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A study on the efficiency improvement of the plant secondary System in NPP

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1. Introduction

The ultimate objective of the diagnostic test for thermal performance of generation facilities is to assist in making an economic decision on operation optimization of power plants by understanding the degree of heat aging due to operation of relevant facilities and planning on this basis the maintenance and repair. In this thesis, the trend in performance change was analyzed against the acceptance performance test conducted after the replacement of the high pressure turbine in 2007, through thermal performance diagnosis conducted at 100 % reactor thermal output after the 19th planned preventive maintenance of Younggwang Nuclear Units 1 and 2, and the power plant operation was optimized by acquiring base line data for management of performance record for each major facility of the secondary system and by improving efficiency of unit instruments and peripheral instruments of the secondary system.

As a result derived from the thermal performance analysis, the increase in electric output of the power plants was achieved through such operation optimizations of efficiency-affecting instruments as optimization of the continuous exhaust flow rate for water supply heaters, vacuum improvement of condensers due to opening the upper/lower screens of heat-transfer-pipe washing system for condensers during summer, and flow rate optimization of the water vapor supplied to MSR (Moisture Separator Re-heater) high-pressure re-heaters. This improves operation of the existing power plants without additional expense and so requires expert review by responsible personnel for practical application.

2. Methods and Results

2.1 Thermal Performance Diagnosis and Optimization Plan for Power Plants

This precision thermal-performance diagnosis was the performance test conducted for the first time at 100 % reactor thermal output (2,912 MWt) of Younggwang Nuclear Unit 1, and the degree of thermal balance (TS30130) presented by Alstom during the contract for replacement construction of the high-pressure turbine was used as the comparative reference for the results in this test.

The factors of each unit facility affecting the electric output (efficiency) reduction of the generation unit in comparison with the degree of thermal balance TS30130 are efficiency of high-pressure and low-pressure turbines, MSR moisture separation efficiency and TTD, efficiency of main feedwater pump, and super-cooling of condensers. The increase in pressure loss of system steam pipes may also reduce the electric output of the generation unit. Therefore, through the thermal performance diagnosis for each unit facility of the secondary system, problems were identified and subsequent optimization was conducted.

2.2 Optimization of continuous exhaust flow rate for feedwater heaters

Since the results of modeling and simulation for thermal performance of the power plants indicate that in case of Younggwang Nuclear Unit 1 the electric output loss of the generation unit due to continuous exhaust of feedwater heater #3 ~ #7 was 1,046 kW, which is higher than other nuclear units, their optimization measures were taken.

The continuous exhaust line installed at feedwater heaters prevents the reduction in heat exchange performance due to tube air bounding of non-condensable gases.

Thus, the continuous exhaust flow rate was controlled to the extent that the performance reduction of heat exchangers (hunting in the exit and exhaust temperatures of feedwater heaters) does not take place.

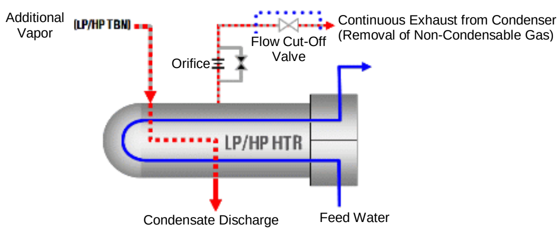

Fig. 1. Simplified Drawing of Continuous Exhaust Facilities for FeedWater Heaters

2.3 Optimal Operation of Condenser Vacuum during Summer

The vacuum pressure of condensers for Younggwang Nuclear Unit 1 is 7 ~ 10 mmHg higher than other units in Younggwang Nuclear Power Headquarter at the same condition of sea water temperature, which directly causes too much reduction of electric output for the power plant. Especially during summer, the electric output reduction of the power plant due to rise in sea water temperature is greater than other power plants and so the operating method of washing system for the heat transfer pipes of the condensers was improved to improve condenser vacuum.

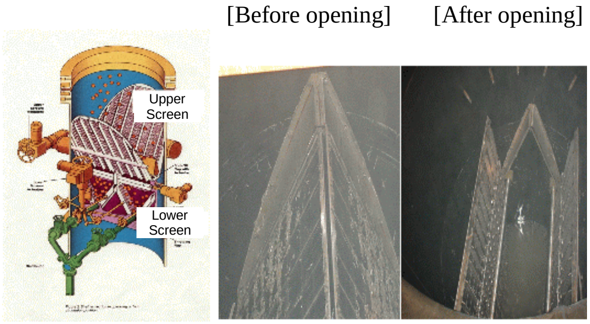

Fig. 2. Screen Structure of Washing System for Heat transfer Pipes of Condensers.

The washing system for heat transfer pipes of the condensers operates while maintaining the upper and lower screens closed to collect the wash balls for heat transfer pipes of the condensers during the normal operation. However, this caused the flow rate of circulation water to reduce due to build-up of marine organism and foreign materials.
Thus, periodical opening of the closed upper and lower screens increased the flow rate of circulation water, improving condenser vacuum and generator output.

2.4 Flow Rate Optimization for Super-heated Steam of Moisture Separator Re-heater (MSR)

The results of the thermal performance diagnosis indicated that the flow rate of steam supplied to MSR high-pressure re-heaters was higher than the design basis.

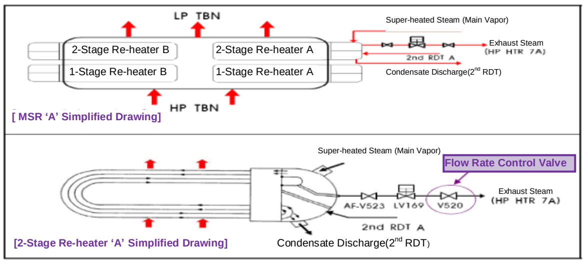

Fig. 3. Simplified Drawing of Exhaust Facilities for Moisture Separator 2-Stage Re-heater

The MSR of Younggwang Nuclear Unit 1 adopts the 4^{th}-Pass Heat-Exchange Type and the control valve installed at the 4^{th}-Pass discharge pipe optimizes the flow rate of super-heated steam.
However, the performance reduction of MSR including the decrease in MSR exit temperature, discharge temperature of the 2-stage re-heater and steam temperature of MSR exit was observed during valve control for the flow rate of super-heated steam at the moisture separator re-heater. Judging from such symptom, it could be presumed that the flow rate of MSR super-heated steam was at the optimal condition.

3. Conclusions

In this research, the analytical procedure for the thermal performance of turbine generators was established through the thermal performance diagnosis of Younggwang Nuclear Unit 1 and a plan for the cause analysis of performance reduction and the preventive maintenance for each unit instrument during normal operation of the power plant was also established to prepare for the basis to deduce the optimal operating conditions by controlling the design, operating, thermodynamic variables of the various instruments affecting operation efficiency improvement and power plant performance.

As a result of thermal performance diagnosis, the increase in generation output (19,410 MW annually) through optimized operation of efficiency-affecting instruments for the secondary system of Younggwang Nuclear Unit 1 brought in an annual cost saving effect of 1 billion won.
It is considered that application of the optimized operating method of Younggwang Nuclear Units 1 and 2 to other existing power plants would improve power plant performance in the future.

REFERENCES

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