Research Experiences for Urban Science Teachers

Monitoring SiC Fuel Rod Cladding Corrosion by Determination of Aqueous Silica Concentrations

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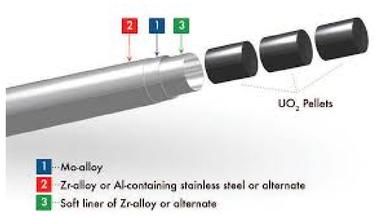
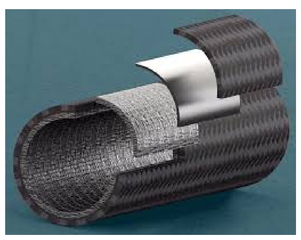
Overview

Research on accident-tolerant fuel cladding is being conducted by the Department of Energy laboratories in conjunction with industry and academia. Currently, there are three industry awards being funded by the DOE, with cost sharing from industry, to develop accident tolerant fuel and cladding. The three industry teams are led by Westinghouse, AREVA, and GE Global Research, but each team includes a large number of research partners from industry, academia and DOE laboratories. Additionally, there are university teams that are funded through the US DOE Office of Nuclear Energy under Integrated Research Proposals to develop accident-tolerant fuel and reactor concepts. These teams are led by the University of Tennessee, the University of Illinois, and the Georgia Institute of Technology, again with a large number of research partners on each team.[1]



Fuel pellets encased in cladding



Cross section of Silicon Carbide Cladding

Justification

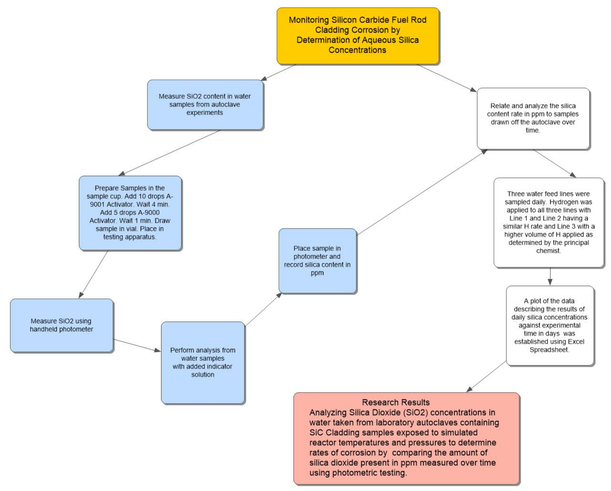
To determine the rate of corrosion of SiO_2 concentrations present in water samples taken from an autoclave apparatus to simulate reactor temperatures and pressures over a period of time.

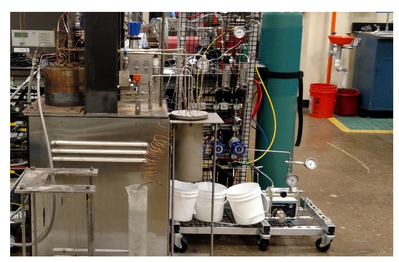
Methodology

Silicon Carbide cladding samples were placed within the autoclave and exposed to an open loop water supply with hydrogen gas added at varying pressures. This experiment is designed to determine the amount of SiO_2 concentrations from three separate sampling sources as an indicator of corrosion and breakdown of silicon carbide samples.

[1] Nuclear Engineering International, April 19, 2013

Master Model of the Experimental Method





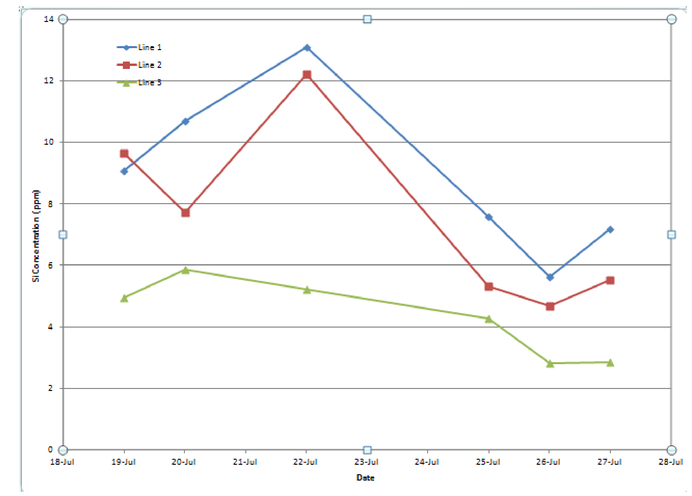
Autoclave Setup

Drawing samples from lines

Photometric testing method

Measured Silica Dioxide in ppm

Results and Conclusions



The chart above shows relative rates of corrosion over a nine day period. Lines 1 and 2 had 5 psig of Hydrogen introduced to the testing, whereas Line 3 had 20 psig of added Hydrogen . These results show an increased concentration of SiO_2 present in samples on day three as the rate of corrosion peaked, then tapered as testing continued. The corrosion rate of line 3, as compared to lines 1 and 2, was significantly less indicating that an increased level of hydrogen reveals a lower rate of corrosion for this testing. This experiment yielded a result that an increased hydrogen level has a direct relative effect on the corrosion rate of silicon carbide cladding in aqueous solution.

Future Work

More experimentation will be necessary for greater correlations to analyze the effects of dissolved silica as compared to total crystallized silica from future experimentation of silicon carbide cladding.

The characteristics of silica carbide cladding does offer promise as an accident tolerant, first layer of protection due to high heat tolerance and very low corrosion rate as compared to zirconium and zircalloys. However further analysis and thorough application testing will need to continue well into the future before the nuclear industry will adopt it as a replacement of zirconium cladded fuel rods.

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