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Development of a Performance Improvement Verification Simulator for Large Steam Turbines

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1. Introduction

This study aimed about the development of simulator we can check what effect to entire turbine cycle when change the primary variable by using the standard large steam turbine simulation model.

Simulator can be applied to number of plants because it is equipped model about power plant. And it has a easily available GUI to field of power plants user instead of existing modeling programs was uncomfortable to use, so utilization is expected to be higher. Also it seems to be various utilization as well as performance monitoring system by steady research and performance improvement.

2. Methods and Results

2.1 Development and Verification of Simulation Model

We use the PEPSE(Performance Evaluation of Power System Efficiency) ver.74 programs which is one of the general-purpose computer codes. This program can calculate thermal performance and efficiency when boiler and turbine cycle of power plants in steady-state.

Design reference model is defined as model developed based on the manufacturer's design data. First of all, we have to draw the heat balance by the data collection for modeling of design reference model. And we manufacture the performance mode each power by placing the components and streams using PEPSE based on the heat balance. After the performance mode manufacturer, we verify the model and manufacture the design mode. It is advisable that convert the model based on performance mode, because making design mode is too difficult.

We schedule the variables each power after the finishing design mode manufacture and verification. If the each power's model coordinates at one model, PEPSI modeling is completed. The process of verifying the design reference model is divided into three stages.

First, we compared the heat rate at the condition that the electrical power was exactly matched by advanced tuning of PEPSE. As a result, the margin of slight error occurred, but it was very small value.

Secondly, we compared the turbine Mollier diagram. When we compared model of PEPSE and manufacturer for each power, both pressure and enthalpy corresponded within 0.5% at every section.

Lastly, as a result of confirm the difference of values to compare the overall heat balance; we confirmed that PEPSE model had perfectly modeling the turbine performance.

2.2 Performance Change Assessment Method

In this section, which performance-changing-mode has to be provided the users and we describe that how to performance is modeling at PEPSE.

First, simulator has to implement performance indicator that can be key of performance management. These indicators include the heat loss, efficiency, temperature, pressure and flow rate.

Some of which need to input data of the simulator and some that are derived as output by input data. Variables that affect the performance changing are main steam flow rate, pressure, temperature, pressure of temperature of reheat steam, efficiency multiplier of turbine, inlet flow coefficient of turbine, exhaust loss, internal seal leakage and external leakage.

Table I: Degradation mode and symptom for each variable

Variable	Degradation mode	Symptom
Main steam	Decrease the flow rate	Decrease the power
	Decrease the temperature	Decrease the power and efficiency
	Increase the pressure	Increase the power and efficiency
Reheat steam	Decrease the temperature	Decrease the power and efficiency
	Decrease the pressure	Decrease the power and efficiency
Internal seal leakage	Radial seal damage	Decrease the turbine efficiency
External leakage	Inter-stage seal leakage	Decrease the power, Increase the heat rate

We performed a series of verification, for determine the modeling methods of performance changing mode are reasonable. Verification is progressed to confirm the qualitatively behavior presented at performance guidelines report.

In verifying, modification of inlet flow coefficient was meaningless to flow coefficient. If we modify the only inlet flow coefficient, change of efficiency and power are not shown consistently. Except for that, most of the symptoms appeared in performance degradation model are consistent to symptoms of performance guidelines report.

2.3 Development of User Interfaces

User interface (GUI) developed to improve the convenience and utilization. By the user provides an easy to use form large steam turbine that possible to simulation about performance changing mode.

GUI conducts as important function to exchange the PEPSE model's input and output that finish the verification by section 2.2. Information that exchange what input and output in PEPSE is saved by excel file named BasicData.xls.

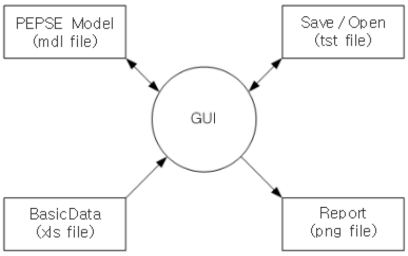

Fig. 1. The entire structure of simulator interface

We use the program to exchange the excel file and information to GUI. At execution process the PEPSE, we can save the changed input and output from a file. Then GUI can save the data that use the file having the extension of tsf, and we can open that file later. Lastly, we can create the input and output data about PEPSE model execution as a report, it is saved by png file.

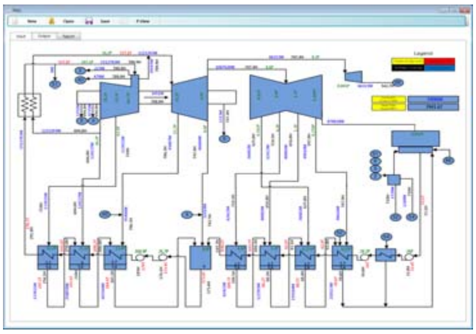

Fig. 2. Input variables screen of PEPSE

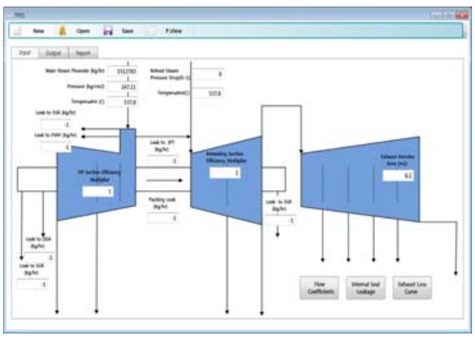

Fig. 3. Output variables screen of PEPSE

2.4 Case of applications

Recently there was a replacement project at standard coal-fired power plant. We calculated the data input the new heat balance using the simulator built-in the model of existing standard power plant. As a result, the condition of detail thermal fluid was different. But we checked that power and heat rate were exactly same.

At that time, input variables are main steam flow rate, pressure and temperature, internal seal leakage, external leakage, reheat steam pressure drop and temperature, HP and reheating section efficiency multiplier, exhaust annulus area, exhaust loss curve and flow coefficients.

First, we reference the heat balance of new large steam turbine model and adjust the value through the input screen of GUI. Variables that can be modified at the input screen can say important variables of performance changing mode. Modify the flow coefficient, internal seal leakage and exhaust loss curve through the three icons which bottom of the screen after the modification the important variables by input screen. We output the under the assumption that the component input values are same. As that result, power and heat rate appeared the error of less than 0.4%. Through this result, we know the possible to apply at various steam turbine models. Furthermore, we expect the more accurate results by the continuing research and development.

3. Conclusions

Due to this study, we develop the GUI that can operate the model and simulation model. It can be used to verify the performance improvements of Rankine cycle. We obtained the achievements such as performance analysis model of large steam turbine, result of performance analysis each power and control communication modules of PEPSE through this study. If we design more detail of input and output screen by more study, we are convinced that can do enough role the plant's thermal efficiency calculation simulator. Also, if we make the simulator that is working online by conjunction with an external database, we expect that is possible to real-time performance monitoring system.

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