ANNOTATION

of dissertation for the Philosophy Doctor (PhD) degree in specialty
"6D072300 – Technical physics" by
Baizhuma Zhandos on the topic "**Technical and technological solution of the problem of icing of working wind turbines in the sharply continental regions**"

General description of work

The dissertation is devoted to the numerical and experimental study of the problem of icing wind turbines operating in extreme continental regions. Using natural, ecologically clean energy, including wind energy, is connected with using wind energy devices. The consequences of the use of traditional energy resources for the production of thermal and electrical energy - global warming - are considered in the dissertation work. Global warming will be dangerous for our planet because the greenhouse effect will occur on Earth, which will lead to climate change. Therefore, many countries from year to year emphasize the need to use renewable energy sources (RES). Kazakhstan pays excellent attention to wind energy, because the wind belt of the Northern Hemisphere of the Earth passes through Kazakhstan, and the reserves of wind energy in the country reach 32.2 trillion kilowatt-hours per year

Relevance of the dissertation theme

Wind energy is one of the fastest growing areas among renewable energy sources. In 2022, the amount of electricity obtained from wind energy reached a record 903 GW. 17% of the energy produced from renewable energy sources accounted for 17%. Compared to the indicators of 2021, this indicator is 9% higher than last year. The reason for such rapid development is new power stations installed on land and at sea. However, this result 2050 is not enough to achieve zero carbon dioxide emissions by 2050: the total capacity of renewable energy sources installed should be 7900 GW.

To achieve the specified goals, new zones for the installation of wind power stations are necessary. In places where wind generators are installed, there should be low population density and high wind power. Such places are located in regions with a harsh continental climate. But wind generators located in these regions are subject to icing on frosty and stormy days. Freezing of ice on the blades of the wind generator primarily harms their aerodynamic characteristics: ice frozen on the surface of the blade reduces its lifting and traction force.

Currently, a number of methods are used to protect wind turbines from icing. One of them is electric heating elements. They are placed along the blade of the turbine and begin to heat the surface of the blade at a known temperature of the environment. The next type of protection from icing is chemical methods that have found wide application in aviation. This method is based on the method of processing the blade surface with special solutions. Solutions prevent the formation of an ice cover on the surface of the oar, in other words, the ice "slides" on the surface of the oar. Using electrical and chemical methods, the engineer proposed a method of cleaning the surface of the blade from frozen ice with the help of ultrasound. However, not all of the above methods are suitable for wind turbines operating at low temperatures for a long time. This is due to the fact that electrical and ultrasonic methods require the

addition of additional heating elements, and chemical methods always require the presence of service personnel nearby. In this regard, the goal of the dissertation was determined

The purpose of the research is the numerical and experimental study of the problem of icing of the Darrieus wind turbine, operating in extreme continental regions; Design and production of Darrieus wind turbine with thermal protection.

In order to achieve the above-stated goal, it is necessary to carry out the following tasks:

1. Investigation of the formation of ice on the blades of the Darrieus wind turbine at different angles of attack and wind speeds;
2. Research of the process of icing the rotating blades of the Darrieus wind turbine;
3. Analysis of the performance of the frozen turbine;
4. Study of natural ventilation of Darrieus wind turbine's hollow elements;
5. Production of 1 kW Darrieus wind turbine with thermal protection.

The object of the research

Three-bladed Darrieus wind turbine.

The subject of the research

Computational fluid dynamics (CFD) model for the study of icing of the Darrieus wind turbine, natural ventilation of the hollow element wind turbine.

Research methods

The main method for studying the effect of icing on the Darrieus wind turbine is computer simulation in the Ansys-Fluent and FENSAP-ICE environment. The natural ventilation inside of hollow elements was studied experimentally.

The main provisions for the defense.

1. Regardless of the ambient temperature, the peak values of the drop collection and convective cooling coefficients are evenly distributed on the airfoil surface.
2. At a wind speed of more than 3 m/s, the turbine makes 12 rpm, as a result of which natural ventilation appears in the hollow elements of the turbine, when these values are reached, an ice crust does not form on the surface.
3. Installing a wind turbine on a modular platform allows you to shorten the rotation shaft from 8 m to 1.3 m, the load on the wind turbine bearings is reduced by 15%

The scientific novelty of the work

The novelty and originality of the work are as follows:

1. The process of icing of the fixed and rotating blades of the Darrieus wind turbine was studied;
2. A numerical method is proposed, which is validated by experimental and numerical research data published in the scientific literature;
3. A method of thermal protection using natural ventilation of hollow elements is proposed;
4. Design documentation for the Darrieus wind turbine with thermal protection has been prepared.

The practical and theoretical importance of the dissertation

The results of the study can be applied to the wind turbine manufacturing.

The reliability and validity of the results

Numerical modeling of icing on the Darrieus turbine blades was carried out using the ANSYS-Fluent and FENSAP-ICE software package. The numerical method was validated with experimental data and showed sufficient accuracy to predict icing.

The personal contribution of the author

The author completed all stages of the research work: determining the purpose and tasks of the study; selecting the research object. During his internship at the Danish Technical University (DTU), developed a numerical method for designing Darrieus wind turbine blade icing, validated the model with experimental data, and studied the effect of icing on the performance of wind turbines, and conducted to determine the natural ventilation of hollow elements.

Approbation of the dissertation. The results obtained in the dissertation were presented and discussed:

–at the International scientific conference Alternative energy sources, materials and technologies (AESMT'18), Plovdiv, Bulgaria, 14-15 May 2018; _

– at the International Scientific Conference Alternative energy sources, materials and technologies (AESMT'20), Varna, Bulgaria, May 8-9, 2020. ;

Fluid dynamics section meeting, DTU, Ljungby, Denmark, August 31, 2020

Publications

4 publications have been published on the topic of the dissertation, including 1 paper in the materials of international conferences, 1 paper in scientific publications recommended by CQASESMES RK for the degree of Doctor of Philosophy (RhD), 2 articles in journals included in the international information resources Web of Science (Clarivate Analytics, USA) and Scopus (Elsevier, Netherlands):

- R. Manatbayev, Z. Baizhuma, S. Bolegenova, A. Georgiev, Numerical simulations on static Vertical Axis Wind Turbine blade icing, Renew. Energy. 170 (2021). https://doi.org/10.1016/j.renene.2021.02.023 . **Q1, SJR 1.88;**
- Z. Baizhuma, T. Kim, C. Son, Numerical method to predict ice accretion shapes and performance penalties for rotating vertical axis wind turbines under icing conditions, J. Wind Eng. Ind. Aerodyn. 216 (2021). https://doi.org/10.1016/j.jweia.2021.104708 . **Q1, SJR 1.24**.

The scope and structure of the thesis

The thesis consists of an introduction, 4 sections, a conclusion and a list of references from 96 titles, and contains 104 pages of basic computer text, including 37 figures, and 22 tables.