ELC F-8
Optimal design & CFD

Project : optimization of the temperature distribution at the outlet of a channel using cooling holes, taking into account (or not) the cost of the control strategy, with 9 design parameters (velocity magnitude and direction, temperature level at each hole). The inlet flow at the (left) channel entrance is not uniform but described by a parabolic profile both for the axial velocity and the static temperature.

Material provided : baseline Fluent case file with the 9 input parameters and 2 output parameters. Design Explorer manual.

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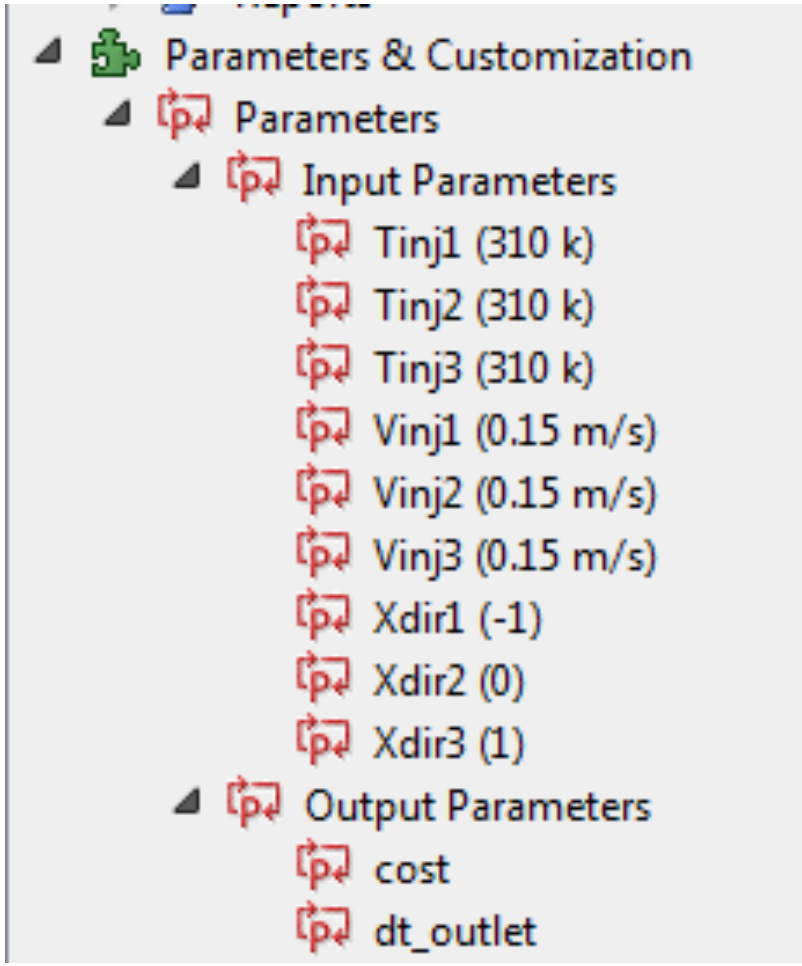
Baseline configuration : all injection velocities set to 0.15 m/s, all injection temperatures set to 310 K, Xdir1 (hole 1) = -1, Xdir2 (hole 2) = 0, Xdir3 (hole 3) = +1



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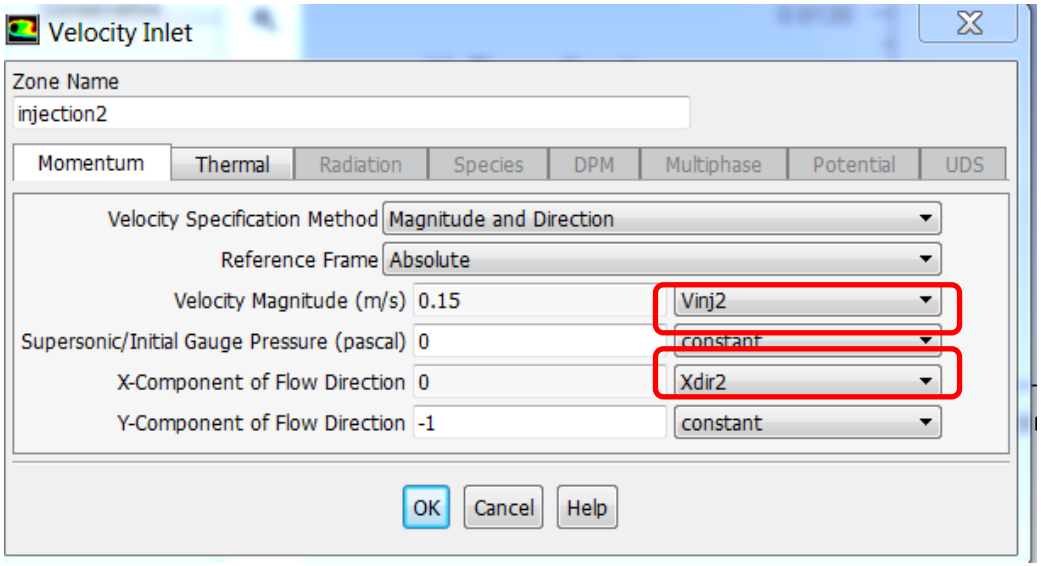
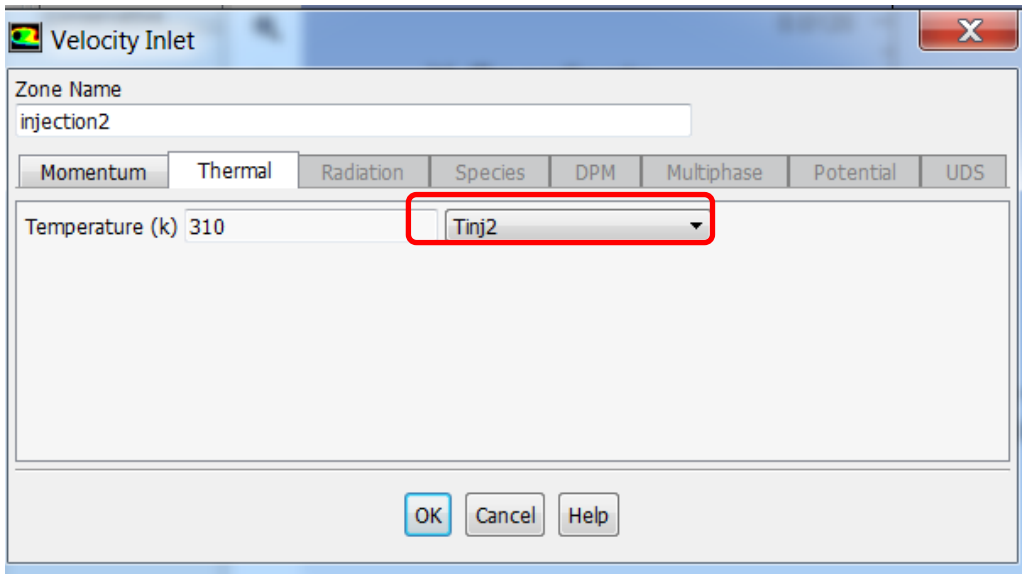
Editing the Fluent case from the WB allows to check the input parameters are indeed used to define the injection boundary conditions (here for hole 2).





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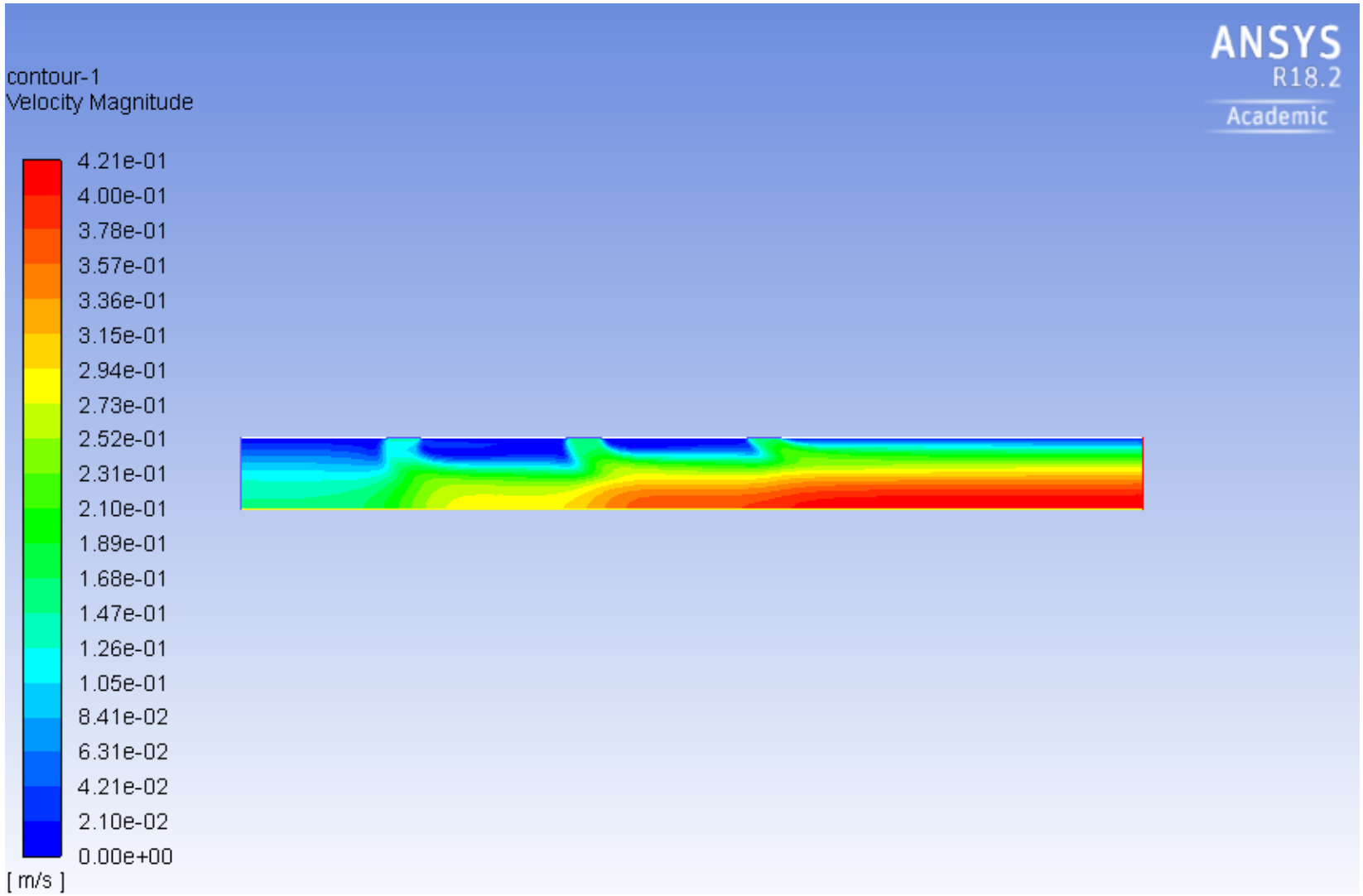

Contours of velocity magnitude

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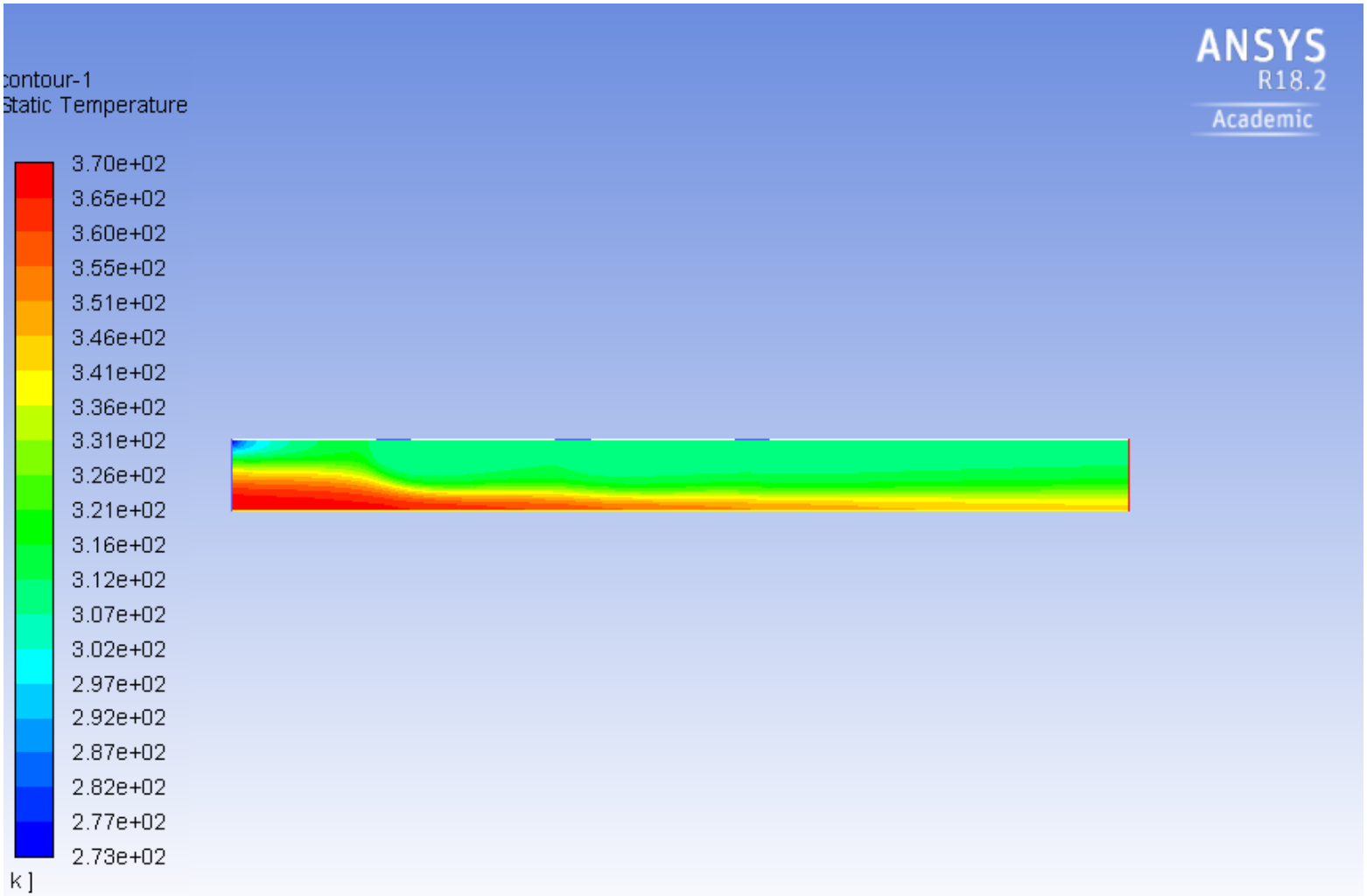

Contours of static temperature

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Baseline configuration : all injection velocities set to 0.15 m/s, all injection temperatures set to 310 K, Xdir1 (hole 1) = -1, Xdir2 (hole 2) = 0, Xdir3 (hole 3) = +1

Velocity vectors colored by the static temperature

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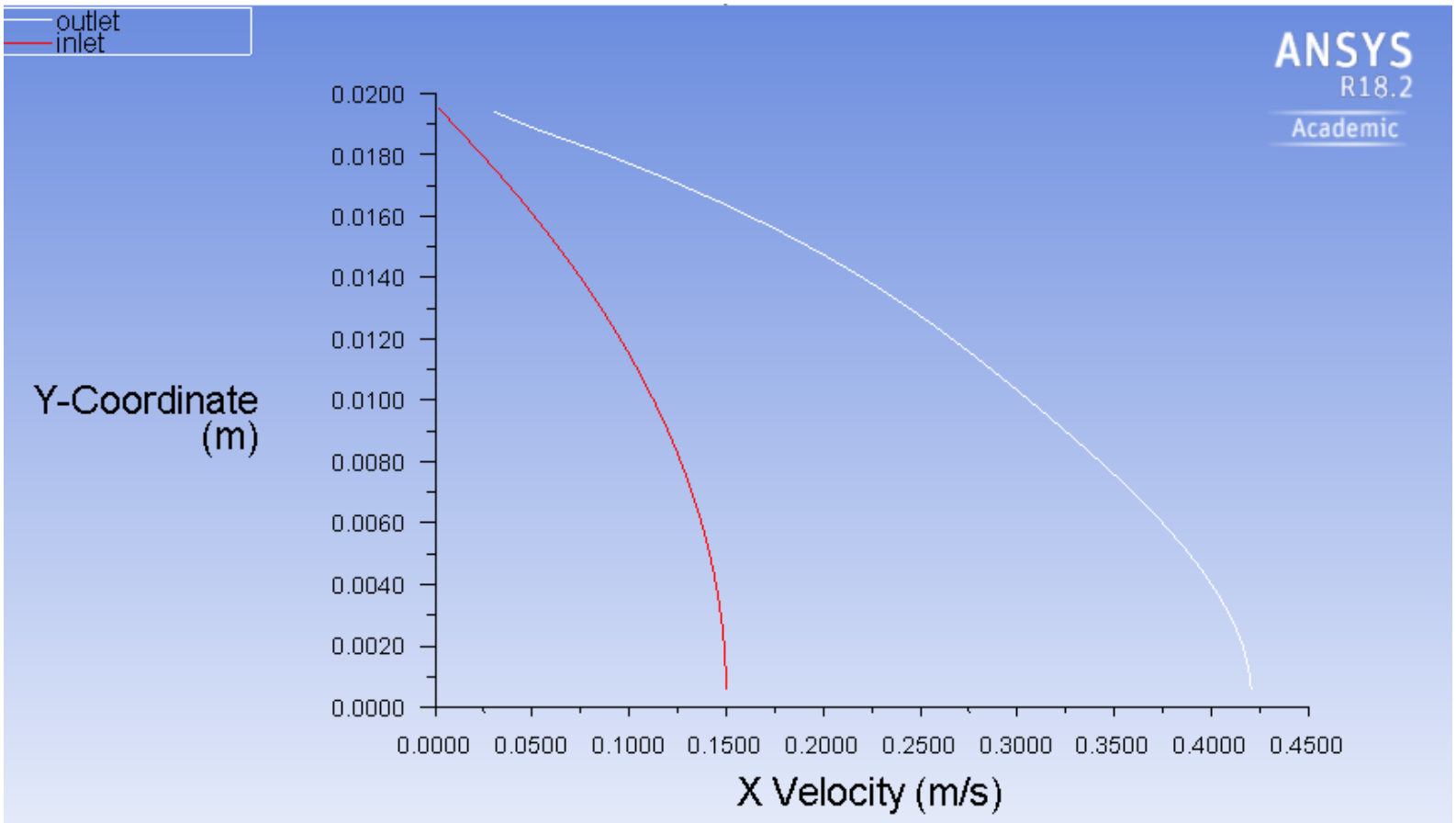

Inlet (red) and outlet (white) axial velocity profiles

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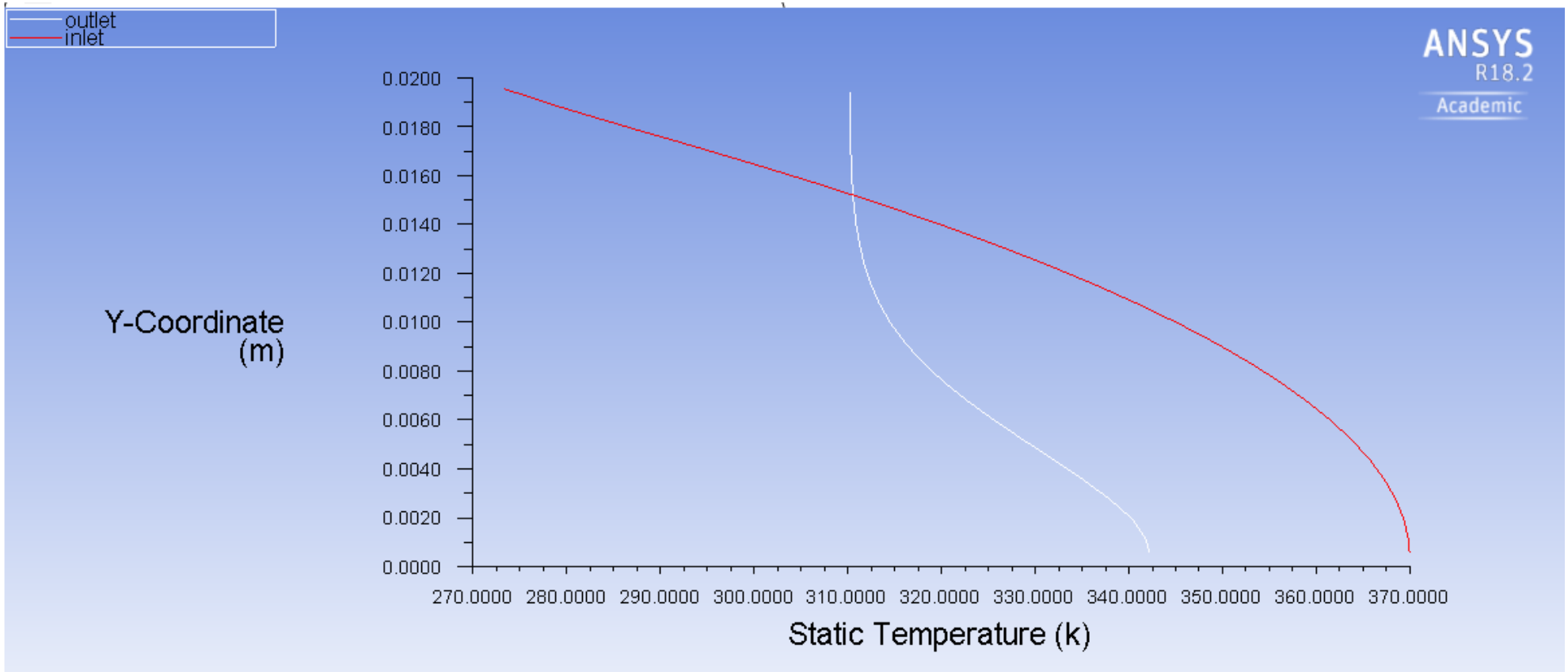
Baseline configuration : all injection velocities set to 0.15 m/s, all injection temperatures set to 310 K, Xdir1 (hole 1) = -1, Xdir2 (hole 2) = 0, Xdir3 (hole 3) = +1



Inlet (red) and outlet (white) static temperature profiles

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Outlet parameter *dt_outlet* is defined as the discrete integral of the temperature difference *dt* |T-320| along the outlet boundary.

Minimizing f_1=*dt_outlet* ensures the outlet temperature distribution will be as close as possible to a uniform T=320 K temperature profile along the channel outlet boundary.

Outlet parameter *cost* is defined as the discrete integral of the custom field *local_cost* along the injection boundaries. *Local_cost* is computed as the product of the velocity magnitude and the temperature difference |T-320|.

Minimizing f_2=*cost* ensures the cost of the control strategy will be minimized, assuming T=320 K is the base temperature of the air reservoir which is used to feed the injection holes .

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The 9 design parameters or input control parameters are respectively :

- the 3 injection velocities free to vary between 0 and 0.3 m/s
- the 3 injection temperature levels free to vary between 250 K and 370 K
- the 3 X-directions for the injected fluid at each injection hole, free to vary between -1 and +1 (the Y-direction is prescribed for each hole equal to -1).

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Question #1 :

Find the combination of input control parameters minimizing the difference between the temperature along the channel outlet and a target uniform temperature distribution T=320 K along the outlet.

You will use the optimization method / tool of your choice.

The answer to the question will be graded based on :

- the quality of the explanations provided regarding the choice of the method, the steps followed to apply the method and obtain results,
- the quality of the proposed optimum,
- the physical analysis of the proposed optimal solution.

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Question #2 :

Let f_1 be the previously minimized objective function, that is the function defined as the difference between the temperature along the channel outlet and a target uniform temperature distribution T=320 K along the outlet.

Let f_2 be a second objective function representative of the control cost. f_2 is defined as the sum of the product between the injection velocity magnitude at each hole and the absolute value of the difference between the injection temperature at each hole and the reference temperature T=320 K. This sum is directly representative of the cost of the control strategy.

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Question #2 :

Find the combination of input control parameters simultaneously minimizing the objective functions f_1 and f_2.
If the objective functions are found to be conflicting, provide at least 5 designs from the global Pareto set / front solution of the problem.
Physically analyze 3 designs along this Pareto front.

You will use the optimization method / tool of your choice.

The answer to the question will be graded based on :

- the quality of the explanations provided regarding the choice of the method, the steps followed to apply it and obtain results,
- the quality of the proposed optima,
- the physical analysis of the proposed optimal solutions.

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Practical requirements :

The class includes 33 students, among which 9 from the Aerospace Engineering master (M1 level).

You will form :
15 groups of 2 students and 1 single group of 3 students.
Each group will include at most 1 student from the AE master.

The deadline to return your report is : Friday the 19th of April 2018.

The report will be uploaded on the course website using the "Assignments" tool, as a pdf file.