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Thermal Tests of the 9FB Gas Turbine Unit Produced by General Electric

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Abstract—In July 2011, a PGU-410 combined-cycle power plant was commissioned at the Srendeuralsk district power station owned by Enel OGK-5. The main equipment of this power plant includes an MS9001FB gas turbine unit (produced by GE Energy Power Plant Systems, the United States), a heat recovery boiler (produced by Nooter/Ericsen, the United States), and a Škoda KT-140-13.3 two-cylinder condensing and cogeneration turbine with steam reheating. In 2011–2012, specialists of the All-Russia Thermal Engineering Institute carried out thermal tests of this power plant in a wide range of loads and under different external conditions. The results from thermal tests of the MS9001FB gas turbine unit are presented and analyzed. The actual indicators of the gas turbine unit and its elements are determined and their characteristics are constructed.

Keywords: gas turbine unit, compressor, turbine, combustion chamber, power capacity, efficiency, temperature, flowrate, cooling

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The MS9001FB gas turbine unit (GTU) is a single-shaft single-casing machine intended to serve as a direct drive of a hydrogen-cooled electric generator. The unit can operate independently or be used, as at the Sredneuralsk district power station (DPS), as part of a combined-cycle power plant (CCP).

The GTU consists of an air intake, a compressor, a combustion chamber, a gas turbine, a comprehensive air cleaning device, an exhaust diffuser, and auxiliary systems.

Atmospheric air is sucked through an air intake chamber, filtered, and compressed in a 17-stage axial compressor, the inlet guide vane (IGV) of which is adjusted for changing the power output and the compression ratio. Compressed air is then supplied to a tubular–annual combustion chamber consisting of 18 fire tubes (arranged around the rotor), where fuel is fired in its medium. Hot combustion products from the chamber enter into a three-stage gas turbine, in which their energy is converted into mechanical work. Spent gases from the turbine are directed through an outlet diffuser into a heat-recovery boiler, and from it they are discharged into the atmosphere through a smoke stack.

At high temperatures, the rotor blades and nozzle vanes of the turbine first two stages are cooled by air.

The combustion processes in the GTU, which is fitted with a DLN2.6+ low-emission combustion chamber, are organized in such a way that the concentration of NO_x emissions is less than 15 ppm during operation at nominal and partial loads.

At high loads (greater than 50% of the nominal load), a preliminarily prepared fuel–air mixture is fired in the combustion chamber, and only at low loads (smaller than 50%) the combustion is stabilized by a diffusion flame.

The GTU is started by its own electric generator operating as a synchronous motor powered by a static frequency converter in the form of a 7-MW thyristor startup device. This startup device is also used for ventilating the gas–air path of the GTU and heat-recovery boiler (HRB) and in washing the compressor.

The pressure of natural gas is increased to the level required for GTU operation by means of gas booster compressors.

The main performance indicators of the GTU during its operation at the nominal load and under the design external conditions (outdoor air temperature equal to +15°C, relative humidity equal to 65%, atmospheric pressure equal to 98.4 kPa, and pressure drop equal to 0.8 kPa at the inlet and 3.9 kPa at the outlet) are as follows.

Power output at the generator terminals, MW	277.05
Mass flowrate of gases at the outlet, kg/s	667
Temperature of gases at the outlet, °C	642.8

The parameters of the GTU working process (pressures, temperatures, flowrates, etc) and, as a consequence, its main characteristics (power output and efficiency) depend on the external conditions (prima-