Impact of a tire fire on an LPG tank

The accident analysis shows that different truck tire fires have occurred in recent years, some resulting in the death of the driver due to the tire explosion. In the case of a tank containing LPG, it also raises the question of the risk of BLEVE during a tire fire.

In this context, FASIS (Industrial Safety Facilitators) conducted an experimental and numerical project to study the impact of a tire fire on a tank containing LPG.

Phase 1: Full-scale experiment.

The test was conducted in a test hall. It focused on the burning of tire on an LPG tank with a capacity of approximatively 51 m^3. The tank contained only air for safety reasons.

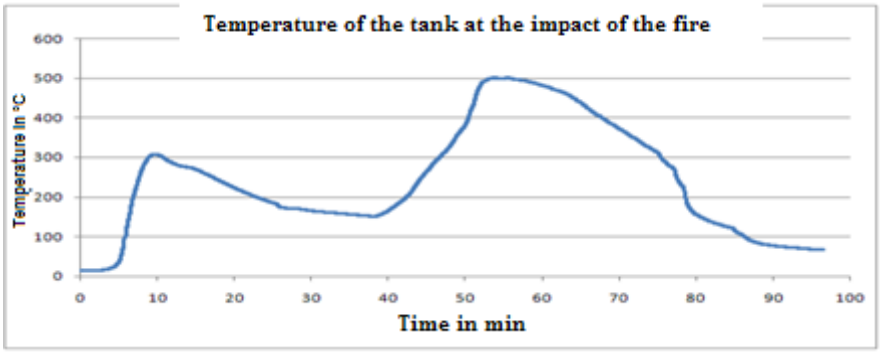
The temperature of the tank wall (inside and outside), the temperature inside the tank and in the environment were measured (forty measurement points). The central tire was first ignited (with 1 liter of heptane).

The experiment revealed two distinct phases. During the first phase, the fire spread from the central tire to the rear tire and then began to diminish until the violent explosion of the central tire (after 25 minutes). Then, the fire began to spread again until the explosion of the second tire (50 minutes).

Fire after 10 minutes

Second explosion

The following curve shows the temperature of the tank, measured at the impact point of the fire above the central tire.



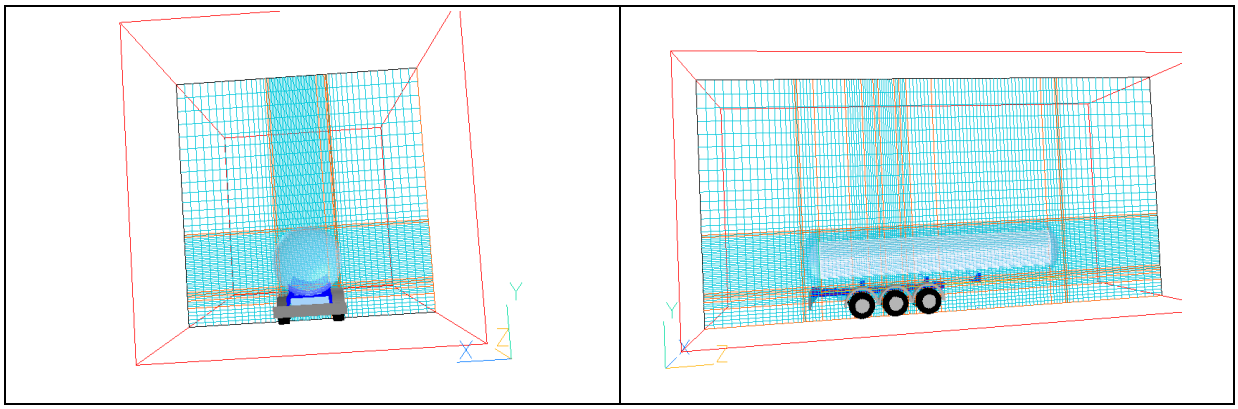
Phase 2 : Numerical approach

The first step was to calibrate Phoenics software with the experiment.

The non stationary Navier-Stokes equations with the Chen and Kim turbulence model were employed.

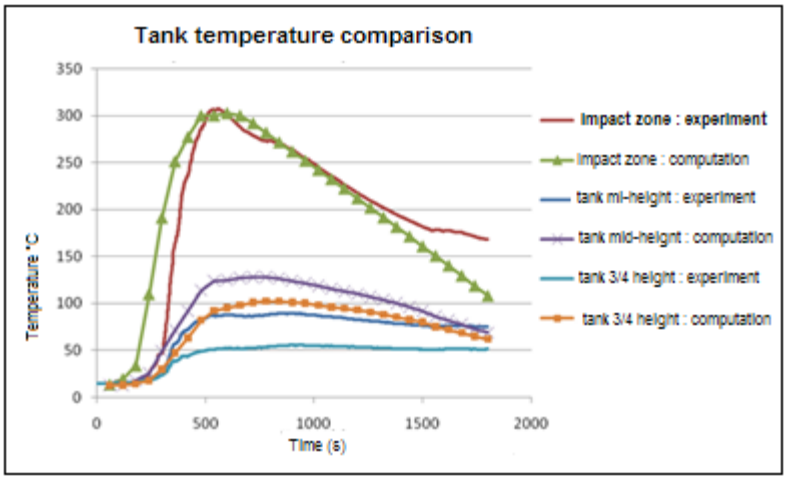
The computation of the conduction through the thickness of the steel presented some difficulties due to its thickness. To remedy the situation, the thickness of the tank was artificially increased by a factor of 10. The steel properties (conductivity, specific heat, density) were modified to reproduce the same heat transfer.

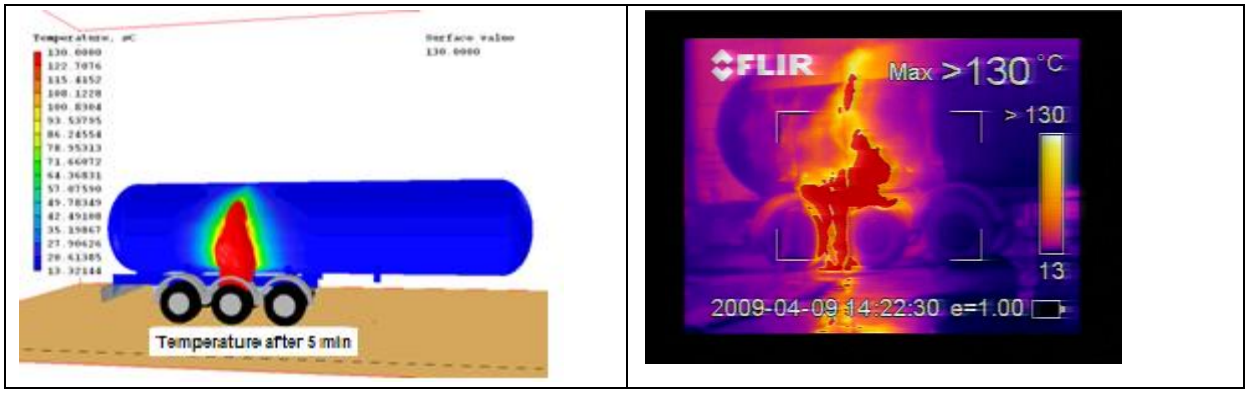
The mesh used was a structured mesh with more than 600 000 cells.



The comparison was made on the first half-hour of the experiment. In the computation, the fire was represented by a volume source term. The heat release rate of the tire was deduced from measurements of heat fluxes.

The following figure presents a comparison of the wall temperature above the central tire. The computation result is in good accordance with the experimental results.

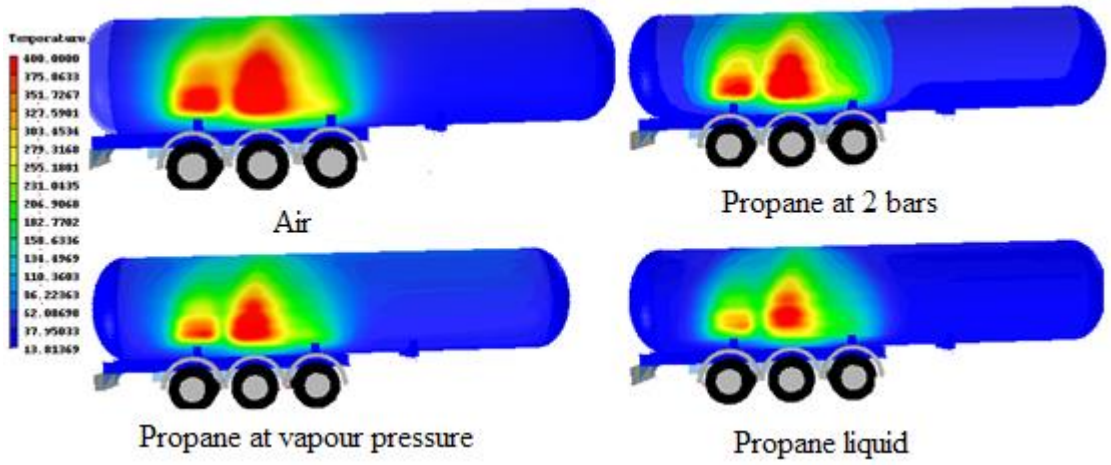




Comparison at 5 min and 10 min : computation and experiment (infra red camera)

After this comparison, we studied the influence of the contents of the tank to the temperature levels. For this, we considered the case of a tank full of propane or butane gas at different pressure levels, full of liquid propane and gas (82% liquid) and full of butane liquid gas (82% liquid). In the case of a tank containing liquid and gas it wasn't considered as a two-phase model. The gas and liquid phases were treated as independent phases.

The following picture represents a comparison of the temperature wall depending on the tank contents.



Conclusion

To study the impact of a tire fire on a tank, a double approach experience-computation was conducted. The comparison with the full-scale showed the ability of Phoenics to model this type of phenomenon. Following the comparison with the experiment, the influence of the tank contents on the temperature levels was explored with Phoenics. However, the model needs to be improved to take into account the phenomena of liquefaction or vaporization inside the tank.