Validation of LS-DYNA Computer Code for Seismic Qualification of Reactivity Control Mechanisms

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Abstract

Reactivity control mechanisms of CANDU®[1] reactors fall under two categories: The first are mechanisms to control the reactivity and power output of the reactor and the second are mechanisms to control the reactor and provide instrumentation for indication. In this paper the shut off mechanism, which is of the second category, is analyzed to seismically qualify it using LSDYNA, a general-purpose finite element computer code based on the explicit time integration method.

One of the objectives of this work is to determine the drop time of the shut off mechanism that ensures the safe shut down of the reactor when required. This mechanism consists of a slender structure that extends over a relatively long travel. During the mechanism's drop, the shut off rods are guided by stationary components, which results in surface-to-surface contact and friction. Drag and damping forces are also acting on the moving parts.

Due to a built-in eccentricity in the mechanism, it generates forces in the horizontal directions while the reactivity mechanism is dropping. Maximum stresses during the drop of the mechanism are evaluated to demonstrate that the jurisdictional requirements for the various components are met.

The results obtained from the finite element analysis are compared with those from static drop tests performed in the laboratory. The drop test results are used to modify the finite element model by fine-tuning various variables such as the drag force, spring constants, damping and friction coefficients between the components, etc. Once the model has been verified, the seismic motion is applied and the results are compared with test data from similar reactors.

It is shown that the results of the analysis of the reactivity mechanism compare well with the test data and the deformation and stresses are well within the acceptable values. These results demonstrate that the LSDYNA code can be successfully applied to seismically qualify a CANDU reactivity control mechanisms.

[1]CANDU®(CANada Deuterium Uranium®) is a registered trademark of Atomic Energy of Canada Limited (AECL)