**Name of the project:** IRN AP19677354 Development of indirect thermal protection systems for asynchronous generators of wind power plants

**Relevance:** One of the directions of alternative energy is wind energy converters into electricity (wind generators). Asynchronous energy converters are usually used when wind generators work together with the industrial frequency electrical network.

Asynchronous generators, working as a converter of wind energy into electricity, are subject to external disturbances, often of a stochastic nature, and as a result, the load of the asynchronous generator can be much higher than the nominal values.

One of the problems of the technical implementation of thermal protection for asynchronous generators of wind farms is the current temperature control of the stator windings. The implementation of current protection of the stator windings does not take into account the intensity of air cooling of the asynchronous generator, structurally located in the upper part of wind farms.

Currently, thermal relays included in the electrical circuit of its total load are used to control the temperature of an asynchronous generator. The disadvantages of this method of protection include not taking into account the intensity of air cooling of the generator and the temperature constant of heating, which reduces the efficiency of temperature control of the stator windings of the generator.

The thermal protection of the stator winding of asynchronous generators relies primarily on measuring or determining the winding temperature. The reliability and timeliness of the information received by the protection system about the temperature of the corresponding elements and assemblies of asynchronous electromechanical energy converters is a key factor in preventing damage to the insulation due to overheating in order to extend its service life.

The most effective way to protect the stator windings of an asynchronous generator of a wind farm from exceeding their temperature, taking into account the dynamic characteristics of the load and the cooling intensity, is an indirect method of calculating the temperature, based on calculating the current value of the active resistance of the stator windings.

**Purpose:** research and development of methods and means of indirect thermal protection of asynchronous generators of wind power plants, taking into account the processes of heat generation and heat removal.

**Expected and achieved results:** The results of the project make it possible to create thermal protection systems for asynchronous generators of a wind farm; to develop methods for indirect calculation of temperature, as well as with the introduction of a pulse component in the power supply circuit of the stator windings of asynchronous generators of a wind farm.

The forms of implementation of the project result will be:

– at least 3 (three) articles and (or) reviews in peer-reviewed scientific publications indexed in the Science Citation Index Expanded of the Web of

Science database and (or) having a CiteScore percentile in the Scopus database of at least 35 (thirty-five);

– at least 3 (three) articles in a peer-reviewed foreign or domestic publication recommended by CQAFSHE;

– development of scientific and technical, preliminary design documentation.

**The results obtained in 2023:**

1. The relevance of the use of wind turbines in Kazakhstan is substantiated. The options for the technical implementation of mass-produced wind turbines by leading enterprises of foreign countries, their technical characteristics, and specific features of operation are considered. The analysis of technical solutions of electromechanical converters is carried out.

2. An analysis of emergency situations occurring at wind turbine installations and in power transmission systems has been performed. The relevance of the research and development of a combined protection system for wind turbine installations is substantiated, which should provide the following types of protection:

- against overload of an asynchronous generator, using a temperature observer of the stator windings;

- a power - controlled semiconductor converter in the mode of energy recovery to the network;

- elements of the mechanical transmission of a wind turbine installation in case of exceeding the maximum permissible wind speed.

The analysis of technical solutions for protective devices of an asynchronous generator with a short-circuited rotor is carried out. The relevance of the development of a temperature observer for the stator windings of an electromechanical converter of an asynchronous type of wind turbines is substantiated.

An algorithm has been developed for the operation of a temperature observer that calculates the temperature of the stator winding of an asynchronous generator. A program of experimental research based on patent search has been developed.

3. The relevance of research and development of indirect thermal protection of an electromechanical asynchronous type converter is substantiated.

The set of tasks to be solved for theoretical research is determined on the basis of a simulation model of indirect thermal protection of an asynchronous electromechanical converter with a short-circuited rotor, taking into account the processes of heat dissipation and heat dissipation.

A mathematical and simulation model of the temperature observer based on a vector mathematical model of an asynchronous type electromechanical converter in generator mode with a short-circuited rotor and the structure of the temperature observer have been developed. Simulation studies were performed for an electromechanical asynchronous converter with a short-circuited rotor in the generator mode of operation of the 4A series with a rotation speed of 750 rpm, and a power from 3 kW to 200 kW in the temperature range of 20 °C to 250 ÷ C.

A block diagram of the hardware of the temperature protection system against overheating of the stator windings of an asynchronous generator with a short-circuited rotor has been developed. The block diagram reflects the main functionally complete nodes of the indirect temperature protection system, as well as reflects the interconnections and the direction of information signals.

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**Information for potential users:** The proposed scientific project is aimed at improving the reliability of asynchronous generators of wind farms and are important for the development of wind power.

**Additional information:** The field of application of the development can be agricultural enterprises remote from power supply systems and industrial enterprises that generate electricity.