The effect analysis of CCP calculated with the 95% power condition of Wolsong-2

You Sung-Chang*, Ryu Eui-Seung
Korea Hydro & Nuclear Power Co., Ltd. 1312, Yuseong-daero, Yuseong-Gu, Daejeon, Korea, 305-343
**Corresponding author: chang38@khnp.co.kr*

1. Introduction

The PHWRs are tendency that ROPT(Regional Overpower Protection Trip) setpoint is decreased with reduction of CCP due to aging effects. For this reason, Wolsong-2 has been operated in less than 100% power due to the result of ROPT setpoint evaluation[1]. The CCP(Critical Channel Power) for ROPT evaluation is typically calculated at 100% boundary conditions like inlet header temperature, header to header different pressure and outlet header pressure but we can't acquire plant data of 100% power condition for Wolsong-2 due to aging effects. Therefore we analyzed the difference of CCP between measured data at 95% power and extrapolated data of 100% power in Wolsong-2(2013). It was identified that the CCP at 100% condition is -0.05%(-3.66kW) less than the CCP at 95% condition for difference of minimum CCP to the worst case(CASE22) used ROPT evaluation as show in Table-Ⅲ. In conclusion, it was identified that calculated results of CCP at 95% and 100% condition in Wolsong-2(2013) are very similar results.

2. Methods and Results

We used NUCIRC[2]/NUPREP[3] codes to make thermal-hydraulic model of Wolsong-2(2013) and to calculate difference of CCP between at 95% and 100% power conditions in Wolsong-2. And we compared difference of CCPs between at 95% and 100% conditions for the following cases

- · CASE001 : using flux shape of steady state condition
- · CASE222 : using flux shape of transient that is minimum CCP of Wolsong-2(2013)

2.1 Tools

NUCIRC/NUPREP codes were used this analysis. NUCIRC is a steady-state thermal-hydraulic code used by designers and analysts to examine the behavior of the heat transfer system(HTS) of a CANDU® nuclear reactor over a wide range of single-phase and two-phase operating conditions.[4]

· NUCIRC/NUPREP 2.3.1.2
- Operating system : WINDOWS XP
- Language : Fortran77
- Compiler : Compaq Visual 6.6.0

2.2 Calculation Conditions

· Wolsong-2(2013) plant data acquired in 80% and 95% power were used to make Wolsong-2 thermal-hydraulic model and to determine aging parameters. Aging parameters of thermal-hydraulic model in Wolsong-2(2013) are feeder roughness, orifice degradation factor and HDR DP gradient etc. to calculate CCP.

· CCPs were calculated from plant data acquired at 95% power and by extrapolating the data from 95% to 100% for Wolsong-2 as shown in Table I. TRIH, HDR DP, PROH are boundary conditions affected by power for CCP calculation.

Table I. Boundary conditions of Wolsong-2(2013)

	Plant data (Wolsong 2)		extrapolation	Diff. 100%-95%
	80%	95%	100%	
TRIH (℃)	263.580	264.147	264.353	+ 0.206
HDR DP (㎪)	1225.437	1234.584	1237.904	+ 3.321
PROH (㎫)	9.971	9.971	9.971	+ 0.000

2.1 Result of CCP calculation

We compared the results of CCP calculation for nominal case(CASE001) and the worst case(CASE222). As shown in Table Ⅱ and Table Ⅲ, the averaged CCP from 100% power condition is about -0.04% less than from 95% power condition. Fig.1 shows that CCP differences for normal operation condition are 4.57kW maximum and -10.77kW minimum. And fig.2 shows that CCP differences for the worst transient condition are 5.20kW maximum and -11.82kW minimum. As the results, CCP differences were from -1.13% to +0.07% for nominal case(CASE001) and from -0.14% to +0.8% for the worst case(CASE222). The CCP at 100% condition is -0.05%(-3.66kW) less than the CCP at 95% condition for difference of minimum CCP to the worst case(CASE22) used ROPT evaluation as show in Table-Ⅲ.

$$CCP\ defference = \frac{(CCP\ at\ 100\%\ power\ conditions - CCP\ at\ 95\%\ power\ coditions)}{CCP\ at\ 95\%\ power\ conditions}$$

Table Ⅱ. The results of nominal case (CASE001) comparative calculation

STC dryout power (㎾)		Boundary Condition		Diff. (100%-95%)
		95%	100%	
Total	Avg.	7664.86	7662.05	-2.81 (-0.037%)
	Min.	4709.59	4708.86	-0.73 (-0.015%)
Center Region	Avg.	8693.09	8688.81	-4.28 (-0.049%)
	Min.	7996.96	7995.57	-1.39 (-0.017%)

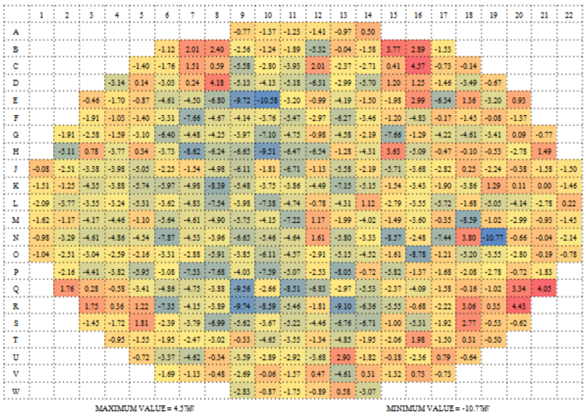

Fig. 1. The results of Nominal case (CASE001) comparative calculation

Table Ⅲ. The results worst case (CASE222) comparative calculation

STC dryout power (㎾)		Boundary Condition 95%	Boundary Condition 100%	Diff. (100%-95%)
Total	Avg.	7401.30	7398.21	-3.09 (-0.042%)
	Min.	4691.71	4691.04	-0.67 (-0.014%)
Center Region	Avg.	8193.16	8188.51	-4.65 (-0.057%)
	Min.	7630.99	7627.33	-3.66 (-0.048%)

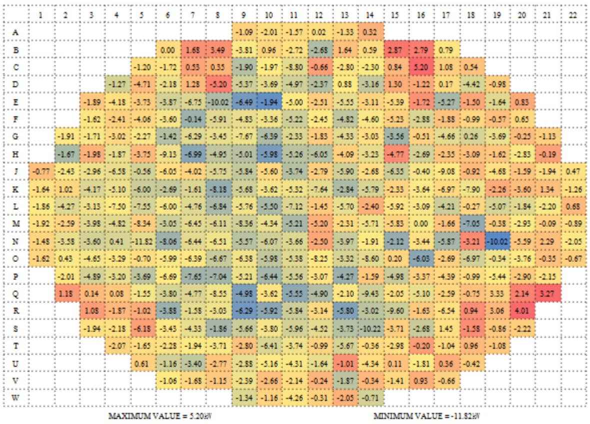

Fig. 2. The results of worst case (CASE222) comparative calculation

3. Conclusions

The PHWRs are tendency that ROPT setpoint is decreased with reduction of CCP due to aging effects. The PHWRs should be re-evaluated the ROPT setpoint and are operated to restrict the operating power according to the results. In addition, Wolsong-2 has been operated in less than 100% power due to the result of ROPT setpoint evlaluation. However CCP(Critical Channel Power) for ROPT evaluation are typically calculated at 100% power conditions. Therefore we analyzed the difference of CCP by variation of the boundary conditions in Wolsong-2(2013) and identified the CCP at 100% condition is -0.05%(-3.66kW) less than the CCP at 95% condition for difference of minimum CCP to the worst case(CASE22) used ROPT evaluation as show in Table-Ⅲ. In extrapolation of the boundary conditions(TRIH, HDR DP, PROH), the small difference of CCP is predicted because the increase of TRIH reduces CCP by increase of incoming energy and the increase of HDR DP increases CCP by the increase of the channel flow. In conclusion, it shows that the results of CCP calculation are very similar between from 95% power condition and 100% power condition for Wolsong-2(2013).

REFERENCES

[1] “Wolsong unit 2 ROPT setpoint and creep penalty evaluations”, KHNP, Jun.2011

[2] “NUCIRC-MOD2.003 User’s Manual”, D. J. Wallace, 153-116190-UM-001, AECL, Jan.2006

[3] “NUPREP-MOD2.003 User’s Manual”, D. J. Wallace, 153-116190-UM-002, AECL, Jan.2006

[4] “NUCIRC-MOD2.003R1(NUCIRC2.3.1) Program Abstract” , D. J. Wallace, 153-116190-SPA-001, AECL, Jan.2007