MAE560/460 Applied CFD, Fall 2022, Project 1 discussion

Task 1

See reference solutions for detailed plots and tables.

For this task, the outlet temperature exhibits a range of variation, depending on mesh resolution. For Task 1a, about 40% of students in the class found T_{out} within the range of 291.4K-292.2K, and 62% reported T_{out} in the range of 291.0K-292.6K. This range of variation is slightly wider than what we experienced in previous years for a similar task. One of the possible reasons is that, for simplicity, this year we neglected to check "buoyancy effect" for the k-epsilon model. (This is in the spirit of keeping things simple, minimizing the number of knobs to turn.) While the "cool waterfall" coming from the inlet can still be simulated without this effect, turning it off makes heat transfer in the bottom boundary layer less efficient, leading to a stronger temperature gradient there. With that, the results become more sensitive to the mesh resolution near the bottom. Nevertheless, the patterns of velocity and temperature fields are broadly consistent across the majority of the reports. For some outliers (mainly with T_{out} significantly above the aforementioned range), we tested and found the results to be reproducible, and full credits are given.

Similar remarks also apply to Task 1b. For that task, 42% of students obtained T_{out} in the range of 289.4K-290.2K, and 67% reported T_{out} in the range of 289.0K-290.6K. The value of T_{out} for Task 1b is robustly lower than its counterpart for Task 1a.

For T_{out} vs. number of iteration, some students produced a smooth curve with a monotonic increase of T_{out}, while the others produced a curve with various degrees of fluctuation (see the two reference solutions for examples). We are able to reproduce both behaviors, depending on the choice of mesh. We will discuss this point in class.

Task 2 and 3 are relatively more straightforward. We will discuss the solutions in class. Please also see reference solutions for further detail. For Task 3, it is worth noting that the air jet that emerges in the outer chamber is almost as narrow as the neck of the device. To resolve this structure, high-resolution mesh is needed not only within the neck but also over the interior of the outer chamber where the jet is located. Many students overlooked this point, such that the simulated jet is too weak or does not sustain a tight structure through the outer chamber.