Numerical modeling

that predicts, optimizes and innovates

Optimization of an Explosive Mixture Cooling Process Including a Phase Change

J.-D. Wheeler[1], C. Coulouarn[2], E. Benade[2], P. NAMY[1]

1. SIMTEC, 8 rue Duployé, Grenoble, 38100, France, +33 9 53 51 45 60
jean-david.wheeler@simtecsolution.fr
2. Thales TDA, Thales, La Ferté-Saint-Aubin, 45240, France
christophe.coulouarn@thalesgroup.com

COMSOL CONFERENCE
2017 ROTTERDAM

10/19/2017

SIMTEC, www.simtecsolution.fr

COMSOL Certified Consultant

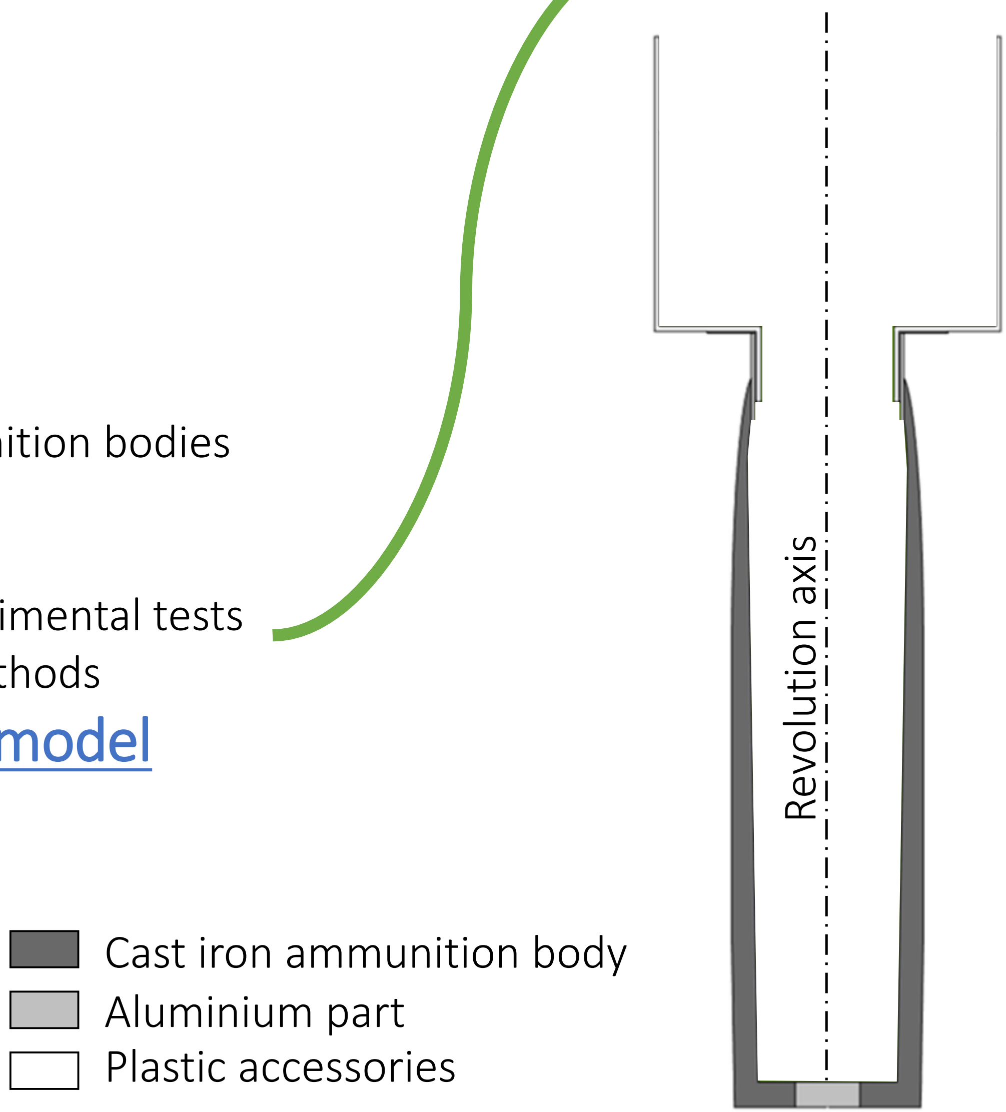
- French company, founded in 2006, 4 Ph. D. Engineers
- Experts in Modeling, COMSOL Certified Consultants:
  - CFD
  - Structural mechanics
  - Electromagnetism
  - Heat transfer
  - Chemical engineering
- Services:
  - Numerical modeling
  - Custom-made training sessions
  - Modeling assistance
- Main Clients:

1. Model description
a) Challenge

Production of the **new** ammunition bodies with melt casting:

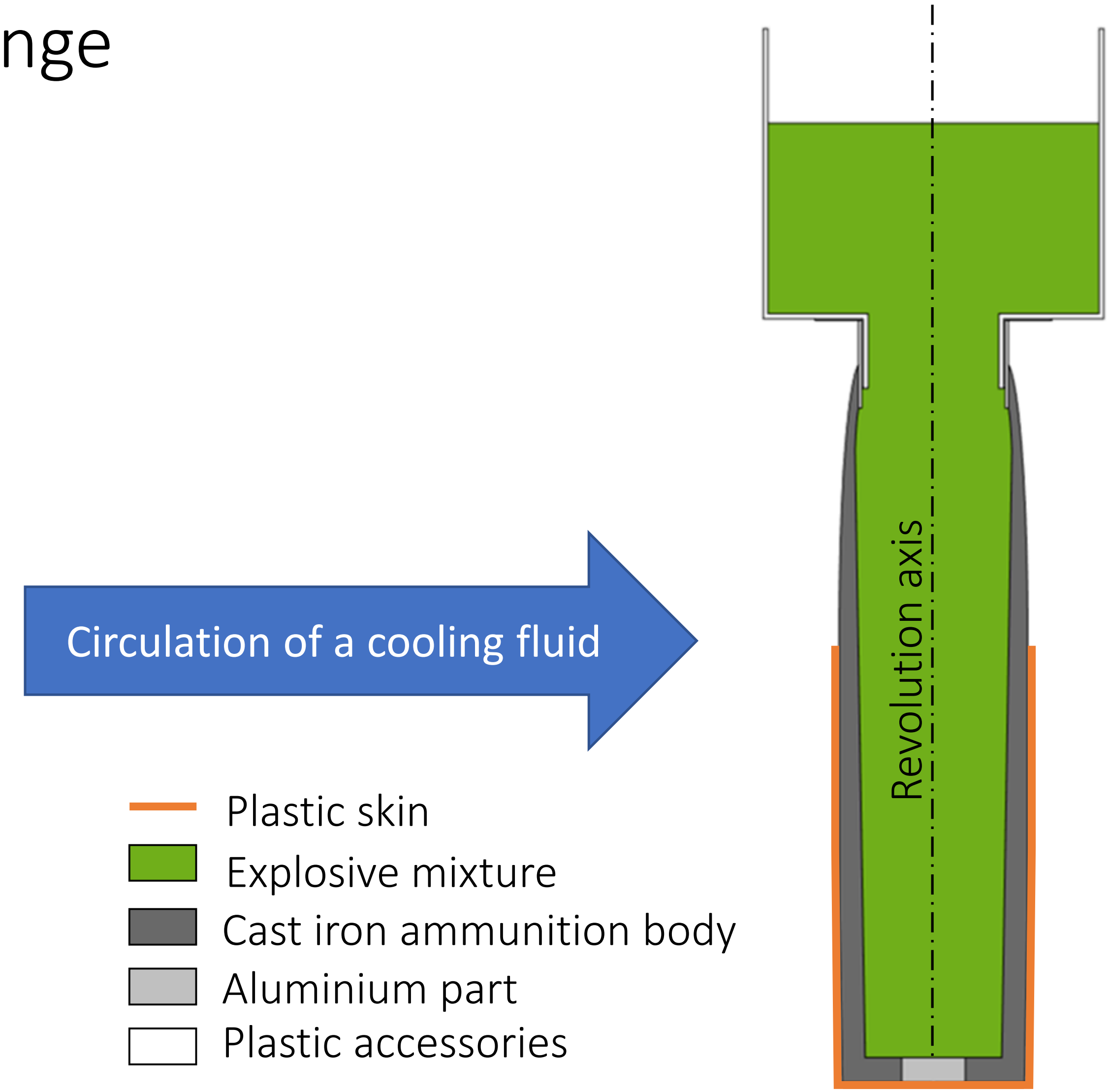
- Good solidification quality
- Minimum amount of experimental tests
- Exploring more cooling methods

→ COMSOL numerical model and application!



Ammunition body with the production accessories

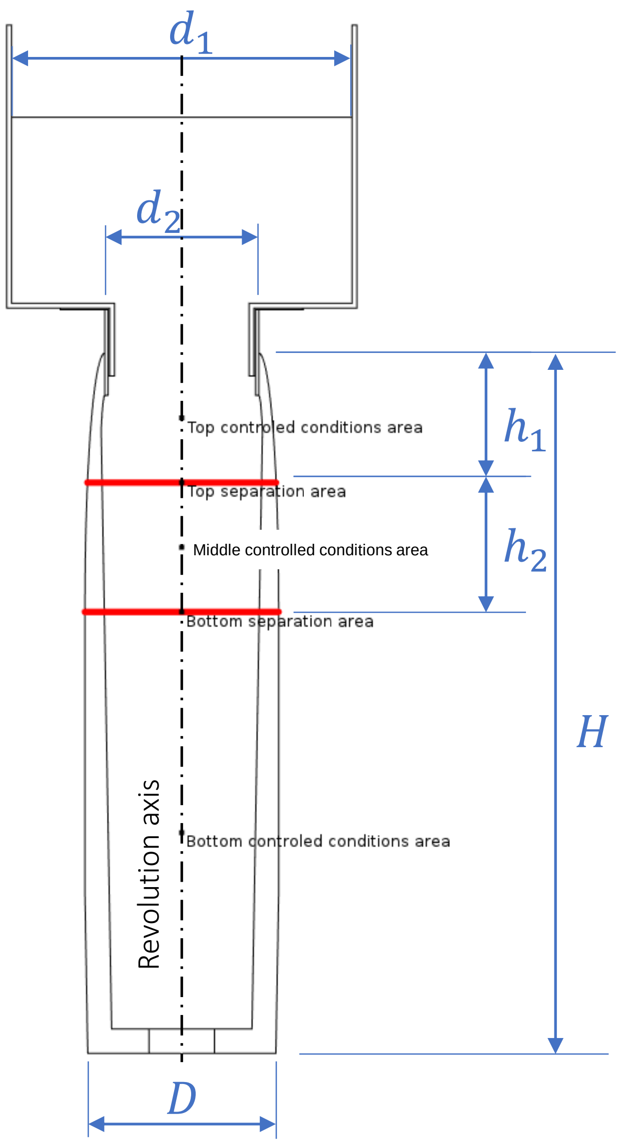
1. Model description
a) Challenge



Ammunition body with the production accessories

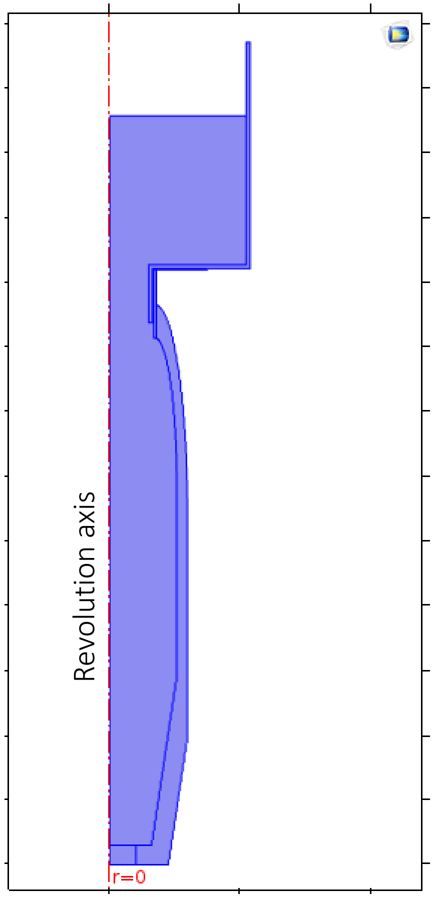
1. Model description
b) Geometry

The geometry is fully parametrised



Ammunition body geometry with the production accessories

1. Model description
c) Physics: the equation



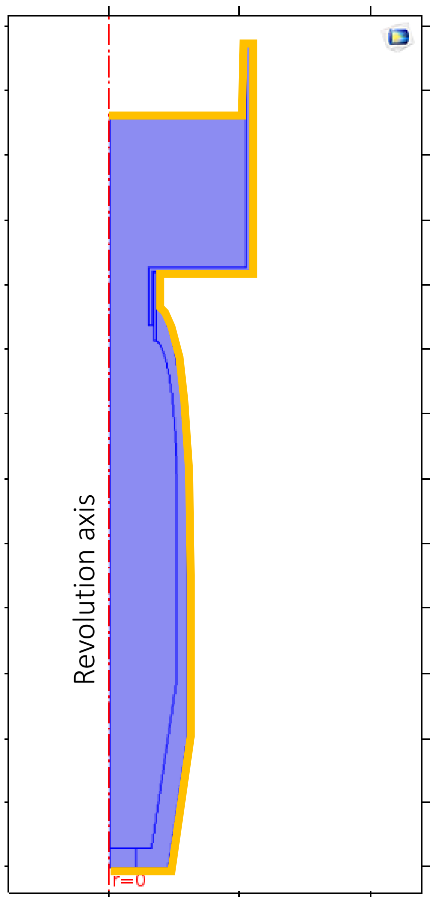
Domain for the heat equation

Axisymmetric model

Heat equation solved:

$$\rho C_p \frac{\partial T}{\partial t} - \nabla.(k\nabla T) = 0$$

1. Model description
d) Physics: the boundary conditions



Boundary condition

Boundary condition: heat flux

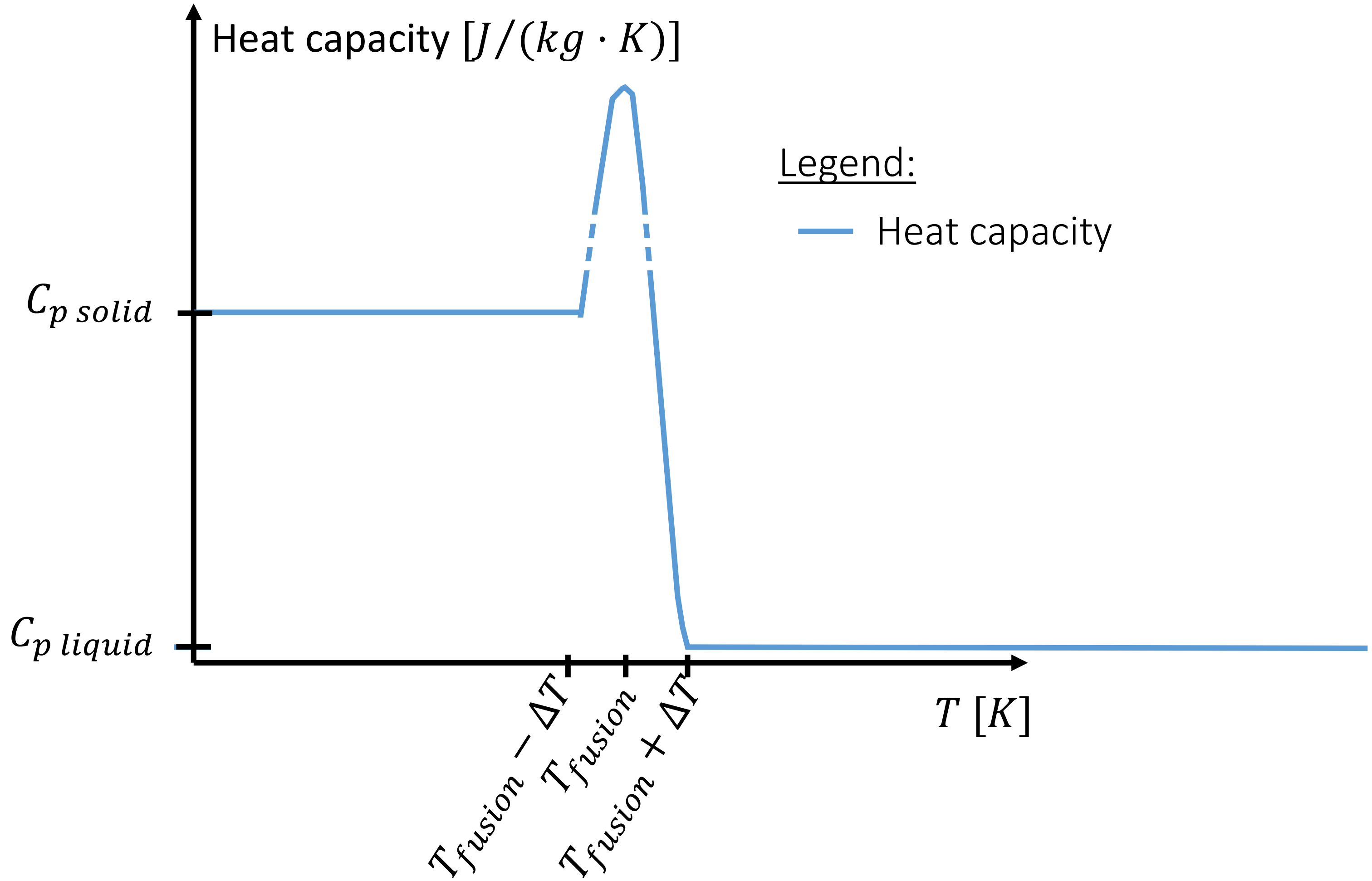
$$q = h \cdot (T_{ext} - T)$$

With h, the HT coefficient which depends on:

- The area of the body
- The time
- The cooling fluid nature
- The cooling fluid velocity
- The cooling fluid temperature
- The convection conditions
- The presence of the plastic skin or not

With T_{ext}, the cooling fluid temperature

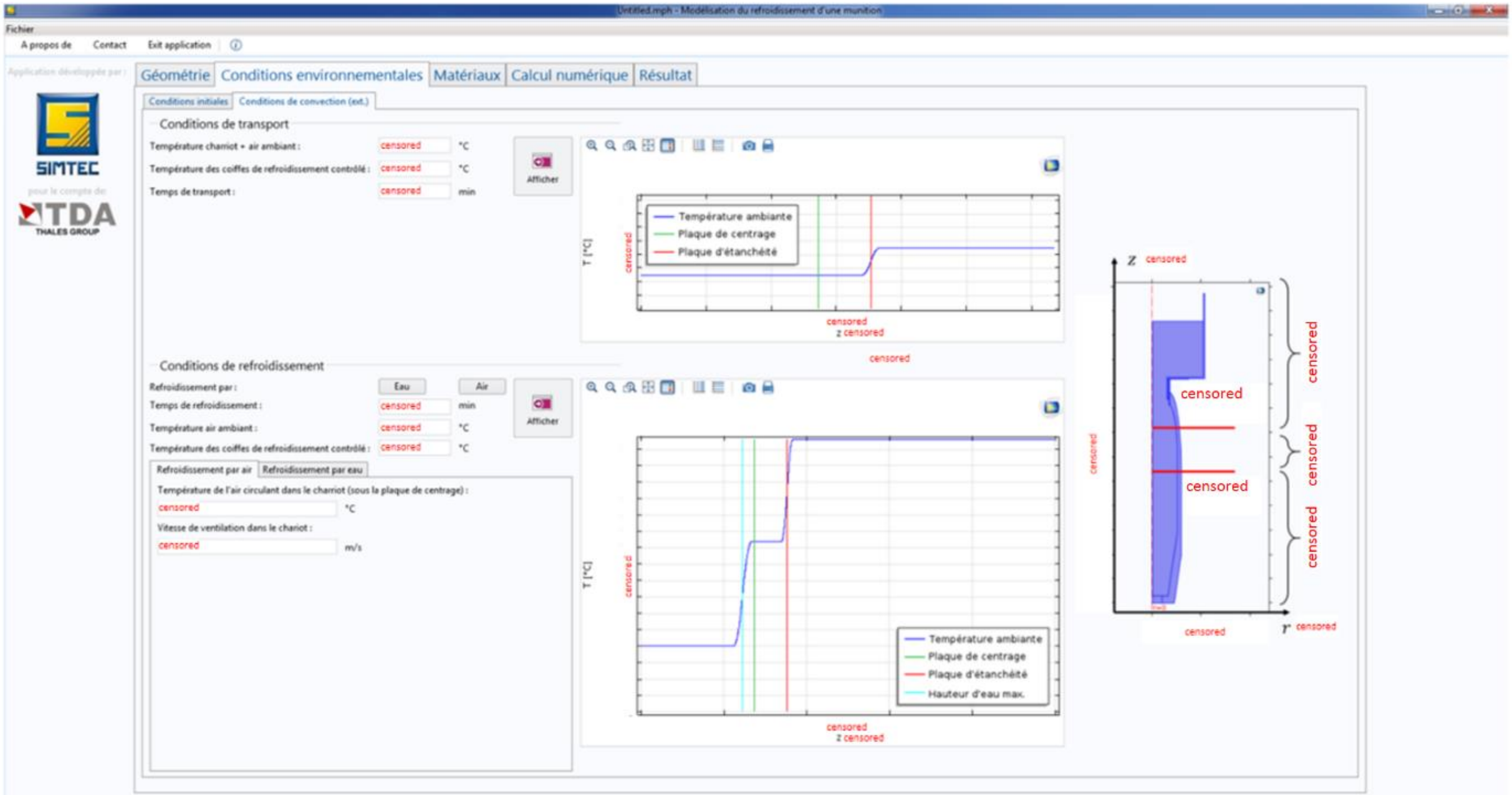
1. Model description
e) Physics: the phase change



Graph of the explosive mixture C_p values which includes the modified C_p method

1. Model description

f) ONLINE HTTPS SECURED APPLICATION!!



Application screenshot: the environmental condition parameters

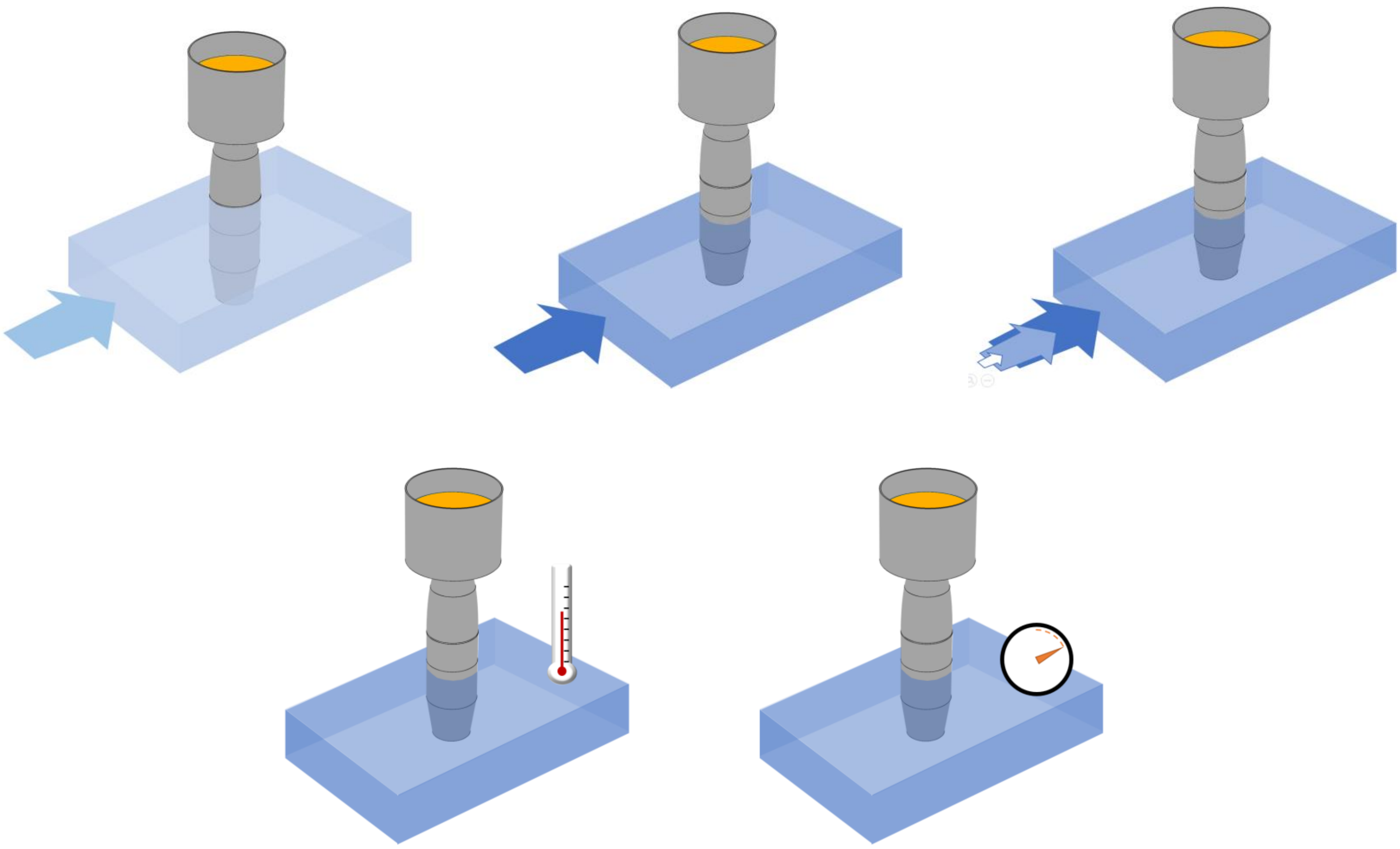
2. Computation / Validation

- COMSOL Server™
- On a SIMTEC https server
- 2.8 GHz processor, 2 cores used for the resolution
- 4h computation time

- **Experimentally validated: comparison with in-situ temperature measurements**

3. Results

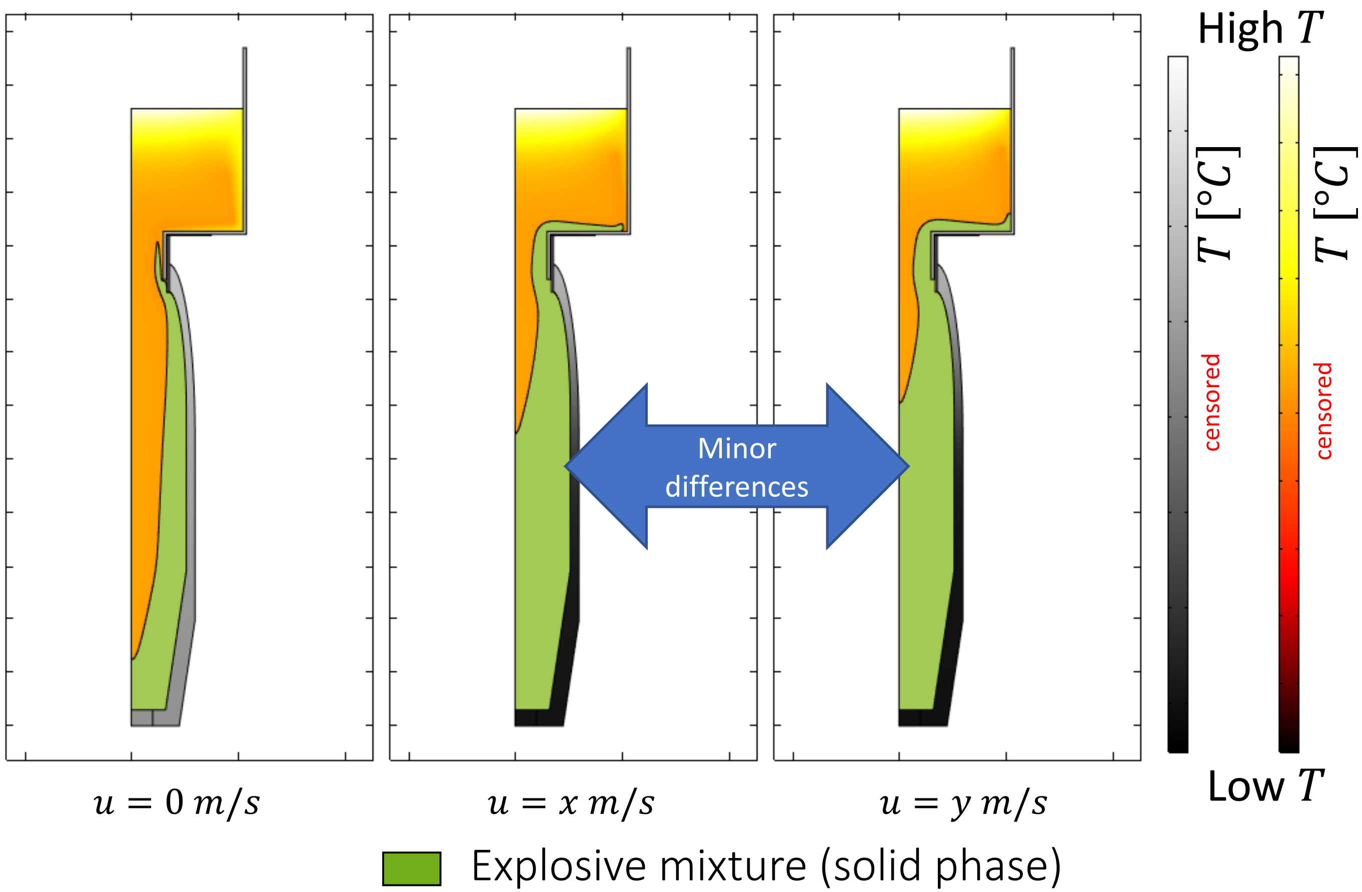
a) A wide range of possibilities!



The cooling process possibilities (fluid nature, velocity, temperature, variation in time…)

3. Results

b) Air cooling: velocity influence on cooling time

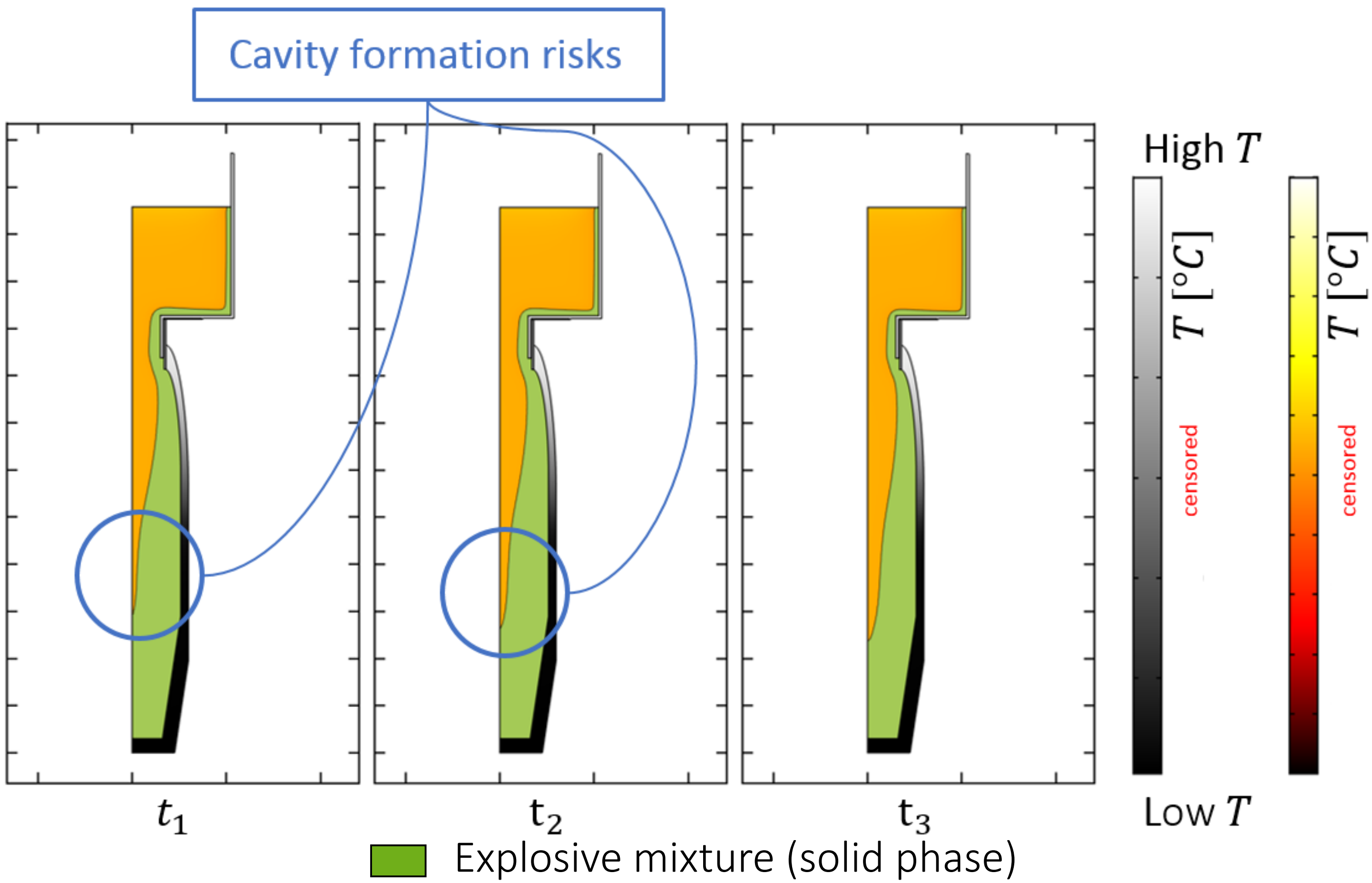


Influence of the air velocity on the cooling time

→Threshold effect identified between x and $y\ m/s$

3. Results

c) Water cooling conditions: quality analysis



Influence of the water cooling process on the solidification quality

→Cavity formation risk identified for water filling times t_1 and t_2

Conclusion

Achievements: SIMTEC

- ✓ Solidification front evolution predictions
- ✓ For many cooling conditions
- ✓ Remote and secured computations

Resulting in: TDA THALES GROUP

- ✓ Faster process optimisation
- ✓ Development of new processes