Using OpenFOAM for Ventilation Design

- Ventilation Design of Road Tunnels and Underground Stations

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Abstract

ILF Consulting Engineers (ILF Beratende Ingenieure ZT GmbH) runs three-dimensional flow simulations with *OpenFOAM* in order to design ventilation systems for any type of complex cavern in road tunnels and underground railway stations beside of analytical methods since two years. ILF Consulting Engineers uses *OpenFOAM* together with the open-source mesh generation software *enGrid* and the open-source 3D computer graphics software *Blender* to perform CFD simulations.

Within the overall design process, 3D CFD calculations with *OpenFOAM* augment conventional methods like one-dimensional analytical pressure loss calculations defining the fan performance. Of course, the 3D flow simulation is primarily necessary to evaluate the character of the three-dimensional flow. In complex caverns, several cross section changes and direction changes create a real 3D situation. To reduce the pressure performance of exhaust fans in direction changes, turning vanes are installed. The geometry of air conducting facilities is designed using the 3D computer graphic software *Blender*. It offers the possibility to easily generate a structured surface mesh for critical elements like turning vanes and cylindrical components. The remaining surface elements are meshed in an unstructured manner using the mesh generation software *enGrid*. *enGrid* is also used to generate the volume mesh.

The general procedure of mesh generation and numerical solving of a typical ventilation problem is exemplified with the help of a current project of the ILF Consulting Engineers, namely the design of the ventilation system for the Bosruck tunnel. The Bosruck tunnel is a 5,509 m long road tunnel which is part of the Austrian Pyhrn motorway connecting Spital am Pyhrn in Upper Austria and Liezen in Styria. In order to investigate the flow situation near working jet fans, a separate 3D CFD study is produced. Momentum sources are used to simulate the jet fans. The outlet velocity is much higher than the tolerable limits stated in the respective guidelines.

For the design of a tunnel ventilation system, the fire event is very relevant for CFD simulation. Different guidelines describe boundary conditions for a fire event. ILF Consulting Engineers produces a 3D CFD investigation of a longitudinally ventilated tunnel for the Austrian Federal Ministry of Transport, Innovation and Technology. The investigation is carried out with a transient solver due to changing heat release and radial heat conduction. A modified version of the chtMultiRegionFoam solver was created to include volumetric heat sources in a conjugate heat transfer simulation. The results of this investigation can have a significant impact on a new revision of the Austrian Tunnel Guideline.

Key words: Ventilation Design, Road Tunnel, Mesh Generation, Impulse Source, Radial Heat Conduction