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INDUSTRIAL APPLICATIONS OF THE X-FEM: SECURITY IN NUCLEAR POWERPLANTS

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ABSTRACT

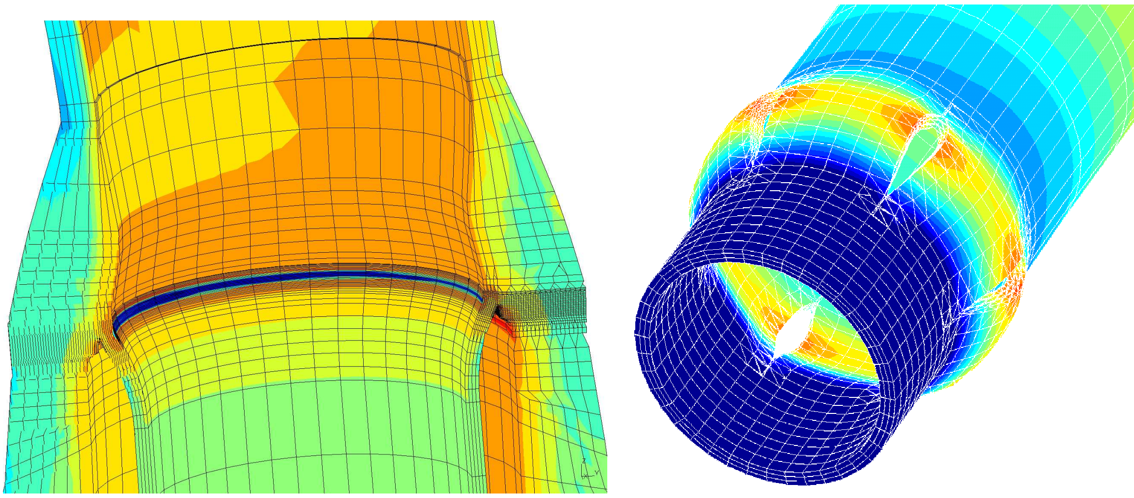
The nuclear engineering and research activities use the finite element method extensively since many years. In computational fracture mechanics, complex geometries of cracks are challenging meshing softwares and the meshing task is still human-time consuming.

To reduce these efforts, the extended finite element method (X-FEM) have been developed recently[1], and allows one to introduce an arbitrary non-meshed crack into a "sane" mesh (that does not contains any cracks). The two main advantages are that the mesh is easier to create, and the mesh does not need to be modified when the geometry of the crack changes. To represent the discontinuity of the displacement field across the crack faces, the basis of the continuous shape functions is extended with discontinuous functions (generalized Heaviside step functions). Special functions with a priori knowledge of the solution are also added near the crack tips for improving the accuracy of the solution.

Few years ago, the researchers team at EDF R&D decided to implement the X-FEM into *Code_Aster*[2], an industrial finite elements software developed by EDF R&D and used by engineering teams for mechanical simulation. In particular, researches have led to develop an algorithm to take into account contact effects on the crack faces[3]. The X-FEM should become soon a standard tool for engineering simulation in fracture mechanics, as many other researcher teams are developing the X-FEM in industrial finite element codes[4,5].

Typical industrial studies have already been carried out with *Code_Aster*, in order to demonstrate the abilities of the X-FEM to solve real problems, with good accuracy compared to the FEM. This paper presents few examples with industrial meshes (up to 800000 degrees of freedom) and complex boundary conditions. The first one is a study of an axisymetrical crack in a sprinkling nozzle of a pressurizer submitted to a thermal shock and inside-pressure. Non-symmetrical efforts and moments make the 3d-modelisation necessary. The stability of the crack is estimated by computing the stress intensity factors for several problems with different crack depths. A second example is a hydro-mechanical studied of multi-cracked pipe in thermo-elasto-plasticity. The pipe is

pre-loaded with a residual displacement and stress fields. Other examples underline the fact that this tool is mature enough to be used by the engineers for real simulations of cracked structures.



(a) (b)

Figure 1. (a) Von Mises equivalent stresses in the sprinkling nozzle of a pressurizer
(b) Displacements of a multi-cracked pipe

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