Gas Turbine Control. Modifications for: Availability and Limitation of Spinning Reserve and Limitation of Non-desired Unloading

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***Abstract*--This paper presents several modifications developed in a gas turbine control system. One of the modifications made in turbine control limits speed deviations to the governor. Consequently, this modification limits turbine power delivered - positive and negative - for Primary Control of Frequency purposes. In addition, this modification avoids that large, sudden power unloading takes place when the grid frequency recovers from a big dip, while original operational control modes are active. Together with complementary modifications made in the power plant centralized control, other turbine control modifications allow operators to adjust set points of grid frequency, dispatched power and required spinning reserve (positive and negative) which are established by the Dispatch Center of Argentinean electrical grid. Another modifications made in the power plant centralized control allows keeping the spinning reserve margins always available in spite of variations of maximum turbine power with weather conditions.**

These modifications were developed in a 120 MW gas turbine, which is part of a combined cycle in Tucumán, Argentina.

Finally, several tests carried out on the turbine are presented together with operational records that were taken during system frequency disturbances. The tests and operational records show the behavior of the turbine power with and without the modifications made to its control system.

***Index Terms*--Frequency - Frequency control - Gas turbines - Governors - Power generation availability - Power generation control - Power generation scheduling.**

I. INTRODUCTION

SEVERAL modifications were made to a gas turbine control system during its commissioning.

The gas turbine is MS9001(E) type, General Electric, with MARK V Speedtronic control system, with 120 MW of nominal power at 15 °C before evaporative coolers. This gas turbine, with another similar existing one, operates in combined cycle with a 150.1 MW steam turbine. Exhaust gases from each gas turbine are directed to its respective Heat Recovery Steam Generators (HRSG) and the resulting steam feeds the steam turbine. This combined cycle is installed in a power plant owned by Pluspetrol Energy S.A. in El Bracho, Argentina.

To allow a new turbine "commercial operation" in the electrical grid, the network authority (CAMMESA) requires the owner to carry out several tests and studies. The tests that are conducted during turbine commissioning must verify some abilities of both the excitation and the turbine control systems. Some of the tests determine whether a turbine is qualified to participate in Frequency Primary Control (FPC). FPC originates an exclusive economic transaction between generators (Reference [4] indicates method employed in Argentina and Reference [1] presents a similar transactional mechanism).

Only the declared available value of spinning reserve is paid, no matter which is the effectively delivered power, and regardless if this delivered value is bigger than the declared one. Therefore, it is convenient to limit the effectively delivered spinning reserve to the declared value, avoiding unpaid turbine strains, which might result, among other non-desired consequences, in an anticipated maintenance.

Maximum operable power of gas turbines depends on weather conditions (temperature, pressure and humidity). These weather conditions keep changing during the day. Consequently dispatched power must be frequently corrected to have the required spinning reserve (defined as a fixed percentage of the maximum operable power) always available.

To avoid continuous operator’s interventions, an automatic calculation was developed in the power plant centralized control. This automatic calculation estimates the maximum operable power in real time. The set point of dispatched power is then continuously readjusted in order to maintain the required spinning reserve always available.

One of the several commissioning tests required by CAMMESA consists of disturbing turbine control, simulating a big, sudden negative error in the measured turbine speed. During this test, some turbines trip due to high temperature of exhaust gases, while others reduce its power (non-desired unloading) when the disturbance disappears.

This non-desired unloading has also been recorded during several system frequency disturbances. The records show that gas turbines reduce its delivered power when the system frequency tries to recover. Power reduction is greater than that expected by airflow reduction in axial compressor. This behavior is very harmful for the system frequency control. This not correct operation takes place when turbines are operating

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