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Development and Experimental Research of a Vertical Axis Wind Turbine

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ABSTRACT: This article presents the results of an experimental study of the mechanical strength of composite materials used in the preparation of vertical axis turbines. In addition, data on the concentration and amount of composite materials spent on making a 1 kW wind energy device are presented, and the results of experimental and theoretical research in certain technical parameters of the device are compared.

KEYWORDS: vertical axis, polyester, fiber glass, wind turbine rail, optimal, influencing forces, carbon fiber, fiberglass.

I. INTRODUCTION

Despite the fact that there are technical, economic and legal conditions for the use of wind energy in our country, the small power wind energy devices that are used in practice cannot be considered sufficient, as the main reason for this, several factors can be cited:

Our region can be divided into desert - dry steppe, mountainous and mountainous zones. Therefore, there are frequent changes in the direction and speed of the wind, temperature in the desert regions is +60 0C in summer and -20 0C in winter. Consumers who are not connected to the central electricity grid are mainly located in desert areas. The blades of the wind turbine installed in such a region lose their physical properties in a short time due to unfavorable temperature, because the climatic conditions of our region were not taken into account for devices manufactured abroad.

In these areas, due to the increase in the amount of dust (normally 0.05 mg/m3) over the norm, as a result of increased wastage in the mechanical parts of the turbine, there are cases of slow or non-starting of the turbines.

In addition, in low-speed wind currents, the heavy weight of the turbines makes it difficult to drive the turbines. Therefore, reducing the weight of turbines and increasing their torque is an urgent issue. According to their construction and technical characteristics, horizontal axis turbines cannot be a complete solution to the above problems. Therefore, in the research work, a solution to these problems is being found by improving vertical axis wind turbines.

As a result of these problems, regional adoption of wind turbines is low, leading to the decline or disappearance of local manufacturers [1].

The mentioned problems do not make it possible to effectively apply standard WPPs (Wind Power Plant). Therefore, there is a need to research vertical axis wind turbines with improved technical parameters adapted to climatic conditions, to create turbine manufacturing technology[2].

The aerodynamic shape of the vertical axis turbine blades used in different regions is optimized, the driving torque is increased, the weight is light and the preparation of the device adapted to the climatic characteristics of the region remains an urgent issue not only for our republic, but also on a global scale.

II. EXPERMINTAL PART

In world practice, polyester resin is used in the preparation of the turbine part of WPP. [3] Determination of the concentration of these chemical products is required when using polyester resin and special fibers. In the production of turbine blades, polyester resin is soaked in special fibers and it is given an aerodynamic shape with the help of molds [4]. Molds are made using gypsum, reinforced concrete alloy, wood or metal structures. The mechanical strength of

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turbines can be increased by adding local products. As a test, we conducted experiments using the following products to determine the strength of additional fibers: (Fig. 1)

Epoxy liquid without the addition of other additional fibers
1.Glass fiber
2. Basalt (Asbestos) fiber
3.Lavsan fabric
4.Gabardine fabric
5.Flax fiber
6.Goat’s fiber
7.Horse’s fiber

Fig. 1. The process of testing local fibers and making turbine parts using these fibers.

According to the results of experimental experiments, it was found that the strength of different types of products (fibers) is different (The experiments were conducted using laboratory devices WP-950, WP-300.). Depending on the local availability, it is possible to increase the strength of the turbine by using products such as goat hair and horse

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wool. Of course, the strength of products in the form of local fibers cannot be the same as the strength of synthetic fabrics, so it is advisable to use local fibers as additional fibers (Table 1)[5]. By increasing the share of local products in production, we can reduce the cost of the device.

Table 1.
Durability of products used in the manufacture of turbine blades.

	Fiber type	Strength limit [MPa]	Modulus of stress [GPa]	Density [g/sm^3]
1	Carbon	2000-5000	200-600	1.8
2	Glass fiber	1950-3500	70-80	2.55
3	Fiberglass fabric	4500-4700	75-90	2.5
4	Kevlar fabric	3000-3150	63-67	1.4
5	Basalt	2800-3100	80-90	2.6-2.7
6	Linen	400-600	12-25	1.2-1.5
7	Hemp	300-700	20-70	1.3-1.5
8	Sisal	350-700	7-22	1.4-1.5
9	Gabardine fabric	150-250	10-20	1.1-1.2
10	Lavsan fabric	350-780	20-30	1.3
11	Cocoon	550-650	4-6	1.2
12	Goat's fiber	700-900	30-32	1.3
13	Horse's fiber	800-1000	35-38	1.4

The blade part of the wind turbine and the support (hand) part holding the blades were prepared in our laboratory. The following amount of fiber was used in the preparation of the turbine part:

Table 2.
The amount of fiberglass raw materials used in the production of the turbine.

Turbine element	The amount of raw materials used for one item	Total amount of raw materials
For one blade:	3 layers of fiberglass with a surface of 0.6 m2	0.6x3x4=7.2 m2
	2 layers of fiberglass fabric with a surface area of 0.6 m2	0.6x2x4=4.8 m2
For one hand:	4 layers of fiberglass with a surface area of 0.15 m2	0.15x4x8=4.8 m2
	2 layers of fiberglass fabric with a surface area of 0.15 m2	0.15x2x8=2.4 m2
Local fiber	3 kg	

Note: The turbine consists of 4 blades and each blade is 3 layers of fiberglass 2 layers of fiberglass fabric, the supports are 8 and each support is made of a two-piece assembly, with 2 layers of fiberglass for each part of the supports 1 layer of fiberglass fabric is used.

Taking into account that 3 m^2 of fiber and 2.8 m^2 of fabric were used for the preparation of the vertical plates on the outer surface of the blades and the generator shell, summing up with the 12 m^2 of fiber and 7.2 m^2 of fabric given in the table above, it follows that 15 m^2 of fiber and 10 m^2 of fabric were used for our turbine. The parts of the wind turbine must be ready within a day after being poured into the mold, for this purpose, a solution that ensures strong adhesion to the polyester resin (Otverditel), a solution that ensures fast hardening (Uskoritel) is a certain concentration Table 3 is added in the amount based on:

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Table 3.

Concentration of use of fiberglass products with solutions.

Liquid / Glass fiber	Polyester resin [kg]	Solidifying solution [kg]	Quick hardening solution [kg]
1 m2 fiber (300 gr/m2)	2.4	0.096	0.048
1 m2 fabric (285 gr/m2)	-	-	-

Effective use of wind energy devices begins with installing the device in the most suitable area and height, that is, by installing the turbine in the wind flow, it will be possible to use it continuously. After the turbine is installed, we need to determine its technical parameters below based on various factors.

- Measurement of wind speed using an anemometer, taking into account the height of the turbine [6].
- Measure the value of the voltage and current coming from the generator through the voltmeter and ammeter before the wind controller and after the controller in the same position [7].
- Measuring the rotational speed of the turbine or generator using a tachometer.
- It is necessary to determine the capacity of the accumulator battery, which should be charged by the wind energy device [8].

The correctness of the measurement results presented above is the reason for determining the true values of the turbine parameters.
A vertical axis wind turbine is designed for consumers with unstable electricity supply and serves to improve the electricity supply for such consumers [9].
The fixed technical parameters of the wind energy device are as follows:

- The type of wind energy device is vertical axis;
- The height of the turbine is 2 [m];
- The diameter of the turbine is 1.5 [m];
- Wing length (chord) 0.3 [m];
- The number of blade is 4
- The total weight of the wind energy device is 80.7 [kg].

Variable technical parameters are:

- Wind speed, density;
- output power of the WPP;
- useful work coefficient of WPP;
- The number of revolutions of the turbine;
- The voltage and current provided by the generator.

The following 4 tables show the theoretical and experimental power of the wind turbine and the difference between these powers using the results of experimental research.

Table 4.
Experimental and theoretical capacities of the proposed WPP.

No	Wind speed	Power in theoretical calculations [W]	WPP experimental power [W]	Difference between theoretical and experimental capacities %
1	3.55	7.323322832	17	-56.9
2	3.9	12.15299686	17.8	-31.7
3	4.02	16.43393739	20	-17.8
4	4.4	22.14865699	24	-7.7
5	5	32.68692	32	2.1
6	5.4	46.06894505	36	27.9
7	5.6	51.82256934	42	23.3
8	6.01	63.62417636	49	29.8

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9	6.4	75.86852045	55.7	36.2
10	6.5	86.69751545	74	17.1
11	7.0	112,1161356	100	12.1
12	7.5	136.8764775	132	3.6
13	8	188.2766592	171	10.1
14	8.6	253.8400833	218.6	16.1
15	9.1	293.2370832	276	6.2
16	9.7	348.558061	345	1
17	10	395.87492	427.5	-7.3
18	10.6	481.5320834	597	-19.3
19	11.2	551.2554629	767	-28.1
20	11.8	639.7142586	815	-21.5
21	12	672.0430752	865	-22.3
22	12.6	755.3424221	866	-12.7
23	13	822.4755448	866	-5
24	14	971.6731752	866.02	12

In the course of the research, the experimental results of the proposed device and the experimental results of a number of similar devices were analyzed.

a) b)

Fig. 2. a) smooth-surfaced WPP (1kW), b) installation process of the proposed WPP (1kW).

The experimental capacities of the considered WPPs were compared and it was found that the efficiency of the proposed device is high in weak wind currents (Fig. 3).

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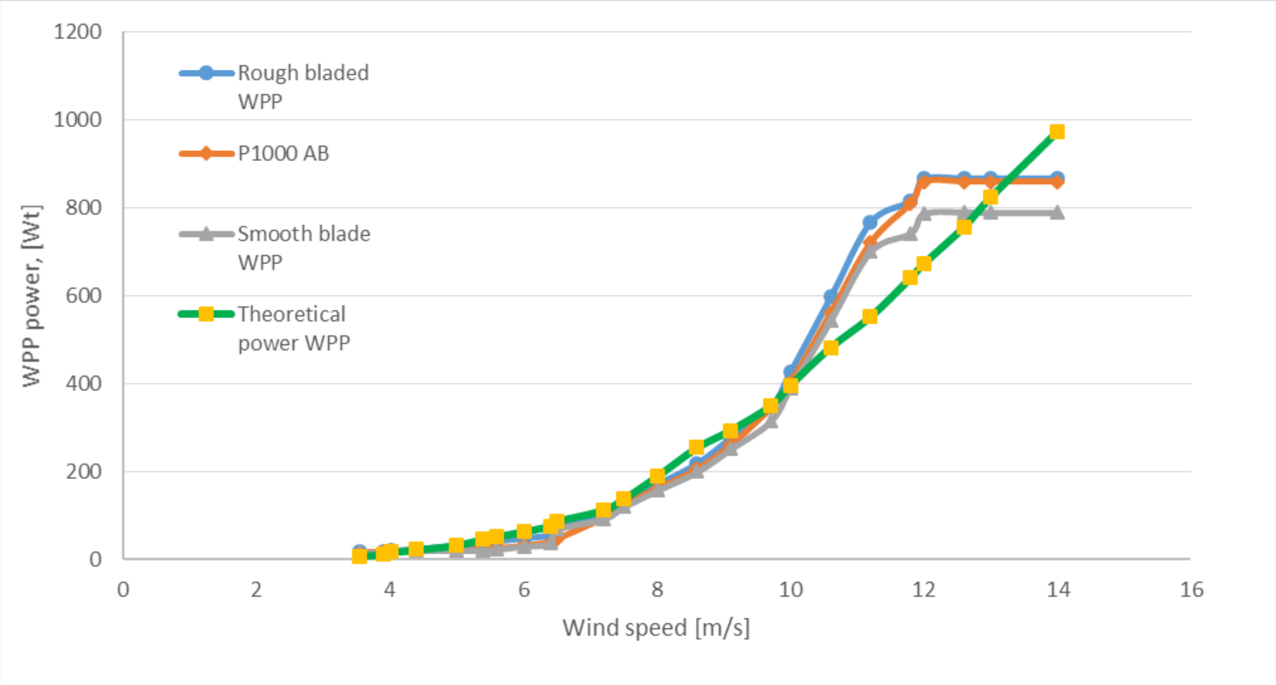

Fig. 3. Power curve of wind turbines

III. CONCLUSION

In the design and theoretical calculations of WPP, the power of the device should be 1000 [W] when the wind speed is 12 m/s. Due to technical errors in the preparation of the turbine and generator, the average difference between the results of experimental research and theoretical calculations was -1.5%.

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