Combined Cycle Plants: Models and In-Situ Reliability Tests

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Abstract: This paper presents models of Boiler and Steam Turbine of combined cycle plants that can be used with any type of Gas Turbine models for grid dynamics studies. These models were obtained through a review of characteristics of large steam turbine and heat recovery boilers that define the behavior of combined cycle plants. Also is presented a Gas Turbine model of a combined cycle plant that was validated by tests developed and applied to evaluate reliability of combined cycle plants that are being installed in Argentinean electric system. Reliability test goals are the behavior characterization of combined cycle plants during large systems disturbances.

Keywords: Combined Cycle Plants - Frequency - Frequency Test Waveform – Gas Turbine - Heat Recovery Boiler - Steam Turbine - Governor - Models.

I. INTRODUCTION

Two isolated parts compose the Argentinean electric system, the biggest one named "Sistema Argentino de Interconección" or SADI in the north, and the smallest one named "Sistema Eléctrico Patagónico Interconectado" or SEPI in the south.

Control and supervision, from the technical point of view, and the management of transactions between companies were assigned to Wholesale Electric Market Managing Company (CAMMESA), whose board all Agents form and whose chair is held by a State organization.

In the last years, the installed number of large gas turbines alone or in combined cycles has been increased remarkably and will be over 30% of installed power in a couple of years.

In first term, this growing generated the necessity of reliability operation of these units, especially when large frequency dips or sustained frequency falls happens in the electric system. In second term, there is necessary a correct modeling of this type of units for grid stability studies.

Technical Procedures were updated by CAMMESA to take into account operation reliability of combined cycle plants and large gas turbines **[1]**.

II. COMBINED CYCLE PLANTS

In **[2]** there is a very good description of combined cycle plants configurations, operations and models.

A) CONFIGURATION

In Argentinean electric system almost all combined cycle plants are multi-shaft kind, particularly those of greatest power. As a general rule, the exhaust heat of each gas turbine is enough to feed a steam turbine of near a half of its own power.

Majority of combined power plants has two gas turbines and one steam turbine, and each turbine drives a similar power generator.

Several of them have additional fires at boilers. Only a few has steam extraction for process use.

Few plants have damper on the exhaust gas that allows operating the gas turbines non-coupled from steam turbine (open cycle). Some of them have steam by-pass to condenser that allows operation of the gas turbines to reduced powers when there is some trouble in the steam turbine.

B) OPERATION

Gas Turbine

Gas turbines are normally operated at a few percents below of their base load to have enough spinning reserve for primary frequency regulation. At base load the output is limited by the maximum allowed temperature at turbine inlet.

At this operation point the guide vanes are full open and has not effect on turbine temperature, being base load operation strongly depending of ambient temperature and compressor speed. Inlet turbine temperature is proportional to a corrected exhaust temperature and this last temperature controls fuel flow.

Steam Turbine

At stationary state, steam turbine consumption follows exactly the steam production. Heat on exhausted gas turbine output fixes this steam production.

Steam turbine can operate: with the regulating valves fixes, so that steam pressure varies as steam production varies; or with regulating valves position controlled to maintain constant the pressure up-stream that valves.

In both cases the speed governor is not controlling regulating valves. Although very fast changes of gas turbine power produces fast changes in drums levels, steam turbine power varies more slowly than those of gas turbine, due to very large storage volumes in drums and piping.