PROJET M3S ANNEE 2016 – 2017

Subject: Numerical assessment of the non-linear material model behaviour – Application to the ITER Vacuum Vessel stainless steel structures

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Context: The ITER project, "International Thermonuclear Experimental Reactor", is a large scale of scientific experiment that aims to demonstrate the technological and scientific feasibility of fusion energy to commercial use. Nuclear Fusion is the process whereby two light nuclei are forced together producing a larger nucleus, releasing significant amount energy (this is the process that powers the stars).

Tokamak is doughnut-shaped vacuum chamber. Inside this vacuum chamber, under the influence of extreme heat and pressure, gaseous hydrogen fuel becomes plasma a hot, electrically charged gas. Tokamak uses a toroidal vessel and powerful magnetic fields to confine hot plasma and allowing it to be heated to the conditions required to achieve fusion of the fuels. The presence of large magnetic fields and the plasma disruptive instabilities generate electromagnetic-type phenomena in transient conditions which lead to strong induced eddy currents and body loads.

In view of the multi-physics loading conditions, the development of suitable materials is one of the major challenges to be faced.

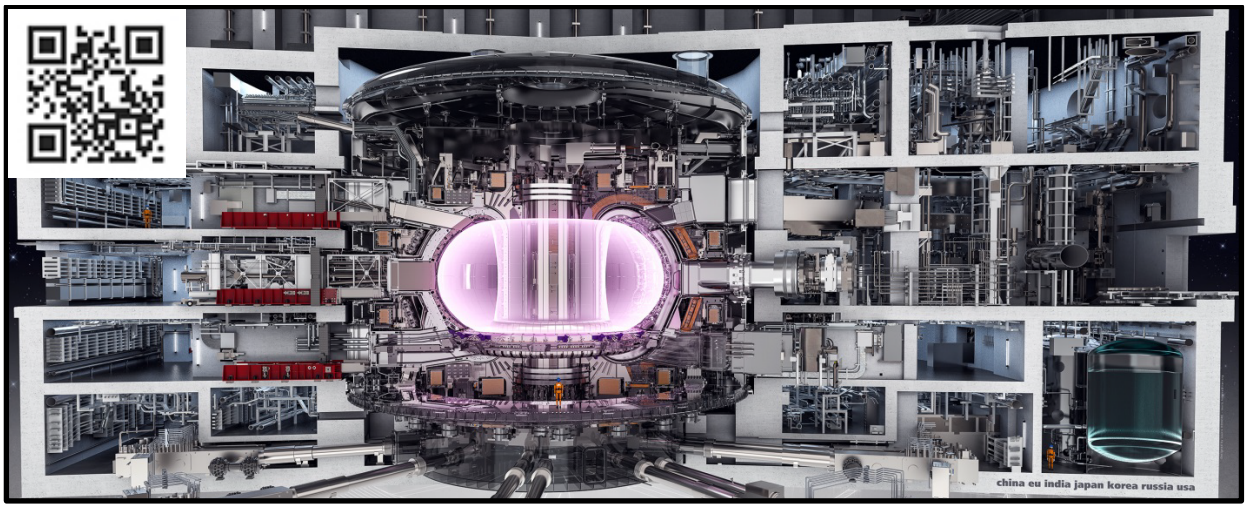

Figure 1 ITER Tokamak sectional views

Objectives: The objectives of this 3A project will focus mainly on the material used for the ITER Tokamak Vacuum Vessel (VV) and its internal components (optionally) which is a high vacuum torus-shaped vessel made in stainless steel in a double wall structure where cooling water circulate. It measures slightly more than 19 meters wide and 11 meters in height, for a mass of more than 5000 tonnes (8500 tonnes including the in-vessel components).
The working plan will follow the following steps:

- Investigation on the non-linear material model behaviour,
- Development of FE benchmarking to emphaze the various phenomena.
- Determination of the material model and its parameters
- FE Application to a real case under cyclic loading: VV Intermodular Key

Reférences:

[1] J.-M. Martinez, Structural damages prevention of the ITER vacuum vessel and ports by elasto-plastic analysis with regards to RCC-MR, Fusion Eng. Des.98–99 (2015) 1552–1555.
[2] ITER Project website ; https://www.iter.org/mach