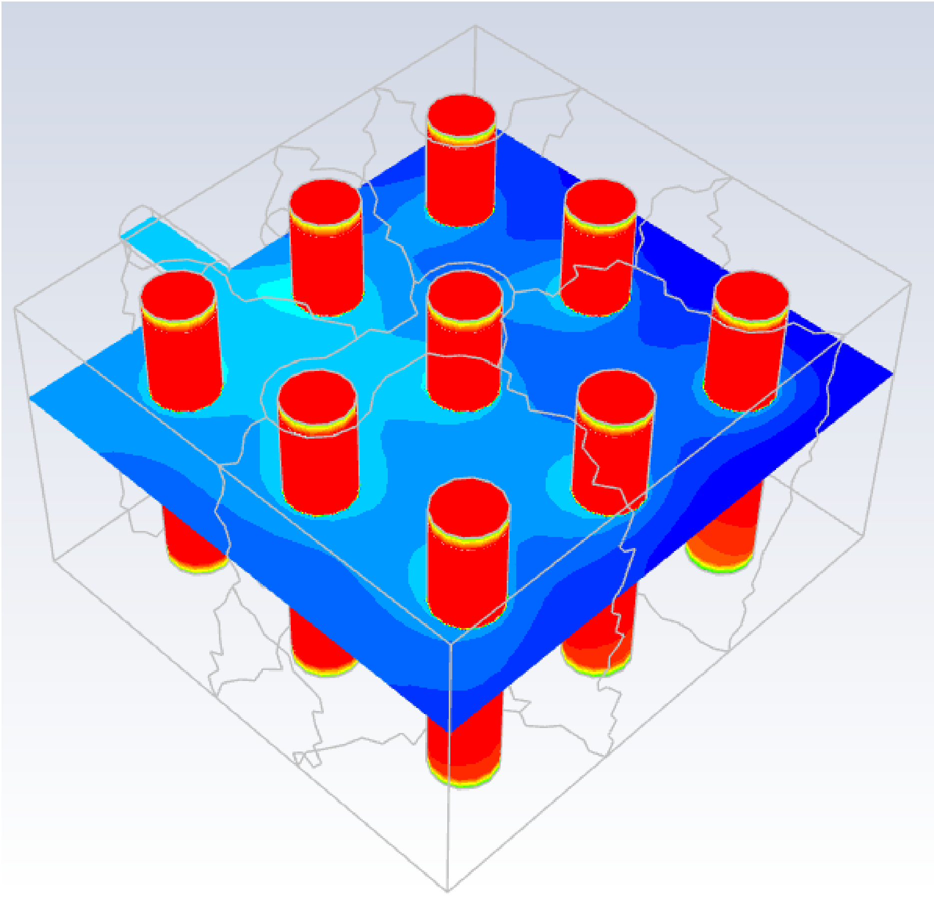

Fig. 5.5 Temperature contours in evaluation cross section

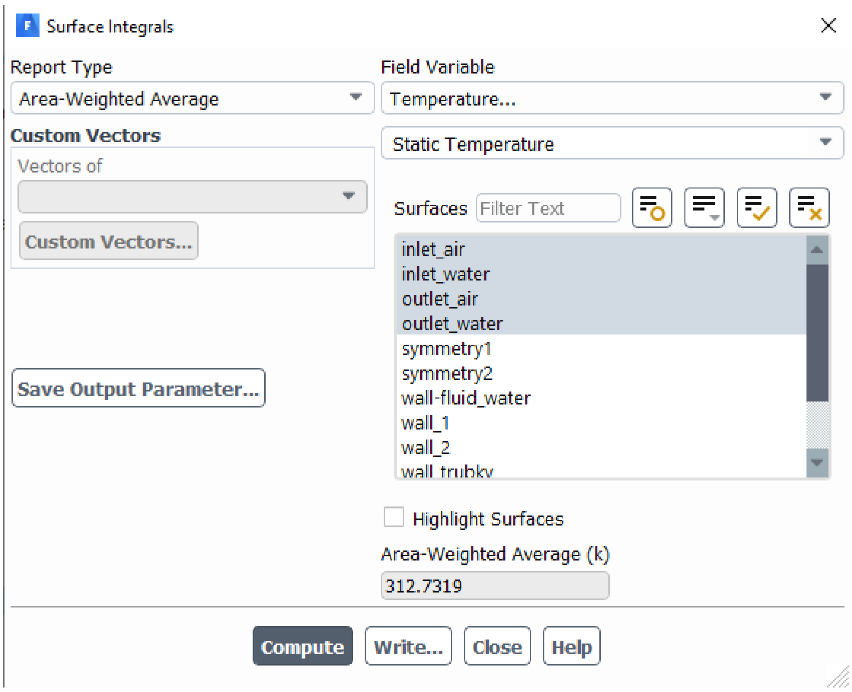

Fig. 5.6 Averaged temperature values at inlet and outlet

6 SOLUTION OF FLOW THROUGH THE STOVE HEAT EXCHANGER WITH THE TUBE BUNDLE IN A ROW, B (EL HASSANE YOUNES) – ENERG - 6

Perform a mathematical simulation of water and air flow in a simplified heat exchanger geometry with the heat transfer from hot water to cold air through the steel pipe wall.. Define the individual areas and parameters according to the specified boundary conditions and evaluate the results.

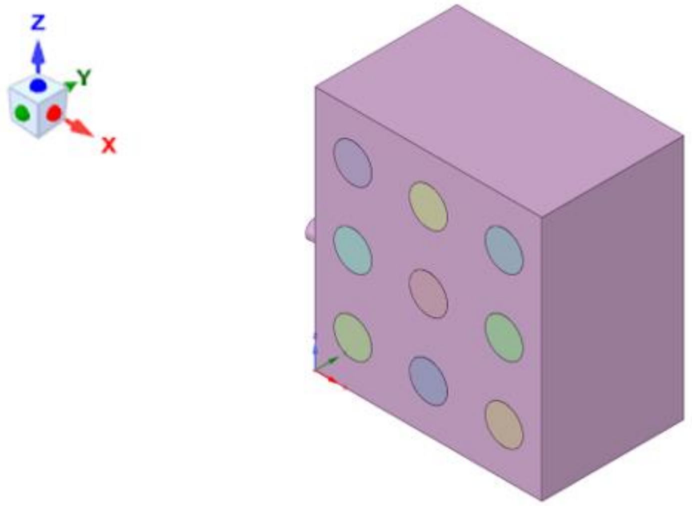

Fig. 6.1 – Simplified geometry of the heat exchanger

The dimensions of this geometry are specified in the following figure.

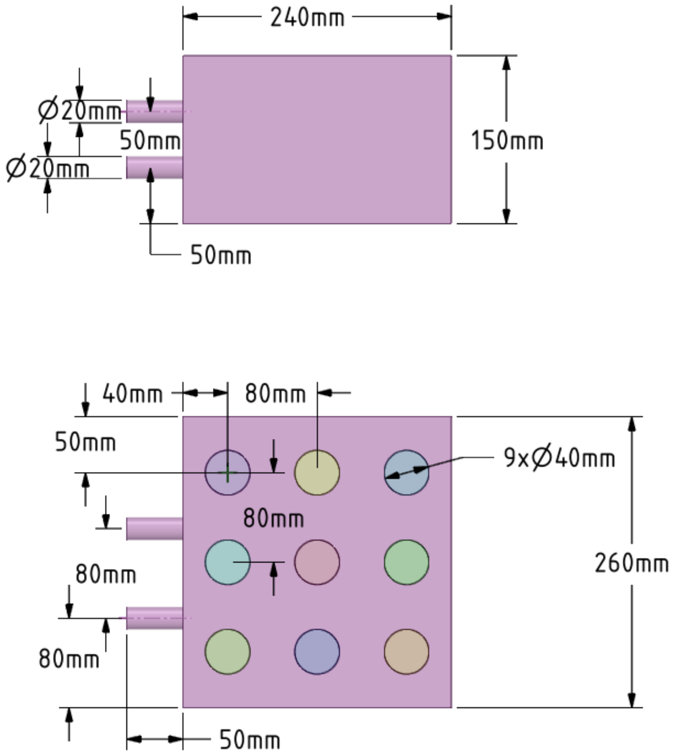

Fig. 6.2 – Dimensions of the heat exchanger area

The boundary conditions of the geometry are displayed on Fig. 6.3

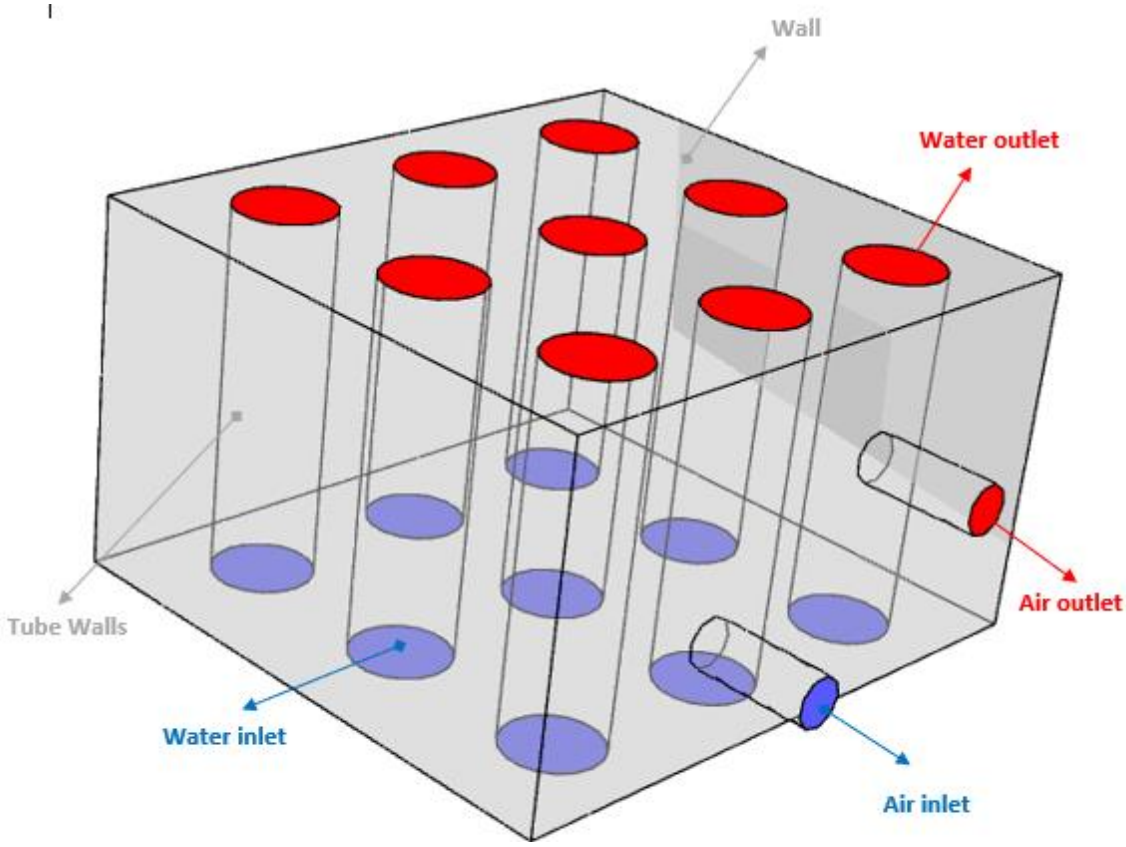

Fig. 6.3– Boundary conditions of the heat exchanger

In ANSYS Meshing, create a computational mesh with densification at the tube walls and use Inflation and Sweep.

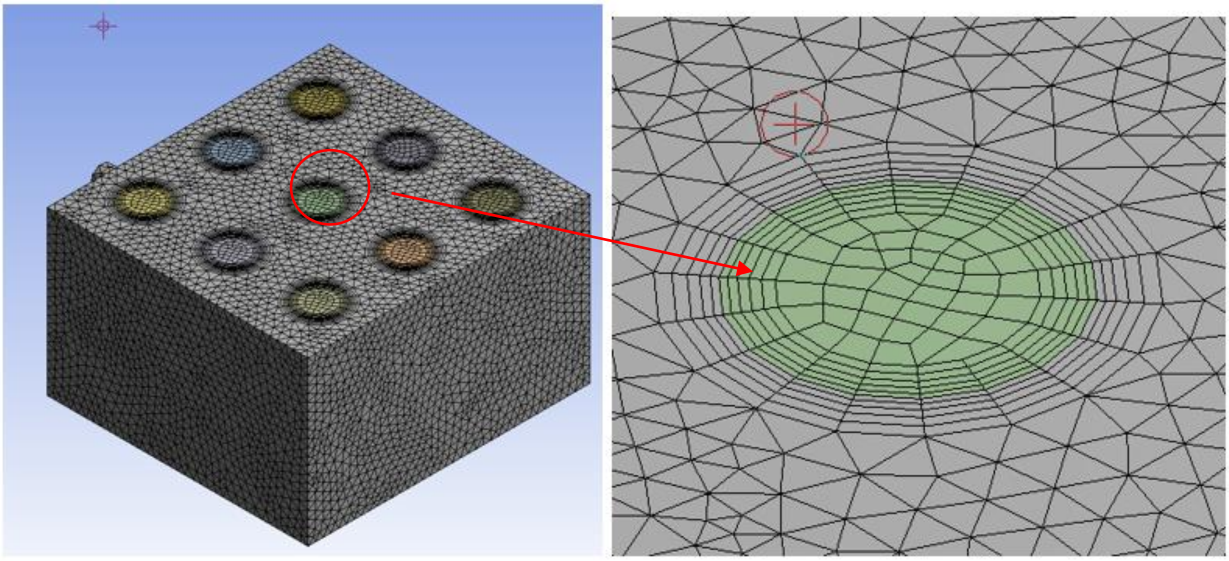

Fig. 6.4 – Cell concentration around pipes with flowing water

The physical properties of flowing media and solid material are defined in Tab. 6.1

Tab. 6.1 – Physical properties of material (steel, air) at 300 K:

Material	Steel	Water	Air	Unit
density ρ	8030	998	1.225	[kg.m^{-3}]
specific heat capacity c_p	502.48	4182	1006.43	[J.kg^{-1}K^{-1}]
thermal conductivity λ	16.27	0.6	0.0242	[W.m^{-1}K^{-1}]
viscosity η		0.001	1.7894e-05	[kg.m^{-1}s^{-1}]

Typy okrajových podmínek jsou následující:

- Water inlet $\Rightarrow$ „Velocity inlet"
- Water outlet $\Rightarrow$ „Pressure outlet"
- Wall $\Rightarrow$ „Wall"
- Tubes wall $\Rightarrow$ „Wall"
- Air inlet $\Rightarrow$ „Velocity inlet"
- Air outlet $\Rightarrow$ „Pressure outlet"
- Water fluid $\Rightarrow$ „Fluid"
- Air fluid $\Rightarrow$ „Fluid"

The specification of boundary conditions is given in Tab. 6.2.

Tab. 6.2– Boundary conditions:

	Water inlet	**Water outlet**	**Tubes wall**	**Air inlet**	**Air outlet**	**Wall**	**Unit**
Temperature T	353	353	coupled	283	283	insulated	[K]
Velocity v	0.2			0.5			[m.s^{-1}]
Pressure p		0			0		[Pa]
Intensity of turbulence I	0.1	0.1		0.1	0.1		[%]
Hydraulic diameter D_h	0.04	0.04		0.02	0.02		[m]

Examples of results:

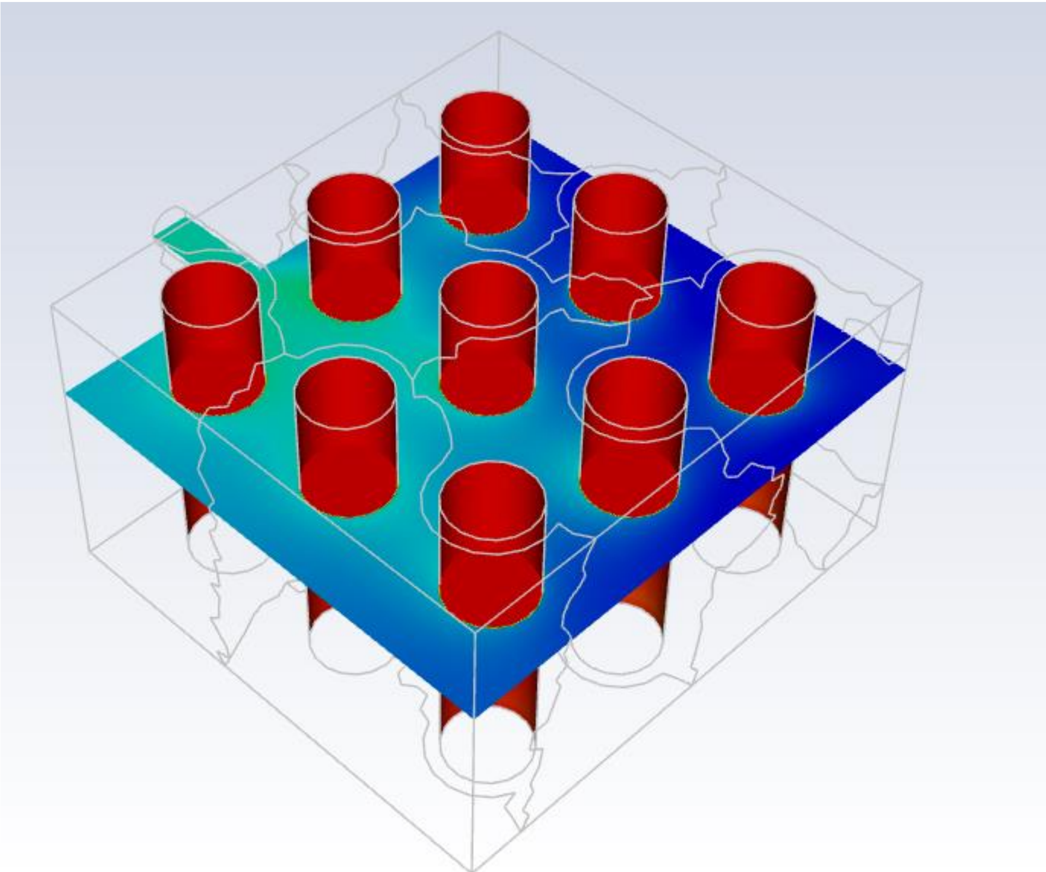

Fig. 6.5 Temperature contours in evaluation cross section

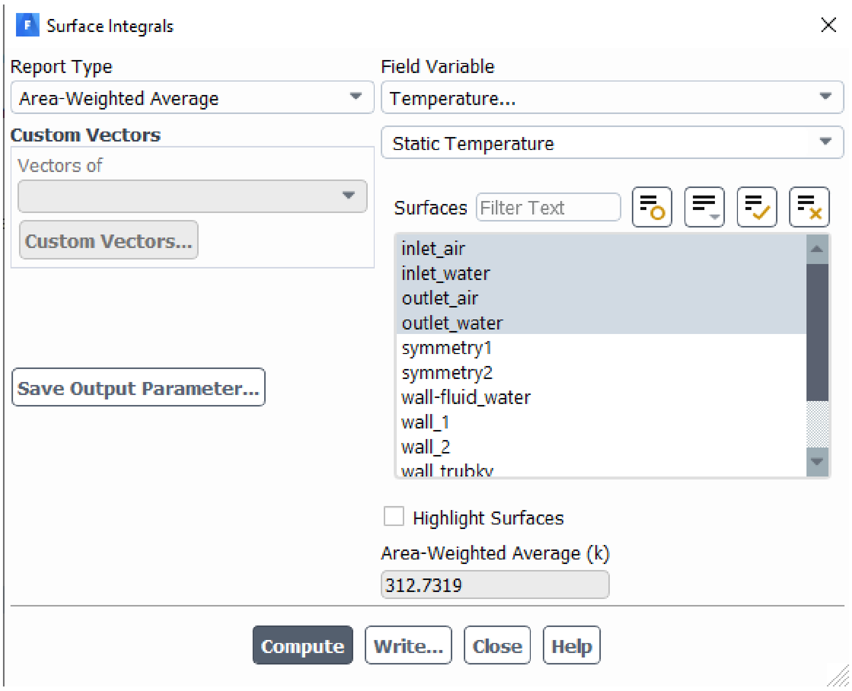

Fig. 6.6 Averaged temperature values at inlet and outlet

7 SOLUTION OF FLOW THROUGH THE STOVE HEAT EXCHANGER WITH THE TUBE BUNDLE IN CROSS, A (NARAYANAN SARAN) – ENERG - 7

Perform a mathematical simulation of water and air flow in a simplified heat exchanger geometry with the heat transfer from hot water to cold air through the steel pipe wall. Define the individual areas and parameters according to the specified boundary conditions and evaluate the results.

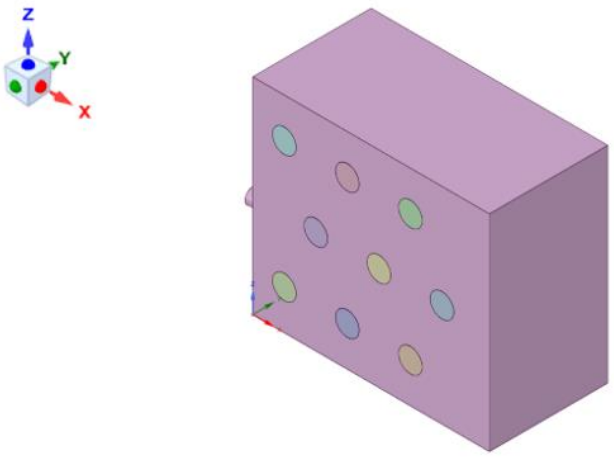

Fig. 7.1 – Simplified geometry of the heat exchanger

The dimensions of this geometry are specified in the following figure.

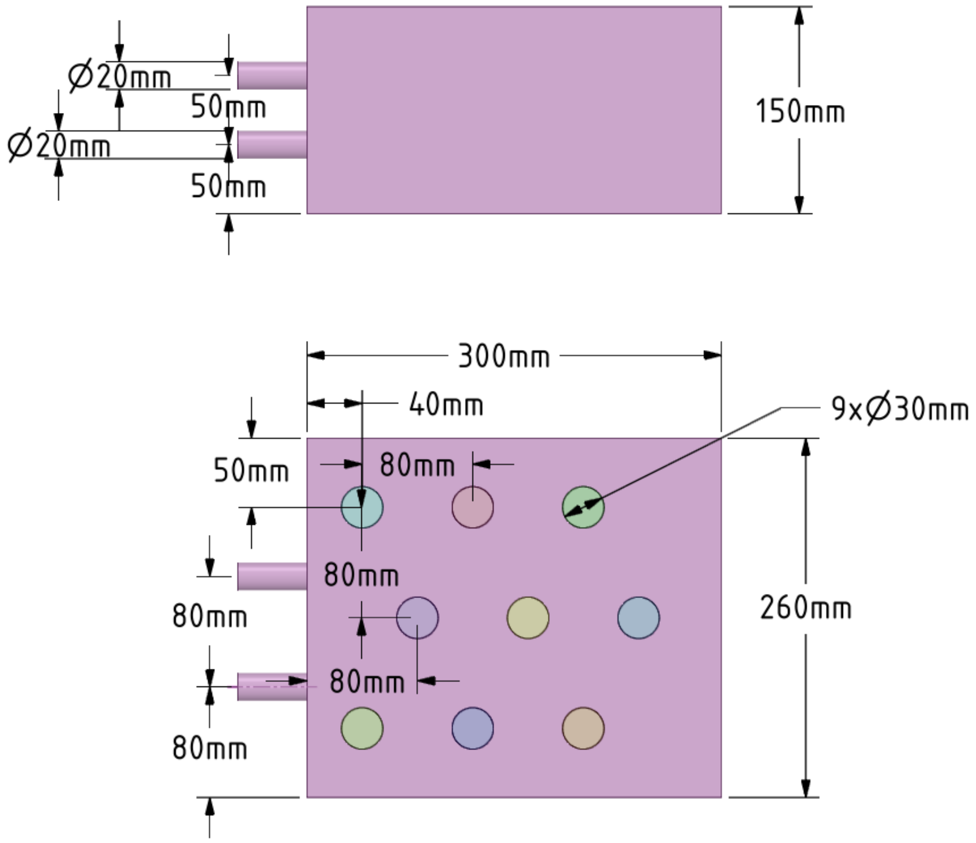

Fig. 7.2 – Dimensions of the heat exchanger area

The boundary conditions of the geometry are displayed on Fig. 7.3.

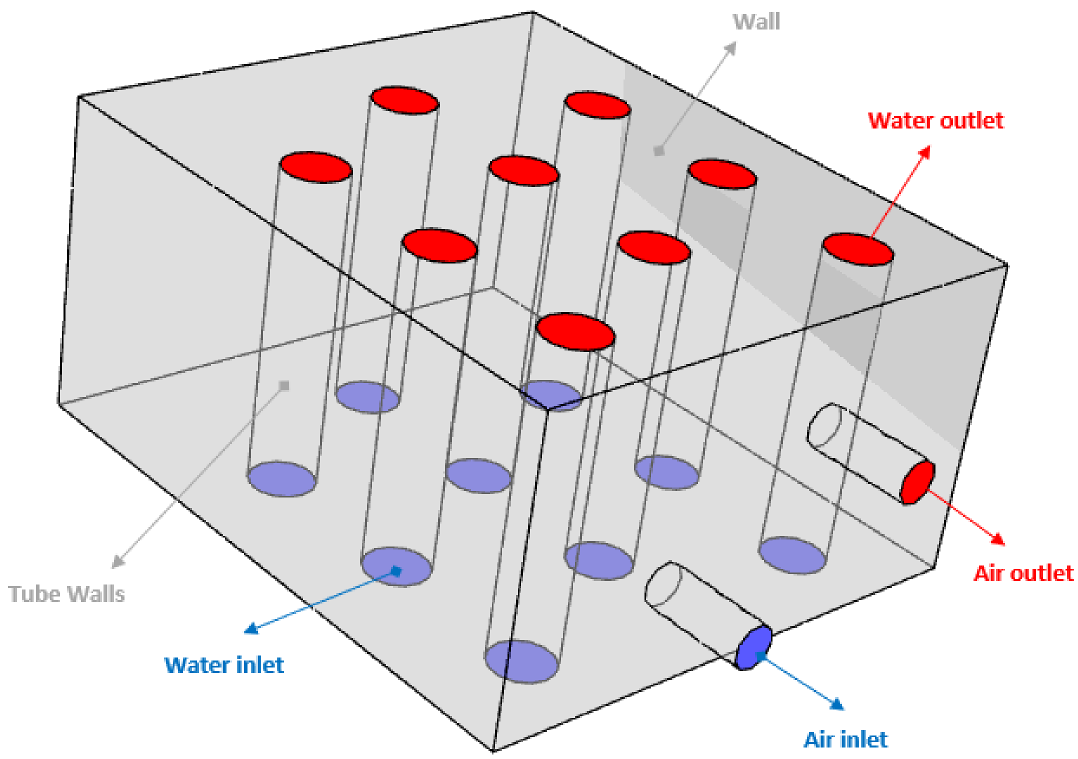

Fig. 7.3– Boundary conditions of the heat exchanger

In ANSYS Meshing, create a computational mesh with densification at the tube walls and use Inflation and Sweep.

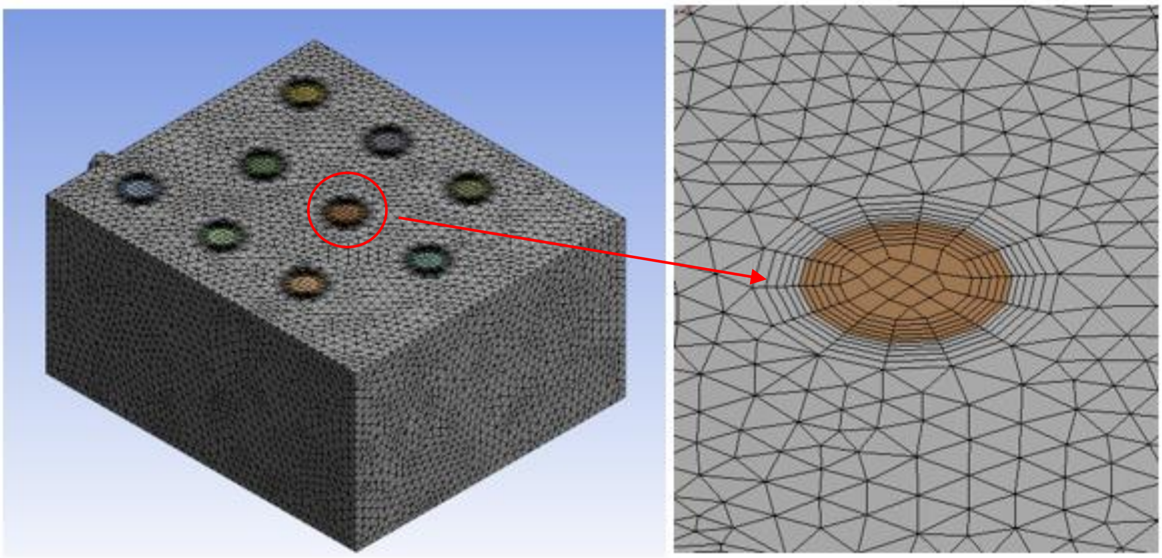

Fig 7.4 – Cell concentration around pipes with flowing water

The physical properties of flowing media and solid material are defined in Tab. 7.1

Tab. 7.1 – Physical properties of material (steel, air) at 300 K:

Material	Steel	Water	Air	Unit
density ρ	8030	998	1.225	[kg.m^{-3}]
specific heat capacity c_p	502.48	4182	1006.43	[J.kg^{-1}K^{-1}]
thermal conductivity λ	16.27	0.6	0.0242	[W.m^{-1}K^{-1}]
viscosity η		0.001	1.7894e-05	[kg.m^{-1}s^{-1}]

The types of boundary conditions are as follows:

- Water inlet ⇒ „Velocity inlet"
- Water outlet ⇒ „Pressure outlet"
- Wall ⇒ „Wall"
- Tubes wall ⇒ „Wall"
- Air inlet ⇒ „Velocity inlet"
- Air outlet ⇒ „Pressure outlet"
- Water fluid ⇒ „Fluid"
- Air fluid ⇒ „Fluid"

The specification of boundary conditions is given inTab. 7.2.

Tab. 7.2– Boundary conditions:

	Water inlet	Water outlet	Tubes wall	Air inlet	Air outlet	Wall	Unit
Temperature T	353	353	coupled	283	283	insulated	[K]
Velocity v	0.2			0.5			[m.s^{-1}]
Pressure p		0			0		[Pa]
Intensity of turbulence I	0.1	0.1		0.1	0.1		[%]
Hydraulic diameter D_h	0.03	0.03		0.02	0.02		[m]

Examples of results:

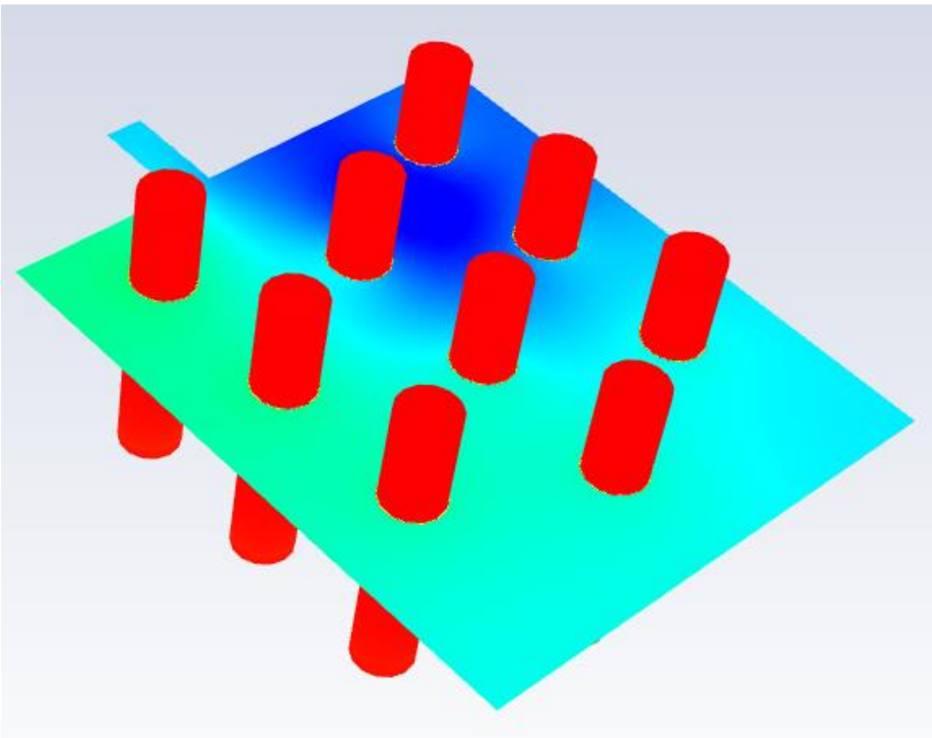

Fig. 7.5 Temperature contour in evaluation cross section

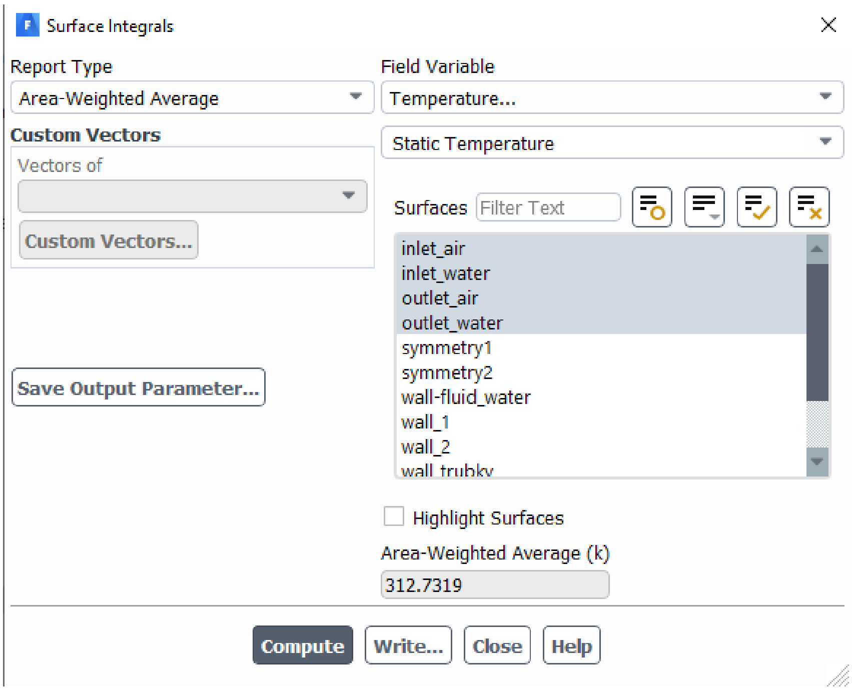

Fig. 7.6 Averaged temperature values at inlet and outlet