Development of a 3D computer code for studies on heat transfer fuel rods in unusual situations

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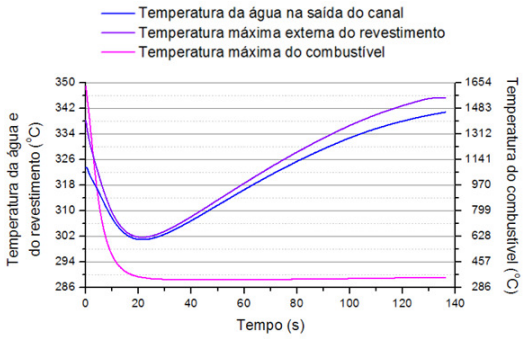
Abstract

The software developed in this work combines characteristics of great importance for the study of heat transfer in fuel rods, especially in situations of accident analysis, in order to solve transient problems with three-dimensional geometry, considering aspects such as axial heat transfer, temperature dependent properties, and DNBR analysis. This is evidenced by the need of predicting limit temperatures to optimize the design of fuel rods. This study aims to develop a computer code in Fortran where are gathered many tools such as the finite element method [1]. Thermo-hydraulic equations and correlations were implemented in the code on achieving a thorough investigation of heat transfer between the fuel rod and the coolant channel, seeking to understand the behavior of both in transient conditions (for example in accident situations). It has been made an analysis on the validity of the approach that disregards the axial heat flow in the analytical solutions. Comparisons between solutions using constant properties and temperature dependent properties were also included in this study. Transient studies involving the shutdown of the reactor, considering aspects such as temperature and limit fuel Departure from Nucleate Boiling Ratio (DNBR), were performed. Moreover yielding results can demonstrate a reasonably good performance of the computer code.

Discussion of the results

One of the studied cases is the reactor shutdown after the loss of the primary circuit main pumps. It showed that in about 140 seconds (as shown below) the water reached its saturation temperature near to the exit of the coolant channel. However it has been realized that it is not decisive for the loss of integrity of the rod, as the maximum temperature of the fuel remained well below the normal operating temperature, as evidenced by the value of DNBR obtained.



Reference

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