SUMMARY OF Ph.D. DISSERTATION

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Title
Study on Flow Measurement in Fuel Rod Bundles and Development of a High Performance Spacer Grid

Abstract

Pressurized water reactor (PWR) spacer grids have mixing structures (vanes) to promote coolant mixing to efficiently remove heat generation from fuel rods. For a future up rating and a longer cycle operation, a higher thermal performance is required for PWR fuel assembly. To meet the needs of fuel market, we have to develop a spacer grid whose pressure loss is less than the current grid and that has higher critical heat flux property.

The purpose of this study is to establish the numerical design method which is verified by experimental data to develop a high performance spacer grid. For this purpose, we have carried out velocity field measurements in fuel rod bundles and other experiments to verify numerical estimation and developed a numerical model.

The first chapter explains the background of the necessity of the high performance spacer grid and the problem of current method for development of new spacer grid. The advantage of design technique in this study for development of a spacer grid and the procedure of this study are also explained.

The second chapter describes the specification for rod-embedded laser Doppler velocimetry (rod LDV) to apply narrow gaps in a rod bundle and the confirmation for applying the velocity measurement in a fuel rod bundle.

In the third chapter, we have used the rod LDV to measure the velocity distributions in rod bundles and inside flow channels of spacer grids. Using the results, we clarified the relationship between the velocity distribution and the grid structure and mixing vanes and between the velocity distribution and the cross flow in the rod bundle. The validity of measured data in fuel rod bundles is evaluated to compare previous studies.

In the fourth chapter, the numerical model for velocity field estimation in fuel rod bundles is discussed with comparing velocity measurements in the third chapter.

In the fifth chapter, we propose the new method which evaluates both of pressure loss of spacer grids and local hot spots around fuel rods relating critical heat flux of fuel using the numerical model verified in the fourth chapter. In the aspect of the compatibility of pressure loss and critical heat flux property, we selected the best performance grid design and carried out thermal-hydraulic tests. The selected design is evaluated about 4% lower pressure loss and 12% higher critical heat flux property than the current design.

In the sixth chapter, the validity of the numerical method in this study is examined. The local enthalpy around fuel rods is assumed to relate the critical heat flux property of the fuel. The estimation of enthalpy distribution around the rods is compared to the experimental results of two kinds of spacer grids and the numerical design method in this study is confirmed to be efficient for designing and developing high performance spacer grids.

In the seventh chapter, the results of our research are summarized.