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ANALYSIS OF THE FUTURE PERSPECTIVES OF AIR FLOW ENERGY İNSTALLATİONS

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ABSTRACT

The article provides information on the creation and study of energy systems based on the power of air flows with maximum use of advantages in processes associated with nature. An analysis of available data in this area is carried out, the advantages and disadvantages of energy installations are indicated. Based on the analysis and theoretical considerations, the indicators of the model for improving the energy system using the power of the air flow, including economic efficiency, are analyzed. Changes in influencing parameters to improve the efficiency of using the design of the energy installation are described, a comparative analysis is given.

Introduction

The ability to use the power of nature to benefit is an indicator of the development of human consciousness. In particular, this can be attributed to the use of wind energy by people for their own needs. At the dawn of science, mankind did not have the slightest knowledge of the physics and movement of air masses across the plane of the earth's surface, but in time, man learned to use the power of the wind as a traction force for navigation on water. In addition, the natural continuation of the development of scientific thought was the appearance of wind turbines or windmills.

Wind power plays an important role in the global transition to sustainable energy sources. As a form of energy, it uses the kinetic energy of air flow to generate electricity and offers several advantages that make it an important component of renewable energy. However, like all energy sources, air flow energy has its problems and disadvantages. Airflow energy is considered to be an industrial and environmentally loyal (ecologically clean) source of electricity because it does not produce any greenhouse gases or air pollutants during its operation. For example, the variability and intermittency of wind power require effective integration with energy storage systems or other energy sources to ensure a reliable and continuous energy supply [1].

Its many advantages, from environmental loyalty to low operating costs, make it a key player on the path to a cleaner energy future, because:

• it is renewable and sustainable

• it is ecologically clean

• its operating costs are low

• its water demand is low

• it has energy efficiency and the ability to use land efficiently

However, there are also disadvantages of wind energy. Among them, in particular, the following can be mentioned:

• Intermittency (because the wind speed is unstable)

• high initial investment cost

• visual and sound impact effectiveness

• the risk of affecting the environment

As we have seen, even if wind energy is considered to be environmentally loyal and renewable, it has its problems and drawbacks. Advances in planning and technology are needed to address these issues and effectively integrate wind energy into our supply grid systems [2].

The next global advance in the process of weather and wind control was at the end of the 19th century, when the first wind power installation was built. The problem that led to the search for an alternative source of energy is the desire to save financial resources, because every year an increase in the prices of other fuel resources was observed.

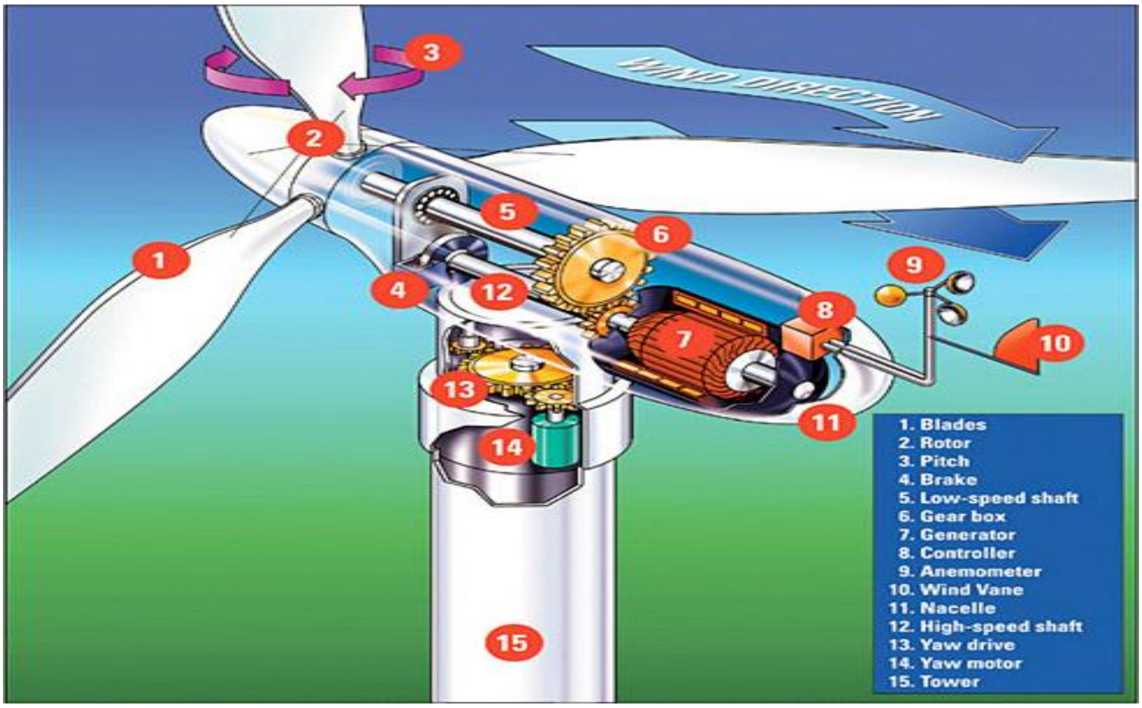

Fig. 1 Wind generator construction scheme.

It is necessary to approach the issues related to the topic in a complex way. There should be a single criterion for determining the power of air flow (streams), so that it can be applied universally (with mutual conversion to other units) in each case.

Often, special terminology is used when reporting on forecasts of wind formation as a result of the movement of air masses (flows), for example: *strong wind, moderate wind, thunderstorm, hurricane, etc.*

It should be noted that the wind speed is measured by the 12-point Beaufort scale, and the corresponding score is determined by quickly comparing the information about the predicted increase of the wind (for example, a speed of 20.8-24.4 m/s corresponds to a "storm" wind of 9 points).

In fact, one parameter is taken into account here, and that is the wind speed (another criterion - the score is conventionally connected to the speed interval and called appropriate). At the same time, the average wind speed on the Beaufort scale is shown at a standard height of 10 meters above an open, flat surface (and wind generators are installed at heights up to and above 50m) to estimate the effect on terrestrial (land) objects or waves in the open sea.

However, as we mentioned, it is practically impossible to determine the effectiveness of air flows based on the existing scale. Here, in addition to the speed of the air flow, its density and pressure on the surface must be taken into account, otherwise the final benefit of air flow energy installations will be very low. For this, a single criterion should be defined, which includes the three parameters mentioned above.

Therefore, first of all, a generalized universal criterion should be determined by conducting theoretical analyzes of the researched field. Based on real (factual) information, that criterion should include such parameters as wind speed, wind direction, impact force on the surface area of the relevant element, air flow regimes, and duration of wind action (generalizing correlation coefficient).

In the second stage, after the relevant information (forecast) received via satellite is processed in a special program in real time (online), based on the received data, comparing it with the above-mentioned criterion, determining the selection of the operation (work) mode of the wind power installation.

Then (in the third stage), achieving a slight increase in the useful work coefficient (UWC) by making minimal structural changes (additions) to ensure the maximum efficiency of the wind power installation in the selected operating mode.

Methods

By analyzing the procedures carried out in connection with the researched topic, certain conclusions can be reached to improve the useful service life (or the useful work coefficient - UWC) in the process of obtaining energy acquisition of air-flow machines and mechanisms.

Thus, today, the use of air flow generators is a very common way to produce electricity, and a modern wind turbine is known in every research area (Figure 1). The leaders in terms of the number of used wind power plants are the United States of America and China, but already other countries also understand that the advantage of wind power plants is the possibility of obtaining cheap energy, and this energy sector is developing seriously [3].

The instantaneous power of the flow (wind) turbine can be calculated as follows (W):

$$P = A \cdot (\rho s v^3 / 2) \quad (1)$$

where, A – coefficient of wind energy use;

ρ – air density, ρ = 1.18 kg/m^3;

S – air flow cross-sectional area, m^2;

υ – wind speed, m/s.

In the calculations, $A = 0.30 \div 0.45$ is assumed for wind energy installations. The annual production capacity of wind turbines (kW) is determined by the following formula (kW):

$$P_{annual} = 8{,}76P \quad (2)$$

However, the value of the annual energy produced is equal to:

$$D_e = P_{annual} \cdot b \quad (3)$$

where b is the price of electricity (determined per kW) [4].

The self-correction period of wind energy (wind-flow power installation) is calculated as follows:

$$T = D_i / D_e \quad (4)$$

where D_i is the value of the wind-flow power installation.

As a result of the analysis of existing studies related to the mentioned issue, it can be concluded that most of the wind turbines in operation in the world cannot produce more than 4% of their declared power when the annual average wind speed is 3 m/s. This, in turn, leads to the estimated payback period of wind turbines, based on the considered conditions (taking into account the coefficient b, which represents the price of electricity), approximately from 50 years to 150 years [5,6].

Investigations and calculations also show that even if the average annual wind speed is doubled, i.e. 6 m/s, it will be able to produce an average of 20% of its declared power, and the payback period in this case will be 10 to 50 years depending on the conditions considered.

As can be seen from the formula (1), among the parameters that affect the increase in the power of the wind-flow power installation (taking into account the limitation of the quantity ***S***) is the ***A*** coefficient.

Despite the possibility of predicting the wind speed and direction during the year, it is very difficult to build a scenario in advance for the processes occurring in nature, and the probability of accuracy is low. Therefore, increasing the coefficient of use of wind energy is an important issue.

Approaching the solution of the issue in a complex way, it can be concluded that the improvement of the technical indicators of wind turbines (as well as the UWC) plays one of the main roles.

At the same time, it should be noted that the construction changes currently proposed by researchers are aimed at making them more complicated and expensive. As a result, the work carried out increases the quality indicators of the devices, but also increases the costs of the production and maintenance of the equipment, making the already quite long-term self-correction coefficient completely unacceptable [7,8].

In this case, it would be more appropriate to make "slight" changes to the air flow energy installations, for example - from improved multipliers, to the introduction of additives (confusers) that increase the concentration of the air flow.

As a result, it could be concluded that

- the formation of a single coefficient by combining the main parameters characterizing the air currents affecting wind power plants in a row will make it possible to select any operation in this field or perform calculations in the correct format in the future (scientific and practical significance is also shown in the implementation stages of the project);

- it is possible, taking into account advanced technologies for transmitting data via satellite, determining the main parameters (wind speed, direction, etc.) based on software analysis with predicted weather changes (meteorological conditions) and preselecting the optimal operating mode for the entire complex of wind-flow power installation in a certain area;

- wind energy contributes to a greener (environmental) and sustainable energy future. Its renewable, low-cost and environmentally loyal (ecologically clean) properties make it an attractive option for reducing greenhouse gas exports and increasing energy independence. However, issues such as business interruption, visual light-shadow and noise issues and impact on wildlife need to be addressed. The role of wind power in the wider energy complex will depend on effective mitigation of these challenges, technological progress and public acceptance. Wind energy remains a valuable solution to the development of a cleaner, more stable world.

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