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5 - Can Operating Conditions affect CANDU® Pressure Tube Resistivity?

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For eddy current based inspections of CANDU® reactor fuel channels, material electrical resistivity is an important parameter. For pressure tube (PT) to calandria tube (CT) gap measurements, material resistivity values are required to ensure accurate measurement of the gap. The resistivity used during inspections are assumed to be the same as that of calibration PTs, which are non-heat treated, non-irradiated and are assumed to reflect that of in-reactor conditions. In contrast, other important parameters in gap measurement are affected by in-reactor conditions, such as PT wall thickness and PT diameter, and are compensated for using in-reactor measurements. To test the hypothesis of whether sustained elevated temperatures, similar to in-reactor conditions, could change a material's resistivity, this study examined the effect of heat treatment on the resistivity of Zr2.5%Nb. Under anaerobic furnace conditions, sectioned PT samples were held for varying periods of time at 400 ℃ and 450 ℃, to partially decompose beta-Zr and produce varying fractions of omega-Zr. Temperatures of 400 ℃ and 450 ℃ were chosen to accelerate the phase transformations that take place over a long period of time under reactor operating conditions, where temperatures are between 250 ℃ and 310 ℃. Using the four-point resistivity measurement technique, the resistivity of the heat-treated PT samples was measured and changes in resistivity with time at temperature were recorded. The magnitude of the resistivity was observed to decrease by up to 10% with time in the furnace. Reduction of resistivity with heat treatment was associated with changes in the microstructure. Examination by transmission electron microscopy (TEM) showed an increase in the volume fraction of hcp omega-phase, and associated bridging between higher conductivity alpha-Zr grains, which consequently would result in an overall decrease of resistivity. These results have implications for the estimated uncertainty of PT to CT gap measurement, where temperature variation arises along the channel and between 6 and 12 o'clock at a given axial position.

Authors: Mr BENNETT, Perryn (Queen's University); Dr TOPPING, Matt (Queen's University); Dr UNDERHILL, Ross (Royal Military College); Dr MORELLI, Jordan (Queen's University); Dr DAYMOND, Mark (Queen's University); Dr KRAUSE, Thomas (Royal Military College)

Presenter: Dr MORELLI, Jordan (Queen's University)

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