THE ESTIMATION OF HEAT SOURCE STRENGTH IN PLATE-TYPE FUEL ELEMENTS WITH CLADDING

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SUMMARY

In the field of heat transfer, the inverse analysis has been widely used for the estimation of surface conditions such as temperature or heat flux distributions, and thermal properties such as thermal conductivity and heat capacity of solids, by utilizing the transient temperature measurements taken within the medium and/or at its boundaries. Most recently internal distributed sources estimation has received more attention with relevant applications in engineering.

One of the fundamental aspects in nuclear engineering design and operation is the knowledge of fuel elements behaviour to ensure their integrity. Different reactor types have different fuel elements shapes, sizes, fissile material and power densities.

In this work the estimation of the strength of a heat source in a nuclear reactor plate-type fuel element with cladding is considered. The thermal contact resistance between fuel and cladding is modeled by a "gap" with known heat transfer coefficient.

For the solution of this function estimation problem, with no prior information on the functional dependence, the Conjugate Gradient Method with an adjoint equation is used. This method has the advantage that regularization is implicitly built in the computational procedure. Its implementation involves the following basic steps: (i) the solution of the direct problem; (ii) the solution of sensitivity problem; (iii) the solution of adjoint problem and the gradient equation; (iv) the conjugate gradient method of minimization, and (v) the discrepancy principle for stopping criterion.

The problem at hand becomes challenging and technologically more relevant when one tries to estimate the timewise dependence of the strength of the heat source within the fuel slab merely from measurements taken at the cladding. The coupling of cladding and fuel takes place through the thermal resistance given by the "gap".

The methodology and test case results are presented. The effects of temperature sensors number and location are investigated, as well as the effects of measurement errors.

Topic: Heat Conduction

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