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The vortex gas-wind turbine

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To raise reliability and provide emergency power supply, all the gas compressor stations are equipped with special emergency stand-by gas-turbine power units. In the context of continuous increase of cost of electric power supplied on a centralized basis, as well as gas transportation costs, it is appropriate to make efforts to reduce and even eliminate the gas compressor stations dependence on expensive energy supply from external sources

One of possible approaches to generate electricity with the use of wind energy to satisfy BOP needs of gas compressor stations, with help of vortex wind power plants. In their hyperbolic frame (stator) whirling air flow is formed that is similar to natural tornados having considerable kinetic energy store. Vortex power plants operating at by far lower wind velocity (2 – 3 m/sec) and having similar areas swept by the wind wheel, can develop power which is five-fold higher than that of bladed wind power plants with a horizontal axis.

Therefore, the creation of power plants designed to satisfy balance-of-the plant needs of gas compressor stations through the development of new types of vortex combined gas-wind power units with vertical axis and the possibility to effectively use energy potential of exhaust gases flows of gas compressor stations and kinetic energy of ram wind flow, is of utmost interest.

Depending on consumption and temperature of exhaust gases of gas turbines of compressor stations, even in calm weather electric capacity of gas-wind power plants can amount to from 80 to 200 kW. Moreover, as wind velocity increases, vortex effect is intensified and, consequently, the plant capacity is raised.

Keywords: gas compressor unit, loss of electricity, gas-turbine power units, wind energy, vortex wind power plant, exhaust gases, combined gas-wind power plant.

To satisfy balance-of-plant needs of each of hundreds of gas compressor stations equipped with gas pumping units approximately 1.5 – 2.5 MW of electric power are consumed. Electric power is supplied to gas compressor from high-voltage power transmission lines located at a distance of tens and hundreds of kilometers from them. In this process, losses during transportation and transformation of electric power supplied on a centralized basis, generally constitute 10 – 15 % of electric power consumed for compressor stations balance-of-plant needs and in general reach impressive amounts in Russia. To raise reliability and provide emergency power supply, all the gas compressor stations are equipped with special emergency stand-by gas-turbine power units [1]. In the context of continuous increase of cost of electric power supplied on a centralized basis, as well as gas transportation costs, it is appropriate to make efforts to reduce and even eliminate the gas compressor stations dependence on expensive energy supply from external sources. It should be mentioned that one of possible approaches is equipping gas-turbine compressor stations with efficient energy-saving gas-turbine or gas-vapor stand-by power units, thus rejecting inefficient stand-by equipment. However, this approach will demand heavy capital expenses.

Another way is to generate electricity with the use of wind energy to satisfy BOP needs of gas compressor stations. Yet the majority of bladed wind power generators installed at towers 30 – 40 m high, with the wind wheel blades 4 – 5 m long and horizontal axis develop power of approximately 800 – 1000 kW at average wind velocity of 5 – 7 m/sec. Relative capital investment into these wind power plants are in the range of 1 200 – 1 400 \$/kW. High cost and the possibility to obtain required capacity only in areas with high wind load make them inefficient for satisfying compressor stations balance-of-plant needs.

Vortex wind power plants have by far lower cost [2, 3, 4]. In their hyperbolic frame (stator) whirling air flow is formed that is similar to natural tornados having considerable kinetic energy store. In near axial central area of vortex formed in a stator, pressure is lowered in comparison with external atmospheric pressure. Due to this factor additional air flow mass is sucked into upward tornado-like column. In the wind wheel of this wind power plant having a vertical axis, kinetic energy of air flow is transformed into mechanical work utilized for electric power generation. Vortex power plants operating at by far lower wind velocity (2 – 3 m/sec) and having similar areas swept by the wind wheel, can develop power which is five-fold higher than that of bladed wind power plants with a horizontal axis [5, 6, 7].

Waste pipes of gas pumping units of gas compressor stations every second emit millions of kilograms of waste gases into the atmosphere at velocity of nearly twenty meters per second and at temperature of up to 400 ° C.

Figura 1 demonstrates the basic diagram of movement of flows of exhaust gases of gas compressor stations, and atmosphere air in the gas-wind power plant. The plant of this type is equipped with an input swirler of air flow, causing its vortex motion accompanied by increased tangential velocity, rarefaction in the vortex axial part and accelerated movement of flow of exhaust gases of gas pumping units. Preliminary whirled gas flow coming from the exhaust pipe of a gas compressor station is fed to the central part of the cylindrical stator of the gas-pumping unit and is mixed with air flow, thus being accelerated with it.

Due to the fact that in the axial part of the stator of a gas-wind power plant minor rarefaction is formed in relation to atmospheric pressure, there will be no gas-dynamic impedance of the exhaust line, as well as reduction of absolute efficiency of the gas turbine or the gas pumping unit capacity.

*Fig. 1. The diagram of gas-air flows in the plant stator:
 C_B , C_T – air and gas flows velocities at the inlet of the gas-wind power plant; C – absolute velocity of gas-air flow at the stator walls; C_Z , C_r , C_ϕ – velocity C projection on the coordinate axes;
 ω and z – tangential and axial velocities of gas-air flow*

If tangential component of whirled gas-air flow dominates at the hyperbolic stator periphery, in its central part axial flow velocity is considerably increased.

Construction diagram of the gas-wind power plant is presented at fig. 2. The plant frame has hyperbolic shape and is installed with air gap under the exhaust pipe of the gas-pumping unit.

With the use of curvilinear guide blades 2 air wind flow is whirled, increasing its tangential velocity, and fed into the plant hyperbolic stator 3 wherein it is mixed with preliminary whirled gases coming from the exhaust pipe 1 of the gas pumping unit. With the use of a guiding device 4 gas air flow accelerated in the plant hyperbolic frame, is fed to the blades of the axial turbine 6 driving the electric power generator 5. Under the outlet part of the stator 3 the Ventury tube is installed on bearings, thus producing additional rarefaction in the upper part of the plant frame. With the use of a guide plate 8 (vane) the Venturytube is installed in the direction of the wind, which enhances capacity of the axial turbine 6 and the electric power generator 5.

Fig. 2. The block diagram of the gas-wind power plant of the gas pumping unit:

1 – exhaust pipe; 2 – curvilinear air channels; 3 – hyperbolic stator; 4 – guide vanes; 5 – electric generator; 6 – axial turbine blades; 7 – Ventury tube; 8 – weathercock

The operating principle and construction diagram of the gas-wind plant make it possible to effectively utilize energy of exhaust gas flows of the gas pumping units and kinetic energy of ram air flow for electric power generation.

In addition, it is characterized by the following advantages:

- higher speed and kinetic energy of gas-air flow;
- higher mass flow through the axial turbine;
- dilution of hot exhaust gases of the gas pumping unit with air flow, reduction of temperature of gas-air mixture and of harmful substances concentration therein, which allows to reduce the height of the gas pumping units;
- due to the use of Ventury pipe, in the exhaust pipe of the gas pumping unit minor rarefaction is formed thus reducing hydraulic losses in exhaust duct and increasing absolute efficiency of the gas turbine with the same capacity of the gas pumping unit;
- major advantage – due to independent electric power supply to satisfy BOP needs the reliability of the operation of gas compressor station at main gas pipelines will be increased;
- if gas-wind power plants are installed at gas-pumping units in combination with centralized electricity supply, expenses for buying electricity from outside suppliers will be considerably reduced, and it will be possible to reduce fuel gas consumption by stand-by gas-turbine power plants.

It is essential that a major part of gas-pumping units of gas compressor stations located at great distance from power plants and transit high-voltage power transmission lines can be equipped with gas-wind power plants of this type.

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The regenerative water-air heat exchanger

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Abstract

The article describes an energy-efficient scheme for using solar energy in district heat supply systems reducing capital and operation costs and to a great extent replacing conventional heat sources. The versatility of systems using this scheme provides their multi-zone applications: from cottages to heating industrial premises and greenhouse complexes.

The principle of the suggested scheme is as follows: a solar collector is attached through heated medium is to an air duct and to antifreeze circulating in the contour tank – accumulator – solar collector. The method of intensification of heat exchange due to the use of intensifiers of hole type. Such intensification efficiency is determined by calculation of daily heat absorption of two-dimensional air collector with intensification by holes and without it, as well as economic effect of the implementation of the suggested method. In accordance with calculations, the suggested scheme of heating and intensification of heat exchange on the surface of integrated collector can provide significant economic effect if implemented.

Keywords: solar collector, heat-carrying medium, design, simulation system, experiment, consumer, control, heat, energy saving, load optimization.

The strategic aim of state energy policy in the field of development of rational fuel-power balance is the optimization of production structure, domestic consumption and export of fuel-power resources with due consideration of requirements of energy security, economical and energy efficiency and improvement of Russia foreign economical