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#05-9 Numerical simulations in support of the design of an ultrasonic device for subassembly identification

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In this paper, it is shown how numerical simulations can help designing an ultrasonic instrument operating in harsh conditions. To prevent fuel handling errors in sodium cooled fast reactors, the identification of fuel subassemblies using ultrasound is being investigated. It is based on the interpretation of a code (aligned notches) engraved on the subassembly head using an emitting/receiving ultrasonic sensor. This reading is performed in liquid sodium with high temperature (up to 600℃) transducers.

A first experiment in liquid sodium demonstrated the feasibility of this method. The reading quality and robustness depend on various parameters related to the ultrasonic beam (spectral response, focal distance, focal spot size), the code geometry (especially the notches'dimensions) and geometrical alignments.

In order to avoid numerous experiments, two numerical models are developed. The first one is a finite element simulation of the sensor providing its radiated field. Unlike well-known analytic one-dimensional models, the finite element model is able to take into account the curved geometry of a focusing sensor. Moreover, it allows to model complex geometries of transducer. Finally, with the continuous growth of computing power, the finite element model allows the calculation of the radiated field with reasonable computational cost. This model is validated with the well-known analytic solution of the Rayleigh integral; then it is applied to the sensor used in the sodium experiment. The focal distance and focal spot diameter are close to the expected values.

The second simulation, using CIVA software, provides the ultrasonic scan of the code. The latter is computed by a ray tracing technique, using the pencil method to derive echoes with their amplitude. It allows computational cost much lower than the finite element modelling. The result is in good agreement with the sodium experiment and a first comparison with a water experiment shows that this numerical tool is relevant for easily taking into account misalignment and misorientation of the scan.

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