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# A Parametric Study of Shock Wave Simulations with Help of COMSOL Multiphysics®

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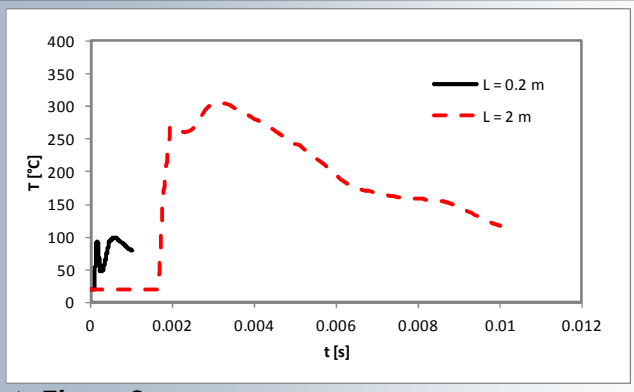
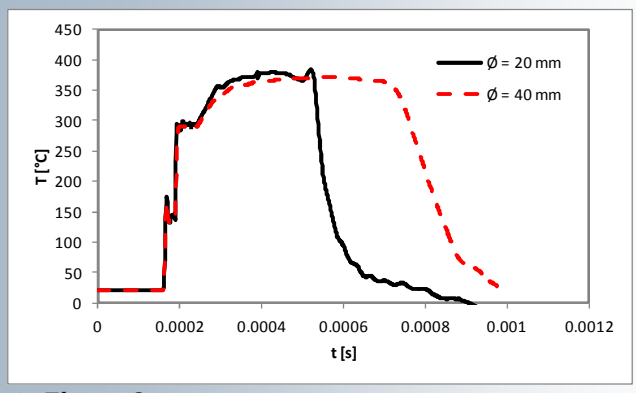
## Introduction

Shock wave simulations (Figure 1) have been carried out with COMSOL Multiphysics® v4.2 with the "High Mach Flow Module", in order to better appreciate experimental results from adiabatic compression tests with tetrafluoroethylene (Meyer, 2009). With help of the computations performed, it was possible to perform a parametric study and to analyze the effect of the pipe length and diameter on the shock wave evolution (Figures 2 and 3).

## Parametric study

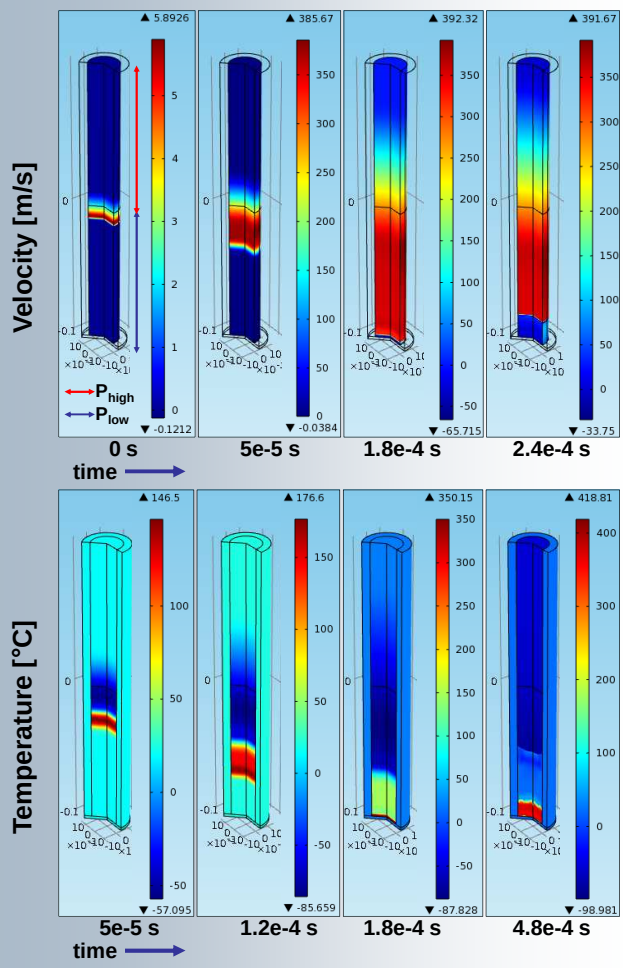



▲ *Figure 2:*
Average temperature over time in the 50 mm zone above the pipe end for simulations of pipelines with two different lengths (settings as Figure 1).




▲ *Figure 3:*
Temperature over time on the pipeline axis at 5 mm from the pipe end for two different diameters. The plateaus in the curves indicate the predicted temperatures of the reflected wave (pipe length 0.2 m, settings as Figure 1, except for heat transfer at the wall with a constant temperature 20 °C).

## Shock wave simulations




▲ *Figure 1:*
Shock wave simulations in a 0.2-m-pipeline of 20 mm in diameter with the following settings:
- high pressure section: nitrogen initially at 20 bara;
- low pressure section: nitrogen initially at 1 bara;
- initial temperature of the system: 20 °C;
- adiabatic walls with slip condition for the flow;
- laminar flow.

The shock wave generation and propagation has been properly computed and the its physical properties reflected the predictions of the Rankine-Hugoniot equations (see Lamnaouer, 2004 for the equation system).

## Discussion

From the parametric study it was observed that higher average temperatures are achieved and maintained for a longer time if the pipe length increases (Figure 2). On the other hand, Figure 3 shows that the temperature of the reflected wave holds longer, if the pipe diameter is larger, due to minor heat losses. The simulations performed were useful for the definition of a further test series yet to be performed, with the aim of achieving reproducible ignitions of tetrafluoroethylene induced by adiabatic compression.

## Literature

[1] Meyer R. Untersuchung des Zündverhaltens des Tetrafluorethens (TFE) durch adiabatische Kompression. Thesis. BAM Federal Institute for Materials Research and Testing. Berlin. Germany. 2009 (in German).

[2] Lamnaouer M. Numerical modeling of the shock tube flow fields before and during ignition delay time experiments at practical conditions. PhD Thesis. University of Central Florida. 2004.

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