MODERNIZATION OF TASHKENT TPP, COMPARISON OF STEAM TURBINE UNIT WITH STEAM - GAS UNITS

SAMATOVA SHOIRA YULDASHEVNA

Karshi Engineering and Economics Institute Associate Professor of the Department "Heat power engineering"

SHODIEV BOBIR TOYIR UGLI

Uzbekistan, Assistant of the Department "Electric Power Engineering"

JURAEV SHUXRAT ABDUJABBOR UGLI

Uzbekistan, Undergraduates: Department of "Heat power engineering"

SAIDOV ULMASJON TOSHKENTOVICH

Uzbekistan, Undergraduates: Department of "Heat power engineering"

Abstract

The environmental assessment carried out showed that the commissioning of the CCGT at TashTEP will lead to a reduction in the anthropogenic load on the environment.

Keywords: Installed capacity utilization factor; number of hours of use of installed capacity; working time coefficient; readiness factor; reliability factor; Excitation; chimneys; Cooling systems; pathogen

Introduction

The Tashkent TPP is designed to supply power to the Tashkent energy hub, as well as heat supply to nearby areas and is part of the unified energy system of Central Asia.

The installed capacity of the Tashkent TPP is 1860 MW. Ten power units have been installed: power units st. No. 1-5.9, 150 MW each, power units st. No. 6,11,12, 155 MW each, power units st. No. 7,8,10 for 165 MW. The main fuel is natural gas from the Shurtan and Bukhara fields, the reserve fuel is fuel oil. The emission of fuel combustion products from 12 power units is carried out through three chimneys 120 m high.

In December 1997, the 3rd Session of the Conference of the Parties to the UN Convention on Climate Change took place in Kyoto. At this conference, the Kyoto Protocol was adopted, in which developed countries (including the countries of the CIS and Eastern Europe) expressed their intention to reduce the average value of emissions in the period from 2008 to 2010. at least 5% below 1990 levels to prevent global warming from the effect of greenhouse gases, including nitrogen dioxide. Japan has set itself the goal of reducing this figure by 6%. Financing of this modernization project is carried out through ODA Loans (Official Development Assistance) of the Japan Bank for International Cooperation (JBIC).

The power generators installed at the station have the following characteristics:

TYPE -TVV-165-2
Manufacturer - Leningrad Electrotechnical
association "Electrosila"
Power, MW -160
Power factor (cosφ) -0.85
Output voltage, kV -18
Excitation - high frequency (400 Hz)
Cooling - hydrogen (under excess
pressure 0.3 MPa)
-rotor, water (distillate)
- stator windings.

Cooling systems of electric generators - closed type. The cooling of hydrogen and distillate circulating in them is carried out in coolers with condensate from the pressure of turbine CEPs. In the hot season, the distillate can also be cooled additionally by the process water supply of the power unit in the cooler, which is included in the distillate circulation circuit in series with the condensate cooler.

Each of the electric generators is equipped with its own exciter with a self-excitation system. The connection of this exciter with the generator shaft is carried out by means of a pin coupling. The exciter is cooled by air, by its own fans: inlet and exhaust, installed in the end straps of the exciter. The air injected into the internal cavity of the exciter is pre-cooled in the water cooler of the process water supply system of the power unit. From the exciter, the air heated in it is removed by a suction fan into the atmosphere, i.e. exciter cooling system - open type.

In addition to its own exciters - electric generators, three standby electric machine exciters are installed at the station. Each of them is driven by an asynchronous electric motor with a supply voltage of 6.3 kV. The first of these exciters has the ability to connect to the generators of power units st. NN 1 and 2, the second - power units st. NN 3 ... 10, and the third - power units st. NN 5...12.

The power generation of the station is carried out at voltages of 110, 220 and 500 kV. At voltages of 110 and 220 kV, a double busbar system is provided with one bypass system and their busbar switches and disconnectors. Under normal operating conditions, the busbar bypass systems are disconnected and not energized. The basic main electrical circuit of the station is shown in the figure.

Block transformers, communication autotransformers, auxiliary transformers are located along the main building, on the site between this building and the outdoor switchgear. The connection of generators with these transformer devices is carried out by means of shielded conductors. Portals for outdoor switchgear busbars are made of metal structures on prefabricated reinforced concrete foundations.

All transformer devices are produced by the Zaporizhzhia High-Voltage Equipment Plant.

The generators of the first two power units are connected to 110 kV buses through their block transformers (TDTs-200000/110 with a capacity of 200 thousand kVA and voltages of 121/18 kV) and switches located on the high voltage sides.

The generators of power units 3 and 4 are connected to 110 kV buses through similar transformers and circuit breakers located on their low and high sides.

Communication between bus systems 110 and 220 kV is carried out by means of two autotransformers with a capacity of 180 thousand kVA. Breaking this connection, if necessary, can be carried out by transferring the switches of these transformers to the "Off" state from any of the 110 and 220 kV busbar systems.

Power unit generators st. 5...8 and 9...12 are connected to 220 kV buses. Generators of the first of these groups - through their block transformers (TDTSG-180000/220 with a capacity of 180 thousand kVA with a voltage of 242/18 kV) and switches located on the high voltage sides, and the second - through block transformers (TDTs - 220000/220 with a capacity of 220 thousand kVA and voltages of 242/18 kV) and two block switches: one on the low voltage side, and the other on the high voltage side.

Electricity supply for 500 kV voltage is provided from 220 kV buses through an autotransformer (3xAODTSTNG-167000/500 with a capacity of 167 thousand kVA each for a phase autotransformer) and their switches located on the 220 and 500 kV sides.

The station's auxiliary voltages are 6.3 and 0.4 kV. Block auxiliary transformers with a capacity of 15 and 16 thousand kVA each (TDN-15000/35 - power units st. 1 ... 6 and TDNS-16000/35 - for the remaining power units of the station) are switched on without switching equipment for a voltage of 18 kV in front of their block transformers.

To back up own needs, two transformers (TDNG-15000/110) with a capacity of 15 thousand kVA and a voltage of 121/6.6 kV are installed, fed through switches from the busbars of ORU-110 kV, and one transformer (TRDNS-32000/35) with a capacity of 32,000 kVA powered by a communication autotransformer of outdoor switchgear 220 and 500 kV [A.1;,2;,3;,5;].

Station performance indicators. Any power plant, as an energy converter, must produce its products (electrical and thermal energy) with the least possible cost of natural energy resources, labor and money.

To evaluate the functioning of power plants, energy, economic and regime indicators are used. The first of them allow us to evaluate the efficiency of using the consumed natural energy resources, the second - determine the cost of producing a unit of output, and the third - characterize the efficiency of the equipment operating modes. [A.2; 5;].

Energy indicators. The production of electrical energy at thermal power plants is carried out in the process of converting one type of energy into another in the sequence: "Natural energy of fuel - thermal energy of flue gases, and then water and steam - mechanical energy of rotation of the rotors of the turbine and generator - electrical energy of the generator" At each stage this process has energy losses. The stage-by-stage and overall efficiency of energy conversion of this process can be estimated by the corresponding coefficients, called efficiency factors. Each of these efficiency factors can be defined as the ratio of the amount of energy usefully used or obtained as a result of the transformation to the total amount of energy supplied or spent in the process of this transformation.

When determining efficiency, a distinction is made between gross efficiency and net efficiency. The first of them does not take into account energy losses for own needs and losses in the cycle, and the second one takes into account all energy costs.

The efficiency of a heat engine and an electric generator of a steam turbine TPP is called the absolute electric efficiency of a heat engine. The value of this efficiency is defined as the ratio of the amount of electricity (in joules or kilocalories) generated by a heat engine to the amount of heat consumed by it. This efficiency is one of the most important and reflects the perfection of the heat engine cycle, taking into account the available heat drop across the turbine, initial live steam parameters, condenser pressure, reheat steam parameters and regenerative feed water heating.

8.1.1.2. The efficiency of the power unit is equal to the product of the absolute electrical efficiency of the heat engine, the efficiency of the boiler unit, the heat flow transport (taking into account all the losses of heat, steam, water, etc. in pipelines and various devices of the thermal scheme) and the coefficient for accounting for heat and electricity consumption for own needs.

The heat flow efficiency characterizes the perfection of the thermal scheme and operation, takes into account heat losses in the plant pipelines, taking into account steam, condensate and blowdowns of the boiler unit. The coefficient taking into account the power unit’s own needs includes all heat and electricity costs spent on fuel supply mechanisms, draft mechanisms and RAH of the boiler unit, feed, condensate, circulation and other pumps and other equipment.

Plant efficiency is defined as the ratio of the amount of electricity supplied over a certain period of time (day, year) ("net generation"), equal to the difference between the volumes of electricity generated ("gross generation") and its consumption for own needs of TPPs for the same period time, to the amount of chemically bound heat, expressed in the same units of measurement, consumed by the fuel. The value of the latter is equal to the result of dividing by the conversion factor (860 kcal / kWh) of the product of the values of the mass consumption of natural or standard fuel consumed by the station for this period and the corresponding calorific value of its unit mass.

Unproductive heat losses in the turbine are due to:

- throttled steam in stop and control valves;
- vortex formations in steam flows in nozzles, diaphragms and blades;
- friction of disks on steam as a result of their rotation in a steam environment;
- steam ducts through the rotor shaft seals;

- increase in steam humidity in the last stages;
- loss of kinetic energy with the output velocity of steam flows after the last stage;
- mechanical losses in bearings, in regulation, etc.;
- heat losses to the environment from the body and steam pipelines through their thermal insulation.
- Similar losses in the boiler unit are due to:
- chemical incompleteness of fuel combustion;
- mechanical incomplete combustion of fuel;
- heat losses to the environment through the thermal insulation of gas ducts;
- losses with the physical heat of the slag;
- losses with outgoing flue gases.

The values of the above efficiencies take into account the heat losses of the fuel only in the process of generating electricity at TPPs, starting from burners and ending with generator clamps. The station also has direct fuel losses in the receiving and unloading devices and warehouses, as well as unproductive fuel consumption associated with start-ups, shutdowns and being in the "hot standby" equipment and losses of water and steam in these and other off-design modes of its operation. As a result, the actual plant efficiency values may differ significantly from the calculated ones.

In addition to efficiency, other important energy indicators of TPPs are the values of specific heat and fuel consumption per one released (or generated) kilowatt-hour of electricity, with the index "net" or "gross", respectively.

In relative units of measurement, the value of specific heat consumption is inversely proportional to the efficiency of the station, and in dimensional units, it is additionally multiplied by the conversion factor (860 kcal / kWh).

The value of the specific fuel consumption can be found as a quotient of the division, expressed in dimensional units of measurement of the specific heat consumption, by the calorific value of a unit mass of natural or standard fuel. [A.3;,4;].

To assess the operation of the station, below, based on the results for 1990-1994, the average annual values of some of its energy indicators are given:

Boiler unit efficiency, in %, brutto - 92...94

	netto	- 87...88
Heat engine efficiency		
(steam turbine generator), in %,	brutto	- 39...39.5
	netto	- 38.5...39.0
Power unit efficiency, in %,	brutto	- 36...37
	netto	- 33.5...34.5
Specific fuel consumption electricity, g/kWh		- 367...369
Electricity consumption for own needs, in %		- 5.4...5.6

Discussion of economic indicators. The main economic indicators of a thermal power plant that supplies only electricity are:

Kst - specific capital costs for the construction of the station;
Ce - the cost of electricity;
Zk - specific reduced costs.

The value of specific capital costs is defined as the quotient of dividing the total cost of the station (Kst) to the value of the installed electric capacity - gross (Ne). Otherwise, this indicator is also called the cost of 1 kW of installed capacity. The lowest values of this indicator are achieved at TPPs with larger power units.

The value of the cost of electricity supplied is defined as the quotient of dividing the value of the total production costs for a certain period of time, month or year, by the amount of electricity supplied during this time (En year).

The total cost of production is made up of:

It - fuel costs, including all costs for its acceptance, storage, processing and transportation to thermal power plants, for cooling water and various operating materials;

Ik - the cost of depreciation to reimburse the main capital investments, for current and major repairs and equipment upgrades;

Iex - operating expenses, which include the cost of wages for maintenance personnel and social security contributions, the cost of auxiliary materials, auxiliary production services and other plant-wide expenses.

Relative to the amount of electricity supplied, the share of each of these components of the total production costs is the corresponding component of the cost of this electricity: fuel, capital costs and operating costs. The first of these cost components is approximately proportional to electricity generation, and therefore is a variable value, and the costs (It) corresponding to production costs are called variable costs. The remaining cost components do not depend on the load and operating modes of the station equipment and are approximately constant values, and the corresponding costs (Ik and Iex) are fixed costs.

To compare options for generating the same amount of electricity, in addition to its cost, it is necessary to take into account the total or specific reduced costs for its production. At the same time, an option can be considered more economical if these costs are lower in it than in another.

Annual reduced costs for the 3rd year are defined as the sum of the product of the total cost of the station (Kst) by the standard coefficient (Rn) of the return of capital investments for their further use in the national economy and the total annual production costs (Yyear). The optimal return on investment depends on many factors, is determined by policymakers, and currently for thermal power facilities is about 8 years. The normative coefficient corresponding to this period is 0.12.

Specific reduced costs - the quotient of dividing the reduced costs by the amount of electricity supplied. Taking into account the foregoing, these costs can be determined as the result of two factors, one of which is the cost of this electricity, and the other is the sum of one and the product of the standard coefficient by the quotient from dividing the cost of the costs for the construction of the station by the amount of annual costs for the generation of the amount of electricity supplied by the station [A.4;,5;].

Regime indicators. The main indicators characterizing the operating modes of the station and / or its individual parts are:

- installed capacity utilization factor;
- number of hours of use of installed capacity;
- coefficient of working time;
- readiness factor;
- reliability coefficient.

The installed capacity utilization factor of a station (power unit) is equal to the ratio of the amount of actually generated electricity for a certain period of time (usually per year, with an average annual number of 8760 hours) to the value of its maximum possible generation when the station (power unit) operates with full installed power Nset during the entire this period of time. The design value of this indicator is 0.628.

The annual number of hours of using the installed capacity of the station (power unit) is equal to the quotient of dividing the amount of actually generated electricity by the amount of installed capacity. Otherwise, this is the number of hours during which a station (power unit) operating at full installed capacity would have generated an amount of energy equal to the amount actually generated in a year. The design value of this indicator is 5500 hours.

The working time coefficient of the unit is equal to the ratio of the actual number of hours of operation of this unit for a certain period of time, regardless of the degree of its load in terms of power, Tfact to the calendar number of hours of the same period.

The availability factor of the unit depends on the time it was under repair and in an emergency (non-working) state for a certain period of time. In the context of the year, the value of this coefficient is determined as the difference between one and the quotient from dividing the sum, expressed in numbers, of the total duration of scheduled repairs and revisions per year and the total downtime of the unit in a non-operating state, including the time to eliminate the consequences of accidents, to the average annual number of hours equal to 8760.
The time the unit is in reserve does not affect the value of its availability factor.

In the context of the year, the value of the reliability coefficient of the unit is determined as the difference between one and the quotient of the division of the total time of the unit being inoperative due to accidents, expressed in hours, including the time to eliminate the consequences of accidents and bring the unit into working condition, by the average annual number of 8760 hours. In the numerator of this expression, sometimes the time of scheduled repairs is also added. This is motivated by the fact that the need for scheduled repairs, their volume and duration depend on the reliability (perfection) of the unit design. There are units that can operate without scheduled repairs and revisions for several years. For some units, manufacturers require revisions after several thousand hours of operation. [A.5;].

CONCLUSIONS

One of the reserves for increasing the efficiency of the station is more accurate and high-quality maintenance of technological parameters at the required level, which can be illustrated as follows:

- reducing the pressure of live steam in front of the turbine by 0.1 MPa increases fuel consumption by 0.1%;
- reduction of steam temperatures in front of the turbine by 1°C increases fuel consumption by 0.03%;
- reduction of vacuum in the turbine condenser by 1% increases fuel consumption by 1%;
- an increase in air suction into the furnace of a boiler unit by 0.1% reduces its efficiency by 0.5%;
- an increase in the temperature of the flue gases of the boiler unit by 10 ° C reduces its efficiency by 0.6%.
- Fuel consumption will be 310 g/kW.h, up 340 g/kW.h

- After the introduction of CCGT at UE TashTES, the results obtained are:

- the concentration of nitrogen oxides in the flue gases of the CCGT will decrease by more than 6 times below the emissions of two power units, which will be stopped after the CCGT is launched;
- the concentration of the main harmful substances in the zone of influence of TashTES will decrease from 1.6 MPC to 1.4 MPC;
- shutdown of boilers Nos. 11 and 12 will reduce fuel oil ash emissions by 225.3 tons/year;
- fuel economy will be 396 thousand tons/year, and, accordingly, CO2 emissions, as the main greenhouse gas, will decrease by 640 thousand tons/year;
- specific fuel consumption at CCGT will be 225 g/kWh, which is 172 g/kWh lower than at TashTES at present;
- water consumption for CCGT needs is 3903.6 t/h lower than at 2 dismantled power units; the discharge of thermal waters into the Bozsu canal will be reduced by 3,473.6 t/h compared to discharges from dismantled power units. Thus, the conducted environmental assessment

showed that the commissioning of the CCGT at TashTEP will lead to a reduction in the anthropogenic load on the environment.

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