Numerical Analysis of the Temperature Distribution in a Subway Tunnel

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Only a few technical modifications are required to use a tunnel as a geothermal source or sink for heating and cooling purposes. This idea is realized in the GeoTU6 project with a geothermal test section inside the Fasanenhof subway tunnel in Stuttgart, Germany. Two tunnel sections are equipped with absorber pipes along a length of 10 meters. The pipes are linked with a heat pump situated in a control room nearby. The tunnel is equipped with measuring devices to determine the temperature fields in the ground, the tunnel lining and the tunnel air. In addition, the tunnel air velocity is measured. The research priority is to investigate how the tunnel air influences the amount of extracted energy of the absorber system.

1 Introduction

Computational fluid dynamics (CFD) is performed to investigate the influence of the tunnel air temperature in dependence on various parameters. Steady state simulation results are compared with experimental data from the on-site measurements. Based on simulation and measurement results, an approximation equation is to be deduced for the tunnel air temperature in dependence of the above mentioned parameters. A 3D representation, containing tunnel air, tunnel lining and surrounding ground is created. The tunnel has a length close to 360 meters. The geometry can be seen in Figure 1. A mesh is generated which contains about 30 million cells. The simulations are performed with OpenFOAM version 2.4. The boundary conditions for the CFD simulations are taken from on-site measurements.

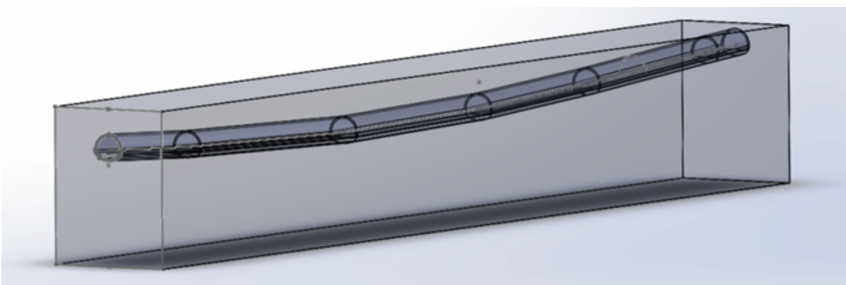

Figure 1: Computational domain of the model

2 Resources

The simulations are performed on the parallel cluster ForHLR I which is situated at the Karlsruhe Institute of Technology in Germany. It is a distributed memory parallel computer and the simulation cases are run on 20-way Intel Xeon compute nodes. Each node has 64 GB of main memory. In order to investigate the appropriate number of compute cores to be used for the numerical investigations a scalability analysis is performed. During this analysis several simulations with a varying number of compute cores are performed. 200 compute cores are selected for the performed simulations, which is equal to 10 nodes. This means that the 30 million mesh cells will be distributed on these cores, leading to approximately 150,000 cells per compute core. The simulations have an approximate simulation time of 21 hours. This leads to a total of 4200 core hours per simulation.

3 Results and Discussion

Qualitative simulation results of the tunnel air temperature distribution and the temperature field of its surroundings can be seen in Figure 2 for the cases November 2014 to March 2015. The temperatures are displayed on a plane going through the middle of the tunnel. It can be seen how the difference in tunnel and soil temperature varies during the year.

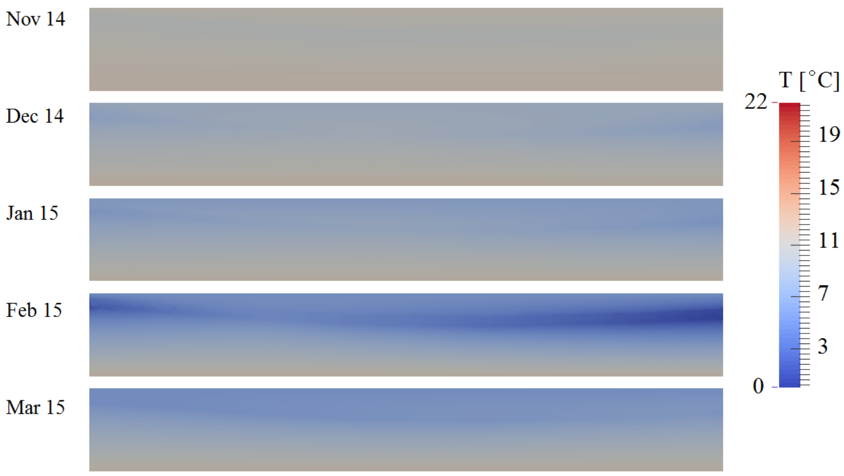

Figure 2: Temperature distribution of tunnel air and surroundings (November 2014 - March 2015)

4 Conclusions

Further simulations and validation will give a closer insight on how well the temperature distribution inside the tunnel is captured by the numerical model.

Acknowledgements

The project is supported by the Federal Ministry for Economic Affairs and Energy and the Stuttgarter Straßenbahnen.