Hydraulic Transients in Hydropower Plant. Impact on Power System Dynamic Stability.

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***Abstract*—Futaleufú hydropower plant has 4 Francis turbines rated 118 MW and it is connected to the power system by 2x330 kV lines. Studies carried out in the past did not predict the instable operation of Futaleufú after a 330 kV line fault, when some Futaleufú turbines are automatically disconnected as a consequence of the faulted line tripping. Load rejection caused by disconnected turbines generate large transients in the remaining turbines due to hydraulic coupling through the common conduits. Then, to improve related models and, therefore, to improve studies results of such a line fault it was necessary to make several tests in Futaleufú power plant. Finally, these models were used to conduct studies to design a new automatism, like the gate partial closing of the remaining turbines, to obtain a dynamically stable operation of Futaleufú after the disconnection by fault of a line of 330 kilovolts.**

***Index Terms*-- Control systems - Governors – Hydraulic turbines –Modeling – Power system dynamic stability - Power system stabilizer – Simulation – Testing.**

I. Introduction

FUTALEUFÚ hydropower plant has 4 Francis turbines rated 118 MW and it is connected by 2x330 kV lines of 550 Km long to SIP, a small power system located in the Argentina south with 1200 MW of peak load. Futaleufú substation feeds a local load (approx. 6 MW) and is connected with Puerto Madryn substation by means of 2x330 kV lines of 550 km long.

Puerto Madryn substation is connected to the South SIP with two 330/132 kV autotransformers, 60 MVA each.

This substation has 2 autotransformers of 330/33 kV, 300 MVA each, to feed a factory for electrolytic aluminum production with 450 MW of load and a power plant of 280 MW (in process of extension to 830 MW of load and to 650 MW of electric power generation).

SIP operated isolated until 2006 when it was interconnected to SADI (the biggest Argentinean power system with 17.000 MW of peak load) by means of a 500 kV line of 360 Km long between Choele Choel and Puerto Madryn substations, through an autotransformer of 500/330 kV, 400 MVA, at Puerto Madryn substation. After the SIP-SADI interconnection, Futaleufú power plant participated in several episodes of instable electromechanical oscillations originated by a 330 kV line disconnection [7]-[8]. In all these cases, studies previously made with available models of Futaleufú power plant predicted stable operation conditions [9]-[10]. Then, it was necessary to use better models of Futaleufú to improve studies results [8]. Moreover, it was necessary to add new models, like the models of water supply system to take into account the hydraulic interaction between turbines [1]-[6].

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II. Futaleufú Hydropower Plant Models

Several tests were carried out at Futaleufú plant to improve models of: Excitation System and its Over and Under Excitation Limiters; Governor; Gate Control; Turbine; and Water Supply System. Tests were reproduced with models developed using Simulink–Matlab.

A. Excitation System

The model ST1A [11] from IEEE was used to represent the Excitation System. The excitation is of static inverting type where the controlled rectifier bridge is fed by an auxiliary transformer connected to the generator terminal voltage.

Tests were carried out not only with the normal settings but also with changed settings in order to identify the control structure of Excitation Control System. Fig. 1 shows the evolution of the measured and simulated terminal voltage (UT) for a small step test [12] made with changed settings.

Also, the evolution of the simulated terminal voltage (UT) using normal settings is shown. There is a good agreement between measured terminal voltage and the simulated one obtained from the ST1A model simulating the same test.

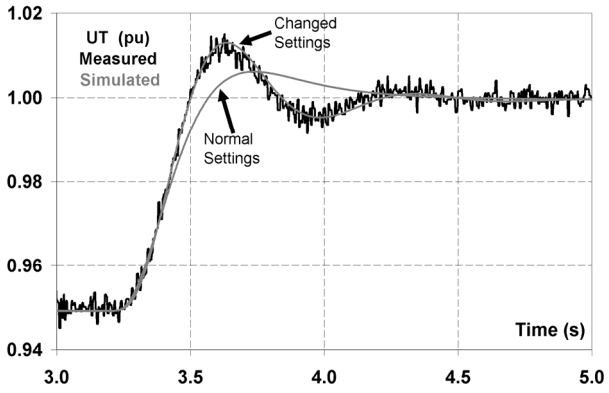

Fig. 1. Excitation system. Small step test. Measured (black) and simulated (gray) Terminal voltage with changed settings, and simulated (gray) with normal settings.