Efficient reclamation of low-grade heat with the help of a small multifuel autonomous power-plant

A S Korobets and S F Stepanov
Saratov State Technical University, Politekhnicheskaya 77, Saratov Russia
andrey-wow.64@mail.ru

Abstract. Autonomous power generators are available which consist of one or more sources of distributed generation and distributed consumers in remote areas from a centralized power system. The question arises sharply in the conditions of difficult transportation of combustible materials for the work of a power plant of an autonomous generator of electricity operating on various combustible substances secondary, waste from wood and paper products.

1. Introduction
There are many promising developments in the development of electrical energy around the world that attract attention, most of it is necessary to improve, optimize and increase the efficiency of existing plants and units. Power plants constitute a special group using the energy of low-grade heat sources. Heat unutilized is dispersed in the atmosphere, which we could use to generate electricity, at the moment.

Low-grade heat is formed when most of the technological processes take place, since heat is released into the atmosphere, the temperature is slightly higher than the air temperature. Such sources are both technogenic systems created by man, and sources of natural origin.

Heat of combustion products of various fuels, the heat of combustion of associated gas, the energy of biofuel, the energy of incineration of industrial waste, the energy of the Earth are the most popular low-potential heat sources. The project proposes the use of an autonomous power plant not only as an additional source energy but also as an independent generator, a full-fledged generator used as a source of backup electricity, also for feeding dacha cooperatives, in emergency response areas, geological expeditions, in communications locations, in remote locations from electrical networks of industrial facilities.

Works are actual and are conducted in all developed countries of the world on the topic of using low-grade heat sources.

2. Theory
Principle of operation of an autonomous power plant is based on the use of low-boiling-coolant-coolant and the Rankine thermodynamic cycle as a working medium. The advantages of using Freon as a working fluid are justified by its low boiling point of -26.1 °C, and at a temperature of 80 °C we get a pressure of 30 bar which can be used to generate electric energy by rotating the rotary Tverskoy engine with an integrated electric generator.
Figure 1. Structural diagram of a small multi-fuel installation with an external heat supply based on the Tverskoy rotary engine: 1 – evaporator; 2 – stop valves; 3 – turbine generator based on the Tverskoy engine rotor; 4 – converter electronic; 5 – the load; 6 – heat exchanger; 7 – the fan; 8 – liquid receiver; 9 – vacuum pump; 10 – circuit closed with refrigerant.

Structure of the system consists of two parts – a thermal circuit that converts thermal energy into a mechanical one, and an electromechanical part that converts mechanical energy into an electric of the required quality for the consumer.

Pump supplies the working fluid to the evaporator under pressure. The working medium undergoes heating; at which it passes from the liquid state to the gaseous state in the evaporator. The gas is fed to a specially designed turbine generator, where it expands to drive it into rotation. The spent gas enters the cooler and into the inlet of the pump, where the working medium passes into a liquid state.

Patent is submitted for a utility model, as well as the design of a small multi-fuel power plant autonomous with an external supply of heat developed up to 10 kW at present. The circuit is heated in the evaporator of a low-boiling coolant from smoke gases of various types of fuel or from sources of low-grade heat.

Rotor of the generator is made of heat-resistant (heat-resistant) enameled with two layers of high-strength enamel of normal thickness of wire of PETV-2 brand. The use of a heat-resistant wire allows the working body to have a high temperature in the gaseous state, which will lead to an increase in the electrical output and improve the characteristics of the working generator.

However, the use of permanent magnets does not provide the possibility to regulate the level of the generated voltage in the generator and when the rotational speed of the rotary Tverskoy engine changes, not only the frequency of the produced voltage changes, but also its amplitude. Electric energy cannot be directly used in a household or industry, taken from the generator terminals, because of this.

Electronic converter is used to provide the given quality of energy by electric power in all modes of operation in the generation system. The DC voltage is converted in the inverter into a voltage with a specified frequency, amplitude and harmonic composition.
3. Results and discussion

Technical result is achieved by the fact that in the proposed turbine based on the rotary Tverskoy engine with a combined brushless generator synchronous with the external rotor on permanent magnets, the rotor of the Tverskoy engine and the external rotor of the synchronous generator on permanent magnets are made in the form of a single component. This made it possible to have one rotating part instead of two, which first led to a decrease in the mass-size parameters of the installation and, secondly, led to an increase in its efficiency, since the thermal losses in the winding of the generator from the passing current do not dissipate into the environment, and remain in the expansion heat engine – Tverskoy engine.

Allows the performance of a rotary Tverskoy engine with a combined electric generator:
1) simplify the design of the device;
2) increase efficiency.

Essence of the construction is explained by the drawing presented in Figure 2.

Figure 2. Block diagram of a turbine generator based on a rotary Tverskoy engine contains:
1 – openings for the entry of a working fluid under pressure; 2 – for the release of the exhausted working fluid; 3 – shut-off drums; 8 – case of Tverskoy rotary engine; chamber, and when it is divided into two parts by the passing blade of the rotor, it forms two chambers separated by a blade – 5 and 7 – working part and 4 and 6 – compression; 1 – the holes of the inlet of the working medium under pressure; 2 – the outlet hole of the exhausted working fluid; 9 – permanent magnets located on the external rotor of the generator; 10 – stator windings; 11 – air gap between permanent magnets and stator windings

Systems with a capacity of more than 10 kW are of practical interest. Scientific and engineering principles will be applied to their creation, worked out in the manufacture of a prototype of low power. Substance will help to use geothermal and low-potential energy as efficiently as possible, which will create operating parameters for the turbine rotation at the required temperatures [1]. Water does not suit us, since its boiling point at atmospheric pressure is +100 °C. Freon meets our requirements, as it will
ensure the rotation of the turbine at a frequency of 1500–3000 rpm at atmospheric pressure and temperature of 20–80 °C [2].

Refrigerant low-grade – Freon R134a (t boiling = -26.1 °C), does not cause depletion of the ozone layer of the earth's atmosphere, being an ozone-friendly refrigerant. It should be used in the experimental setup as a low-boiling heat carrier, which drives the turbine blade [3], which will spin the electric generator rotor to generate electricity.

4. Conclusion
A small multi-fuel power plant based on the Tverskoy engine rotor with an integrated power generator has an effective efficiency and allows expanding the range of fuel types used from one to 4-5: gasoline, diesel, wood, waste and low-grade heat. This allows us to expand the boundaries of the field of use of an autonomous power plant and solve the problems and problems posed for this installation [4].

Temperature range: The waste heat is utilized as a rule with the help of thermal oil, water or glycol. The plant is able to use the incoming heat in a low-boiling heat-transfer medium in the temperature range from 50 to 150 °C. If the temperature is less than 100 °C, the heat flow should be at least 12.3 kW of thermal power per 1 kW of electrical power. The heat transfer rate increases with increasing temperature.

Our standard working fluid is an organic liquid such as R 134a (the ozone layer is not depleted) which operates in the range from 50 to 150 °C. The system efficiency is 12 – 14%. The total thermal and electrical efficiency is about 80%.

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