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AUTOMATION AND HEAT CONTROL IN POWER ENGINEERING

Development of a Process Control System for the Gas-Turbine Units Operating at the Thermal Power Plant of the Tuapse Oil Refinery Plant

I. A. Shavochkin, L. L. Grekhov, and E. A. Dubov

ZAO Interavtomatika, Avtozavodskaya ul. 14, Moscow, 1115280 Russia

Abstract—The characteristics of the thermal and electrical circuits for the six gas-turbine units operating at the thermal power plant of the oil refinery plant in Tuapse are reported. Operational modes of the equipment at different steam to electricity-consumption ratios are considered. The structure of the distributed control system of the process control system (PCS) and its characteristics are presented. The paper provides basic solutions for controlling thermal and electrical loads of the gas-turbine units. The designing features of circuits to control the power plant's basic parameters are shown.

Keywords: gas-turbine unit, thermal load, electrical load, PCS, steam main line, power flow to the grid, active power, reactive power, grid frequency, voltage in the bus system

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One of the main activities in power engineering is the development and commissioning of thermal power plants (TPPs) designed to supply large-scale industrial enterprises with thermal and electric power. A specific feature of such plants is the wide range of probable operating conditions that provide for various ratios between generated thermal and electric power depending on the composition of the industrial consumer's equipment. The TPP in Tuapse designed to meet the needs of a large-scale oil refinery plant may be an example of such a plant.

ZAO Interavtomatika started designing the process control system (PCS) in June 2010. Work on specifications, ordering, designing, and testing of the equipment for the distributed control system (DCS) was completed in a year. The considerable scope of installation and adjusting work was postponed until May 2013 owing to the failure of manufacturing the process equipment on time.

DESCRIPTION OF THE PROCESS FLOW SCHEME

The Tuapse TPP features six SGT-800 gas-turbine units (GTUs) manufactured by Siemens (SITAB, Sweden) with a rated power of 47 MW each.

The gas is delivered from the turbine exhaust into E-65 heat-recovery boilers (denoted with HRB in the figures) manufactured by EMAlyans, which generate steam with a rated pressure of 4 MPa, a temperature of 440°C and a steam rate of 65 t/h. A control valve—a relief valve (RV in the figures) for venting gases downstream of the turbine past the heat-recovery boilers—is provided in the process flow scheme between the gas turbine and the heat-recovery boilers to vary the balance between measuring out steam and electric energy according to the demand of the refinery. Thus, the basic elements of every GTU are a gas turbine (GT in the figures) with a generator, heat-recovery boilers, and a relief valve.

The steam-power unit of the GTU presents a station with cross links (see Fig. 1): the steam is delivered from the heat-recovery boilers into the unified 4-MPa steam main line. Two E-50 oil–gas steam boilers (manufactured by ZAO ZIO-Bel-centr) with chamber-fuel combustion are connected to the steam main. The steam output of each boiler is 50 t/h with a pressure of 3.9 MPa and a temperature of 440°C. In this way, reserved deliveries of the thermal power are ensured, which is especially significant in the cases when the demand for heat exceeds the demand for electric energy. The steam at 4 MPa is supplied to the plant's consumers both directly and via low-pressure (1.3 MPa) steam pipelines.

A back-pressure turbine (manufactured by Kaluzhskii Zavod) with a rated power of 12 MW is the main 4/13-MPa reducing device. A set of 4/1.3-MPa high-speed reducing–cooling units (denoted with HRCU in the figures) supplements the steam turbine (ST in the figures) and ensures its reservation. Steam at a pressure of 1.3 MPa arrives at the refinery's installations and is also delivered to the 0.35-MPa mainline to supply the auxiliaries of the GTUs of the power plant (TPP-GTU). To reduce the steam pressure, a set of 1.3/0.35-MPa reducing–cooling units (RCU in the figures) is used.