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MODELLING COMPLEX FLUID-STRUCTURE INTERACTION PROBLEMS WITH EUROPLEXUS FAST DYNAMIC SOFTWARE

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ABSTRACT

In the framework of nuclear safety, analysing the consequences of reference accidents, such as Loss Of primary Coolant Accident (LOCA) or Containment Accident, requires the modelling of brutal transient phenomena involving one or several fluids and a structure interacting together. EUROPLEXUS is an explicit code designed to perform such simulations [1]. Its development is controlled by means of a consortium involving the French Commissariat à l'Energie Atomique (CEA), the Joint Research Centre of the European Commission (JRC Ispra), co-owners of the code, and several major partners including Electricité de France.

This paper first provides a description of EUROPLEXUS specific potentialities dedicated to nuclear simulations. Fluid and structure are modelled using finite elements. In 2D and 3D, an entirely automatic algorithm is proposed to write link conditions between them regardless of the geometrical complexity. These links are then treated exactly using Lagrange Multipliers throughout the simulation. The family of Fluid-Structure Interaction (FSI) algorithms, originally based upon the hypothesis of nodal conformity of the fluid and structure meshes along their interface, has been extended to the case of nonconforming interfaces [2]. Without the constraint of matching nodes, fluid and structure domains may be meshed independently with a good level of regularity and a fineness adapted to the physics of each media. Moreover, significant CPU time savings may be obtained when passing from matching to non-matching meshes.

Special features allowing the complete and detailed modelling of the whole primary loop of a PWR (Pressurized Water Reactor) in LOCA conditions are available in EUROPLEXUS. This includes pipe models, using intrinsically coupled pipe-like elements accounting for FSI effects, interconnected with 3D FSI models involving 3D fluid elements, used to describe the flow in reactor's core, and 3D or shell structural elements modelling reactor internal structures.
For the particular case of Sodium Fast Reactors, EUROPLEXUS is also able to model violent explosions involving three different fluids and a containment vessel, as demonstrated by a comparison between numerical and experimental results for the Mara

experiment [3].

Secondly, latest developments are presented. This mostly deals with the implementation of a finite volume solver (for 2D and 3D formulations) to better represent fluid flows in very complex geometries. High order schemes are provided to limit numerical diffusion, as well as an original coupling method between 1D pipe like finite elements and 3D finite volumes. This important increase of the overall efficiency of EUROPLEXUS simulation capacities allows now its systematic use in large-scale industrial studies involving fully coupled FS analyses.

REFERENCES

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