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Features of using gas turbine units as a source of electricity and heat at mini - thermal power plants

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Abstract

This article discusses the problem of introducing more resource-intensive methods of generating electricity and heat, the main of which is the use of small-sized gas turbine units (GTU). The creation of a Mini-Thermal Power Plant on the basis of the GTU allows solving the problem of the shortage of heat and electric energy in certain regions, ensuring uninterrupted power supply to the housing and communal sector and industrial enterprises. This is due to the possibility of combined production of heat and electric energy, as well as products and services required in the municipal services of the city. This article presents ways to improve the energy efficiency of thermal power plants through the use of GTU.

Keywords: GTU, consumers, Mini-Thermal Power Plants, harmful emissions.

Аннотация

В данной статье обсуждается проблема внедрения более ресурсоемких методов выработки электроэнергии и тепла, основной из которых является использование малогабаритных газотурбинных установок (ГТУ). Создание на базе ГТУ Мини-теплоэнергетического Завода позволяет решить проблему нехватки тепловой и электрической энергии в отдельных регионах, обеспечить бесперебойное электроснабжение жилищно-коммунального сектора и промышленных предприятий. Это связано с возможностью комбинированного производства тепловой и электрической энергии, а также продукции и услуг, необходимых в муниципальных службах города. В данной статье представлены способы повышения энергоэффективности тепловых сетей за счет использования ГТУ.

Ключевые слова: ГТУ, потребители, мини-теплоэнергетические сети, вредные выбросы.

Currently, more resource-intensive methods of generating electricity and heat are being actively introduced, the main of which is the use of small-sized gas turbine units (GTU). The creation of a Mini-Thermal Power Plant on the basis of the GTU makes it possible to solve the problem of a shortage of heat and electric energy in certain regions, to ensure uninterrupted power supply to the housing and communal sector and industrial enterprises.

The greatest economic effect from the GTU installation can be obtained with the maximum time of its use during the year. Therefore, at the first stage, the choice of the gas turbine capacity should be made according to guaranteed year-round heat supply from heat sources (this can be heat supply for hot water supply in the summer months or in the form of constant steam supply for production needs). At subsequent stages, the power of the gas turbine can be selected based on the coverage of winter loads.

The advantages of mini gas turbine plants are:

- minimal damage to the environment: low oil consumption, the ability to work on production waste; emissions of harmful substances;
- low noise and vibration level;
- compact size and low weight make it possible to place the gas turbine unit in a small area, which allows significant savings. There are options for roof placement of low-power gas turbine units;

- the ability to operate on various types of gas allows the use of a gas turbine unit in any production on the most economically profitable type of fuel;
- operation, both in stand-alone mode and in parallel with the network;
- the ability to work for a long time at very low loads, including idling;
- maximum permissible overload: 150% of the rated current for 1 minute, 110% of the rated current for 2 hours;
- the ability of the generator and exciter system to withstand at least 300% of the generator rated continuous current for 10 seconds in the event of a three-phase symmetrical short-circuit at the generator terminals, thereby providing sufficient time for the selective switches to operate;

The GTU is intended mainly for autonomous operation, which does not exclude its use in various energy networks, including large ones.

The circle of consumers includes:

- all enterprises and organizations of all spheres of activity and types of property, including household enterprises;
- residential sector, including private owners;
- production and residential facilities completely isolated from power grids, including recreation centers;
- consumers using autonomous power plants, both in basic and peak operation classes;
- consumers using only electricity, electricity and heat (cogeneration);
- consumers for whom the technical characteristics of the installation are most important, and consumers for whom the main thing is its relatively low cost;

Currently used gas turbines are divided into three main types [1]:

- created on the basis of aircraft jet gas turbine engines;
- created on the basis of gas turbine engines for marine use;
- created specifically for energy use;

GTUs belonging to the first and second categories are more forced and lighter installations, characterized by ease of maintenance, less infrastructure requirements, but also less resource (See Figure 1).

Figure 1. Forced and light GTU installations

Usually, the total number of independent shafts in gas turbine plants based on aircraft engines and marine engines is 1-3, and the shafts located in the gas generator have a variable speed (depending on the load) in the range of 6-14 thousand rpm.

Engines for marine use, converted for gas fuels, constituted the so-called "intermediate class", since in the spectrum of gas turbine technology they occupied a niche between converted aircraft and engines designed specifically for power use. Such installations have the advantages of aircraft engines (small weight and dimensions, ease of replacing the entire engine or its separate module to perform high-quality repairs in a specialized production environment, high throttle response, which allows them to be used in peak mode). In addition, the technologies, materials and coatings used to create these engines allow them to be used in a maritime climate: on ships, offshore platforms, onshore and offshore facilities, etc.

GTUs belonging to the third category are, as a rule, single-shaft plants with a constant rotation frequency equal to the generator rotation frequency. To ensure reliability, thermal efficiency, cost reduction and operating costs, these power gas turbines are designed according to the simplest cycle. The technical solutions of such installations correspond to the principles that have historically developed in power engineering: a heavy rigid shaft, plain bearings, blades of a constant profile along the main length of the flow path (except for the first stages of the compressor and the last stages of the turbine), etc. Air is the main cooler for rotor blades and nozzle blades (See Figure 2).

Figure 2. Diagram of single-stage GTU: 1- air compressor; 2- gas turbine; 3- combustion chamber; 4- atmospheric air; 5- exhaust gases; 6- fuel

GTUs of the third category have much higher requirements for construction works and infrastructure. The service life of such installations is much higher and corresponds to the values prevailing in steam turbine installations.

GTU (Mini-Thermal Power Plants) have a lot of advantages over Thermal Power Plants, the main one being lower emission of harmful substances such as nitrogen oxide (NO) and nitrogen dioxide (NO_x). These indicators are 2-3 times less than at conventional CHPPs, but they are not the limit of perfection for GTUs - constant research and development is being carried out in the direction of reducing harmful emissions.

Methods for combating harmful emissions from gas turbine plants:

- various kinds of reconstruction of combustion chambers;
- improvement of the gas burner;

- organization of the very process of fuel combustion in the chambers;
- method of premixing a certain portion of air and fuel before feeding them into the combustion chamber.

In recent years, attempts have been made to create so-called two-zone chambers for combustion of fuel in them. The use of two-stage fuel combustion in combustion chambers makes it possible to reduce the output of nitrogen oxides to 45-50% of the initial output when burning natural gas. However, two-stage fuel combustion is associated with the development of a rather complex design of the combustion chamber, which is not fully compensated for by a decrease in nitrogen oxide emissions.

Currently, the simplest and relatively cheap way to reduce emissions of nitrogen oxides with combustion products should be considered a method based on preliminary mixing of fuel with air (lean mixture) before the components are fed into the combustion zone. Increasingly, gas turbine plants are being improved by just this method [2].

In conclusion, we can say that the future of heat power engineering belongs to Thermal Power Plants based on gas turbine units - this is not only a justified decision from the economic point of view, but also from the environmental one. Low emission and noise levels, absence of vibration, make this equipment the only one suitable for use in densely built-up areas such as residential areas, business and resort areas. These features make it possible to consider this equipment as the most popular and promising for use in low-power energy complexes.

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Zamaleev M.M., Zhukova Yu.V., Abramov A.V., Abaidullina Yu.R.
Improvement of a plant for recycling polyethylene and polypropylene waste

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Abstract

This article deals with the problem of recycling polymer waste. It is global in nature and is associated primarily with the steady growth of industrial production, which is accompanied by an increase in the amount of solid household and industrial waste. This is due to the possibility of combined production, as well as products and services required in the municipal economy of the city. This article presents the ways to improve the installation for recycling waste polyethylene and polypropylene.

Keywords: Polymer waste disposal, recycling, extruder, electricity.

Аннотация

В данной статье рассматривается проблема утилизации полимерных отходов. Она носит глобальный характер и связана в первую очередь с устойчивым ростом промышленного производства, что сопровождается увеличением количества твердых бытовых и промышленных отходов. Это связано с возможностью комбинированного производства, а также продуктов и услуг, необходимых в муниципальном хозяйстве города. В данной статье представлены способы усовершенствования установки, утилизации отходов полиэтилена и полипропилена.

Ключевые слова: Утилизация, переработка, экструдер, электроэнергия.