EXPERIMENTAL AND COMPUTATIONAL STUDY OF RIBBED CLADDING FOR PWR ROD BUNDLES HEAT TRANSFER ENHANCEMENT

L. A. Carrilho[*], M. B. Dzodzo[+]
Westinghouse Electric Company
[*]5801 Bluff Road, Hopkins, SC 29061, USA
[+]1000 Westinghouse Drive, Cranberry, PA 16066, USA
carrilla@westinghouse.com; dzodzomb@westinghouse.com

J. A. Khan
Department of Nuclear Engineering
University of South Carolina
300 Main Street, Columbia, SC 29208, USA
khan@cec.sc.edu

ABSTRACT

PWRs fuel assemblies utilize spacer grids with flow mixing vanes to generate lateral flows and augment the coolant turbulence intensity and improve convective heat transfer from the fuel rods surface. However, the large eddy structures and turbulence intensity generated due to mixing vanes decays downstream of the spacer grids so the benefit is reduced as a function of distance. Artificial roughness will improve convective heat transfer at fuel rod surface as it acts as a boundary layer disturbance in the near-wall turbulent flow to promote higher momentum and more uniform heat transport along the surface of the rod. The empirical correlations based on the gas cooled fuel rod rough surfaces test data were used by Meyer et al [15] to perform an analysis to predict heat transfer and friction factor increases for artificially roughened fuel rod bundles at High Performance Light Water Reactors, but their applicability has never been experimentally confirmed. A Single Heater Element Loop Tester (SHELT) was designed to investigate the use of the artificial roughness for improved heat transfer in PWR rod bundles. The observations during the experiments included measurements of volumetric flow rate, electrical power, differential pressure, water and heated single rod wall temperatures across the smooth and the ribbed surfaces at pressures and temperatures in the range of 0.2 to 0.5 MPa and 20 to 120^{o}C, respectively. Also, the corresponding Computational Fluid Dynamics (CFD) model of conjugated heat transfer was developed and validated by comparing with experimental results. This study shows that transverse square ribs improve heat transfer in PWR rod bundles by a factor of 1.47. On the other hand, the friction factor results indicate an increase in flow resistance by a factor of 1.50. Further studies are needed to check if an application of helical ribs might reduce the flow resistance without significant decrease of the obtained heat transfer enhancement.

KEYWORDS
Nuclear fuel rod, artificial roughness, test loop, convective heat transfer, CFD

1. INTRODUCTION

Modern PWR fuel assembly designs rely on mixing vanes for improved heat transfer within fuel rod bundles. These vanes generate global flow turbulence in the form of lateral flows and swirls, which

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