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Rotors Of Wind Aggregates and Their Construction Problems

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Abstract – This paper presents the problems associated with the design and application of wind energy-using aggregate rotors. The dynamic characteristics of the aggregate are analyzed based on the research work carried out on the basis of the patent for the invention obtained by the author. Based on the findings, a new rotor design is proposed. Information is given about its construction structure, working principle, advantages.

Keywords – Wind, rotor, wing, angle of rotation, angular velocity, aggregate, construction, torque, force, radius, forehead resistance.

In recent decades, the use of "green energy" in the world has accelerated. The reason is an energy famine and an environmental problem that has manifested itself to humanity.The fossil fuels available to us are running out. The ecology of our planet is on the verge of an irreversible tragedy. The solution to the two global problems mentioned above is a complex process [1]. The use of wind energy can be seen as part of this process.

The invention of efficient designs of wind power plants requires the solution of technical, advanced technological issues, continuous scientific research. There are many types of such machines available today.These include rotors mounted on towers over 100 m in height, hybrid (based on a wind turbine) aggregates.[2], [3], [4].

The world's wind energy is mainly propeller-type rotors. Their efficiency is high. However, it has a number of shortcomings:

1. In instantaneous and periodic changes in the rotor wind, it is not possible to ensure that the working surface is independently perpendicular to the wind vector, which is another problem, especially for large diameter rotors..

2. Since the starting torque value is small, the process of starting the unit will not be without problems.

3. During strong wind speeds (drums), the propeller wings come under great pressure. It is exposed to large frequency oscillations under the influence of instantaneous changes in wind speed. The "fatigue" of the wings accelerates.The rotor operates at maximum efficiency only at certain wind speeds (10÷12m/sFigure 1) [5].

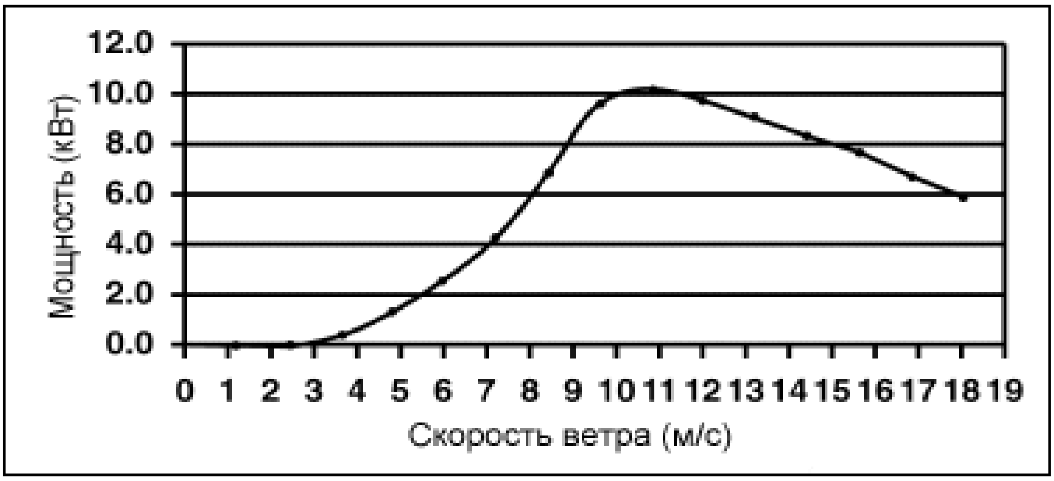


Figure 1. About the dependence of the rotor power on the wind speed

The collapse of the wings, towers, fires in the aggregate mechanisms are due to the above-mentioned shortcomings.Our many years of experience show that the mentioned shortcomings can be overcome with the help of vertical axis rotors. [6].

We cite theoretical considerations on the obtained invention potential [7],[8].

Figure 2 shows the scheme for calculating the rotor driving torque.

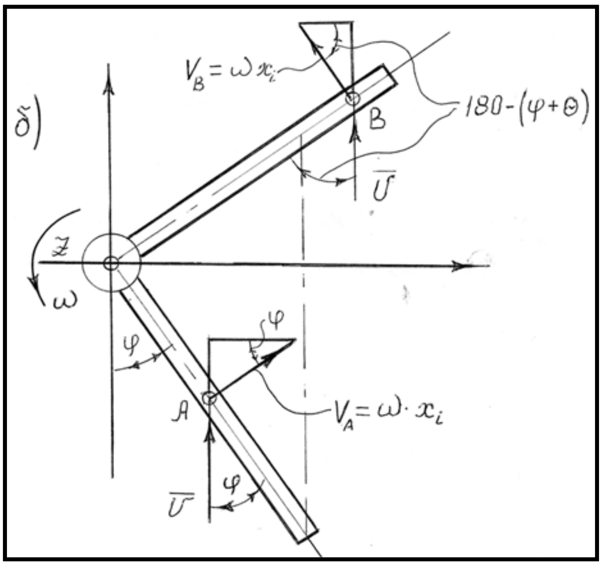


Figure 2. On the calculation of the moving torque generated by the rotor

At point A is the value of the driving moment generated by the active wing

At point B, the moment that partially formed the active wing was calculated.

As can be seen from the figure, no more than two wings are in working condition in vertical axis rotors.

Pressure falling on the working surface as the rotor moves at an angular velocity $p=p_{wind}-p_{\omega}$

The moving torque depends on the location of the wings $M_x= M_{active}$ 1 per wing works

$M_x= M_{active} + M_{кис.\ active}$2 as if each wing worked.

In that case the power, $P = M_x\cdot\omega$ takes the form of an equation.

The defined equation is as follows [7]:

$$M_1 = \frac{1}{24}\cdot\rho\cdot C\cdot h\cdot \ell^2\cdot \mathrm{Sin}^2\varphi[(6\cdot\upsilon^2\cdot(1-k^2) - 8\cdot\upsilon\cdot\omega\cdot\ell\cdot(1-k^3)\cdot\mathrm{Sin}^2\varphi + 3\cdot\omega^2\cdot\ell^2\cdot\mathrm{Sin}^4\varphi\,(1-k^4)]$$

The moment of formation of a partially active wing,

$$M_2=\frac{1}{24}\cdot\rho\cdot C\cdot h\cdot \ell^2\cdot[6\cdot\upsilon^2\cdot(Sin^{3}(\varphi+\theta)-Sin^2\varphi)-8\cdot\upsilon\cdot\omega\cdot\ell\cdot(Sin^3(\varphi+\theta)-Sin^3\varphi)\cdot Sin(\varphi+\theta)+3\cdot\omega^2\cdot\ell^2\cdot(Sin^4(\varphi+\theta)-Sin^4\varphi)\cdot Sin^{3}(\varphi+\theta)] \qquad (1)$$

Here, P_1 – active wing power, M_2 – partially active wing power, c_x – the forehead resistance of the wing, ρ- air density, h - wing height, ℓ - wing radius, υ - wind speed, φ- the angle between the wing radius and the wind speed vector, θ- angle between wings, ω- rotor angular velocity, k= d / ℓ - the coefficient of openness of the wing

From the dynamic characteristics of the wind turbine rotor we draw the following important conclusions (Figure 3):

1. The value of the driving torque of the rotor in the quiescent state is 2-2.5 times greater than its value in the operating state (Figure 3 (a)).

2. In order to ensure maximum power output in some of the obtained geometric dimensions of the rotor, some of the obtained values of the wind speed correspond to its angular velocity and some obtained values of the effective resistance moment

(Fig. 2 (b, c)) – $P_{мах}= f\,(M_{opt.}\,;\,\omega_{opt.})$.

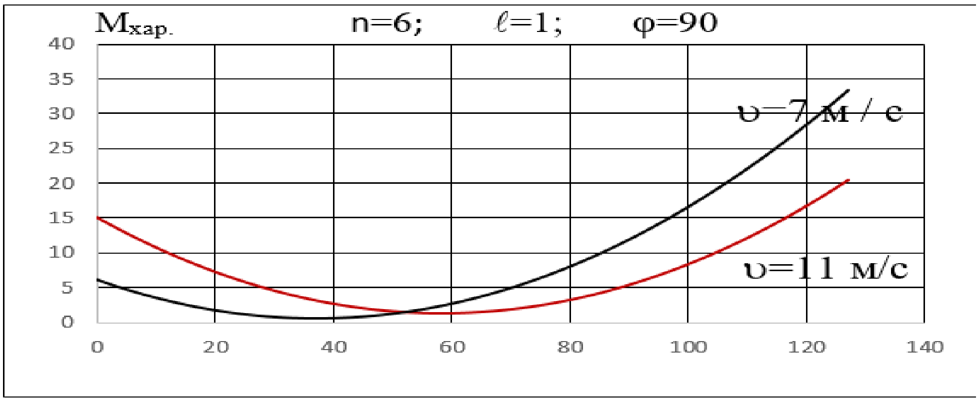


Figure 3 (a). The angular momentum of the rotor

depending on the speed value

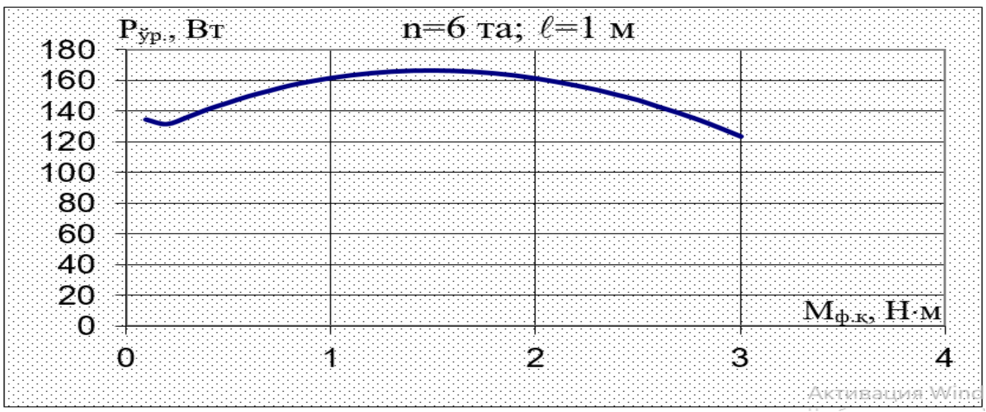


Figure 3 (b). It is a matter of optimizing the relationship between the driving torque value of the rotor power

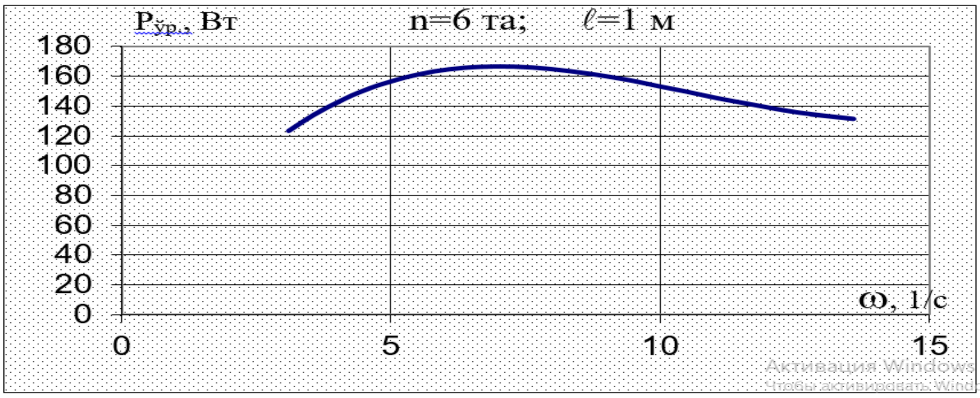


Figure 3 (v). Angular velocity value of rotor power

on the issue of optimizing the relationship between

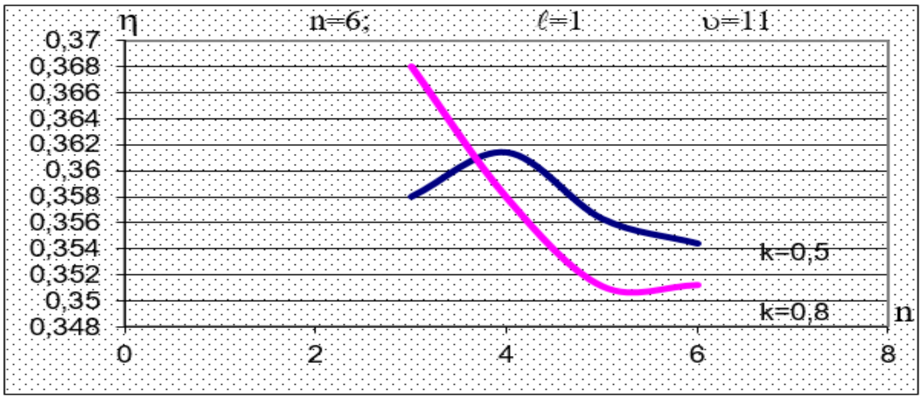
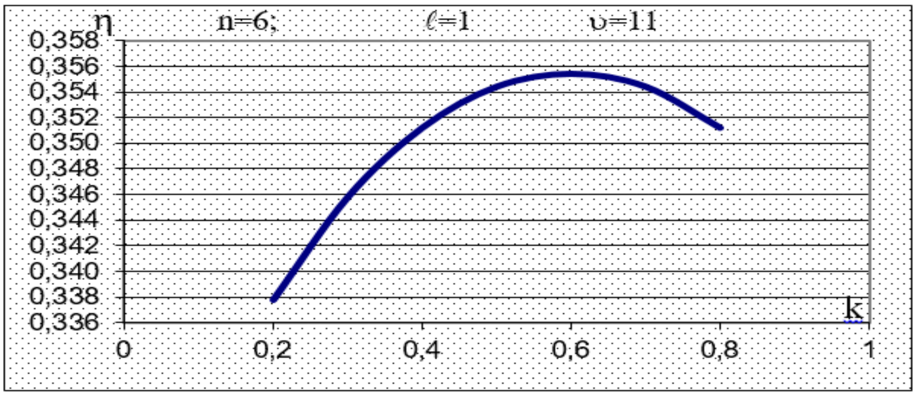


Figure 3 (g). The number of wings and the efficiency of the coefficient

dependence on the coefficient of openness



3 (d). Profitability ratiodependence on the coefficient of openness

3. In order to maximize the useful work value, it is necessary to bring the openness coefficient along with the kinematic, dynamic parameters of the rotor to the required value (Figure 3 (g)).

4. In vertical axis rotors, the value of the generated power may decrease with increasing value of the efficiency, and vice versa. (Figure 3 (d)) - As the working wing surface decreases, the force drop value associated with the decrease in the value of the driving torque relative to the increase in force due to the increase in angular velocity becomes greater.

From these characteristics, it is clear that the vertical axis rotors come into the working position freely, they need a control mechanism that ensures that the angular velocity and the useful resistance value are at the required value to maintain the optimal working condition. The power value for vertical axis rotor`s efficiency is more important than the indicator.

The rotor absorbs maximum energy when it has 6 wings,when it has 3 wings, it has the maximum efficiency.

This feature is also a problem for propeller-type rotors [9], [10]

Based on the findings, the authors propose a new design of the wind turbine rotor (Figure 4).Structure of the new rotor design: The rotor consists of two wings with three wings moving in opposite directions (Figure 4).In the central part of the wings there is an open surface that allows wind flow. At the bottom of the tier shafts form a bond with a differential mechanism that directs the movement in one direction.The top views of the rotor tiers are shown in Figure 5, and the schematic view of the assembled structure is shown in Figure 6. The aerodynamic process occurring along the open surface wings is shown in Figure 7.

The main features of the new vertical axis rotor:

1. The optimal operating position of the rotor does not depend on the direction of the wind vector.

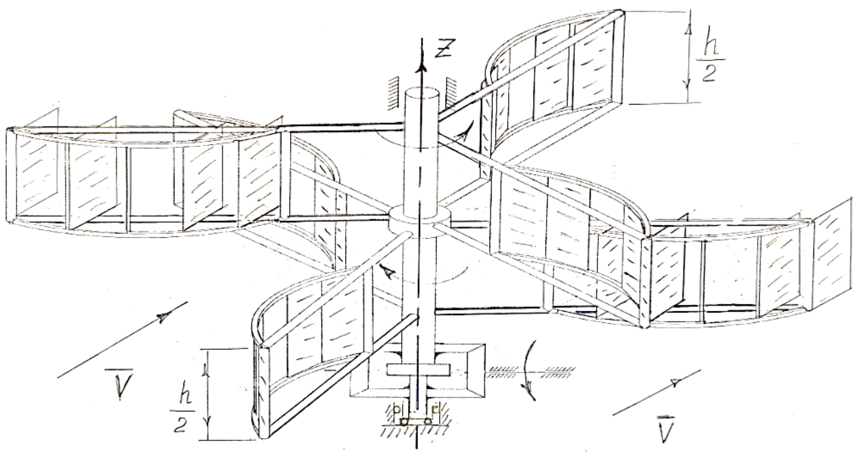


Figure 4. Vertical axis rotor of wind unit - "Samarkand"

(Application for an invention patent IAR 2020 0106)

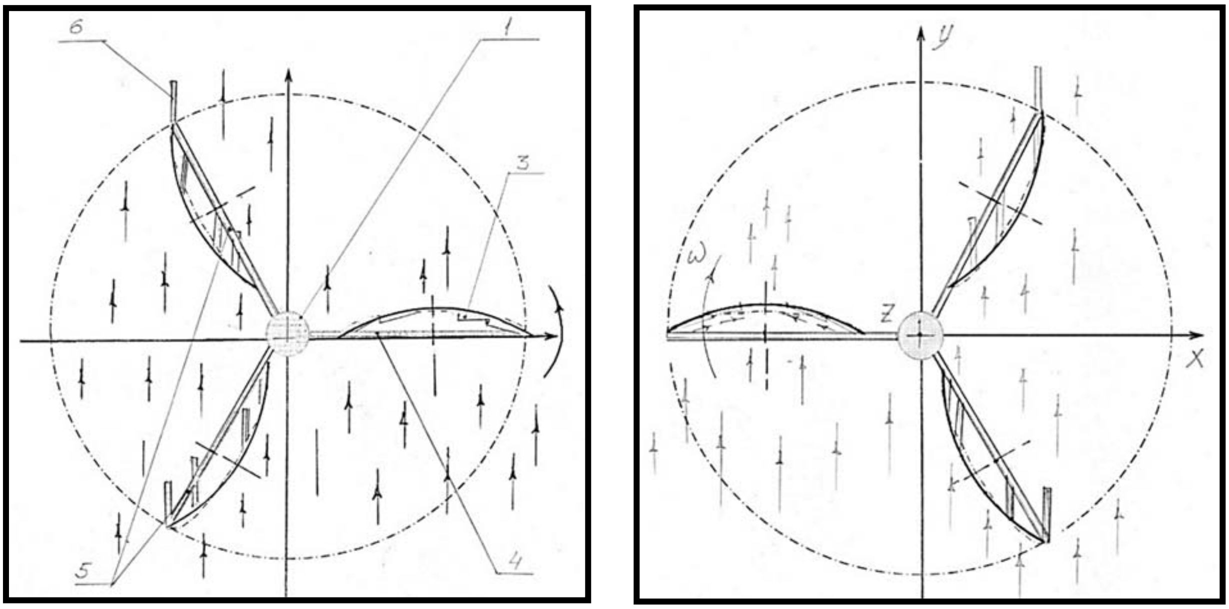


Figure 5. Top view of the lower (right) and lower (left) tiers of the rotor split in two and rotated 180^0around the 0y axis

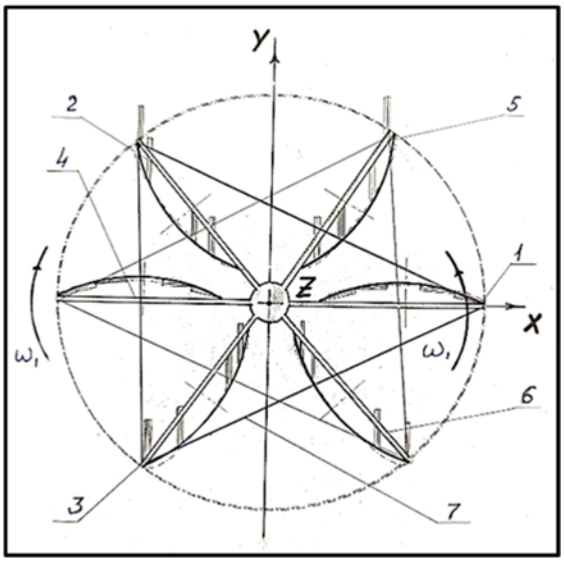


Figure 6. Top view of a two-tiered rotor: 1-4 active wings, 3,4,5,6 - passive wings, 7 steel ropes

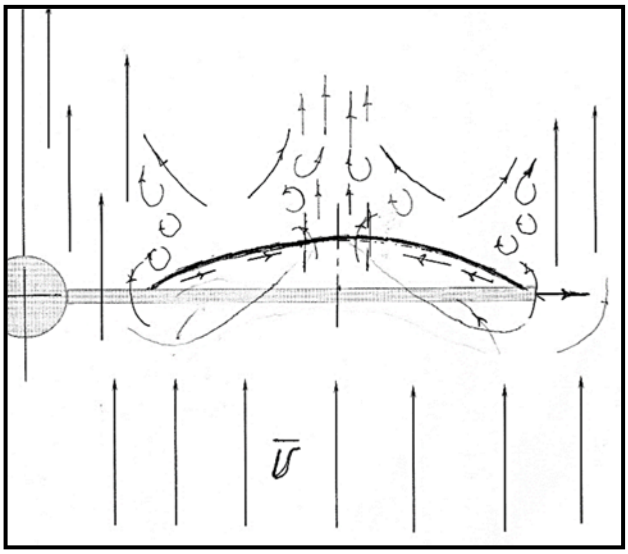


Figure 7. Regarding the aerodynamic properties of the wind flow flowing along the wing with the wing center open

2. The wing misses the wind flow from the center when it is approximately 45^0 - 135^0 relative to the wind direction vector. This process causes the wing back air under relatively static pressure to be absorbed along with the main kinetic pressure flow. The wind current transfers its kinetic energy to the working surface and accelerates the process of moving away from it.

3. The value of the rotor forehead resistance increases to 1.4.

4. The rotor can automatically reduce the pressure on the wing surface at strong wind speeds

5. Vibrations caused by instantaneous changes in wind speed are almost imperceptible on the wings of the rotor - the wings are pulled by reciprocating steel ropes.

6. The rotor is suitable for inertial systems.

7. The unit is initially in a relatively inert state, monotonically connected to a system of inertial mechanisms with a working speed.

Since each tier consists of three wings, the active working intervals of the wings increase, f.i.k. value 3 wings, the generator works as a power value 6 wing rotor. The use of wind energy serves energy supply, environmental cleanliness. Uzbekistan, which has more than 25 economically viable wind farms, needs to have its own wind energy network and start a wind turbine industry, among other developing countries. This goal has become a reality today, as the new Uzbekistan, with its domestic potential, invests heavily in research and attracts foreign investors.

CONCLUSION

Today, there are dozens and hundreds of designs of wind turbine rotors. We believe that the new design mentioned above will find its place in this technical environment. Importantly, the design works successfully in inertial aggregate systems. This is important in the context of Uzbekistan, as we do not have the technology to install propeller-type structures of aggregates at a height of one hundred and more, and the production of their complex intermediate mechanisms. This unit is distinguished by the simplicity of the manufacturing process, the fact that the installation work does not require complexity. It can increase the power value at the expense of the driving torque, no additional motors are required to put the unit into working condition.

At present, the authors have developed a new mechanism of the utility module, and this simple mechanism ensures that the rotor always operates in optimal mode. We will announce this mechanism and its working principle in the coming days.

The use of wind energy in the new construction will serve the energy supply, environmental cleanliness. Uzbekistan, which has more than 25 economically viable wind farms, needs to have its own wind energy network and start a wind turbine industry, among other developing countries. This goal has become a reality today due to the fact that the new Uzbekistan with its domestic potential invests heavily in research and attracts foreign investors.

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