A Study on the Secondary Thermal Power Reduction Factor of KSNP

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1. Introduction

As an effort of a Korea Standard Nuclear Plant (KSNP) to improve the efficiency of the secondary thermal power, we are investigating the reduction factors of the unplanned capacity loss at KSNP. To obtain the better efficiency improvement and reduce the unplanned capacity loss, the several important factors of turbine steam cycle to improve the efficiency are considered. This study is describing reduction factors that are the Steam Generator tube plugging, the FeedWater Flow depletion, the uncontrolled level fault of Heaters and the vacuum depletion of Condenser. It is describing the influence of each factor on the secondary thermal power and applicable solutions of it at KSNP

2. Influences and Solutions on Thermal Power

In this section, it is describing the cause and effect of five factors on the secondary thermal power and the applicable solution of each reduction factor at KSNP.

2.1 SG Tube Plugging

The SG generates the steam by exchanging the heat that is produced from the primary side(Reactor) and is the boundary between the primary and secondary side. Because the sectional area of heating surface determines the volume of heat transfer rate, the gross sectional area of the SG tube is the important factor in steam cycle. The SG tube plugging causes a decrease in the sectional area of heat transfer rate and the capacity of heat transfer. As a result, the efficiency of the secondary thermal power is decreased. The cause of the SG tube plugging is abrasion and corrosion. The protection method of abrasion and corrosion is monitoring the quality of feed water. To protect the SG tube from abrasion and corrosion, all nuclear plants consolidate the standard of feed water quality management, develop and apply the SG ageing management program. Although this factor has a small effect in the beginning, it has a continuous and prolonged influence on the secondary thermal power during the plant life time.

2.2 Feed Water Flow Depletion

A measurement error on the feedwater flow rate is the single largest contributor to the secondary thermal power calculation. The secondary power is calculated at Core Operating Limit Supervisory System(COLSS). The output energy of SG is formularized as follows.

$$EG = M_f(h_s - h_f) - M_b(h_s - h_b) \quad (1)$$

where, EG : SG energy, M_f : feedwater mass flow, M_b : blowdown mass flow, $(h_s - h_f)$: change of Enthalpy

the secondary thermal power is greatly influenced by change of a little feedwater flow. For example, because of feedwater venturi fouling at the end of cycle the secondary thermal power decreases for quite a long time at YGN 5. According to the formular of COLSS, if feedwater flow changes by about 20 ton/hr , the secondary power decreases by about 4.6 MWe.

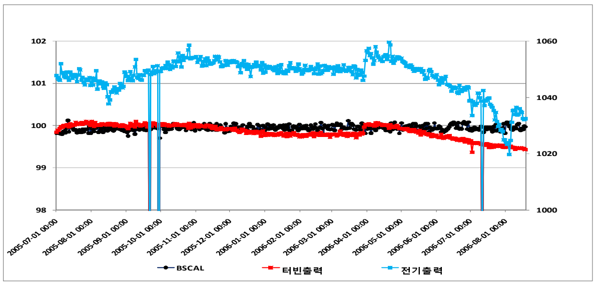

Fig 1 YGN 5 the power change of venture fouling

To prevent the decrease in the secondary power for feedwater venturi fouling, YGN 5 changes a reactor thermal power calculation method from the feedwater flow-based thermal power(FWBSCAL) to the main stream flow-based thermal power(MSBSCAL). Through such a change, YGN 5, 6 solves the power decrease at the end of cycle

2.3 Uncontrolled Level Fault of Feedwater Heaters

Feedwater heaters improve the plant efficiency by heating the low-tempertune feedwater. Ex-traction steam supplied from LP turbine is used to heating the low-temperature feedwater. Although turbine power is decreased because of using a part of steam that is supplied to turbine, the plant efficiency is increased by heating the low temperature feedwater. It reduces the irreversibility and the plant efficiency is increased as a result. At the turbine steam cycle a change of one degree feedwater temperature affects the turbine power approximately 7 MWe. Although the feedwater temperature is affecting the turbine cycle quite a bit, but the change of it not frequently occurred so it is not greatly influenced. It is mainly occurred in the abnormal condition of a level indicator.

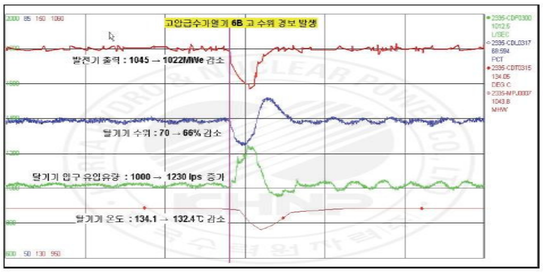

Fig.2 the power change of heater level indicator fail

In order to solve the problem, YGN 5, 6 install the M/A station in the turbine building. By doing this, local operator is able to control a feedwater heater drain valve at abnormal condition. All operators are preparing the abnormal conditions through the image training education.

2.4 Vacuum Depletion of Condenser

The condenser changes the vent steam of LP turbine to the saturation water using the circulating water. The condenser is operated in a vacuum and the vacuum is formed by converting steam to water. To decrease back-pressure of turbine, the condenser pressure has to retain low. To retain low vacuum pressure, the dissolved gas is removed by circulating water. In the case of YGN 5, 6 the optimized vacuum pressure is about 27mmHg. Fig. 1 shows change of the secondary power

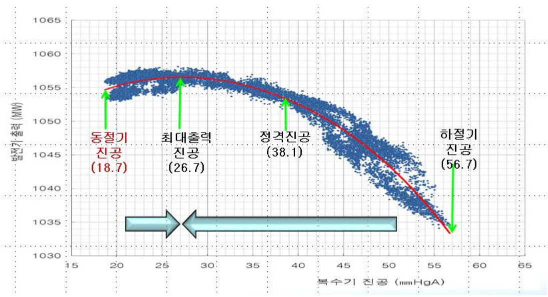

Fig.3 Influence of condenser vacuum on the secondary power

The optimized vacuum pressure is obstructed by the dissolved gas and the reduced flow of circulating water. In order to retain the optimized vacuum pressure, it is important to prevent inflow of a dissolved gas and the flow depletion of circulating water. Although there are several causes of flow depletions, most of them are the tube plugging caused by abrasion and corrosion and fouling caused by microorganism and shellfish. To solve the flow depletion problems due to an alien substance, YGN 5 installs debris filter to prevent an alien substance. By doing this, the operation of condenser tube cleaning system and the flow depletion is quite reduced. Even though the condenser vacuum pressure is changed by a sea water temperature, we cannot control a sea water temperature, so we do not mention it here.

2.5 Summary

There are many reduction factors of the secondary thermal power, but we are describing the four factors. In summary in a table, it's as follows

Table I: Cause and Solution of Reduction Factors

Reduction Factor	Cause	Effect of Power	Solution
SG Tube Plugging	abrasion and corrosion	Small but Long term	Feedwater Quality Management
Feedwater Flow Depletion	Venturi Fouling	Great effect Quite a long	Power Calculation Change
Uncontrolled Level Fault of Heaters	Level transmitter fail	Great effect Temporary	Install M/A Station
Vacuum Depletion of Condenser	Flow Depletion	Great effect Quite a long	Install Debris Filter

3. Conclusions

KSNP try to improve efficiency of the secondary thermal power continuously. They are trying to replace a device, change a calculation method, enforce the management standard and install new equipment. As a result, KSNP reduce the unplanned secondary thermal power.

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