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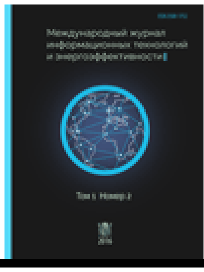

УДК 66.681

ПРАКТИЧЕСКОЕ ПРИМЕНЕНИЕ ПАРОГАЗОВЫХ УСТАНОВОК В КАЧЕСТВЕ СПОСОБА УТИЛИЗАЦИИ ТЕПЛА ГАЗОТУРБИННЫХ УСТАНОВОК НА КОМПРЕССОРНЫХ СТАНЦИЯХ

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В работе представлено применение парогазовых установок в качестве способа утилизации тепла газотурбинных установок (ГТУ) на компрессорных станциях. ГТУ были выделены, как основные источники энергии среди вторичных энергетических ресурсов на КС с точки зрения возможности преобразования ее в полезную механическую или электрическую. Предложено использовать парогазовую установку с котлом утилизатором с целью нивелирования потерь тепла, уносимого отработавшими газами ГТУ.

Ключевые слова: Газотурбинная установка (ГТУ), компрессорная станция (КС), парогазовая установка (ПГУ), отработавшие газы, котел-утилизатор, водяной пар, конденсатор.

APPLICATIVE USAGE OF COMBINED CYCLE GAS TURBINES AS A DISPOSAL METHOD OF GAS TURBINE HEAT AT GAS-COMPRESSOR STATIONS

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Article presents an applicative usage of combined cycle gas turbine at gas-compressor stations as a method of heat utilization of gas turbine. Gas turbine units (GTU) were identified as a basic energy source among secondary resources at compressor stations by means of its conversion into useful mechanical or electrical energy. Utilizing a combined cycle gas turbine unit with a utilizer-boiler in order to minimize heat losses carried away by GTU exhausted gases is suggested.

Keywords: Gas turbine unit (GTU), gas-compressor station (GCS), combined cycle gas turbine (CCGT), exhausted gases, recovery boiler, water vapor, refrigerator.

Nowadays, gas transport is an essential part of Russian energy sector. Anyway, industrial development in the domestic energy sector is fraught with difficulties. Specifically, Russian natural gas industry leads the list of energy-consuming spheres, especially due to the heavy energy demand for gas compressing. Most of the supplied heat is carried away into the atmosphere in the form of exhausted gases (about 60%). Thus, waste of useful energy at gas-compressor stations is a considerable issue. Thermal losses in gas turbine units, according to sources [1,2,3], can vary from 80 to 100 GW.

It is worth mentioning that GTUs are not the only heat sources at GCSs. There are secondary production sites with a large amount of by-product energy resources (SER). Such energy sources are distinguished by huge amounts of energy for the usage of utilization into mechanical and electrical energy:

- oil cooling system used for leveling the friction force of dynamic units of technological equipment;
- heat exchangers, adsorbers and separators used for liquefaction and purification of natural gas;
- recirculated water for temperature control of process main equipment;
- exhaust systems of process areas [4].

Derived energy from GTUs, most commonly, is used as a heat transfer agent in water boiling processes in heating installation and engineering systems of GCSs or rarely for the needs of nearest settlements (the drawback is seasonality of this method). Flow diagram is presented in Figure 1.

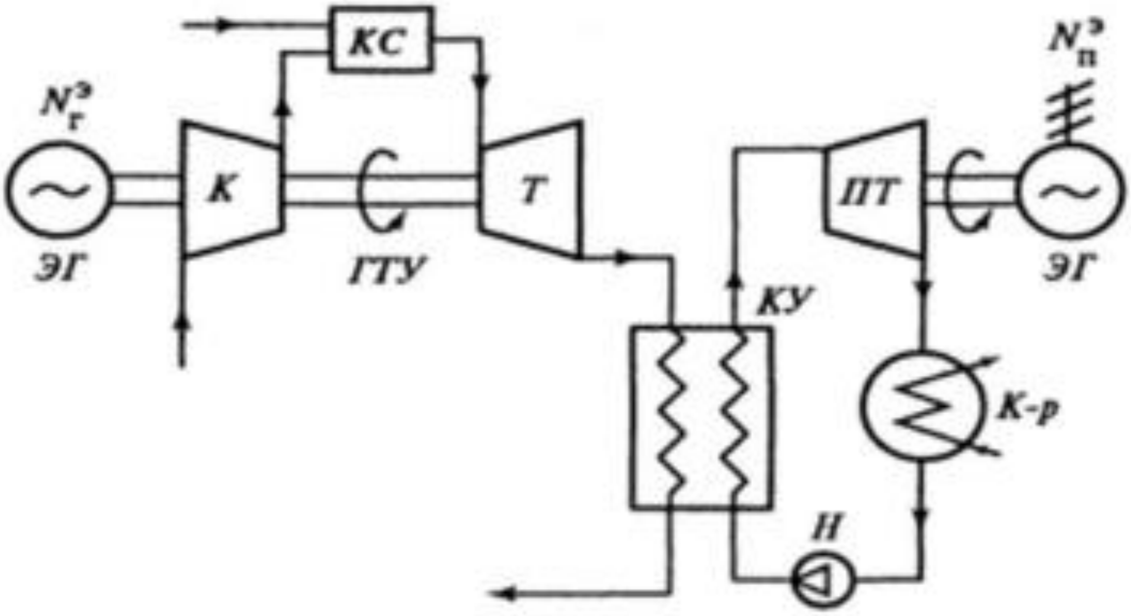

Figure 1 – Flow diagram of CCGP with recovery boiler:
ЭГ - generator; К - GTU compressor; КС - GTU combustion chamber;
Т - GTU gas turbine; Н - feed pump; КУ - recovery boiler; ПТ - steam turbine; К-р - refrigerator [1].

Source: Timoshenko, D. V. Possibility of superstructure of gas turbine units of gas pumping units with utilisation combined cycle gas turbine units / D. V. Timoshenko, V. O. Remeslovskiy

The process works as follows:

1. GTU’s exhausted gases carry away thermal energy into the recovery boiler, which is essentially a simple heat exchanger;
2. Vapor-water working substance gains heating energy through the recovery boiler;
3. The obtained water vapor is sent directly to the steam turbine plant (STP);

4. The water vapor expands and does a mechanical work, mainly acting as a catalyst for the current generators in the steam turbine plant;
5. Finally, vapor sets in the refrigerator and extracts in a cycle for its pretreatment and return to the recovery boiler.

Technical and thermal specification of the most common gas turbines currently used at gas-compressor stations is shown in Table 1. The values presented in the table confirm the above-mentioned data about high flow rate of GTU's exhausted gases and significant value of their temperature.

Table 1 – Technical and thermal specification of gas turbine units [5]

Version of GTU	Number of units	Energy consumption, MW	Efficiency factor, %	Flow rate of exhaust gases, kg/s	Temperature of exhausted gases, °C
GTK-10	646	10	32	86	303
NK-16ST	618	16	29	103,1	378
NK-12ST	322	6	26,1	57,6	302
DR-59L	268	10	28,5	81,5	330

Source: Karyshev, A. K. Perspective technologies of heat utilisation of exhausted gases of gas pumping units / A. K. Karyshev, A. A. Zhinov, D. V. Shevelev

Modifications of combined GTU and turbine cycles called STIG-installations also can be applied at gas-compressor stations. The basis of their work is to affect the exploitation of gas turbines by injecting steam into the feed gas. At the same time, this technology is not identical from the CCGT for utilization of exhaust gases. The main objective is to increase turbine power by 25% and to reduce NOx concentration in exhaust gases [6]. The flow diagram of STIG unit operation is shown at figure 2 (Figure 2).

The main disadvantage of STIG-cycle implementation at combined usage of GTU and CCGT is the necessity to have a constant supply of fresh water and a treatment plant for its purification and injection at a given volume, which can change all the time. Nevertheless, it is worth noting that nowadays STIG systems are an actively studied and experimentally developed area of gas turbine heat utilization development. In the near future, they may become the most economically and environmentally developed solution for supporting efficient maintenance of power plants.

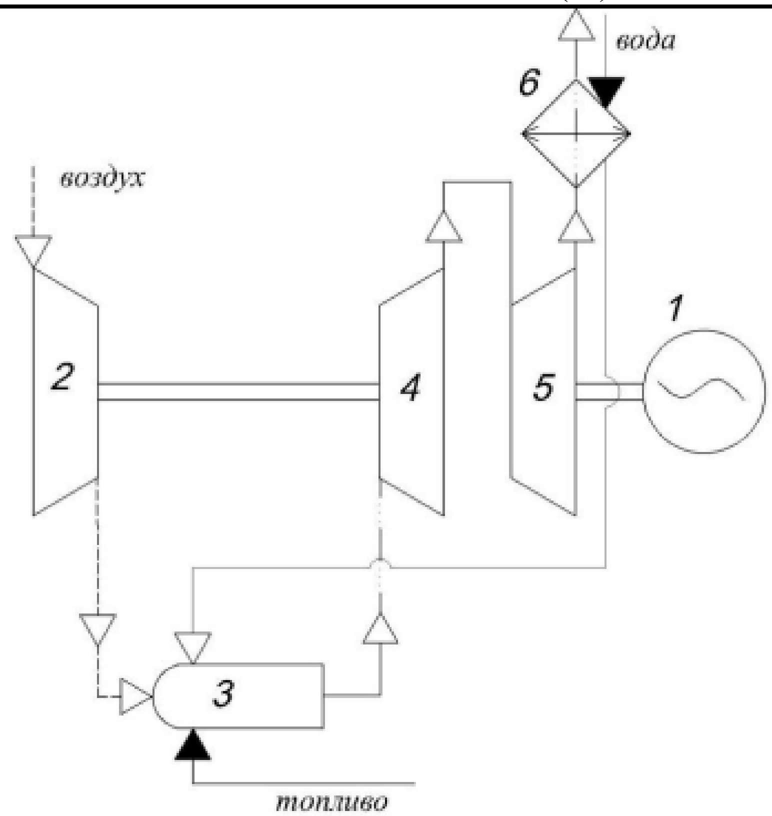

Figure 2 – Flow diagram of STIG unit operation:
1 - energy consumer; 2 - compressor; 3 - combustion chamber; 4 - high-pressure turbine; 5 - low-pressure turbine; 6 - CCGT [7]
Source: Liefer, D. S. State and prospects of development of steam-gas plants with steam injection / D. S. Liefer, A. I. Samsonov

As a reference point for further development of the STIG-cycle, it is possible to point out the introduction of a heat pump into the process, which is able to improve the technological base of the plant exploitation, due to the possibility of decreasing heat losses in the refrigerator. Heat preservation leads to the growth the efficiency of the combined heat and power plant. In that case, the operation of heat pump will occur as follows: the cooling agent removes heat from the condenser, compresses in the compressor, increases the temperature and gives off heat in the evaporator.

Nevertheless, drawback of steam-gas units for utilization of heat energy are worth discussion. First of all, the low efficiency factor of the steam turbine part. The reason behind this are insufficient initial parameters of vapor and low efficiency of the refrigerator. Also, steam turbine is rather expensive and complicated in exploitation due to a large number of operating units.

The above-mentioned facts led to the development of alternative methods by scientists and engineers. As an option, the use of utilization gas turbine units (UGTU) was proposed in research papers.

In conclusion, we can say the problem of oil and gas industry - the usage of by-product heat energy resources at gas-compressor stations was discussed and a result, gas turbine units were reasonably selected as the most high-potential source of secondary energy. In the article a detailed explanation of CCGT’s utilization at gas-compressor stations with a recovery boiler for conversion of heat energy. Is given the most wide spread way of useful energy application is seasonal heating of technological sites of gas-compressor stations.

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