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DEVELOPMENT OF SAIL TYPE WIND TURBINE FOR SMALL WIND SPEEDS

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The present article is devoted to the development and establishment of low-power multiblade wind turbines for generate electricity using blades with dynamically changeable form. The prototype of wind turbine with dynamically changeable surface shaped blades was developed. The aerodynamic characteristics of the prototypes of blades of a wind turbine with dynamically changeable form were investigated. As a result of experimental researches dependence of the aerodynamic traction force from the speed and attack angle of wind flow, the rotation frequency of the wind turbine from the flow speed were obtained.

Keywords: wind turbine, wind energy, aerodynamics characteristics, wind tunnel, wind turbine blades.

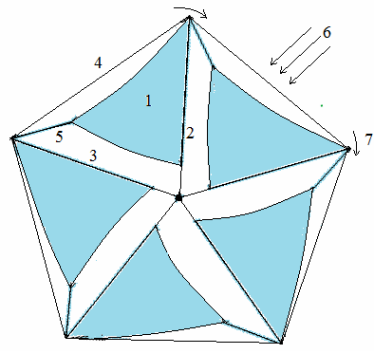
Energy is actual topic of the most news at present, which discusses problems of increasing consumption and increasing the cost of electrical energy, the depletion of natural resources, environmental impact and dangers of global warming. Wind energy has great potential in reducing dependence on traditional resources such as oil, gas and coal. It should be noted that wind energy does not pollute the environment and is able to produce a clean, inexhaustible energy in the local area. All power stations, which built in the 60s or 70s of the last century, sooner or later have to be replaced. In the last decade political and economic demands are changed, and global environmental problems should not be ignored.

One of the modern tasks for the dynamic development of the economy of Kazakhstan is the rational use of energy resources. Implementation of renewable energy sources is played an important role. Under the instruction of President Nursultan Nazarbayev, government of Republic Kazakhstan has developed a National programme of wind power generation development of the Republic of Kazakhstan for 2007-2015 with a perspective to 2024. This program has been prepared as a joint project of the Ministry of energy and mineral resources of RK and development Programme of the United Nations «Kazakhstan - initiative of development of wind power market». In most parts of the territory of Kazakhstan located zones with low values of average annual wind speeds. For these areas are not yet established industrial wind turbines of small and medium capacity.

In this regard, creation of wind power installations, which effectively working in the conditions of small average annual wind speeds, is very actual for Kazakhstan and corresponds to priorities of development of science in the republic. This problem at the present stage of development of science in our republic gained relevance of communication with preparation of Kazakhstan for a World exhibition of achievements of science and technology «EXPO-2017». The main thematic directions of "EXPO-2017" are the "Energy of the Future" and "Ecological clean Energy" concepts.

Sail type wind turbines have a unique feature, they work equally well for both small wind speeds and at high wind speeds on account of dynamic changeable shape of work surface under the influence of wind flow.

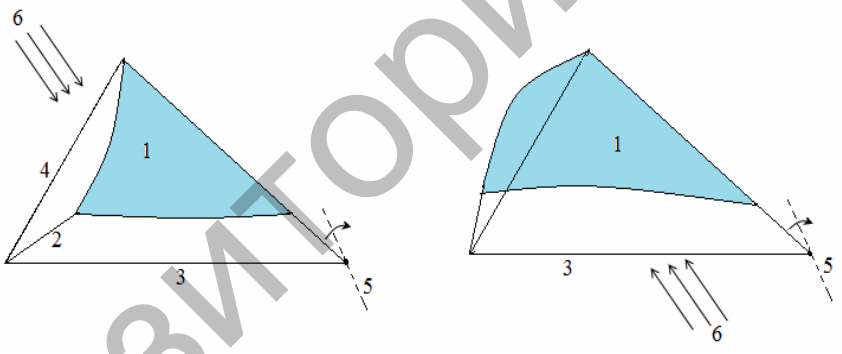
Novelty of the work is the use as power elements of the wind turbine blades with dynamically changeable shape surfaces, which made in the form of a triangular sail with flexible movable end. Fig.1 shows a scheme of a wind turbine with a dynamically changeable shape of the surface of the blades.



1 - wind turbine blade with a dynamically changeable form, 2,3,4 – frame, 5 - adjustable flexible bracing of the movable end of the blade and made of strong thread, 6 - direction of the wind, 7 - the direction of rotation of the wind turbine

Fig.1. Scheme of the wind turbine with a dynamically changeable shape of the blades surface

Wind turbine operates as follows: the wind turbine triangular blade, that placed to the direction of wind flow, under the influence of the wind flow, is experienced the lateral pressure force and according to the laws of aerodynamics pushes the carcass, resulting in its rotational movement. Emerging force is traction force of blade and converts wind energy into rotational motion of the wind turbine. When the wind direction changes to the opposite direction rotation axis wind turbine is not changed (Fig.2).



a) b)

Fig.2. Scheme of wind turbine blade at forward (a) and opposite (b) wind directions

As shown in Fig.2, when the changing the wind direction the blade (1) with dynamically changeable surface shape is toggled to to the other side of the rotating frame of the wind turbine, thus ensuring the preservation of the original direction of rotation axis wind turbine. Fig.2 shows the following notation: 1 - wind turbine blade, 2 - flexible bracing of the movable end of the blade, made from a nylon thread , 3,4 - frame rods of wind turbine, 5 - rotation axis and a curved pointer - direction of rotation axis of wind turbine, 6 - the pointers show the direction of the wind . Work the blade at the forward and opposite directions of the wind are designated by letters *a* and *b* respectively.

Known methods and devices of convert wind energy into electrical energy are given in [1,2]. Efficiency of the use of wind turbines at small wind speeds described in [3]. Close analogs designed for operation at low average wind speeds are given in [4-7]. Articles of Bychkov N.M. [6,7] and N. Murakami (Japan) [8] describes a wind turbines for small wind speeds based on the Magnus effect.

The closest analogue is described in works of Voitsekhovsky B.V. [4,5]. Weakness of this design is the absence the dynamically changeable surface shape of the blades, which does not allow to optimize the aerodynamic characteristics of a wind turbine in the work process. Moreover, the

change of wind direction to the opposite direction leads to a change in the rotation axis of the wind turbine also the opposite that is inconvenient when working wind power aggregate.

For creating the real design of wind turbine with sailing blades several prototypes of blades made of flexible, lightweight and durable materials were tested. Test models of sailing blades with movable end in the wind tunnel T-1-M were conducted. Experiments to study the aerodynamic characteristics of the blades for three different materials were conducted: polystyrene caprone, polyester.

The dependence of the traction force and lift force of sailing blades made of different materials from the wind speed was studied. From the results of the comparison of aerodynamic characteristics of the sailing blades with the movable end made of different materials was revealed that has optimum aerodynamic characteristics has polyester. Therefore, the most suitable material for the construction sailing blades of wind turbine is polyester.

Fig.3 shows the wind turbine prototype with a triangular shaped sailing blades.

Fig.3. Photo of a wind turbine prototype with triangular shaped sailing blades

The diameter of the working area (frame) of the wind turbine is 1.6 m. Wind wheel holds six-blade turbine, midsection of sailing blades is a triangle. The proposed design of the wind turbine comprises a shaft, support bars, binders of support rods, disk of rotation of the wind turbine, the bearing, frame rods, pulleys and support rods. The proposed wind turbine due to the self-regulating surface shape of the blades under the influence of wind flow rotary motion has optimum aerodynamic characteristics. Wind turbine in a wind flow is self-assembled device and effectively converts wind energy into the energy of rotational motion.

The dependence of the aerodynamic characteristics of wind turbines from the regime parameters was investigated. Fig.4 shows dependence of traction force of wind turbine sail type from the flow speed in the forward direction of the wind. Fig. 5 shows the dependency of traction force of the wind turbine from the flow speed in the opposite direction of the wind flow relative to the location of the wind turbine.

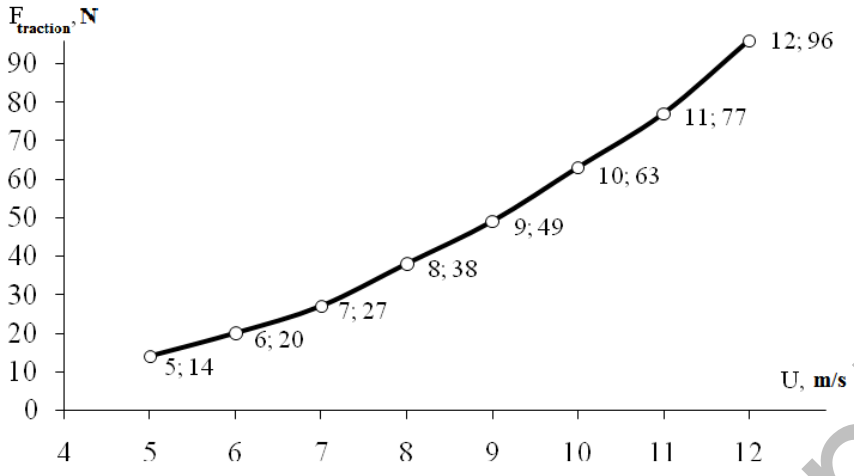


Fig.4. The dependence of traction force of wind turbine from the flow speed in the forward direction of the wind

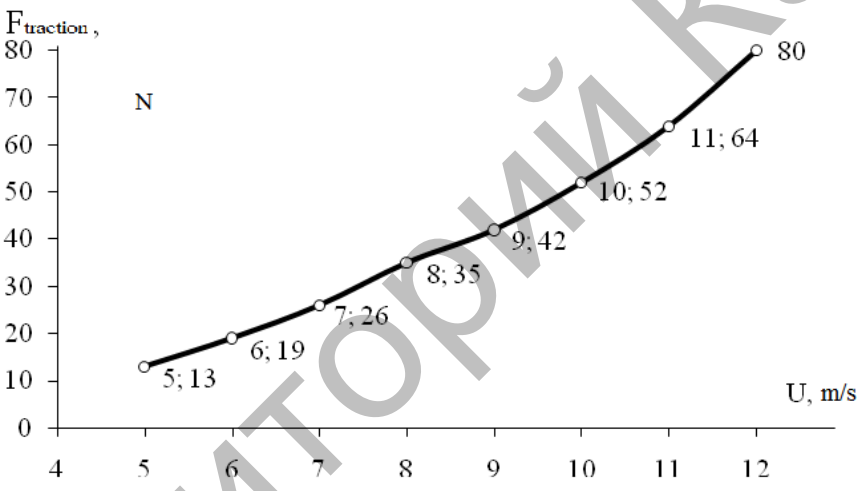


Fig.5. The dependency of traction force of the wind turbine from the flow speed in the opposite direction of the wind flow

Comparison of Fig.4 and 5 shows that the forward flow direction of the wind traction force value is higher thanin the opposite direction of wind flow. This is because operating elements in the rear part of the wind turbine are arranged, which prevent the flow of blow sailing blades and thus lead it into rotary motion. Fig.6 shows dependence of traction force of the wind turbine from the wind speed at different attack angles of the wind flow. As seen in Fig.6, with increasing wind speed there is observed increase traction force. Thus, the wind turbine rapidly increased to traction force. The wind turbine is capable of operating in a range of wind speeds of 5 m/s to 12 m/s. Comparing the above relation, there is determined that in the forward direction of wind flow (attack angle α = 0 degree) achieved a maximum thrust at 12 m/s.

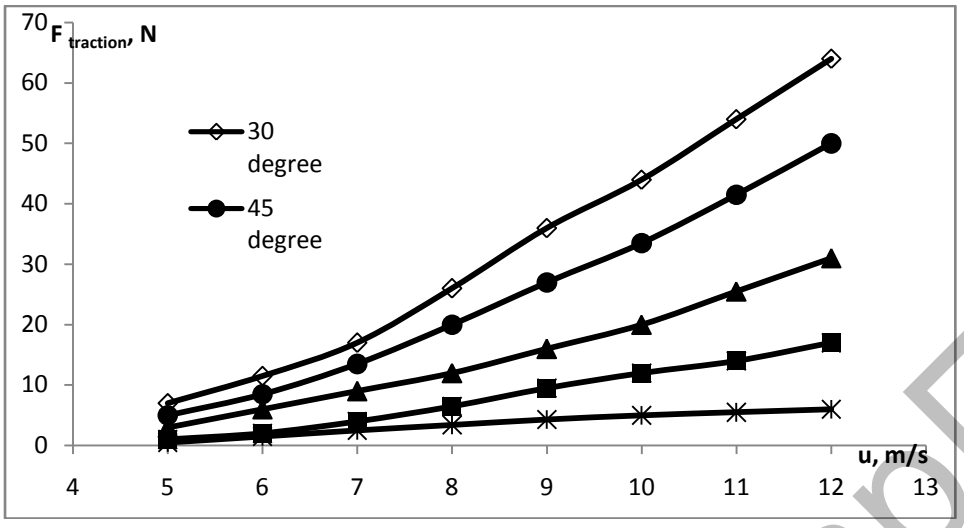


Fig.6. The dependence of traction force of the wind turbine from flow speed at different attack angles of the wind flow

Fig.7 shows dependence of traction force of the wind turbine from the attack angle of wind flow at different speeds of wind flow: 5 m/s, 7 m/s, 9 m/s, 12 m/s.

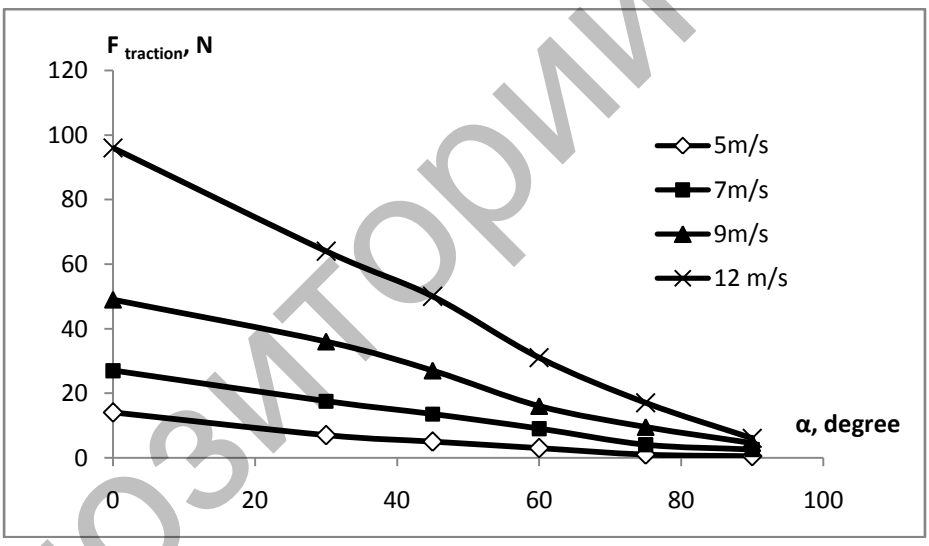


Fig.7. The dependence of traction force of the wind turbine from the attack angle of wind flow at different speeds of wind flow

As seen in Fig.7 at a constant speed magnitude and direction of traction force is changed due to changing of the attack angle of the wind flow. With increasing attack angle of the wind flow values of aerodynamic traction force of the wind turbine were decreased. This is explained by a decrease in the area of the midsection of the wind wheel.

Fig.8 shows dependence rotation frequency of the wind turbine from the wind flow speed.

From Fig.8 that at increase of wind speed leads to an increase of the number of revolutions per minute of the wind wheel. This is due to the fact that with increasing of wind speed incident on the wind wheel, increased delivery pressure force acting on a sailing blades.

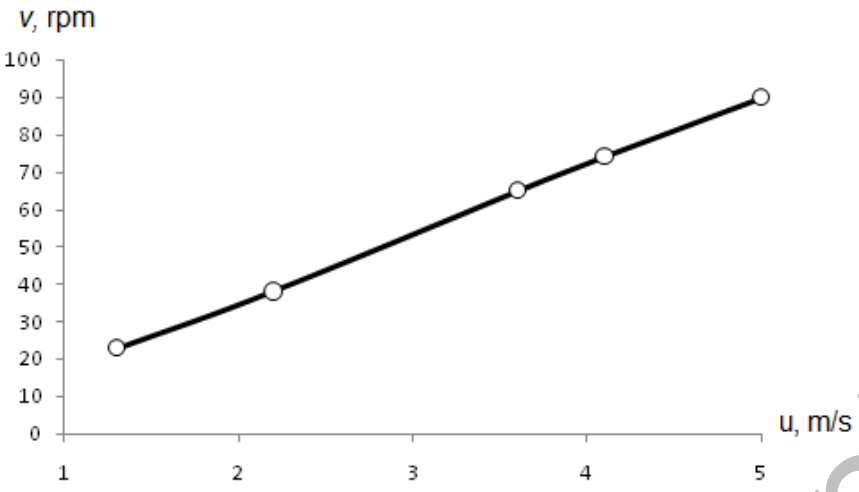


Fig.8. The dependence rotation frequency of the wind turbine from the wind flow speed

Unlike wind turbine propeller-type, designed wind turbine sail type works silently, which is very important for the ecology of the locality.

The advantage of the proposed wind turbine is the design does not provide a turn of the wind turbine when changing of the directions of wind flow. Advantages of the proposed wind turbine:

- wind turbine has reduced requirements for aerodynamic parameters of the blades, which allows them to perform on the simplified technology of cheap materials in the form of sails with a rod frame;

- wind turbine is able to use the wind energy from two mutually opposite directions, without requiring a reversal in the flow direction of the wind;

- small size of wind turbine allows a low-cost means to adjust the structural elements of the wind turbine for the further modernization and move on to new generations of wind turbines;

- it is possible to maintain a constant rate of wind turbine when the different wind speed by changing the length of the fixing threads of the movable end of the blades depending on the wind speed.

Thus, as a result carried out experimental researches dependence of the aerodynamic traction force from the speed and attack angle of wind flow, dependence of rotation frequency from the speed flow were obtained.

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