A study on Feedwater Fouling and Its Countermeasure

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1. Introduction

As a part of Korean standard nuclear power plants including Youngkwang 3&4 unit measure feedwater flow supplied by a steam generator to calculate reactor thermal power . The established reactor thermal power is Feedwater Flow-Based Reactor Thermal Power(code name is FWBSCAL, hereinafter FWBSCAL). However, as operation time passes while nuclear power plants run, fouling and defouling of foreign materials is being found from a feedwater flow measurement system, the main feed water venturi. Reactor thermal power that is measured by using feedwater flow is sometimes evaluated bigger or smaller than the real one. A new measurement method is adopted to solve this problem generated when reactor thermal power is measured by using feedwater flow.

2. Methods and Results

2.1 Main problems

When an existing thermal power calculation methodology, feedwater flow-based reactor thermal power(FWBSCAL) is used, as operating time passes while nuclear power plants are running, reactor thermal power is evaluated smaller than the real case due to fouling of foreign materials in the main feed water venturi, so the electric power output is often reduced.

2.1.1 Fouling phenomenon of Youngkwang 5 unit Feedwater venturi

The reduction of main operating variables related to output(Tavg, BSTAT, main steam flow, feedwater flow temperature/pressure, one-stage turbine) means the actual reduction in reactor thermal power and electric power output. The reason why COLSS BSCAL maintains output constantly is due to over-evaluation of COLSS BSCAL from feedwater flow measurement errors. According to the result of verification using enthalpy changes showed about 2% of output was reduced in the primary part. (Fig 2.1, 2.2)

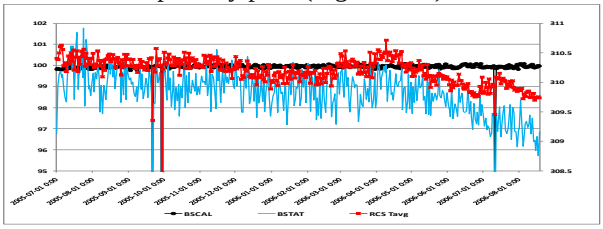

Fig. 2.1 Change of FWBSCAL and BSTAT

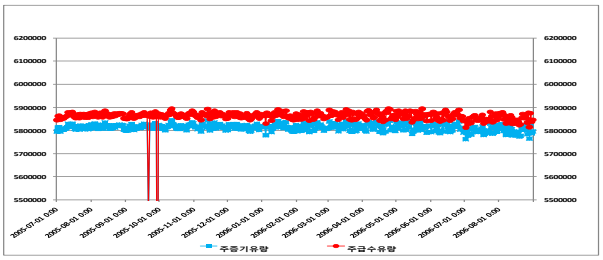

Fig. 2.2 Change of Feedwater and Main steam flow

2.1.2 FWBSCAL Thermal power calculation

$$Q_{FW} = W_{FWM} * (h_{MS} - h_{FW}) - W_{BD}(h_{MS} - h_{BD})$$

Q_{FW} = FWBSCAL Steam Generator Thermal power
h_{MS} = Main Steam Enthalpy
h_{FW} = Feed Water Enthalpy
h_{BD} = Blow Down Enthalpy

$$FWBSCAL = Q_{FW1} + Q_{FW2} + EL - EC$$

Q_{FW1} = Thermal power of Steam Generator #1
Q_{FW2} = Thermal power of Steam Generator #2
EL = Energy loss from control Volume
EC = Energy credit from control Volume

2.2 Methods of applied countermeasures

To solve problems such as fouling and defouling of foreign materials in the main feedwater venturi that is generated during the process of feedwater flow measurement used in FWBSCAL, a methodology calculating reactor thermal power(MSBSCAL) is established by using measurement main steam flow suitable for characteristics of a nuclear power plant.

2.2.1 Thermal power calculation methodology

The MSBSCAL methodology is established by applying a basically same type of a mass flow measuring method and a thermal power measuring method, and it applies a method of deciding main stream flow measurement pressure and vapor compression coefficients in order for the calculated MSBSCAL thermal power to include conservatism.

2.2.2 MSBSCAL Thermal power calculation

$$Q_{MS} = W_{MS} * (h_{MS} - h_{FW}) - W_{BD}(h_{BD} - h_{FW})$$

Q_{MS} = MSBSCAL Steam Generator Thermal power
h_{MS} = Main Steam Enthalpy

h_{FW} = Feed Water
h_{BD} = Blow Down Enthalpy

MSBSCAL = Q_{MS1+} Q_{MS+} EL – EC
Q_{MS1} = Thermal power of Steam Generator #1
Q_{MS1} = Thermal power of Steam Generator #2
EL = Energy loss from control Volume
EC = Energy credit from control Volume

2.2.3 Thermal power monitoring application

Monitoring of the power in nuclear power plants using MSBSCAL thermal power is set to be allowed over 95 % of power. If it doesn't meet allowable conditions, it is set to be automatically returned by thermal power standard monitoring operation of previous FWBSCAL.

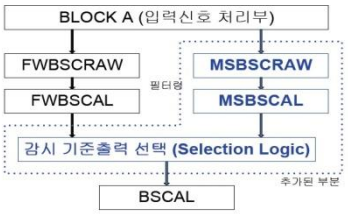

그림 2-5 COLSS 열출력 계산 모듈 개념

2.3 Result of applied countermeasures

The fundamental cause of electric power reduction in Korean standard nuclear power plants is that feed water flow, the important measurement factor of secondary thermal power(FWBSCAL) is highly measured. To solve this problem, all power-related variables(RCS Tavg, main steam flow, feedwater flow, main stream pressure, feedwater flow temperature, one-stage turbine) of nuclear power plants regarding feedwater flow Venturi fouling problems (feedwater flow measurement errors) resulting from the introduction of secondary thermal power(MSBSCAL) are constantly maintained. (Fig 2.3, 2.4)

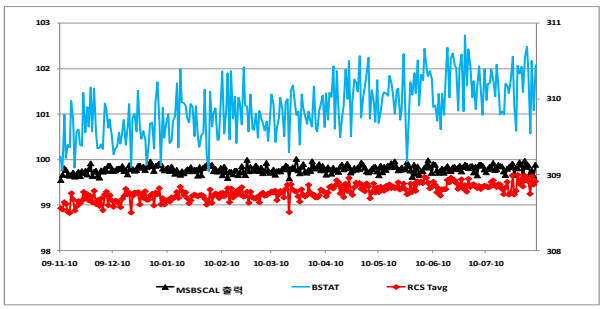

Fig. 2.3 Change of MSBSCAL and BSTAT

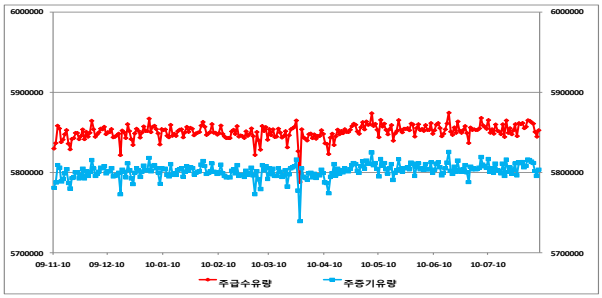

Fig. 2.4 Change of Feedwater and Main steam flow

3. Conclusions

This study described the FWBSCAL thermal power calculation methodology as well as nuclear power plants' main phenomena that the calculated reactor thermal power is evaluated smaller than the real case due to fouling of foreign materials in feedwater flow venturi when an existing thermal power calculation methodology, feedwater flow-based reactor thermal power(FWBSCAL) is used in Korean standard nuclear power plants as operating time passes during operation. In addition, it explained the main stream flow-based thermal power(MSBSCAL) methodology as a new reactor thermal power calculation method to solve problems of feedwater flow-based thermal power(FWBSCAL).

It also established the measurement formula of main steam flow mass to calculate thermal power by using main stream flow instead of feedwater flow and the empirical formula for determining input factors of the measurement formula, and described conservatism of a new methodology.

This study lastly described main phenomena of nuclear power plants to solve feedwater flow venturi fouling of Koran standard nuclear power plants according to the introduction of MSBSCAL.

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