

OPERATING EXPERIENCE

Modern gas compressor technologies as a factor of the reliable operation of generating equipment



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The importance of complex gas treatment and guaranteed fuel supply for ensuring the uninterrupted operation of power facilities is shown on the example of the combined-cycle plant CCGT-230 at Minsk CHPP-3.

In the Belarusian power grid, Minsk CHPP-3 (a branch of RUE Minskenergo) has been operating since 1951. At that time, it was the first experience of commissioning high-pressure power equipment in Belarus. MCHPP-3 is part of a single production and process complex for the generation, transmission and distribution of thermal and electric energy. Its installed capacity today is 442 MW for electricity and 1,632 Gcal / h for heat.

The power plant operates according to the heat load schedule, providing heat supply to the industrial area of Minsk and its social sphere, including part of the city centre. The power facility has a complex thermal scheme, equipment with different steam parameters and cross-links. Constant planned upgrade and reconstruction of equipment supports the reliable and cost-effective operation of the CHPP.

CCGT-230 COMBINED CYCLE GAS TURBINE UNIT

In 2009, a new stage began in the production life of Minsk CHPP-3 – a combined cycle gas turbine unit was put into operation as part of the reconstruction (*Photo 1*).

CCGT-230 is equipped with efficient equipment with high technical indicators. There is gas turbine unit (GTU) – manufactured by the Alstom – a gas turbine of the GT13E2 type with a 50WY21Z-095 generator with a rated capacity of 168 MW. It is remarkable that at MCHPP-3 this GTU acquired its own name – Gertrude.

By the by, this is the first GT13E2 turbine installed in the CIS. In Russia, similar units were first commissioned in 2014 at the Novogorkovskaya CHPP.



Figure 1. Model of GT13E2 gas turbine

The GT13E2 has an increased efficiency (more than 38 % in a simple cycle and 55 % in a combined cycle) and is one of the most versatile in its class. The turbine is characterized by unprecedented operational flexibility, robust construction and long overhaul intervals. It also offers high performance at partial loads (up to 50 %) and low NO_x emissions with functioning over a wide temperature range. The prompt start of the engine is carried out in less than 15 minutes. Currently, over 190 GT13E2 turbines are in operation in the world, which have worked 14 million hours in total.

From turbine, the exhausted hot gases (fuel combustion products) enter the HRSG / DP01.1 two-circuit waste-heat boiler (SES ENERGY) that generates steam for secondary power generation.

The resulting steam is sent to a turbo unit with a rated capacity of 65 MW based on a T-53 / 67-8.0 steam turbine (Ural Turbine Works) and a TF-80-2UZ generator (Elsib).

Therefore, the technologies used in the combined-cycle plant provide combined energy generation, high fuel efficiency and overall facility efficiency. The electric capacity of the CCGT-230 is 222 MW, thermal capacity is 136 Gcal / h, efficiency of power unit – 52.5%.

The main and reserve fuel is natural gas.

ENSURING THE RELIABILITY OF FUEL GAS TREATMENT

The supply of the CCGT with fuel gas with the established parameters in terms of purity, temperature, pressure, and flow rate is provided by the gas treatment system, which until recently was based on a booster compressor station manufactured by VPT Kompressoren GmbH (BCS-1).

The problem was the operation of BCS-1 without redundancy, which forced to combine the periods of maintenance



Photo 1. CCGT-230 combined-cycle plant at Minsk CHPP-3



Photo 2. New booster compressor station for fuel gas from ENER GAS

and repair of generating and process equipment, and most importantly, it created a risk of unplanned shutdowns of the combined-cycle plant. Therefore, at MCHPP-3, it was decided to upgrade (enlarge) the gas treatment system.

March 22 this year, a booster compressor station supplied by ENER GAS (Photo 2) was put into operation at the CCGT site. The new BCS-2 is made on the basis of a screw oil-filled compressor with an electric engine as a drive (Photo 3) and is a block-modular process unit with a maximum integration of the components on a single frame.

The station is placed in its own sound-absorbing shelter which equipped with life support systems (heating, ventilation, lighting). According to safety requirements, the module is equipped with fire detection, gas detection, alarm and fire fighting systems.

This BCS is the second most powerful among all 234 gas compressor stations of screw type, previously put into operation by ENER GAS in the electric power industry and at various facilities in the oil and gas industry.



Photo 3. Basis of BCS-2 – screw compressor with electric engine

Unit with a nominal capacity of 38,160 kg / h compresses fuel to the required designed values (2.7 MPa) and feeds it to the gas turbine of CCGT. Gas flow rate depends on the dynamics of changes in the turbine load and is controlled by means of a special two-circuit regulation system.

The first circuit (control by the compressor spool valve) provides smooth, stepless gas flow regulation in the range of 15 ... 100%. To control the capacity in the lower range 0 ... 15 %, the first circuit is combined with a gas recirculation system (second circuit), that allows you to respond quickly and correctly on a sharp change in load during transient operating modes of conjugated turbine.

The multi-stage fuel gas filtration system is composed of an inlet strainer, a gas-oil separator of the 1st stage of purification (Photo 4) and duplex coalescing filters of the 2nd stage (Photo 5). Residual content of impurities in gas at the outlet of the BCS-2 is not more than 1 ppmw (mg / kg).

The process flow scheme provides for the stable maintenance of the calculated fuel temperature. The delivery line

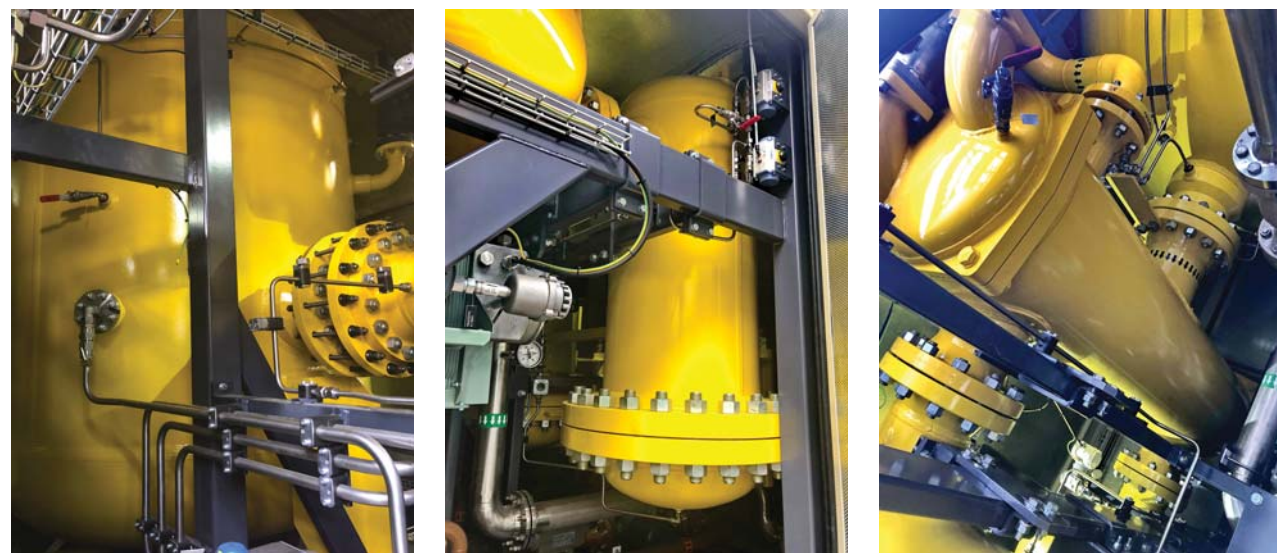


Photo 4-6. Elements of gas filtration and cooling systems (from left to right): separator of the 1st stage of purification, filter of the 2nd stage, heat exchanger



Photo 7. Both compressor stations are controlled from the upper level – from the CCGT control room

of the compressor station is equipped with a shell-and-tube heat exchanger (Photo 6) that cools the working medium and ensures the optimum gas supply temperature (+50 °C) set by the turbine manufacturer and design requirements.

The oil system of BCS-2 uses ester synthetic oil of the new generation ESTSYN, which is specially created for screw gas booster units. The oil of ESTSYN CE100 brand ensures efficient operation of such units, increases their reliability and service life.

The new equipment also includes an air compressor station. The modular auxiliary air CS, housed in a separate block-box, provides compressed, dry and pure air for the pneumatic components of the BCS-2.

COMPREHENSIVE TESTING OF BCS-2

The commissioning of gas compressor station No. 2 was preceded by comprehensive testing under load – in conjunction with an Alstom GTU. 72-hour tryout was carried out stepwise under various turbine capacity modes; during testing, BCS-2 has operated normally, without any complaints. The station confirmed the main design characteristics and achieved guaranteed functional indicators:

- Gas flow rate is 10.6 kg / s;
- Rated delivery pressure is 2.75 MPa;
- Gas fuel temperature at the BCS outlet is up to +50 °C;
- Range of volume capacity control is 0 ... 100 %;
- Vibration state of the gas compressor – in accordance with the manufacturer's technical documentation;
- Sound pressure level at a distance of 1 m from the BCS-2 is no more than 80 dBA.

UPGRADE OF THE GAS SUPPLY SCHEME OF THE CCGT

In addition to enlarging the process capabilities of the fuel gas treatment system, the gas supply scheme for the CCGT has been upgraded.

The peculiarity of BCS-1 and BCS-2 operation is that they function alternately, evenly distributing the operational load. When one unit is turned on, the second one switches to the hot-standby mode.



Photo 8. Comprehensive commissioning of the equipment was fulfilled by the ServicENER GAS experts

Their own ACSs implement launch (and preparation for start), shutdown, and maintaining the optimal operating mode; they control the working characteristics and gas pollution in the process compartments of BCSs; they provide automatic protections and alarm; they handle the parameters of the main processes and emergency events with the issuance of information to the operator panel via a standard exchange protocol.

To fulfil this task qualitatively, ENER GAS has equipped the compressor stations with a two-tier automated control and regulation system (ACRS), which combined local ACS of both BCS and integrated them into the automated processes control system of a facility. Remote control (operator workstation – WKS) is placed in the control room of the CCGT (Photo 7).

The ACRS made based on microprocessor technology, using modern software, switching equipment and communication channels and protocols. Control from the upper level is carried out in full, similar to the control «in site».

The comprehensive commissioning of the BCS-2, air CS and ACRS (erection supervision, start-up and adjustment works, individual and integrated tests), as well as training of the operating personnel were fulfilled by the specialists of the ServicENER GAS (ENER GAS Group).

Implementation of the project, based on modern gas compressor technologies, increases the reliability of fuel supply to the highly efficient combined-cycle plant and ensures uninterrupted operation of the CCGT-230 in all modes and under any climatic conditions.



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