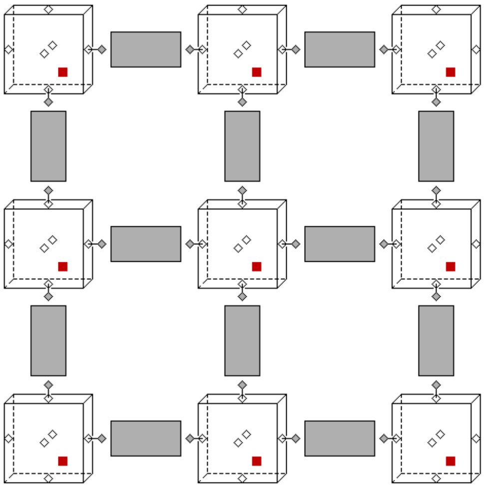
VEPZO – Velocity Propagating Zonal Model for the prediction of air-flow pattern and temperature distribution in enclosed spaces

Victor Norrefeldt Gunnar Grün
Fraunhofer-Institute for Building Physics
Fraunhoferstr. 10, 83626 Valley, Germany
victor.norrefeldt@ibp.fraunhofer.de gunnar.gruen@ibp.fraunhofer.de



This paper presents the VEPZO-model (VElocity Propagating ZOnal model), the first three dimensional airflow model for indoor spaces that has been implemented in Modelica. It is developed from the idea of zonal models. A zonal model divides a room into typically 10 to 100 zones exchanging air through flow paths. Zonal models are a compromise between the computational speed provided by the assumption of a perfectly mixed air volume and the high local resolution provided by computational fluid dynamics.

The model predicts airflow and temperature distribution in a room. Former zonal models incorporate the assumption that air rests in the zones and only moves in the flow paths. Therefore, driving airflows resulting from a jet or plume need to be described by special correlations instead of the zonal model. Once the velocity in the correlation is dissipated below a certain threshold, the zonal model is used again. A Modelica implementation of this suggestion would require the model to change its set of equations during runtime to be able to switch from the zonal model to a correlation model where needed. However, this structural dynamics is currently not foreseen in Modelica.

The VEPZO model considers the airflow velocity as a further property of the zone which results from the incoming and leaving airflows. This property is propagated to the flow models. By this procedure, driving airflows are carried into space. Furthermore, the acceleration of airflow is computed in the flow models. This acceleration results from forces acting on the flow path. Losses of the airflow are modeled by an increased viscosity (0.001 Pa·s) similar to the idea of turbulent viscosity.

The VEPZO model uses components like the air models from the Modelica.Standard library. Furthermore, it allows interfacing to components by e.g. using the standardized heat connector.

In an application example a displacement ventilation of a twin-aisle aircraft cabin is investigated. The VEPZO model shows a quick prediction of the temperature distribution in the cabin. With the displacement ventilation a comfortable thermal environment can be achieved.

The use of Modelica to solve this problem showed to be advantageous as many of the auxiliary components (walls, air in other compartments, air properties in zones) are represented with predefined models allowing the research engineer to concentrate on the core of the development, in this case the VEPZO model.