Using Special Option Six for Acceptance Testing

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Abstract

When using PEPSE's special option six (SOP6) for acceptance tests, it is important to know that for data that is off standard design conditions its group II corrections are not accurate for vendor comparison. The group II correction that has the largest impact is the hot reheat temperature correction. Reheat temperature that is different from design by more than 10 degrees and then corrected is not comparable to the General Electric corrected results using their correction curves. This is especially evident for low reheat temperatures that are less than 960 degrees Fahrenheit. These low temperatures when corrected have a large impact on output.

This situation came to light when we were doing acceptance testing on our Winyah 1 unit. During initial testing we were able to match General Electric's test results and their corrected results accurately. This was due to the fact that the test conditions were within five degrees of design temperature. Later a second test was required for some modifications that were installed. During this test the results between the PEPSE SOP6 model and those calculated by GE did not match the corrected conditions. The results for the corrected output had the largest difference. In our case the results were off by about 1,800 kW. It was theorized that the reason for this was that the SOP6 deck uses type 8 turbines. These model components fix the efficiency in the HP, IP and LP turbine. When reheat temperatures are more than 10 degrees lower than design, the actual turbine efficiencies change by small amounts. These small amounts can lead to differences in corrected output as large as 600 kW or more for larger units (above the 300,000 kW output). When testing for trends this accuracy difference is not as important since repeatability is the key parameter. This study shows what was done to test and prove out this theory.

Introduction

Winyah 1 is one of four generating units at Santee Cooper's Winyah Generating Station, located in Georgetown, South Carolina. It is a General Electric (GE) turbine with an output of 289 MW gross at 1,888 klbs/hr, 1000/1000°F throttle/reheat inlet temperatures, 2 inches Hg condenser pressure and 2,400 psig throttle pressure. The boiler is a Riley boiler rated at 2,000 klbs/hr, 1005/1005°F superheat/ reheat temperatures and 2,475 psig superheater outlet pressure.

In the fall of 1996 this unit was upgrade to the GE "aero" design high pressure and intermediate pressure turbine. The new turbine specifications changes to an output of 303 MW gross at 1,983 klbs/hr steam flow, 1000/1000 °F throttle/reheat inlet temperatures, 2 inches Hg condenser pressure and 2,400 psig throttle pressure.

An acceptance was completed after the "aero" upgraded and the analysis used PEPSE's special option six test deck. The corrected PEPSE results matched the corrected GE results. GE's heat rate and output were 7,625 Btu/kWh and 307 MW, PEPSE SOP6 heat rate and output were 7,630 Btu/kWh and 307 MW. The heat rate and output comparison for this test were within .07 and .01 percent of each other.

In the spring of 1997 GE installed a modification to the control valve area to minimize the vibrations that were occurring. Another acceptance test was scheduled to insure the modification had no impact on the turbine efficiency. For this analysis we again used the SOP6 deck. During this test analysis PEPSE's corrected results were different from the GE results, the difference was .6 and .3 percent of corrected output and heat rate respectively.

The SOP6 model was reviewed and the design model was run at both design and test conditions. This revealed that the possible cause of the problem was the type of turbines SOP6 model uses. The design model uses PEPSE turbine types 1 to 7, the SOP6 model uses only type 8 turbines. Type 8 turbines fix the turbine section efficiencies for all PEPSE cases run. In this instance the large changes in temperature caused differences in section efficiencies. Design PEPSE model results revealed these differences in turbine efficiency. These differences are important to account for in an acceptance test when looking to achieve an absolute result in heat rate and output.

Results

The above simulation provides information to users for using SOP6 decks when tests require absolute accuracy. For simplicity only reheat temperature and pressure drop were analyzed. Similar results are expected for throttle temperature and pressure. Condenser corrections do not appear to impact the HP and IP section efficiencies. Therefore if SOP 6 is to be used for acceptance testing the initial inlet conditions must be set as close to design as possible. The study results are reflected in the table below.

PEPSE Study Results

PEPSE Design Model	Units	GE Turbines Base	GE Turbines At Test Reheat Conditions	General Type Turbines Base	General Type Turbines at Test Reheat Conditions	General Type Turbines Adjusted for Efficiency Change
Steam Flow	lbs/hr	1,982,739	1,982,739	1,982,739	1,982,739	1,982,739
Hot Reheat Pressure Drop	%	10.0	8.5	10.0	8.5	8.5
Hot Reheat Temperature	F	1,000.0	942.1	1,000.0	942.1	942.1
Heat Rate	Btu/kWh	7,671	7,717	7,671	7,701	7,717
Output	kW	304,272	297,313	304,272	297,991	297,313
GS	%	80.41	79.28	80.41	80.41	79.28
HP	%	89.31	89.38	89.31	89.31	89.38
IP-1	%	86.06	85.79	86.06	86.06	85.79
IP-2	%	87.49	87.24	87.49	87.49	87.24
LP-1	%	90.72	90.52	90.72	90.72	90.52
LP-2	%	90.50	90.31	90.50	90.50	90.31
LP-3	%	90.50	90.06	90.50	90.50	90.06
-4	%	71.73	71.87	71.73	71.73	71.87

References

The following references were used during the course of the analysis and in preparation of this paper.

1. PEPSE computer code, SCIENTECH, Inc , 440 West Broadway, Idaho Falls, Idaho 83402, Version 62H

2. PEPSE manual: volumes I, II, III, IV, SCIENTECH, Inc, 440 West Broadway, Idaho Falls, Idaho 83402, Version 62H