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About New Type Wind Turbine Possessing Vertical Shaft with Ladles

Key words: Wind Turbine, Ladle, Shaft, (Wheel) hub, Spoke, Diaphragm, Hinge/Joint, Curved wall

Abstract

It is known that the main source for generating electrical energy is nuclear energy and hydrocarbon compound in form of oil and gas that are accumulated in nature's interiors. Usage of nuclear energy in order to receive electrical energy requires great care because of radiation hazard. For the same purpose, the intensive expense of oil, coal and natural gas reduces raw materials that are very valued for chemical industry and cause ecological crisis in the whole world. Therefore, the search for alternative ways of generating energy is an urgent issue. Wind energy represents one of such sources.

The main goal of the research was to receive wind turbine with such optimal, geometric, kinematic and power-producing parameters that would ensure the effective transformation of wind energy into rotating mechanical energy.

There was designed rotor-type wind unit simpler from kinematic point of view; this unit does not require the rotating part to be oriented on the wind and current-conducting contactors.

New rotor-type wind turbine has higher level of usage factor of wind energy than existing models. The components of new type wind turbine are placed in such a way to ensure the maximal usage of wind energy. In order to increase torque on turbine shaft, the joint action of reactive force and Magnus force together with active force of the wind must take place.

Modern methods of energy-kinematic calculations and design were used during the present research.

1. Introduction

Energy resources represent main parameter of economic development of any country; As the most convenient form of energy in production and domestic practice is the electric energy; therefore in most of the cases they try to transform energy resources existing in the country into electric energy. Usage of nuclear energy in order to receive electric power requires great care because of radiation hazard. For the same purpose, the intensive expense of oil, coal and natural gas reduces raw materials, which are very valued for chemical industry and cause ecological crisis of the whole universe [5].

Therefore, it is important to find alternative sources to receive energy. One of such sources is the kinetic energy carried in the wind. Due to the fact that there is a shortage of oil, coal and natural gas fields and high water rivers, usage of wind energy to receive electric power becomes actual [2].

Modern methods of energy-kinematic calculations and design were used during the present research.

The main goal of the research - was to receive wind turbine with such optimal, geometric, kinematic and power-producing parameters that would ensure effective transformation of wind energy into rotating mechanical energy.

2. Problem Formulation

There exist many kinds of turbines that transform wind's kinetic energy into electric energy; Wind turbines are divided into two general types according to placement of basic shafts: The first one – the basic shaft is placed horizontally and is turned by means of interaction with propeller wind; The second one – the basic shaft is placed vertically and it is moved after operation of wind rotor [3].

If we compare first type of wind turbine with the second one (the existing structures are taken into consideration), it has relatively high wind energy usage factor, but it requires additional equipment to be oriented on propeller wind and also special contactors to transfer electric power generated by generator from rotating casing to fixed body [4,6].

It is true that the second type of existing turbines does not have high wind energy usage factor/ratio, but they do not require rotor to be oriented on wind and due to vertical placement of basic shaft they do not require current-conducting contactors [1,7].

Due to this advantage, authors decided to create turbine which would be able to increase the usage of wind energy considerably

3. Problem Solving

As it is known airflow having certain longitudinal cross section possesses kinetic energy

$$E = \frac{mu^2}{2} \qquad (1)$$

that after collision with moving part of turbine causes rotation of the latter, yet total power of wind flow is:

$$P = 0.00049 \rho A u^3 \, (\text{kW}) \qquad (2)$$

In reality one part of wind energy is used to overcome different resistance, the second part is transformed into energy of desired type, but the other part is spread in the area with slowered speed but by certain kinetic energy. Therefore, power of wind engine is different from the power of airflow and can be defined by the following relation:

$$P = 0.00049 \rho A u^3 \xi \eta \qquad (3)$$

here ρ is air density $\rho = 1.23 \, (\text{kg/m}^3)$;

A - wind attacking space of moving part of turbine (m^2);

u - wind velocity (m/c);

η - wind turbine factor;

ξ - Wind energy usage factor.

It can be seen from the formula (3) that wind turbine power is proportional to wind attacking space of its moving part and third degree of wind velocity.

In spite of the fact that power received from wind is proportional to third degree of wind velocity, it is still problematic to use wind to receive energy. Its problematic character is conditioned by comparatively low density of air and its unstable character from the viewpoint of its movement direction and from the viewpoint of its velocity value.

As it can be seen from formula (3) efficiency of wind energy usage depends on ξ factor. The value of this factor depends on structure of turbine and its wings. Therefore, the aim of the research is to create the structure that would increase wind energy usage factor.

Defining optimum methods of wind energy usage, first of all means creation of efficient wind turbine structures.

Modern wind turbines should be response to the next criteria:

- The structure of wind turbine should be as simple as it is possible;
- Wind turbine should have high factor of wind energy usage;

Based on these criteria several variants of wind turbine were developed with laboratory tests of its models. Laboratory tests have revealed optimum structure of wind turbine that ultimately met the criteria.

New type of wind turbine (Fig. 1a) comprises fixed body – 1, on which the rotating part of the unit is fixed that includes main shaft -3 and (wheel) hub fitted on it-4 with spokes-5 with the ladles-6 suspended at its ends. Main shaft is fixed vertically, by means of upper supports -2 and lower supports -7. In their turn, ladles - 6 (fig. 1b) are composed of cylindrical - 8 and flat walls that are connected to each other by means of diaphragm – 10.

The essence of wind unit can be explained by drawings, for example on fig.1a, general view of the unit is given, but on fig. 1b the longitudinal sections of ladles in large scale placed on diametrically opposite sides from the center of rotation are shown. Two different directions I and II of wind action are also given as an example.

Wind unit works in the following way:

1) Wind if it acts in direction I (fig. 1b) confronts flat 9 and cylindrical 8 walls at the same time. As a result active force on ladles is created. Besides, along internal surface of cylindrical wall, the flow of moving air during reflection creates active reactive force on cylindrical wall and active Magnus forces on flat wall. All these forces in total create rotating moment attached to main shaft 3.

2) When wind acts in direction II (fig. 1b), one part of air flow confronts with flat wall 9, and besides the opposite movement during repulsion creates moving reactive force on ladle

As a result of wind action, on ladles both in case I and II, and also when wind has different direction, the moving and opposite forces are created that in total create active rotating moment attached to main

shaft. Actuated main shaft operates generator connected to it that converts mechanical energy into electrical one.
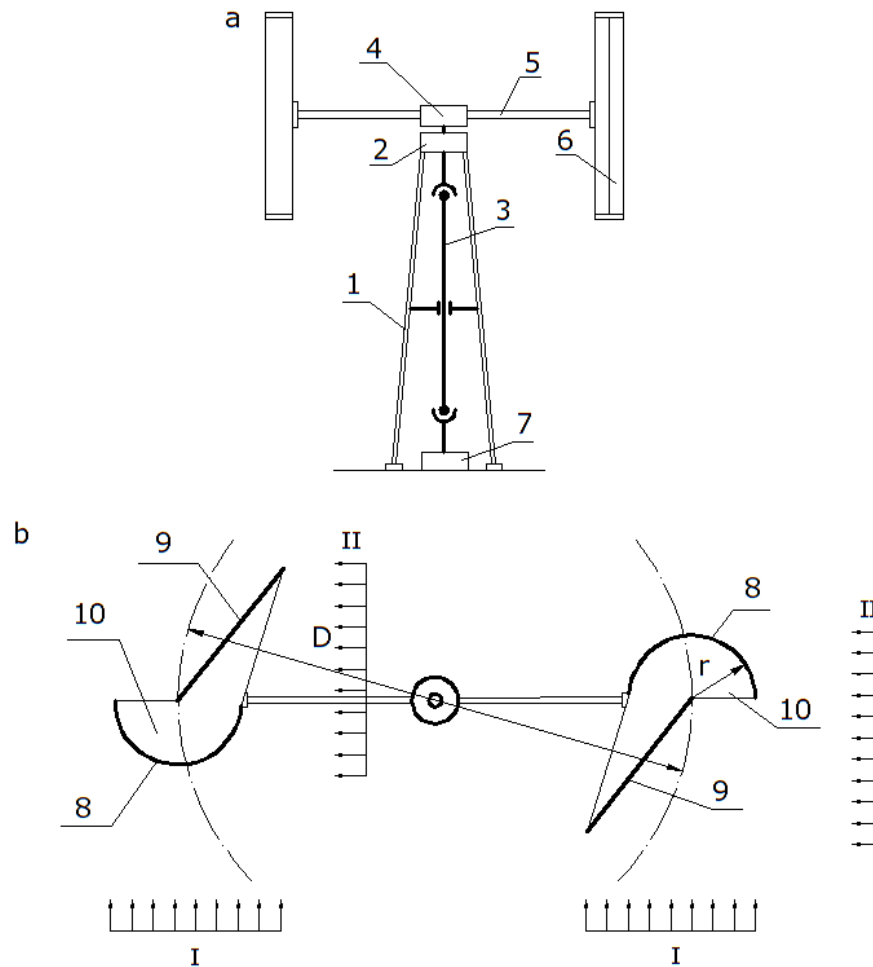

Fig. 1 wind Turbine

a- general view of the turbine; b - the longitudinal sections of ladles in large scale
1-fixed body, 2-shaft support, 3-shaft, 4- wheel hub, 5-spoke, 6-ladle, 7-wind lower support, 8-cylindrical wall, 9-flat wall, 10-diaphragm (D-circle diameter of ladles placement, r-radius of ladle cylindrical wall)

4. Experimental Research

New type Wind turbine has passed experimental test by using air flow (wind). Velocity of wind flow was measured by anemometer. During rotation, thread was wound on the shaft of the model, load of definite weight was attached to its free end. During established movement thread was wound on shaft and load was taken to certain elevation. Time of this shift was measured by seconds counter. By means of the received kinetic and power parameters, the power of the model was defined on basis of the following formula:

$$P = \frac{G \cdot H}{t} \ (W) \tag{4}$$

Where G is load weight in newton
H - elevation of load lift
t - Time of lifting load to H elevation

5. Results

1. Experimental research has shown that proposed wind turbine possessed comparatively high factor of wind energy usage $\xi = 0.25 \div 0.35$ that is high value for rotor type wind turbines.

2. From the kinematic point of view we received simple rotor type wind unit that does not require moving part to be oriented towards wind direction and current transmitting contactors.

6. References

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