DEN: Thesis SL-DEN-19-0117

RESEARCH FIELD

Mechanics, energetics, process engineering / Engineering science

TITLE

Phase-field description of the brittle crack propagation in nuclear fuels

ABSTRACT

Modeling the brittle crack propagation in oxide nuclear fuels using a phase-field approach.

In nuclear fuel elements, fission reactions generates heat used to produce electricity. From a safety point of view, those elements must retain the fission products that shall not be disseminated in the reactor core. Modeling the in-reactor behavior of Pressurized Water Reactors fuel elements is one of the missions of the Nuclear Energy Division at the French Alternative and Atomic Energy Commission (CEA) [4,7].

Modelling and simulation is made complex by the myriad of coupled, nonlinear, chemical, mechanical, thermal and microstructural changes that take place within the fuel. From the mechanical point of view alone, various contributions must be taken into account: brittle fracture of the fuel pellets, thermally and radiation induced viscoplasticity, etc. [4,7,8]

Simulating these phenomena is challenging both from a numerical standpoint and from the point of view of the physical phenomena involved. As a result of this, advanced and robust numerical techniques are necessary.

The candidate will focus on the treatment of the fuel cracking through a phase-field approach which has been considerably developed by the scientific community working in the field of non-linear mechanics during the last decade [5,6,9,10,11]. This approach is now mature enough to be introduced in large-scale fuel performance applications. However, there is still a great deal of debate around how to deal with unstable crack propagation is this will be specifically studied in the course of this work [1,2,3].

The numerical treatment of the phase field approach must also be made compatible with the treatment of the visco-plastic incompressibility of the fuel [13,14,15], a subject that has rarely been treated so far in the literature.

The PhD will be supervised by the team in charge of the development of the Cast3M finite solver [12] and the team in charge of the development of fuel performance applications.

The open nature of the subject, which far exceeds the domain of nuclear applications, will allow the student to develop very valuable competences in the academic and/or industrial world.
References


8. HELFER, Thomas. Étude de l’impact de la fissuration des combustibles nucléaires oxyde sur le comportement normal et incidentel des crayons combustible. thèse de doctorat. École
Centrale de Lyon, 2006.


12. http://www-cast3m.cea.fr/


**LOCATION**

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