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Modelling tool for industrial application – Melt-cast ammunitions

IMEMTS 2019 – SEVILLA, SPAIN

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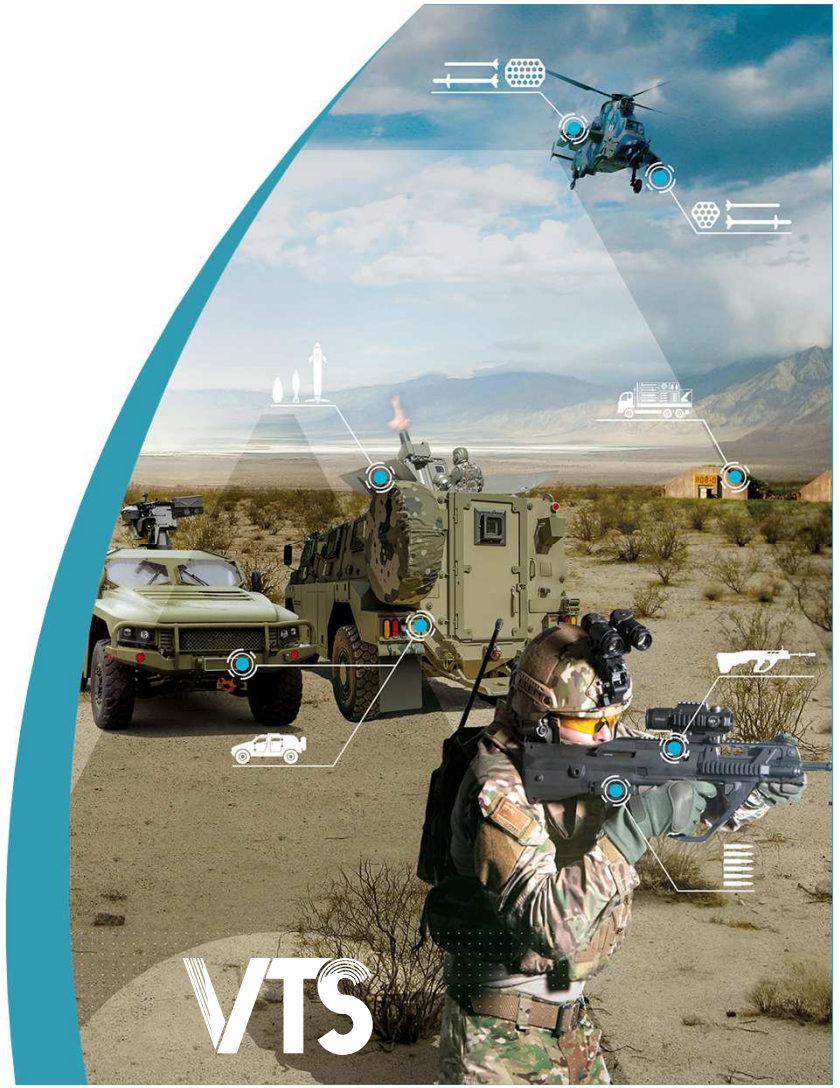
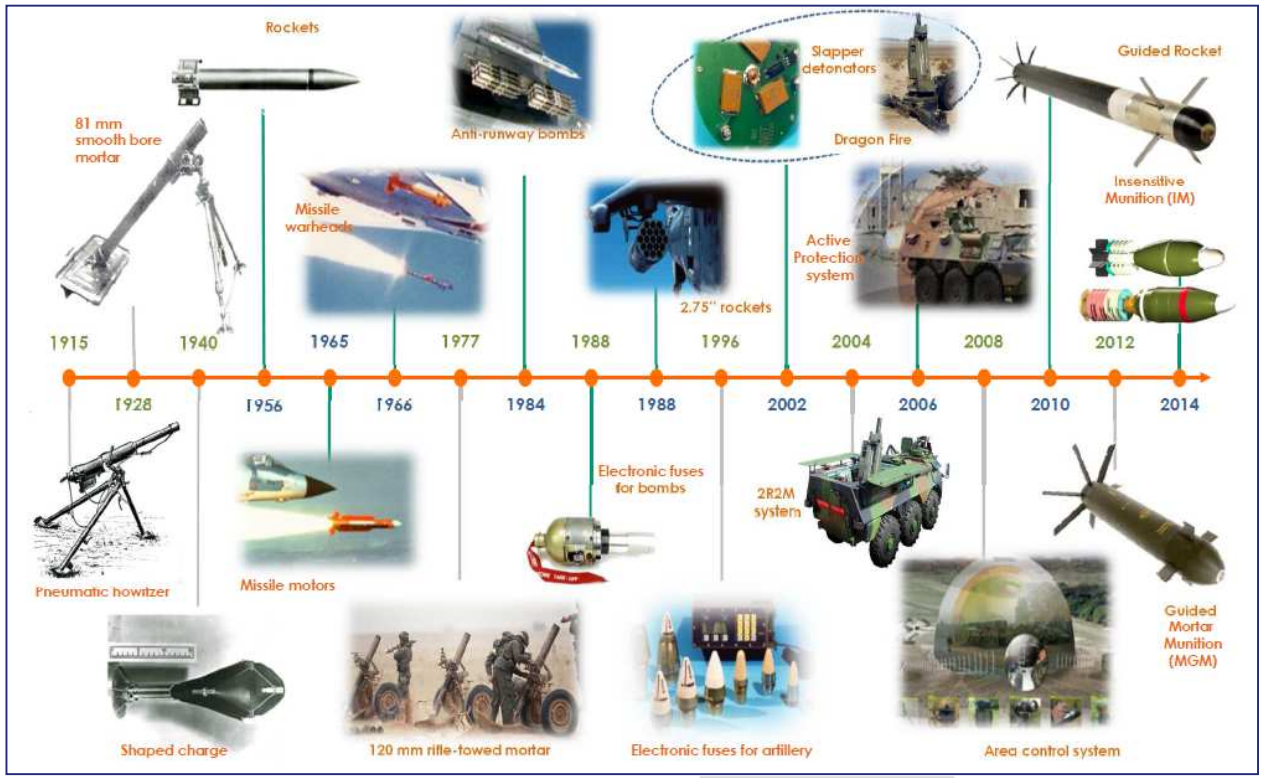
Abstract n°22252



Summary

Thales VTS Fr activities

Last centuries



- Mortar
- Shaped charge
- Rockets
- Anti-runway bomb
- Pyrotechnics components
- Area control system
- Active protection systems
- Guided rocket
- Guided mortar
- Insensitive Munitions

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Need of a numerical tool for cooling optimization phase

Objectives

Development of a numerical tool to implement TNT-based explosive composition in a shell body

- Whatever the shell
- Whatever the energetic material formulation
- Quick definition of set parameters for industrial equipment
- HMI for industrial use

Need of a numerical tool for cooling optimization phase

Data Acquisition on melt-cast process

- Process parameters
  - Preheating phase
  - Formulation process
  - Controlled solidification
- Ammunition design
  - 120/81 mm mortar ammunitions
  - Shaped charge
  - Rockets
- Energetic materials
  - Liquid and solid density
  - Thermal properties

Modelling interface

Process parameters

> Preheating system analyses

- 120 probes
- 2 temperatures
- 6 h registration
- 6 cart's positions
- 2 weeks studies

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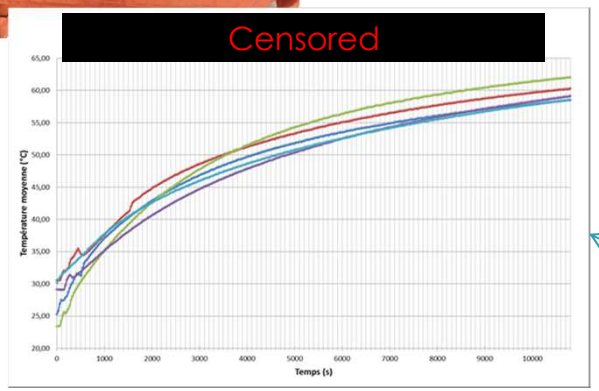
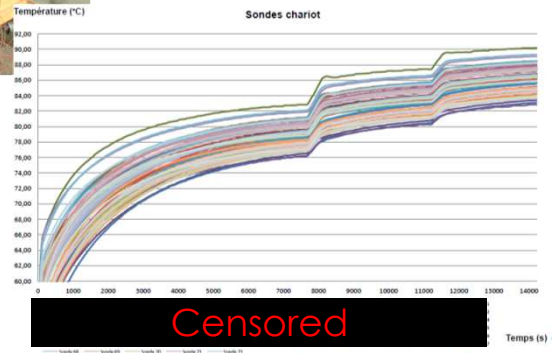


> Cooling system characterization

- 72 probes
- 3 temperatures
- 4 h registration
- 12 positions
- 1 week



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Abacus

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Modelling interface

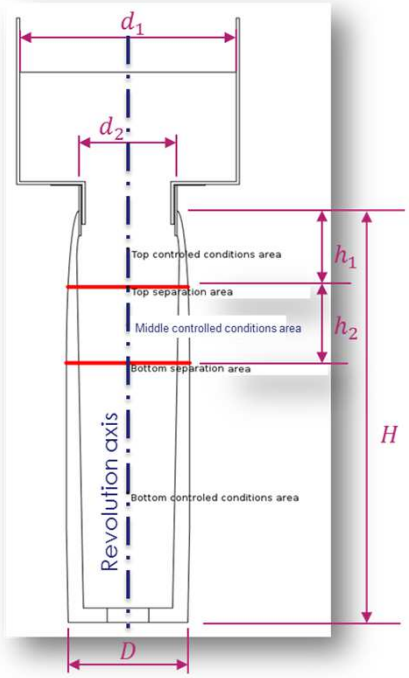
Geometry parametrization

- Fully parametrised

Axisymmetric model

Heat equation solved:

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



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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

With T_{ext}, the cooling fluid temperature

Modelling interface

Energetic materials

	TB I180	
State	Solid	Liquid
Density	Censored	Censored
Specific Heat capacity ($J.kg^{-1}.K^{-1}$)		
Thermal Conductivity ($W.m^{-1}.K^{-1}$)		
Thermal diffusivity ($mm^2.s^{-1}$)		
Solidification point (°C)		
Heat of solidification ($kJ.kg^{-1}$)		

TB I180

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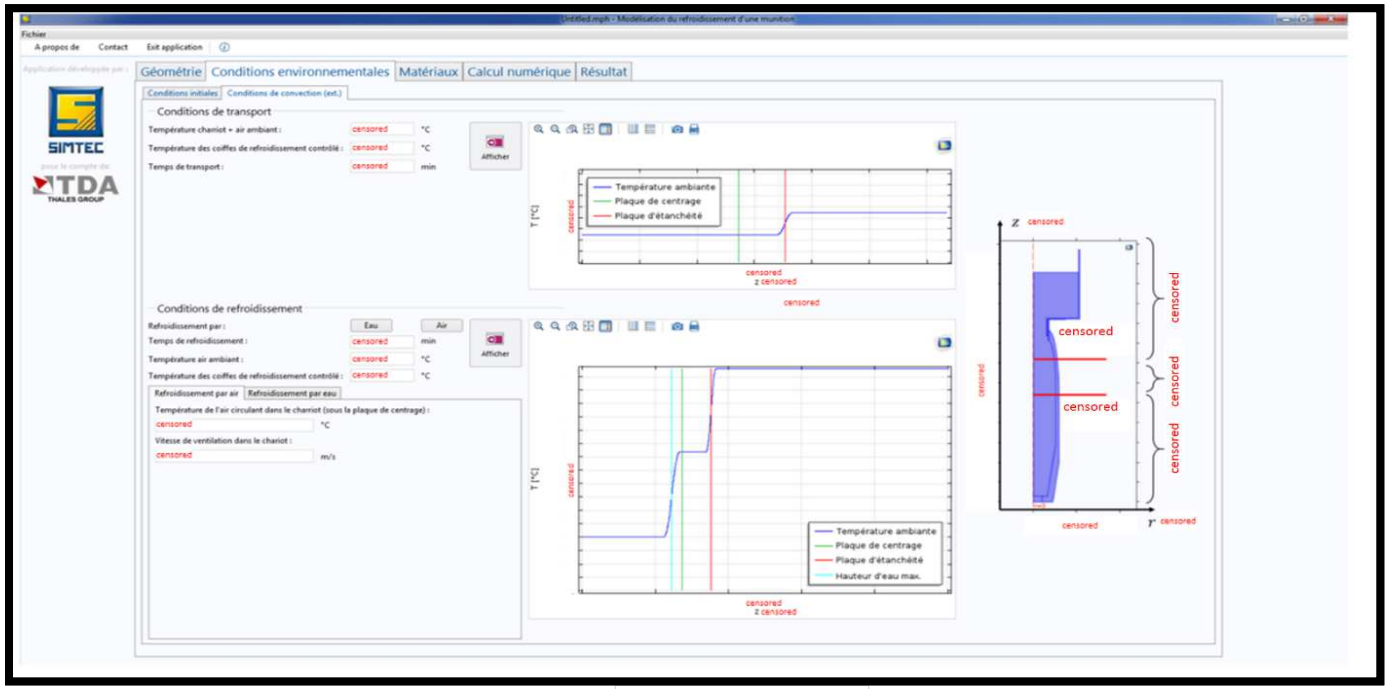
Modelling interface

Implementation on customized interface

- Using COMSOL Multiphysics software



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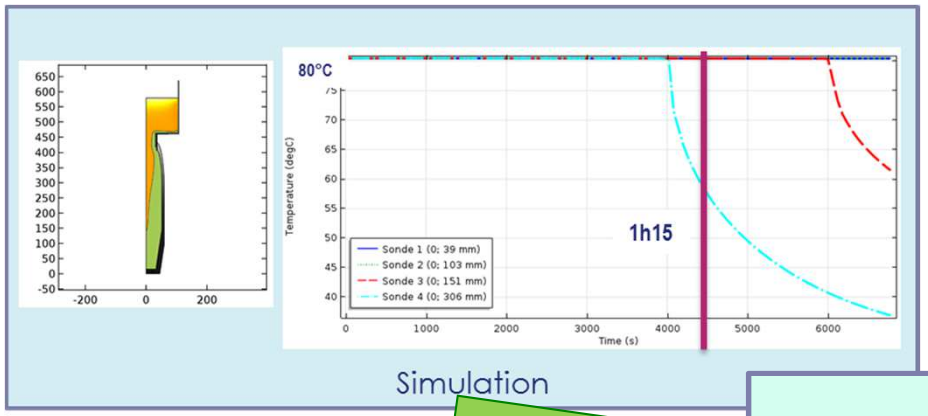
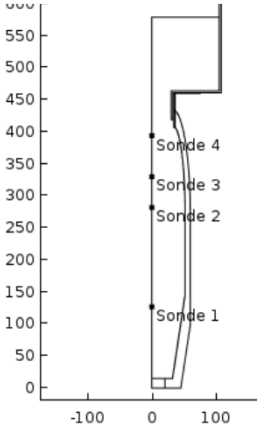
Modelling interface

Correlation and validation



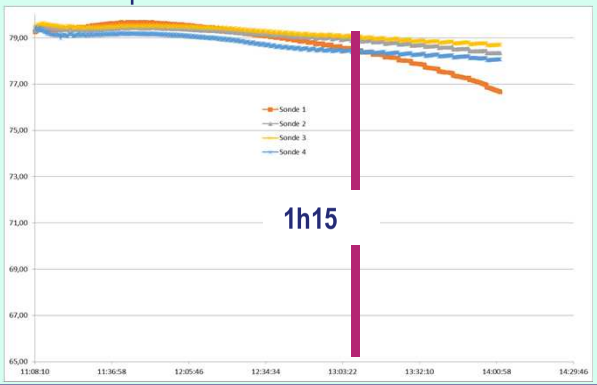
Simulation



Probe positions

Good correlation between simulation and real life

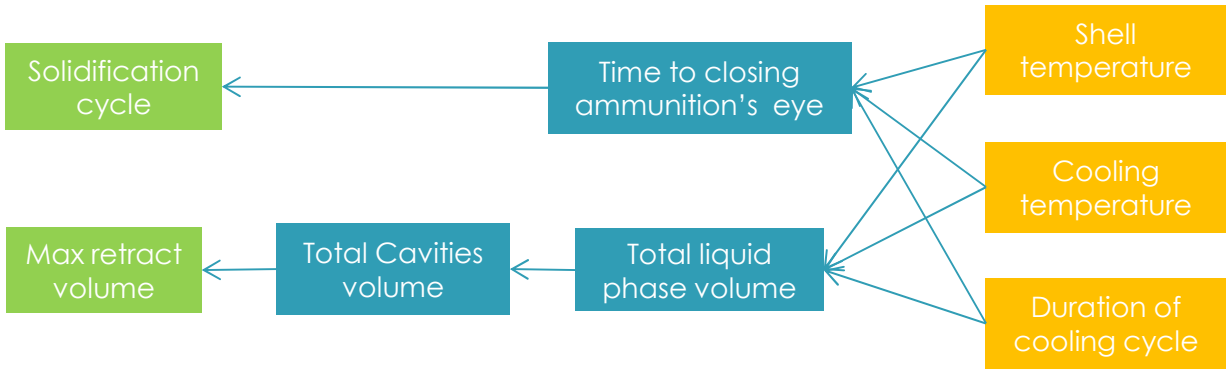
Experimental value

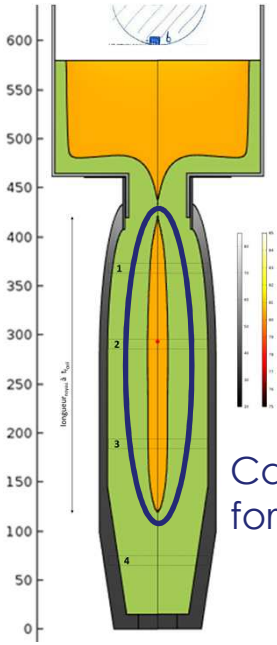


Theoritical study on retract

Phenomena analyses

- Retract are linked to different liquid and solid densities





Cavities formation

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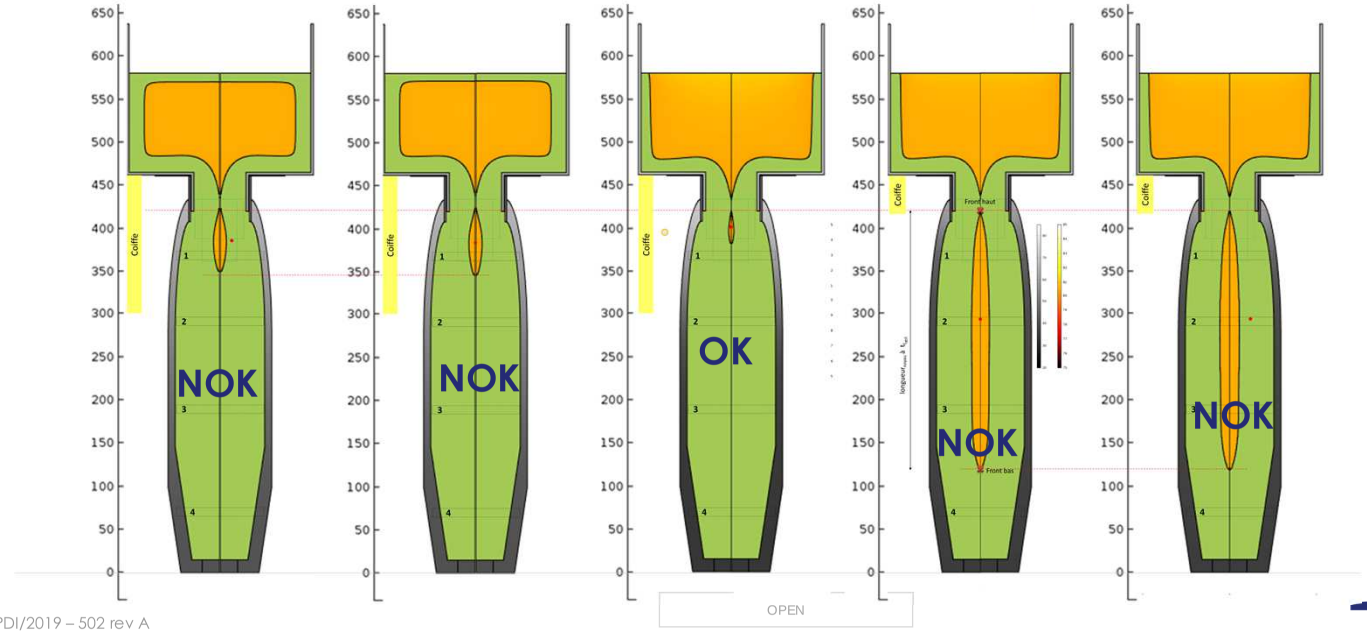
Theoritical study on retract

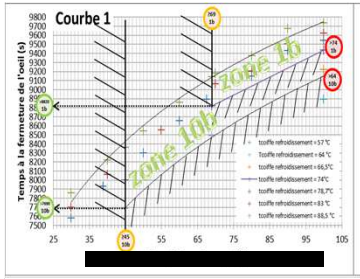
Some Results

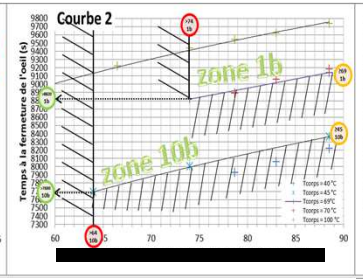
- Shell temperature : 83 °C
- Colling temperature : 50 °C

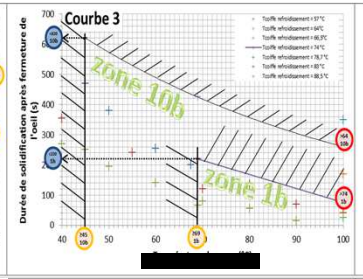


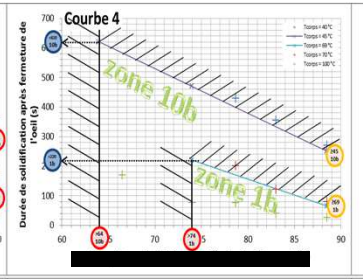
Theoretical study on retract

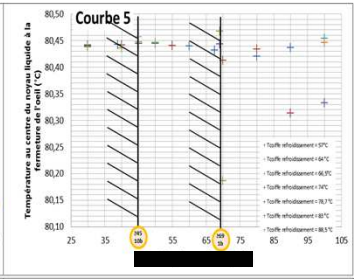
Determination of industrial parameters





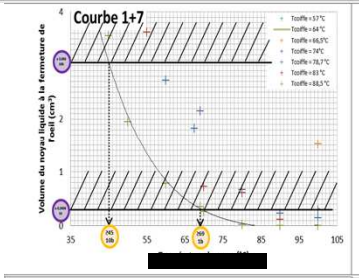


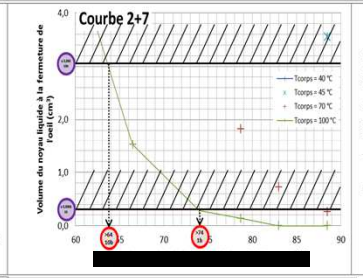


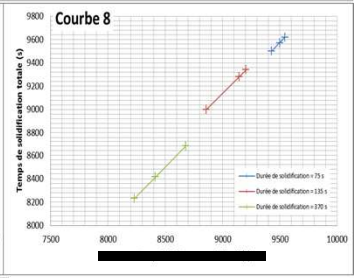


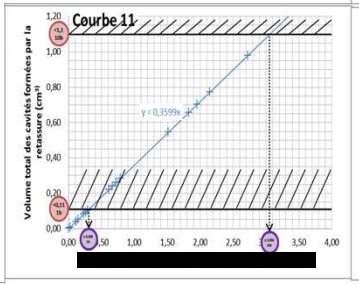
Two working zones:

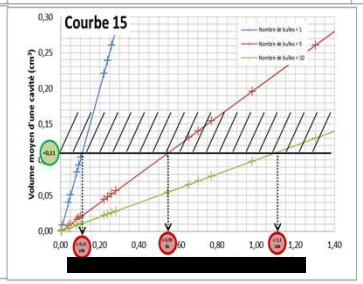
Shell temperature > 69 °C
And
Cooling temperature > 74 °C











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Conclusion

Development of HMI modelling solidification of melt-cast process

- Requires lots of industrial data
- Needs of design parameters
- Characterization of formulations

Useful for

- Mastering the production process
- Implementation of new ammunition design or formulation to industrial scale

Future

- Optimization for implementation of retract

Log of changes and approval

Log of changes

Revisions	Description	Date
001	Creation	
002		
003		

Approval

Actors	Name and role	Signature	Date
Written by	T. GILLOUX		
Verified by	C. COULOUARN		
Approved by	P. DOIGNON		