Compressible Flow Modelling Applied to Depressurization Process

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Abstract

In order to predict and optimize the design of pipes and reservoirs during a depressurization process, the gas behavior must be precisely understood. Numerical modeling is an effective tool to study and understand the effect of each gas properties on the gas behavior. Nevertheless, compressible flow modeling still remains quite challenging, especially when the Mach number is close to one.

In order to simplify the problem, a 1D-model is developed in COMSOL Multiphysics® by using the Nonisothermal Pipe Flow physics interface. The ability to model compressible flow is firstly shown by developing a "study case", based on many assumptions. Numerical results are confronted to analytical results to validate this model.
Secondly, the same approach is used to predict the evolution of thermodynamics variables (temperature, pressure, density…) during gas expansion in a depressurization process. The geometry is composed of two reservoirs connected by a thin tube. The gas is highly pressurized in the first reservoir and expands brutally in the second. Both reservoirs are modeled by "Point Ordinary Differential Equations". Mass and energy balances are performed to solve the gas evolution in reservoirs and tanks. The transient problem is solved and different operating conditions are studied by varying the pipe diameter and the high pressure values. Numerical results, as shown in Figure 1, are studied and finally compared with experimental trends.

Figures used in the abstract

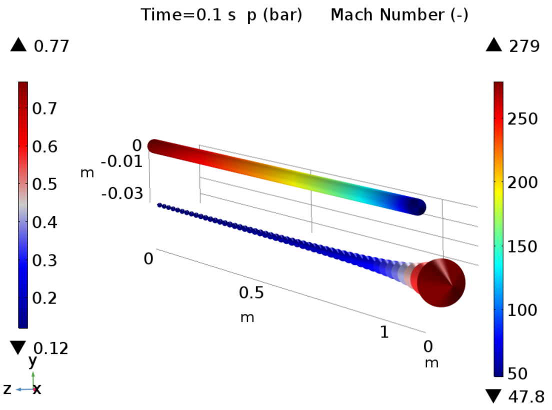

Figure 1: Pressure (color) and Mach number (colored arrows) in the pipe.