ASSESSMENT OF FUEL COOLING UNDER SHUTDOWN CONDITIONS IN GENTILLY 2

by

P. Gulshani
AECL, 2251 Speakman Drive, Mississauga, Ontario, L5K 1B2,
e-mail: gulshanp@aecl.ca

H.M. Huynh
Hydro Quebec, 1000 rue de la Gauchetiere Ouest, Montreal, Quebec
H3C 4W5

SUMMARY

This paper presents the results of an analysis of Gentilly 2 station data recorded during the 1996 annual plant outage. One of the tasks performed during this outage was repositioning of the garter springs in some of the fuel channels using SLARETTE.

A primary concern during the outage was to provide adequate fuel and fuel channel cooling and heat sink for the fuel decay heat. In a reactor shutdown state, the primary heat sinks are the steam generators (for a full primary heat transport system, PHTS) or the shutdown cooling system (SDCS) heat exchangers (for full or drained PHTS). The PHTS or SDCS pumps circulate the coolant and transfer the fuel heat to these heat sinks. If forced circulation is unavailable, secondary heat sinks are either the steam generators (for full PHTS) with thermosyphoning transporting the decay heat, or the coolant and piping subcooling (for partially full PHTS) with standing start or intermittent buoyancy induced flow (IBIF) transporting the decay heat.

During the 1996 Gentilly 2 annual plant shutdown, the PHTS inventory was drained to the header level. The inlet and outlet headers were connected to the shutdown cooling system (SDCS) to remove the fuel decay heat. In this low level drained state, the water level in the inlet-header inlet lines was about 0.3 to 0.35 m higher than that in the outlet header outlet lines. This water level difference was used to maintain sufficient flow through the core. On different days during the plant outage, fuel was removed from some fuel channels and SLARRETTE operation was performed on these channels.

During the period April 17 to June 06, 1996, some tests were performed. In these tests, the recirculating cooling water (RCW) flow to the SDCS heat exchangers was stopped and subsequently resumed, and the rise and subsequent drop in the outlet feeder temperatures were monitored. During these tests, inlet and outlet header temperatures and some of the

inlet and outlet feeder temperatures near the end fittings were measured. Furthermore, outlet feeder temperatures near the headers were measured .

The station data showed that the outlet feeder temperature increased after the RCW flow was stopped. For most of the channels, the outlet feeder temperature decreased after the RCW flow was resumed. However, for some of the channels, the outlet feeder temperature increased for a period before decreasing after the RCW flow was resumed. Furthermore, the temperature in these outlet feeders did not decrease significantly and remained relatively high. The outlet feeder temperature increase after the resumption of the RCW flow occurred when the temperature in the other outlet feeders had decreased significantly.

Recorded temperatures and an energy balance were used to compute the flow in the channels with high outlet feeder temperatures. These channel flows were computed to be very low implying that the coolant in these channels were almost stagnant. It is postulated that these channel flows were low because air pockets partially blocked the inlet feeders to these channels and/or because air bubbles in the inlet feeders reduced significantly the hydrostatic heads in these feeders. It is postulated that these air bubbles could have entered the coolant circuit from two sources. They could have entered the inlet headers from the channels and then entered the inlet feeders when the fueling machine was connected to the channels. The air could have also entered the inlet headers and feeders after the SDCS flow entrained air bubbles.

An examination of the station data seems to indicate that air entrainment with the SDCS flow was the more likely scenario. This entrainment occurred when the water level in an inlet-header inlet line dropped below the elevation of the top of a SDCS line at its connection with the header inlet line. This level drop occurred when the circuit coolant temperature decreased and the coolant volume shrank after the RCW flow was resumed. This water level drop caused the water emerging from the SDCS line to travel through air before penetrating the water surface.

Two possible air entrainment mechanisms were considered. One mechanism would be pull-through of air bubbles by the coolant flow in a header inlet line. The second mechanism would be entrainment of air by the flowing SDCS water column as it travelled through air and penetrated the water surface in a header inlet line. It is shown that the second air entrainment mechanism is the more likely mechanism.

Fuel temperature was calculated using the models THERMOSS-III (References 1and 2) and AMPTRACT (Reference 3) assuming that channel coolant stagnated due air bubbles or pockets in the inlet feeder. For the worst case scenario, the resulting limiting temperature is computed to be about 216 ^{o}C. For this temperature, the fuel sheath integrity is assured and the fuel can be safely returned to full power.

References

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