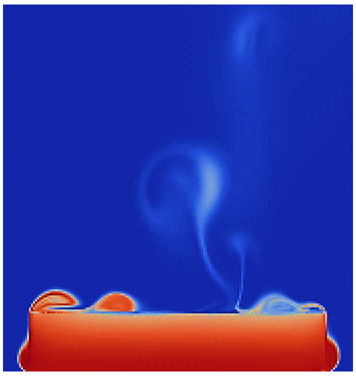
PHD OPENING

MINES Paris | PSL

Space qualification of ceramic satellite components using the numerical simulation of thermal shock testing

Expected profile

- Master of Science or equivalent in applied mathematics, physics, or mechanical. engineering, with competences in fluid dynamics, and scientific computing.
- Experience in programming (C, C++) and in data post-processing and analysis.
- Excellent writing skills, fluent in English.
- Rigorous, autonomous, and motivated by working at the edge between fundamental research and industrial applications.



Working conditions

The proposed work will be carried out in the research group *Computing & Fluids,* recipient of Joseph Fourier Atos Award as best national research group in numerical simulation, and located at the CEMEF Research Center of MINES Paris PSL in Sophia-Antipolis, France.

This grant covers a three-year doctoral contract (including benefits) that should start in October 2024.

Contact and application procedure

For further information, please contact:
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Deadline for application: 30th of June 2024

Thales Alenia Space has been using technical ceramics in its optical instruments for over a decade. The most used ceramic is Si3N4 (silicon nitride) in the constitution of telescope structures, because it has particularly good thermoelastic properties and water stability. Space qualification of such ceramic parts used in satellites is required to assess the conformity of components with technical specifications. Currently such proof testing consists of static and dynamic stress analysis which demand considerable resources and are subject to uncertainties. Therefore, it is crucial to develop an alternative non-destructive test to qualify ceramic components for space, which is cost-effective and reliable, reducing the risk of damage to the part, while allowing to characterize more sophisticated geometries as well as a wider range of sizes than standard tensile tests.

The objective of this thesis is to simulate thermal shock testing of ceramic components by the quenching process. Indeed, while classic thermoelastic analysis provides an insightful basis, it is restricted to simple configurations, and determining the parameters experimentally for each configuration is unconceivable. Accurate numerical simulation of the process is required to optimize the process according to the safety margins. Since the order of Thermal Stress Resistance in ceramics has been proved to vary considerably depending on the heat transfer conditions, a precise description of the temperature distribution in the surrounding fluid environment and the heat transfer across the solid-liquid interface, driven by the boiling dynamics and phase transition at the liquid-vapor interface, is therefore crucial.

The novelty of this project is the development of a high-fidelity numerical framework to allow such characterization of the process, while most existing studies of thermal stress fracture are restricted to simple geometries and initial data. The work will be based on the parallel solvers developed by the CFL research team, using stabilized finite element methods on anisotropic meshes for the simulation of the entire quenching process in realistic three-dimensional configurations.