A T-113/145-12.8 Cogeneration Steam Turbine for the PGU-410 Combined-Cycle Plant at the Krasnodar Cogeneration Station


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Abstract—Turbine design, essential features of its control, economic indicators, and main solutions taken for the thermal circuit and layout of the T-113/145-12.8 turbine unit are considered.

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The T-113/145-12.8 cogeneration steam turbine is intended to operate as part of the combined-cycle plant (CCP) installed at the Krasnodar cogeneration station. This CCP also incorporates a 303-MW M701F4 gas turbine of Mitsubishi Heavy Industries and a heat-recovery boiler (HRB) produced at OAO EMAl’yans (Alliance for Constructing Power Machinery and Equipment) in accordance with the project developed by at Czech–Austrian company A&E.

The T-113/145-12.8 steam turbine is a three-cylinder machine (Fig. 1), the cylinders of which have many new design features, primarily due to the fact that it was designed to operate as part of a three-loop CCP and has increased parameters of steam in the high-pressure (HP) loop.

High-pressure steam from the HRB is supplied to the valve unit (VU). The aerodynamic configuration of the steam boxes and valve pairs of the stop valve (SV) and control valves (CVs) has been retained the same as in the VU of the T-53/67-8.0 turbine produced by ZAO Ural Turbine Works (UTZ) that was designed for the PGU-230 combined-cycle plant at the Minsk TET’s-3 cogeneration station. Extensive work on improving the aerodynamic characteristics of the VU was carried out in the course of developing the T-113/145-12.8 turbine, as a result of which a considerably smaller pressure drop across the VU has been obtained [1]. However, the use of higher pressure of HP steam in this turbine ($p_0 = 12.8$ MPa) as compared with the pressure for which the shell of this VU was designed generated the need to modify the designs of the shell and the flanges through which the covers and shell are connected.

The high-pressure cylinder (HPC) is made with throttle admission of steam, a solution commonly accepted for steam turbines operating as part of a CCP at sliding parameters of steam. This cylinder contains 11 pressure stages with the root diameter of rotor blades equal to 800 mm. The disks of the stages are forged together with the shaft. Stages Nos. 1 through 11 are furnished with high-efficient overshroud seals.

The HPC has a two-shell design, steam in which moves in accordance with a straight-flow scheme. The two first stages are placed in the inner shell, and the remaining nine ones, in the outer shell. The outer shell is made on the basis of the casting of a T-110/120-12.8-5MO turbine, the shell of which has a design different from standard T-100/110-12.8 turbines, and features improved reliability and maneuverability, as well as reduced metal intensity. The need of installing the inner shell stems from the fact that the required strength and tightness of the shell are not achieved in case of using a single-shell design in view of the high values of pressure in the steam admission chamber ($p_0 = 11.9$ MPa) and temperature ($t_0 = 557°C$). The design with an inner shell made it possible, not only to obtain the required tightness and strength, but also to retain high maneuvering characteristics of the HPC as a whole.

The intermediate-pressure cylinder has a two-shell design that allows it to be easily cast and sealed (Fig. 2). It consists of a cast part, which includes the shell’s upper generatrix, steam admission fittings, and flanges of the horizontal joint, and a forged part, which serves as the shell’s lower generatrix. The main feature of the construction is that the horizontal joint of the inner cylinder is tightened not only in its outer (cast) part, but also in its inner (forged) part, due to which the required tightness of the inner shell is achieved; i.e., steam leaks through the horizontal joint are excluded. The fasteners of the inner part are installed in special pockets on the side of steam space.

Steam from the HPC is forwarded to the HRB, where it is mixed with steam from the intermediate-pressure loop’s steam superheater, after which it passes through a reheater and enters into the intermediate-pressure cylinder (IPC) through two intermediate-pressure VUs, the design of which is similar to that of the VUs for the IPC of a T-250/300-23.5 turbine (referred to henceforth as a T-250 turbine).

The intermediate-pressure cylinder has a two-shell design with steam moving in its flow path in accor-
dance with a loop trajectory. The need to use such a solution is mainly dictated by the fact that the zone of high-temperatures (the steam admission zone) is brought to the maximum distance away from the IPC supports. The design solutions used in the IPC’s inner welded-cast shell are in principle similar to those described above for the HPC’s inner shell. The IPC’s inner shell has an assembled design and consists of a