REACTOR INSTRUMENTATION AND CONTROL

1. 370/CSMP Dynamics Simulation of PWR Power Plant, *H. Austregésilo Filho, R. Y. Hukai, V. R. Schad (IEA-Brazil)*

A mathematical model for the dynamics simulation of a PWR power plant was formulated to study response functions and control parameters of the plant under large load variations. In this simulation, models of the components of primary and secondary circuits were programmed using the Continuous System Modeling Program[1] (CSMP) language in an IBM 370/155 computer. It was shown that modeling in CSMP language can provide a simple digital computer simulation in agreement with predicted PWR power plant transients. Figure 1 is a schematic diagram of the overall control system.

For the reactor core simulation, point kinetics with 6 delayed-neutron precursors was used. The input for the kinetics equations are the reactivity due to control rod movements and feedback from fuel and coolant temperature and pressure coefficients. Temperature distribution in the fuel element and coolant was obtained using n (usually 12) heat transfer axial mesh points.

A simplified model was developed to simulate the once-through countercurrent steam generator. Six mesh points were shown to be adequate to simulate the analyzed transients. The simulated pressurizer controller was programmed to give an adequate insurge and outsurge in accordance with the thermodynamic conditions in the primary circuit. In the calculations, the primary pressure is determined by mass, volume, and energy balance and is controlled by immersion heaters and spray valves. All primary piping sections were simulated to account for the time delays.

In the secondary-circuit steam line, turbogenerator and feedwater line were simulated. The enthalpy of the steam line was considered to be constant but account was taken of the steam compressibility and momentum, and the propagation of pressure transients (40-psi peak pressure limit for steady-state operation). The turbogenerator was simulated by a single pressure stage unit; steam quality and flow change instantaneously with the electric power. The feedwater line was considered run by a constant speed pump and controlled by a flux variable feedwater valve.

The following control systems were simulated: (a) reactor control system composed of a temperature mismatch system that constantly monitors the average temperature of the coolant and compares this to a reference temperature which is a function of the electrical load demand; power mismatch system that constantly compares the thermal and electric power. This control system regulates the control rods; (b) pressurizer pressure control system that commands the heater and spray system to compensate pressure variations; (c) steam dump control system which allows large and sudden (up to 85%) load decrease through four bypass valves to the condenser. To simulate the Angra I Plant, four levels of temperature error signals corresponding to the actual four power levels were taken; (d) a simplified model was used to simulate the control system of the steam admission valve to the turbine and the feedwater control valve.

Various transients were examined including large step load rejections of 85 and 50% of full load, ±10% step load change, and 5% min ramp load increases and decreases. Satisfactory results of the plant performance and its control system were verified by comparing these results

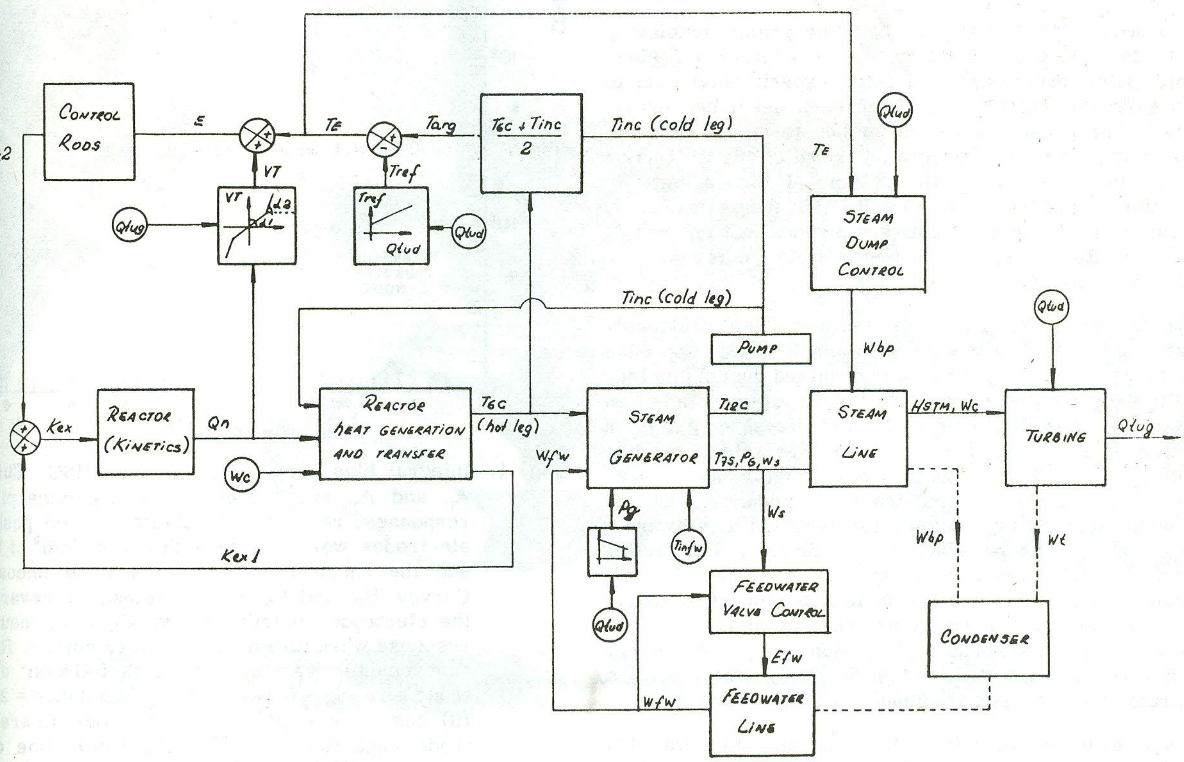

Fig. 1. Block diagram of the control system for a PWR plant.