# On the simulation of quenching processes using a full Eulerian FE framework

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**Résumé**

Quenching processes of metals are widely adopted procedures in the industry, in particular automotive, nuclear and aerospace industries since they have direct impacts on changing mechanical properties, controlling microstructure and releasing residual stresses. Today there is a strong demand from many industrial companies to control this cooling process taking into account optimal combinations of quench parameters with their complexity in order to obtain the desired metallurgical properties such as hardness and yield strength.
We propose in this work to develop ground-breaking numerical tools dedicated to the understanding and full modeling of liquid-to-vapor phase change induced by direct fluid-solid-heat coupling. It is based on an accurate adaptive Eulerian framework that account for complex boiling phenomena surrounding the heated solid. It uses the levelset method as a modeling support for the solid-liquid-gas simultaneous interactions. Therefore, consequent models for both the phase change and the conjugate heat transfer are developed and will be presented.

For the numerical resolution, two challenges will be described. The first is related to the accuracy of the coupled two-fluid flow solution with heat transfer and fast moving interfaces. While the second is related to the mass conservation which also amplified due to the successive adaptation-interpolation operations.

We present then general adaptive and modified stabilized finite element methods, for both the levelset-transport equation and the Navier-Stokes equations. It relies mostly on treating implicitly the reinitialization step for the levelset equation, on combining different criteria to be used by the error estimator for dynamic anisotropic meshing, and finally on applying adequate restrictions to ensure conservative interpolation.

Several numerical examples and new benchmarks, in 2D and 3D, will be presented to illustrate the efficiency of the approach.

**Mots-Clés:** Traitements Thermiques, Trempe, Ebullition, Changement de phase

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