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Fretting Wear Comparison of Cladding Materials for Reactor Fuel Cladding Application

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Abstract

Relative motion between the fuel rods and fuel assembly spacer grids can lead to excessive fuel rod wear and, in some cases, to fuel rod failure. Based on industry data, such grid-to-rod-fretting is a significant cause of fuel failures in U.S. pressurized water reactor power plants. Kanthal advanced powder metallurgy technology or APMT, an FeCrAl steel alloy, and a braided SiC fiber, Chemical Vapor Infiltration SiC matrix (SiC/SiC) cladding by General Atomics are possible alternatives to conventional fuel cladding in a nuclear reactor due to their favorable performance under accident conditions. Tests were performed to examine the reliability of the cladding candidates and a conventional cladding, Zircaloy-4, under dry fretting conditions at elevated temperature. The contact was simulated with a rectangular and a cylindrical specimen over a line contact area. Confocal scanning laser microscopy was used to obtain a 3D map of the surface, which was in turn used for wear and work rate calculations on the samples. The wear rate coefficient was used as a measure of the performance and wear under fretting. Additionally, Energy Dispersive Spectroscopy was performed to qualitatively describe the microchemical changes the material undergoes during fretting. While APMT steel and SiC/SiC can perform favorably in loss of coolant accident scenarios, they also need to perform well when compared to Zircaloy-4 with respect to fretting wear. Wear coefficient measurements showed that APMT steel performs favorably in comparison to Zircaloy-4 with respect to fretting wear.

Keywords: APMT, Cladding, Fretting, SiC

1. Introduction

Flow-induced vibration (FIV) can cause severe fretting wear damage, in nuclear reactor components, such as steam generators, heat exchangers, and fuel assemblies [1, 2]. Fretting is a low amplitude oscillatory motion between contacting bodies which results in wear and fatigue damage [3]. The type and extent of wear and fatigue damage is sensitive to many parameters such as amplitude, normal force, and coefficient of friction (COF) [4]. Fuel rod fretting is a significant concern for pressurized water reactor fuel designers. Core and assembly flow distributions are important in understanding both the fuel assembly and fuel rod vibration behavior. At the vibration levels of these fuel rods and fuel assemblies, interaction