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PREDICTION OF ENERGY ABSORPTION CAPABILITY AND DAMAGE DISTRIBUTION OF A COMPLETE LMFBR SUBASSEMBLY UNDER PRESSURE PULSES

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Summary

New computational results achieved by the computer code CORTRAN demonstrate the capability of complete LMFBR subassemblies to withstand the pressure pulses caused by supposed molten fuel-sodium interactions. Reference data for the validation of the theoretical model which describes the complex interaction of duct internals, surroundings and material behaviour of a single LMFBR subassembly was available from full-scale drop tower and explosion tests.

Obviously the transient model response is the result of the simultaneous effects of various submodels all of which cannot be directly monitored during the experiment. Therefore a system analysis based on simple hypotheses on the physical nature and the interaction of the most important subassembly deformation mechanisms gives an additional insight into subassembly dynamics. Earlier approaches used experimental output immediately to define submodel behavior in a simple, straightforward way. CORTRAN can contribute more to the understanding and prediction of the mechanical energetics and the spatial damage distribution relevant to the arrest of local failure propagation.

Impact tests can usually realize a slower time scale (typical loading: 60 kN over 50 msec) than explosion tests (typical triangular pulse: peak force 100 kN, duration 5 to 10 msec). In both cases, however, the total absorbed energy becomes stationary after a slight overshoot within one or two pulse durations, roughly. A representative energy absorption within a ductile core is in the range between 1 to 2 kJ per subassembly. The precise value depends mainly on the material chosen and on the pulse shape derived from the pressure-time-history. Obviously the time scale has a great influence on the backpressure forces produced in the coolant behind the subassembly. Laboratory experiments can lead to higher energy absorption (typical value: 5 kJ) and therefore be useful for better singling out the influence of the dynamic plastic behavior of the duct material.

Typical midspan values of permanent damage (deformation) are 1 to 2 cm flattening and 3 to 5 cm bending deflection for the impact tests and 1 to 2 mm and 3 to 5 mm, respectively, for the explosion tests. The agreement between the measured early time histories of deformation and the corresponding computed results which are presented in the paper seems good enough to make the comparison of permanent deformations meaningful. It is emphasized, however, that the spatial resolution of damage distribution over the hexcan could only be computed while the experimental instrumentation was limited. Therefore representative experimental values must be compared with averaged computational results. These interpretations give rise to the question how to choose the accuracy of model input with respect to appropriate output data. Some dangers ob overparametrization are discussed in this context.

The significant achievement is the quantification of the safety against local mechanical failure propagation in terms of energy absorbed and permanent damage for a single subassembly.