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IMPROVING THE CALANDRIA TUBES FOR CANDU REACTORS

C.E. Coleman, R.W.L. Fong, G.L. Doubt[1] and D.B. Sanderson[2]

Abstract

CANDU calandria tubes are made from annealed Zircaloy-2 sheet formed into a cylinder and welded along its length to make the tube. The current calandria tubes have given exemplary service for many years. With more stringent regulations and the need to accommodate warm cooling water in tropical countries, we started a development program to increase the margins for failure during postulated accidents. These improvements involve increasing the tube strength and optimising the heat-transfer from an excessively hot fuel channel to the cool moderator. If the postulated accident involves a pressure tube break, it would be desirable if the calandria tube withstood the full pressure of the heat-transport system. The weakest link in current calandria tubes is the weld. Thickening the weld can increase the strength by 20% while seamless tubes can be 45% stronger than current tubes. The latter tubes can hold full system pressure for many hours without failure. If during the postulated accident the fuel and pressure tube become excessively hot but do not touch the calandria tube, the radiant heat loss must be maximised. Current calandria tubes have an absorptivity (emissivity) of about 0.2. To protect the fuel and the fuel channel we have devised a finish to the inside surface of the calandria tube that increases the emissivity to 0.7. If during the postulated accident the hot pressure tube touches the cool calandria tube, the contact conductance and the critical heat flux must be optimised to ensure nucleate boiling of the moderator at the outside surface of the calandria tube and therefore efficient exploitation of the moderator as a heat sink. In laboratory tests small ridges on the inside surface and roughening of the outside surface have been shown to increase the margins against failure and increase the possible moderator temperature thus providing the opportunity to decrease the cost of the moderator heat-exchange system and remove restrictions on reactor operation in warm climates.

Fuel Channel Components Branch
Reactor Materials Division
Chalk River Laboratories
Chalk River, Ontario K0J 1J0

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[1] Mechanical Equipment Development Branch, CRL
[2] Containment Analysis Branch, WL