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#06-239 X-Ray Imaging Calibration for Fuel-Coolant Interaction Experimental Facilities

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During a severe accident in sodium-cooled fast reactors, jets of molten nuclear fuel may penetrate into the coolant resulting in fuel-coolant interactions (FCI). Experimental programs are being conducted to study this phenomenology and to support the models development for evaluating consequences of severe accident. Due to the optical opacity of the test section walls and sodium coolant, high-speed X-ray imaging is the preferred technique for FCI visualization. The configuration of these X-ray imaging systems, whereby the test section is installed between a fan-beam X-ray source and a scintillator-image intensifier projecting an image in the visual spectrum onto a digital camera, entails certain imaging artefacts and uncertainties, not limited to vignetting, geometric distortion and noise in the detected photon flux. Although the X-ray imaging configuration can observe FCI process qualitatively, it ideally requires precise calibration to enable detailed quantitative characterization of the FCI. Calibration tests have been conducted for a new, enlarged, sodium test section at the MELT facility. To this end, 'phantom'models have been fabricated using polyethylene, either steel or hafnia powder, and empty cavities to represent the sodium, molten fuel and sodium vapor phases, observed during FCIs, respectively. The checkerboard configuration of the phantom enables calibration and correction for distortion artefacts which magnify features towards the edge of the field of view with fan-beam X-ray imaging. Polydisperse steel ball configurations enable precise determination of the minimum object size detectable by the camera, and the estimation of parallax errors which introduce uncertainty in an object's silhouette dimensions due to the uncertainty in its position within the depth field. Analysis of these calibration tests is presented with the objective of establishing a universal procedure for the optimization of FCI visualization experiments.

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