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ROD CLUSTER DROP TIME SIMULATION USING A CONTINUOUS CONTACT FORMULATION EXTENDED TO BEAMS

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ABSTRACT

One of the safety control mechanisms in nuclear reactor cores relies on the drop of a rod cluster filled with neutron absorbing materials. The localization of an hypothetical geometrical deflection of the fuel

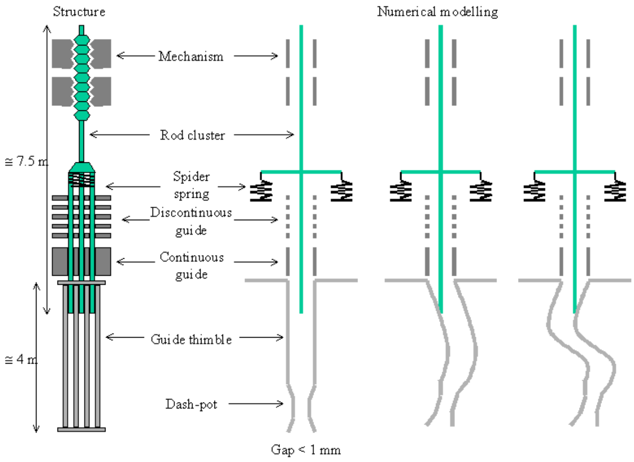

Figure 1: Description and modelling of a rod cluster control assembly at its withdrawn position with a straight, a C-shaped and a S-shaped guide thimble.

assembly can be achieved by analyzing either the rod cluster drop velocity or the guiding system reaction force during an insertion simulation. The drop time of the rod cluster into the core along a guiding system must not exceed a threshold value so that the reactor start up may not be prevented in case of an emergency procedure.

A structural finite element model of the rod cluster insertion and drop simulation is adopted. The rod cluster and the guiding system are modeled with beam elements. The latter is slightly curved to take into account possible permanent deflections observed experimentally on production sites (see figure 1). The friction force generated by the contact between the rod and the deflected guide mainly controls the rod cluster drop time. The solid continuous lagrangian frictional contact formulation [1] is extended to simulate contact between beams in large transformations framework by revisiting the contact model. The calculated insertion force and drop velocity derived from a placement and velocity based contact formulations ([1],[2]) are compared to solutions obtained by a discrete lagrangian method for contact and friction [3], and to experimental results (see figure 2).

Due to the reduced gap, the insertion force analysis reveals a sharp and localized increase of the reaction force when the tip of the rod is located in front of the dash pot (see figure 1). Consequently, the contact analysis by means of a thin structure FE model of the control rod when it passes through the dash-pot would be irrelevant. A promising multimodel methodology, which consists in super-imposing and gluing a 3D local model in the vicinity of the dash-pot to a structure global one in the Arlequin framework ([4],[5]), is currently under investigation. Numerical results exemplifying our approach will be reported during the conference.

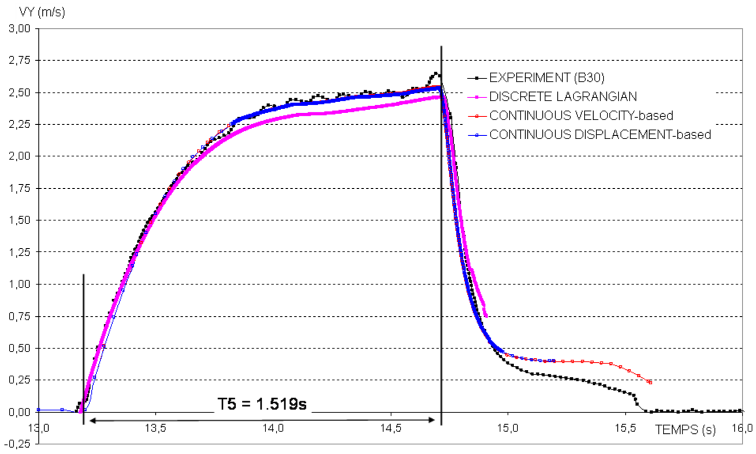

Figure 2: Rod drop simulation - Comparison between the calculated discrete and continuous placement and velocity based formulations and the measured drop velocity for an S-shaped guide thimble.

All numerical implementations were achieved with thermomechanical FE software *Code_Aster*, developed by the research and development mechanical engineering department of Électricité de France and available as a free software under the GPL licence.

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