Abstract

"Increasing the efficiency of a trigeneration gas unit with the use of heat recovery from the internal combustion engine"

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The doctoral dissertation addresses the matters related to increase of the efficiency of trigeneration gas aggregates "producing" heat and cooling energy along with electricity in a combined manner.

The main objective of the dissertation is to develop the actual model of a trigeneration unit and its testing with pilot installation on a real facility, based on a previously prepared concept of the individual installations built in the test device. This doctoral dissertation also includes an analysis of the work of a trigeneration unit with the recovery of the condensation heat of water vapor contained in the exhaust gases discharged from the unit and an analysis of the work with the recovery of heat dissipated by the engine and generator body. A comparison was made between a trigeneration gas system operating without condensation heat recovery and using steam as an additional heat source under varying outdoor atmospheric conditions.

A secondary objective of the dissertation was to develop a control algorithm for individual actuators of the installation and the gas aggregate as a whole, in order to optimise the use of the components used in the construction of the device and to increase its efficiency, durability and functionality.

Chapter 1 introduces the subject and the most important matters related to the construction and operation of heat pumps, in particular gas trigeneration units.

Chapter 2 specifies the purpose and scope of the work and formulates theses.

Chapter 3 presents a literature review related to gas aggregates and proposes a method for won prototype solution.

Chapter 4 presents the conceptual framework for the construction of the trigeneration unit in ideological terms, relating to both the design and the heat flow and driving power.

Chapter 5 describes the construction of the aggregate, the main sections of which are: a drive unit with gas installation, freon installation of a heat pump with the characteristics of a

lower heat source, hydraulic installation of engine cooling, hydraulic installation of heat and "cold" transfer to receivers, and power supply and control installation.

Chapter 6 describes the devices used for the construction of the trigenerator in the target operation conditions, such as: internal combustion engine, compressor of the heat pump system, generator, fans, lamella-tube heat exchangers and plate heat exchangers.

Chapter 7 shows the appearance and characteristic dimensions of the device.

Chapter 8 presents energy balances of individual trigenerator devices and energy balances of the operation of the entire device in all trigenerator operation modes.

Chapter 9 presents the results of tests carried out on the constructed and installed trigenerator prototype. The tests were carried out with the use of the data acquisition system installed on the pilot facility in all operating modes of the device.

Chapter 10 briefly characterizes the noise level produced by a working trigenerator.

Chapter 11 confirms the theses of the dissertation and formulates the most important conclusions from the conducted research, the most important of which are:

- increase the final efficiency of the unit by 9% by recovering heat from the combustion engine body and generator,
- increase the final efficiency of the unit by 7% by recovering the condensation heat of the water vapour contained in the flue gases,
- increase in the use of primary fuel of approximately 16 %,
- increase in the thermal output of the unit by approximately 7 kW,
- the operation of the trigenerator under conditions of frost in the lower source heat exchangers is energy justified,
- maintaining a constant nominal load of the internal combustion engine by adjusting the level of electricity production improves engine durability, thermal efficiency and the functionality of the trigenerator.

Chapter 12 presents photographs from the course of assembly works of the trigenerator itself and its assembly on the pilot facility.

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