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Sensitivity Analyses on Ageing Elements for Wolsong Unit 1 Using RELAP/CANDU-SCAN Coupled Code System

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1. INTRODUCTION

Wolsong Unit 1 is in operating for 23 years since 1983. As a result of long-term operation, structure, systems and components (SSC) have in general suffered from ageing. However, as up to now, the researches for ageing are only focused on the individual system, component or structure [1]. Meanwhile, a comprehensive safety analysis considering integrated ageing effects for a nuclear power plant (NPP) has not been performed so far.

Therefore, in this study, the ageing effects on the safety analysis for Wolsong Unit 1 were identified and assessed using RELAP/CANDU-SCAN coupled code system [2] to present the technology basis applied to continuing operation.

2. METHODS AND RESULTS

2.1 Selection of Ageing Effects

The elements of ageing effects that could be considered in the primary heat transport system are as follows:

- inlet / outlet feeder pipe wall roughness
- inlet feeder pipe orifice loss coefficient
- inlet end fitting wall roughness
- fuel channel wall roughness
- fuel channel flow rate, hydraulic diameter, loss coefficient, and coolant volume
- primary inner diameter and wall roughness of steam generator
- rated pump head and rate flow of primary heat transport pump.

The parameters for the given point can be obtained by NUCIRC code, which are developed applying the NPP condition of specific point. In this study, only three elements, which are fuel channel wall roughness, end fitting wall roughness, and rated pump head and rated flow of PHT pump, are applied to the Wolsong Unit 1 nodalization model. The other elements will be added if the database of ageing effects will be obtained in the future.

2.2 Initial Steady-State Conditions

Two reactor power cases (81.59% and 103% FP) were calculated using RELAP/CANDU-SCAN coupled code system and the simulation results of 81.59% FP were compared with those of both NUCIRC [3] code and CATHENA code calculation. First, five cases were tested for 81.59% FP as shown in Table 1. One is the original case which doesn't consider any ageing effects. Another is the case which considers all the three ageing effects. And the others are the cases that consider each ageing effect, respectively.

Compared with the original case, the simulation results considering only pump rated head and rated flow showed that 0.08MPa pressure increase at the inlet header pipe, 0.94K temperature decrease at the outlet header pipe, 58.85kg/sec mass flow rate increase at fuel channel and 0.08MPa differential pressure increase between inlet and outlet header pipes.

The simulation results considering only fuel channel wall roughness showed that 0.18MPa pressure decrease at the inlet header pipe, 1.69K temperature decrease at the outlet header pipe, 105.5kg/sec mass flow rate increase at fuel channel and 0.18MPa differential pressure decrease between inlet and outlet header pipes.

On the other hand, the simulation results considering only end fitting wall roughness showed few differences from the original case.

The simulation results considering all the three ageing effects showed that 0.12MPa pressure decrease at the inlet header pipe, 2.69K temperature decrease at the outlet header pipe, 175.4kg/sec mass flow rate increase at fuel channel and 0.11MPa differential pressure decrease between inlet and outlet header pipes. In spite of some differences, these results were somewhat similar with those of NUCIRC model and CATHENA code calculation. If the remaining parameters of ageing effects are added, the differences will be smaller. There were no boiling phenomena in the primary side for 81.59% FP case.

Next, numerical simulations for 103% FP case were tested just as 81.59% FP case. In this case, there are no references such as NUCIRC model and CATHENA code calculations in 81.59% FP case. So sensitivity studies for the considerations of ageing effects were performed.

The sensitivity study showed that the ageing effects on the initial steady-state conditions for 103% FP case were similar with those for 81.59% FP case. One difference is that there are two phase flow having 0.03～0.046 quality values at the outlet header for 103% FP case.

In both cases, the fuel channel wall roughness among the three selected ageing effects had the maximum effects on the initial steady-state conditions. And the end fitting wall roughness had the minimum effects.

Table 1. Summary of initial steady-state conditions for 81.59% FP (Full Power)

Parameters	RELAP/CANDU					HT_W1_1999 Prediction (CATHENA)	NUCIRC Prediction
	Ageing Element						
	no	pump	fuel chanel	end fitting	pump+fc+ef		
IHD Pressure [MPa]	11.41	11.49	11.23	11.41	11.29	11.19	11.16
IHD Temperature [K]	534.76	535.00	535.13	534.77	535.40	537.03	536.22
OHD Pressure [MPa]	10.04	10.04	10.04	10.04	10.04	10.00	9.94
OHD Temperature [K]	576.56	575.62	574.87	576.53	573.87	575.73	576.21
Core Flow [kg/sec]	1980.7	2039.6	2086.2	1982.7	2156.1	2121.8	2095.5
Head Pressure Drop [MPa]	1.37	1.45	1.19	1.36	1.26	1.20	1.20

2.3 Transient Simulations

The analysis for 35% RIH break with loss of class IV power was performed. Two cases were simulated for each reactor power. One is the original case and the other is the case that considers all the three ageing effects. The ageing effects on the power pulse for 81.59% FP case were ambiguous. But for 103% FP case, the trip time and the peaking power were different from each other as shown in Fig. 1.

As shown in Fig. 2, there were some differences in the fuel channel flow rates between ageing and no-ageing cases before the trip of PHT pump. But as PHT pump stops, the differences become small quickly.

The fuel cladding temperatures at critical path were shown in Fig. 3. As is expected, the 103% FP case had higher temperature than the 81.59% FP case. There are some differences depending on the consideration of ageing effects in both cases. The differences are more distinct in the 103% FP case compared with 81.59% FP case.

And the other parameters, such as break discharge flow, and the pressure and temperature at inlet/outlet header pipe, showed no remarkable differences between ageing and no-ageing cases at both 81.59 and 103% FP cases.

3. CONCLUSION

The assessment of ageing effects for the safety analysis of Wolsong Unit 1 were performed using RELAP-CANDU/SCAN coupled code system. Initial steady-state conditions were calculated and compared with those of NUCIRC model and CATHENA code. The safety analysis for 35% RIH break with loss of class IV power was also performed. The results of this study will present the technology basis applied to continuing operation of Wolsong Unit 1.

ACKNOWLEDGEMENT

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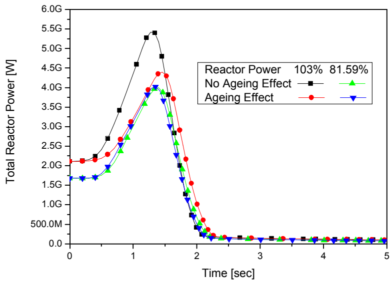

Figure 1. Total reactor power at 81.59 & 103% FP

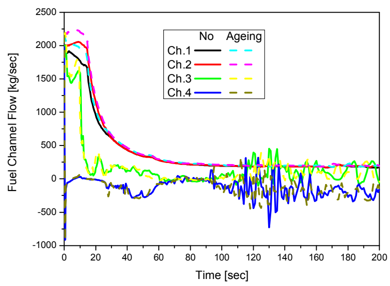

Figure 2. Fuel channel flow at 81.59% FP

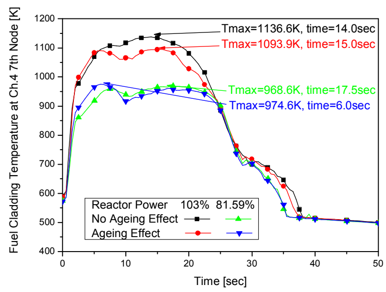

Figure 3. Fuel cladding temperature at 81.59 & 103% FP