Study on Rod Control Setpoints Optimization for K3,4/Y1,2 Units

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1. Introduction

K3,4/Y1,2 units have experienced spurious control rod stepping during full power steady-state operation. That spurious rod stepping was caused by steady state aperiodic hot leg temperature fluctuation and steady state aperiodic neutron flux variations. These phenomena have been noted at other similar Westinghouse type plants. The hot leg temperature fluctuation impacts the median RCS average temperature. Median RCS average temperature and neutron flux variation signals are inputs for the control rod. If these signals are large enough to move control rod at steady state the spurious rod control stepping is occurred. To avoid spurious rod control stepping, optimization of the control rod system setpoints and time constants were studied.

2. The control rod setpoint optimization

The 10% step load increase transient analysis is performed to determine the impact of rod control system using some proposed time constants and setpoints on plant response.

2.1. Analysis method

The transient analysis was performed using LOFTRAN code and applied to the power-uprating. The best estimate reactivity feedbacks(MTC, DPC, Rod worth ...) at BOL, EOL, high Tavg and low Tavg are assumed. The following rod control setpoints are considered.

- Power mismatch break point: 1%(current), 2%, 3%
- Median Tavg lead/lag time constants: 80/10(current), 60/10, 50/10, 40/10, 20/10
- Med Tavg lag time constants: 5(current), 7, 10, 15

2.2. Analysis results

The plant parameter responses are shown in Fig 1~2. Tavg channel is primarily designed to restore plant stability near equilibrium conditions. Fig 1 shows that high lead/lag ratio and high lead time constant reduce the peak Tavg but more amplify the noise. The current lead/lag setpoint 80/10 is caused to spurious control rod stepping in current system, and 60/10 and 50/10 also generated similar results. As the compromise, lead/lag setpoint 40/10 will be effective so that setpoint is recommended.

Current lag filter setpoint is 5sec, to help avoiding control rod stepping 10sec is recommended.

Power mismatch channel provides the fast response to turbine load and restricts the overshoot. As shown in Fig 2, all experienced power mismatch break points are acceptable, but the current break point can be a cause to control rod stepping in current system. As compared with current setpoint, 2% break point is recommended. In actual, the measured power mismatch is less than 1% at full power steady state. The power mismatch is anticipated within 2% range after power uprating.

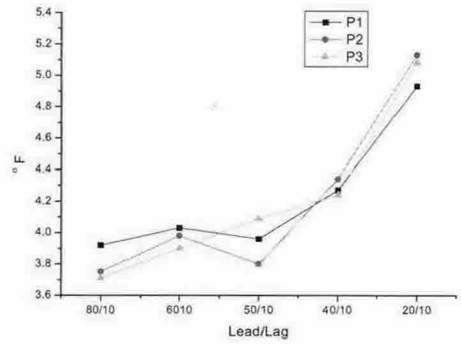

Fig 1 Peak average temperature

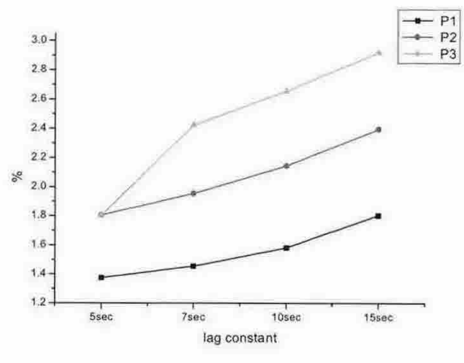

Fig 2 Overshoot

3. Plants data analyses

The purpose of the data analysis is to show the effectiveness of rod control setpoint and time constants. Current and recommended setpoints were evaluated based on measured in the current system and hypothetical data

3.1. Data analyses method

Because the plant data may not capture the worst temperature and NIS fluctuation, the "hypothetical" spikes are used. As shown in Fig 3, although the actual median average temperature range is about 1°F, the hypothetical range is regarded as 2°F range. Power mismatch shape is arbitrary but the magnitude of the peaks are based on other similar Westinghouse type plants.

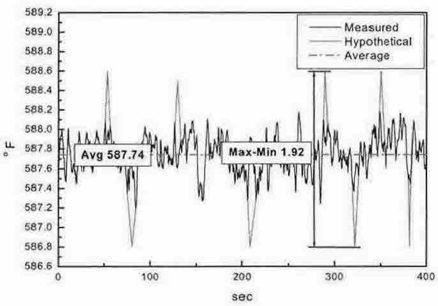

Fig 3 Hypothetical average temperature

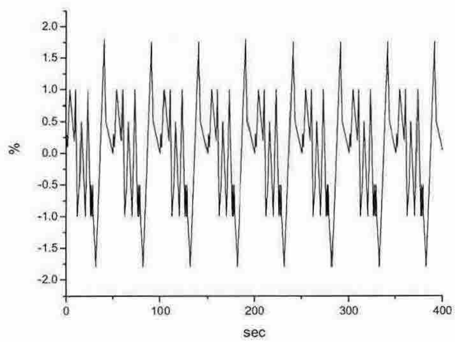

Fig 4 Hypothetical power mismatch

3.2. Data analysis results

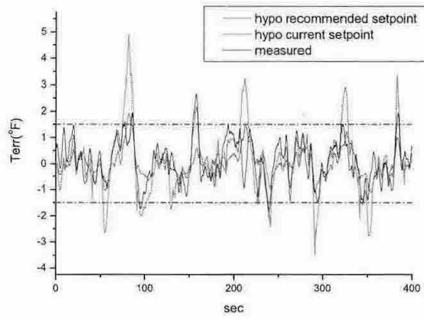

Fig 5 Terr for control rod

Fig 5 shows the output of total Terr for control rod, the measured Terr is sometimes exceed the rod control dead band. At the hypothetical data analysis using recommended setpoints, Terr is remained within dead band.

4. Conclusion

To avoid spurious control rod stepping, some available setpoints were evaluated and following setpoints were recommended. If recommended setpoints are adopted to K3,4/Y1,2, units, the spurious control rod stepping will be prohibited at any steady state condition such as BOL, EOL, high Tavg, low Tavg in both current and after power uprating system.

	Current	Recommended
Tavg lead/lag	80/10(sec/sec)	40/10(sec/sec)
Tavg lag	5(sec)	10(sec)
Power mismatch break point	1(%)	2(%)

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