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Operation Strategy during Loss of a Main Feedwater Pump for Kori Units 3 & 4 and Yonggwang Units 1 & 2

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1. Introduction

The loss of a main feedwater pump transient was evaluated to determine the steam generator (SG) narrow range level (NRL) behavior and margin to the NRL trip setpoints for the 4.5% uprate program of Kori Units 3 & 4 and Yonggwang Units 1 & 2. After the power uprating, two feedwater pumps have a maximum capacity of 94.8% of the required flow, which is insufficient to meet the feedwater flow demand for 100% power uprated conditions. Therefore, some analyses were performed in case of a loss of a feedwater pump to determine the optimal target power level after the turbine runback, and in addition, the optimal runback rate. This will be done for two tasks: (1) loss of a feedwater pump event from three feedwater pump operation at full power, and (2) loss of a feedwater pump event from two feedwater pump operation at reduced power. These analyses were performed using advanced continuous simulation language (ACSL) plant simulation model KSR010, which was also used for the 4.5 % uprate program. KSR010 is a plant transient computer model that simulates the steady state and transient responses of the SG secondary side at operational transients in Westinghouse type plant[1,2,3].

2. Analysis Methods

2.1 Loss of a Feedwater Pump

Prior to analyzing the following cases for Task 1, a base case was analyzed in order to determine the minimum steady state flow conditions required with two pumps in operation to support a power level of 94.8%; this was done by adjusting the KSR010 input variable for the number of operating pumps, NUMP. Steady state conditions were achieved when the SG level remained at 50% of span, the pump speed at the maximum speed of 5550 rpm and the feed water regulating valves at 100% open. For the various cases, the feedwater flow determined using two pumps was proportionally increased to simulate three pumps.

Task 1 is the analysis of loss of a feedwater pump from three feedwater pump operations at full power as follows;

1) Turbine runback to 90% of power with 100%/min. runback rate
2) Turbine runback to 85% of power with 100%/min. runback rate
2a) Turbine runback to 60% of power with 100%/min. runback rate
3) Turbine runback to 90% of power with 150%/min. runback rate
4) Turbine runback to 85% of power with 150%/min. runback rate
5) Turbine runback to 85% of power with 150%/min. runback rate (no steam dump)

2.2 Loss of two Feedwater Pumps

The purpose of Task 2 is to determine the optimal runback target power level when a loss of one feedwater pump occurs during two pump operation at reduced power levels. For the various cases, the feedwater flow from two pumps was proportionally decreased to simulate feedwater flow from one pump. Based on the results of Task 1, the turbine should be runback from 100% power to 90% power or less when there is a loss of one feedwater pump from three pump operation. Therefore, operation with two intact pumps should begin at 90% power or less.

Task 2 is the analysis of loss of a feedwater pump from two feedwater pump operation at reduced power as follows;

7a) Turbine runback from 90% power to 45% of power with 100%/min. runback rate
8a) Turbine runback from 90% power to 45% of power with 150%/min. runback rate
7b) Turbine runback from 70% power to 45% of power with 100%/min. runback rate
8b) Turbine runback from 70% power to 45% of power with 150%/min. runback rate
7c) Turbine runback from 60% power to 45% of power with 100%/min. runback rate
8c) Turbine runback from 60% power to 45% of power with 150%/min. runback rate

3. Analysis Results

3.1 Loss of a Feedwater Pump

Variations of the turbine runback termination point and the turbine runback rate were analyzed for a loss of a main feedwater pump event at full power (Task 1). For the various cases (cases 1 through 5), the minimum and maximum SG level responses were similar; the differences were insignificant. Note that for cases 1 through 5, there was some margin to the SG level low-low (greater than 17% span) and high-high (greater than 78% span) trip setpoints. Despite the minor variations in the SG level responses for the various cases analyzed, the two intact pumps would have to operate at the maximum pump speed (5550 rpm) in order to obtain steady state conditions for cases 1 and 3 (100% to 90% power at 100%/min and 150%/min, respectively). For cases 2, 4 and 5 (100% to 85% power at 100%/min, 150%/min and 150%/min with no steam dump, respectively), the two intact pumps would have to operate at 5350 rpm in order to obtain steady state conditions. However, cases 1 and 3((100% to 90% reduction) provide most smooth operating conditions for the remaining intact pumps. Cases 2a would provide the plant with the largest amount of SG level shrink (i.e. a decrease from 67 to 32% span). The runback rate affected negligibly level control stability. Therefore, case 1(100%/min) and case 3(150%/min) showed similar results in Figure 1.

During a loss of a feedwater pump event from three pump operations, it is recommended that the turbine be runback to 90% power at 150 or 150%/min(1,3 case) in order to obtain optimal operating conditions. However, if it is necessary to operate with two pumps for an extended period, it is recommended that the plant power level reduce from 90% power to 60% power by following the appropriate plant procedure. Operating at 60% power can ensure that the plant will survive an additional loss of a feedwater pump from two pump operation. This was determined from the analysis of loss of a feedwater pump from two pump operations. Figure 1 shows the results of case 1 though 5

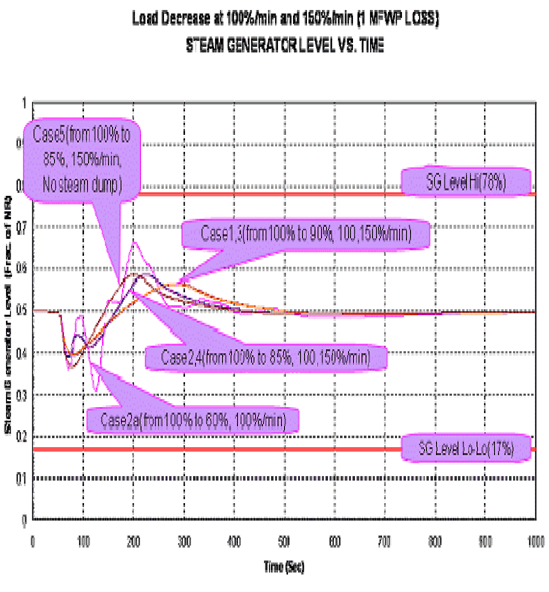

Figure 1. SG Level at the Transient of One Feedwater Pump Loss

3.2 Loss of two Feedwater Pump

Variations of the turbine runback power level and the turbine runback rate were analyzed for a loss of a main feedwater pump event from two pump operations at reduced power (Task 2). Cases 7c and 8c (60% to 45% power at 100%/min and 150%/min, respectively) provided the most ideal operating conditions for the remaining intact pump; the minimum and maximum SG level responses were approximately 36% span and 64% span, respectively, and the one intact pump would have to operate at approximately 5031 rpm in order to obtain steady state conditions. The turbine runback rate affected negligibly level control stability. Therefore, analysis of 100%/min and 150%/min case showed similar results in Figure 2 as shown in Figure 1. Note that cases 7a, 7b, 8a and 8b did not provide acceptable results. Therefore, these cases are not recommended. Therefore, during a loss of a feedwater pump event from two pump operations, it is recommended that the turbine be runback from 60% to 45% power at 100 and 150%/min(case 7c, 8c) in order to obtain optimal operation conditions without reactor trip by SG level high or low. Figure 2 shows the results of case 7 (a,b,c) and 8 (a,b,c).

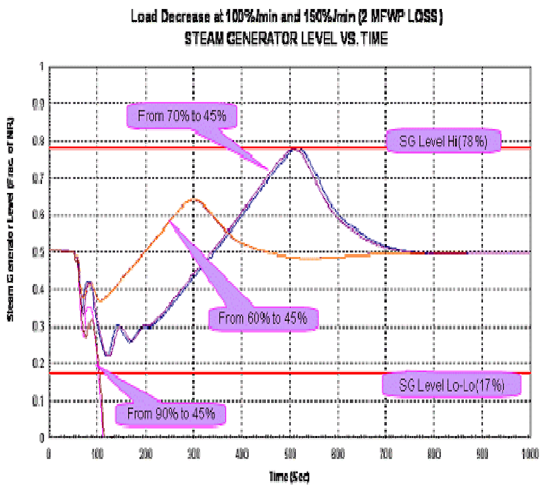

Figure 2. SG Level at the Transient of Two Feedwater Pump Loss

4. Conclusions

In this paper, the optimal target power level and the turbine runback were determined after 4.5% power uprate, in case of one feedwater pump loss and two feedwater pump loss.

REFERENCES

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