Scaling Analysis for Application of RD-14 Tests to the ACR-700

Of particular concern in the study of a transient following a loss of coolant accident (LOCA) n an ACR-700 reactor is the time spent by the fuel rods at elevated temperatures. This time is largely dependent on the duration of periods of low coolant inventory when fuel channels may be exposed to two-phase conditions. In order to better understand the phenomena and processes taking place, simulations of LOCA scenarios are frequently conducted with thermal-hydraulic codes such as CATHENA or TRACE.

Experimental studies are performed to support the computational work and provide data for validation. To be most useful, experiments should reproduce the conditions following a postulated LOCA in a real reactor as closely as possible and capture all the important aspects of the transient. In practice, however, experimental facilities are scaled-down models of reactors and may exhibit qualitatively different behaviour from their full-sized counterparts.

The purpose of this study was to determine which factors are most important in controlling the transient behaviour and so provide guidelines on how best to design experiments so that the principal phenomena and processes can be captured. The work focused on the “critical break” transient, which corresponds to a break at an inlet header with an area equivalent to that of a 25% guillotine break (i.e. 50% of the header cross sectional area). Simulations have shown this case, which is regarded as a worst case scenario, to result in very low flows in the adjacent fuel channels, leading to high fuel temperatures.

The procedure used is known as a top-down scaling methodology. In this approach, the first step is to divide the transient into different phases, based on the main controlling factors and flow features. For each phase, conservation equations and models for important phenomena are used to develop a lumped parameter model for the system. These lumped parameter models express key variables such as flow rate or pressure drop in terms of quantities such as coolant temperature, heat transfer rates or flow resistances of lines. The equations are then written in non-dimensional form and those groups that have the most effect on the transient can be identified. Application of these simplified models to the full scale ACR-700 and the small-scale rig RD-14 showed good agreement with CATHENA simulations and experimental data, providing a useful validation.

As a result of the work, recommendations were made for how the experimental rig used should be configured for the next series of tests, so as to behave in a similar manner to the full scale ACR-700.