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Peridynamic Simulation of Pellet-Clad Mechanical Interaction in Nuclear Fuel Rods

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ABSTRACT

The thermomechanical response and potential cracking in nuclear fuel rods are extremely important for nuclear safety analysis. The Pellet-Clad Mechanical Interaction (PCMI) is a significant factor for the thermomechanical behaviors of pellet and clad. This study presents a PCMI model based on ordinary state-based peridynamic (OSB-PD) theory, which considering the heat transfer through the gap and contact heat transfer between pellet and clad. The two-dimensional (2D) models are constructed through irregular non-uniform discretization. The pellet model includes the random variability of the critical stretch of each bond based on normal distribution. The contact model with non-uniform discretization is proposed in this paper, and its accuracy is validated against the Finite Element Method (FEM) results. Subsequently, the behavior of PCMI and crack patterns of fuel pellet are studied at different power levels. Also, the role of friction coefficient between pellet and clad on the pellet cracking is explored with a constant power level. The results show that the thermomechanical response and damage possibility of clad increase with the power level raise up, as well as the pellet damage. The pellet-clad friction has an important influence on the pellet crack distribution, and the number of cracks is positively correlated with the friction coefficient.

KEYWORDS

Nuclear fuel pellets; Pellet-Clad mechanical interaction; frictional contact; random variability; crack distribution

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