Mini Project 1: Train on fire

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The considered system consists of an underground train station and the tunnel in which a train is burning at rest, 80 meters from the station entry. The fire, situated in the center of the train acts as heat and smoke source. The station is equipped with a security ventilation system (SVS) which is supposed to guarantee a safe walk from the burning train to the station for any passengers.

As a first step, the simulated temperature field has been considered, see Fig 1. One can easily identify the heat source in the middle of the train, on the right of the figure. The asymmetric distribution of the hot air (red) around the train shows that there is a flow away from the station. In order to study the properties of the air flow, streamlines are computed. As seen in Fig 2, the flow of the air entering at the station mainly consists of a vortex around the axis of the tunnel. From the vortex, the air is then pushed towards the exits of the tunnels in both directions.

Having a look at the velocity and smoke distribution along a slice of the tunnel in front of the train, one sees in Fig 3 that the smoke concentrated at the roof of the tunnel slows down the air. Note the no-slip condition, which assures that the velocity at the boundaries (tunnel walls) is zero.

In Fig 4 and 5 the velocity components orthogonal to the tunnel axis are shown. These components are two orders of magnitude smaller than the X-component. The flow is thus strongly directed parallel to the tunnel.

The performance of the SVS, generating the air flow from the station to the exits of the tunnel, is studied by considering the region of the fire in the train.

Fig 6 shows the temperature field in the region of the fire in the train. It is remarkable that the temperature at the exit of the train, where the fire is, decreases this rapidly when leaving the train along the Z-direction. Once outside the train, passengers can walk to the station along the minus X-direction being exposed to temperatures of only 17°C. Note that the surface of the train is significantly hotter towards the exit of the tunnel. This asymmetry is obviously caused by the SVS.

A crucial quantity regarding the safety of the passengers walking to the station is the smoke concentration. Fig 7 shows how the smoke is kept at the roof of the tunnel. The streamlines and the smoke concentration indicate that in the region just behind the fire the smoke gets down to mid height of the train, which would still be sufficiently high for passengers to walk below the concentrated smoke. On the other side of the fire, towards the station, the smoke is only present on the roof as it has been shown in Fig 3.

The SVS is effectively transporting heat and smoke towards the exits of the tunnels. What still needs to be verified is that the air velocity in the tunnel is not too strong, so that it is possible for humans to walk against the air flow. The velocities reaching up to 2.2 m/s are well below the velocity of stronger winds having more than 8 m/s .

As a conclusion the SVS is fulfilling its job satisfactory and assures a safe walk from the train to the station, at room temperature, low smoke concentration and sufficiently low air velocities.

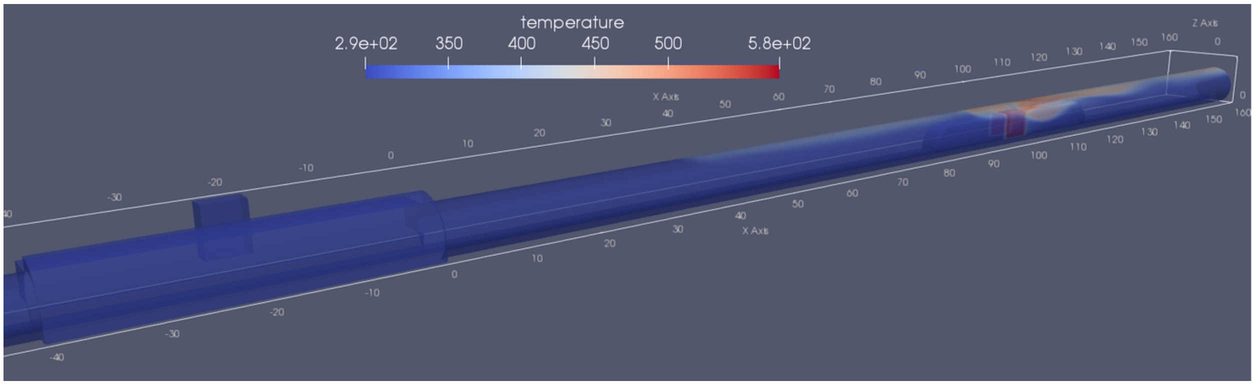

Figure 1: Temperature field of the station and the tunnel where the train is situated.

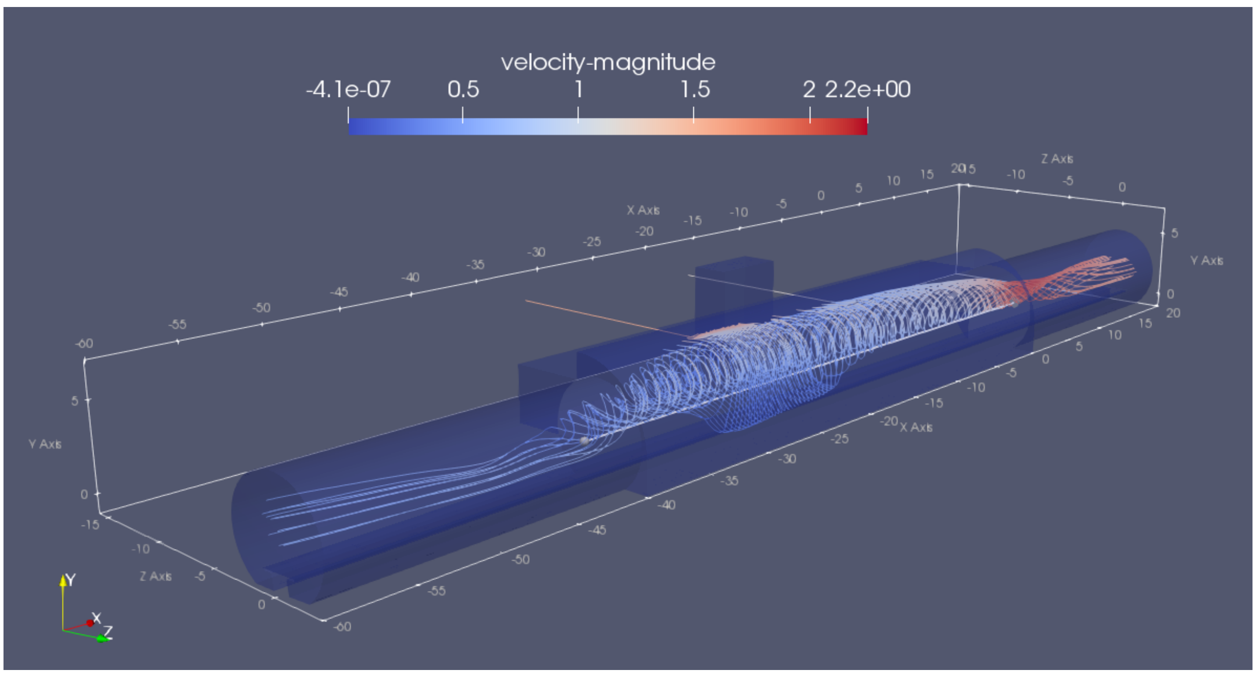

Figure 2: Vortex created by fresh air at the station

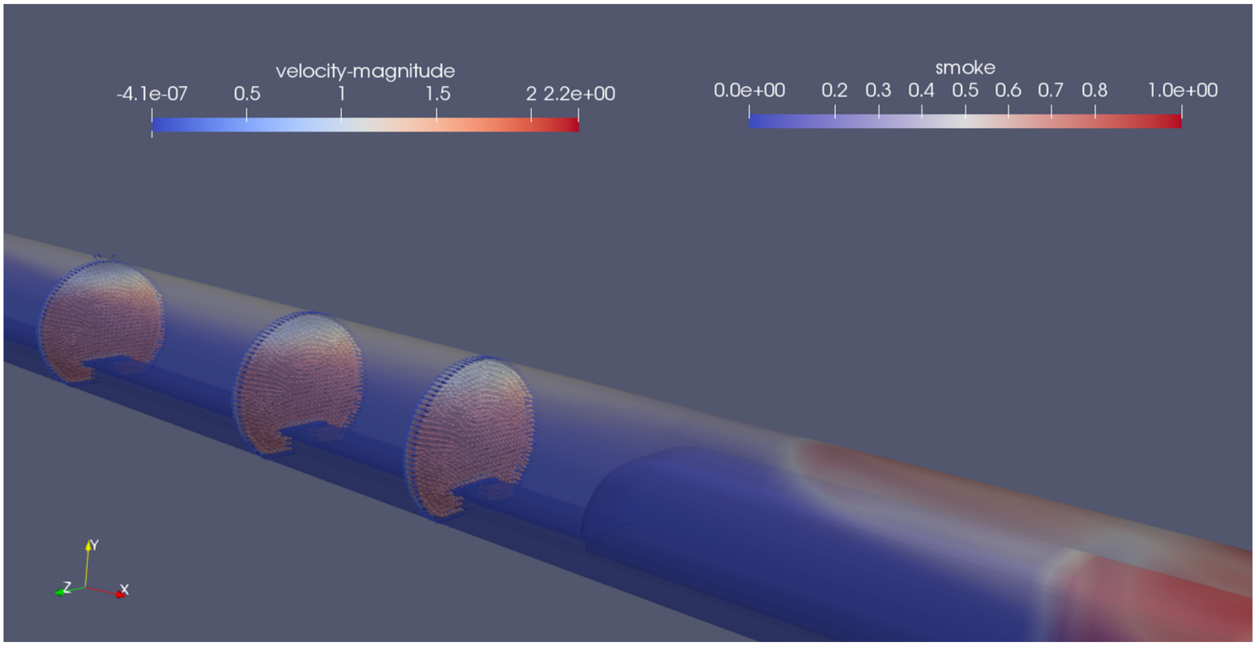

Figure 3: Velocity profiles in front of the train. The smoke on the roof slows the air down.

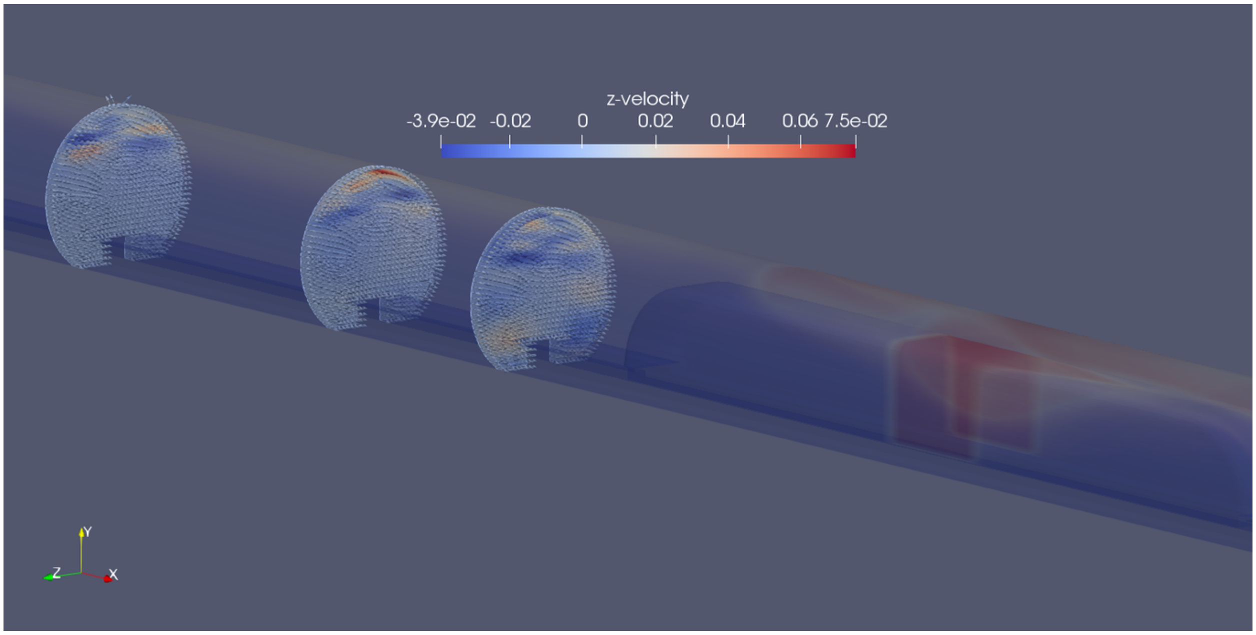

Figure 4: Z-component of velocity

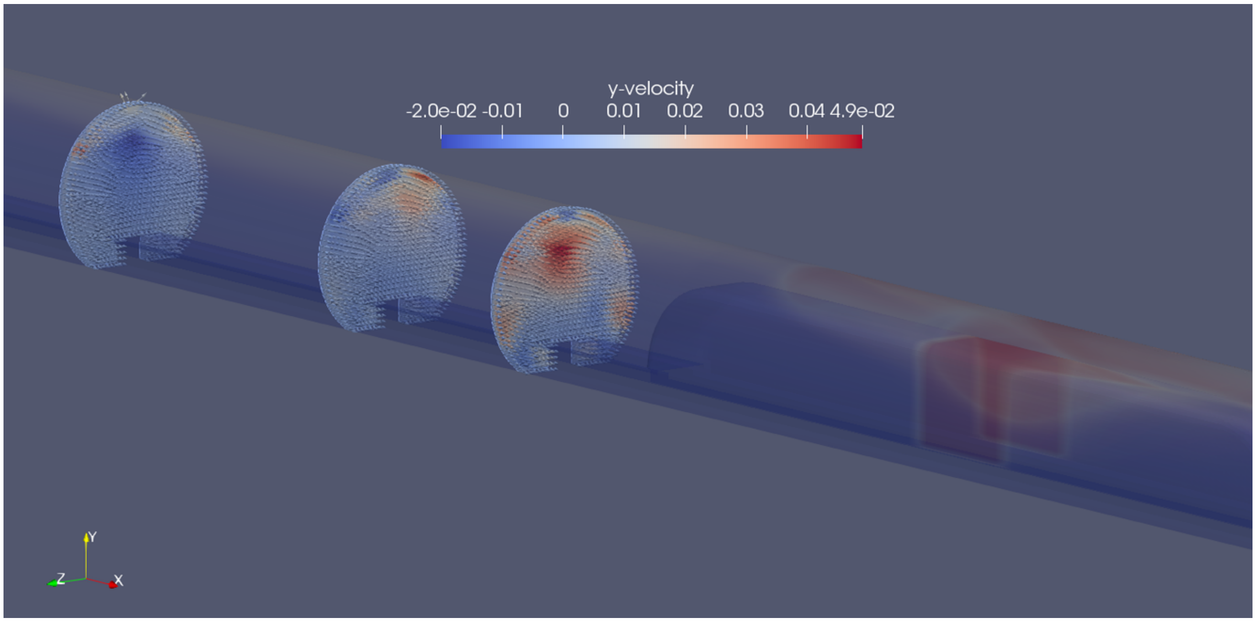

Figure 5: Y-component of the velocity

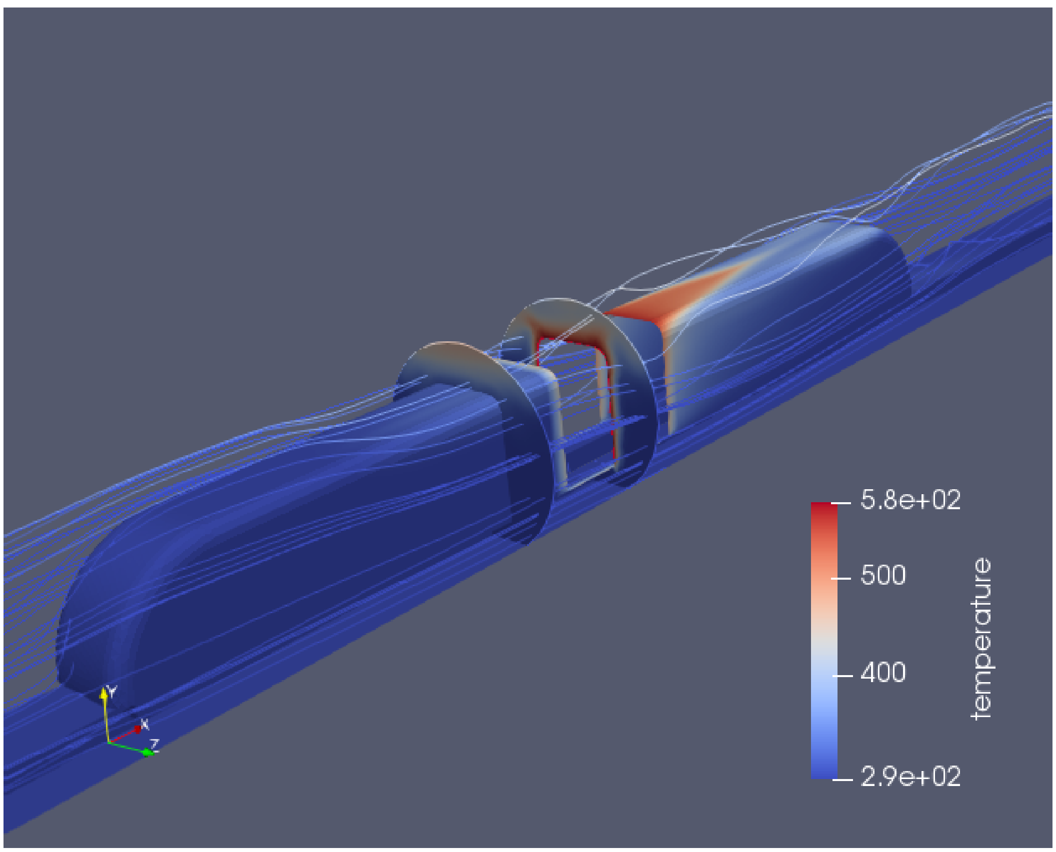

Figure 6: Temperature field on the surface of the train and slices of air with streamlines.

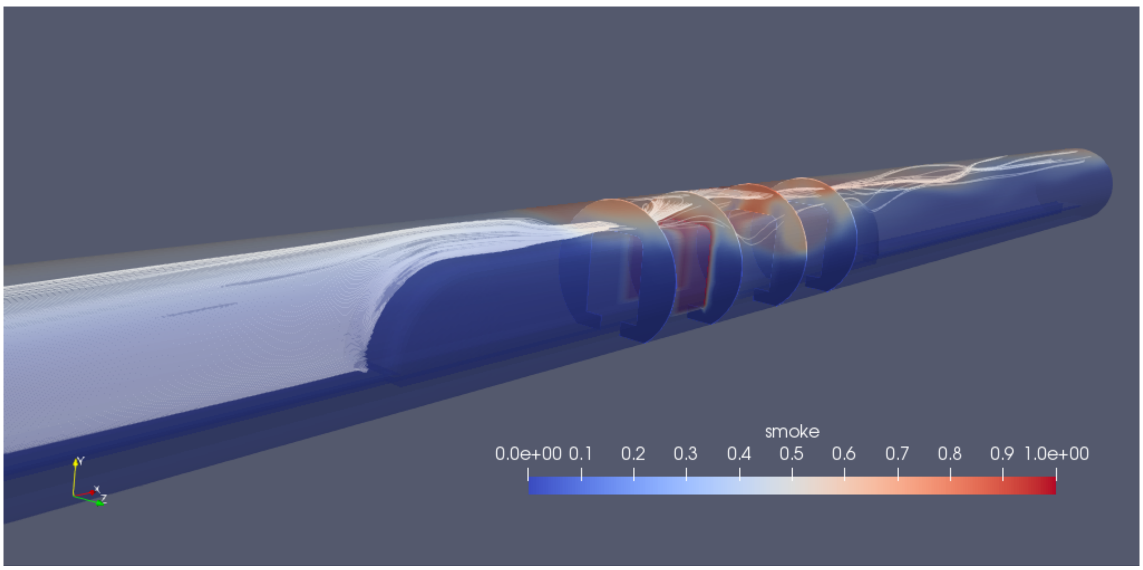

Figure 7: Smoke concentration in the region around the fire in the train