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PRACA DOKTORSKA

MODELOWANIE PROCESÓW ROZPRZESTRZENIANIA SIĘ WYBRANYCH CZYNNIKÓW W OBUDOWIE BEZPIECZEŃSTWA REAKTORA PWR PO AWARII LOCA

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Gliwice 2014

Abstract

A huge emphasis is put in the research concerned with nuclear power plants into analyses of accidents conditions. Among a number analysed accidents, Loss of Coolant Accidents (LOCA) are regarded as the most serious ones. These accidents take place after rupture of the pipe of the reactor primary circuit. In this case the hot radioactive water leaks from the pipe of the circuit into the reactor containment and evaporates immediately. The containment atmosphere is filled by water vapour, oxygen, nitrogen, hydrogen generated in the reactor core during father accident periods and moisture resulting from vapour condensation. The containment walls become this time the only barrier protecting the environment from radioactive fission products. Complex processes of heat and mass transfer of liquid and gas with change of phase take place in the reactor containment during LOCA.

Models of three stages of transport processes taken place in the pressurised water reactor (PWR) containment during LOCA have been developed and checked under the presented thesis using the commercial CFD ANSYS Fluent code.

The first model concerns the beginning stage of LOCA. The model includes multiphase mass and heat flow in the containment compartment, and it assumes coexistence of liquid water and a mixture of water vapour and air. The change of phase and the heat transfer into the containment walls are taken into account as well.

The second model is connected with mixing of water vapour and a light gas (helium simulated hydrogen). It assumes a single phase flow of a mixture of air, water vapour and helium taking into account the mass diffusion.

The last developed model concerns a passive autocatalytic hydrogen recombiner and a model of a compartment containing the passive recombiners. The models describe transport of water vapour, oxygen, nitrogen and hydrogen in a post-accident atmosphere of a pressurized water reactor containment. Kinetics of exothermic catalytic reaction of hydrogen and oxygen taken place on the surface of the recombiner plates are also included. The problem of the hydrogen recombiner placed in the compartment was depicted in two ways - a two-dimensional model with exact geometry of the catalytic part of the recombiner as plates and a three-dimensional model with the catalytic part modelled as a porous zone.

The results show that CFD modelling of the first stages of LOCA is possible, but very time consuming, that makes this approach useless. This results from the intensity this time and complexity of the processes occurring in the large volume containments. CFD can be however successfully used to model the passive autocatalytic hydrogen recombiners that are located in the reactor containments and play a very important role during father periods of LOCA.