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PROPULSION FORCE OF A WIND TURBINE ROTOR

Перспективы развития альтернативной энергетики и инновационных технологий

Perspective development of alternative energy and innovative technology

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Аннотация: В статье приведены уравнения крутящего винта с вертикальной осью и криволинейным крылом, возникающего под давлением ветрового потока. В уравнении отражена связь между динамическими, кинематическими и геометрическими параметрами.

Annotation. The article of moment gives the equations of a twisting propelling rotor with a vertical axis with a curved wing arising under the pressure of the wind flow. The relationship between dynamic, kinematic and geometric parameters is reflected in the equation.

Key words: Differential equations, numerical method, wind, rotor, assembly, wings, pressure, curved area, linear velocity, angular velocity, momentum

It is known that the rotor may operate in four distinct positions, each associated with a corresponding change in the driving force applied to the wings during one cycle of operation. In this paper, we will analyze the second and third positions and derive their respective expressions.

The second position occurs when the second wing is restricted from moving in the direction of the wind at point B of the first wing, in shape 1. The third position is when the second wing travels from point A of the first wing relative to the direction of the wind, in shape 2.

The thrust moment they are generated by the rotor when in position 2 is influenced by the angle at which the wings are oriented relative to the oncoming wind. This angle significantly impacts the thrust generated, which is determined by how the operating surface of the second wing varies. The first wing is always fully operational. [3],[4]. This is the statement of the

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second wing:

$$\ell \cdot sin\varphi = r \cdot \sin(180^0 + \delta)$$

Equality begins with finding a solution. Precisely,

$$\delta = arc\ sin\left(\frac{\ell}{r} sin\varphi\right)$$

when equals the value, the angle of inclination of the first wing in the starting position begins with angles at the corners of the first and second wings. As a result, the forming surface of the second wing at a α_s4 angle generates no driving torque. In this case, α_s4 increases as φ increases, and its value can reach 90 degrees. Consequently, it is completely blocked by the second wing. In Form 1, α_s4 represents an angle. The challenge lies in determining how α_s4 varies when the angle of inclination changes.

Occurs when the value is. When the values of the φ and φ+120^0 angles on the second wing increase, the angle of inclination of the first wing at the initial position begins to move toward the second wing. As a result, the surface formed at the base of the corners of the second wing doesn't create driving torque. In this case, the α_{s4} angles increase by φ and their value reaches 90^0. This is fully covered by the second wing when in form 1. In form 1, the α_i angles are represented as number α_{s4}, where the question of determining the change in value from φ to α_{s4} when the angle moves from [5] answered.

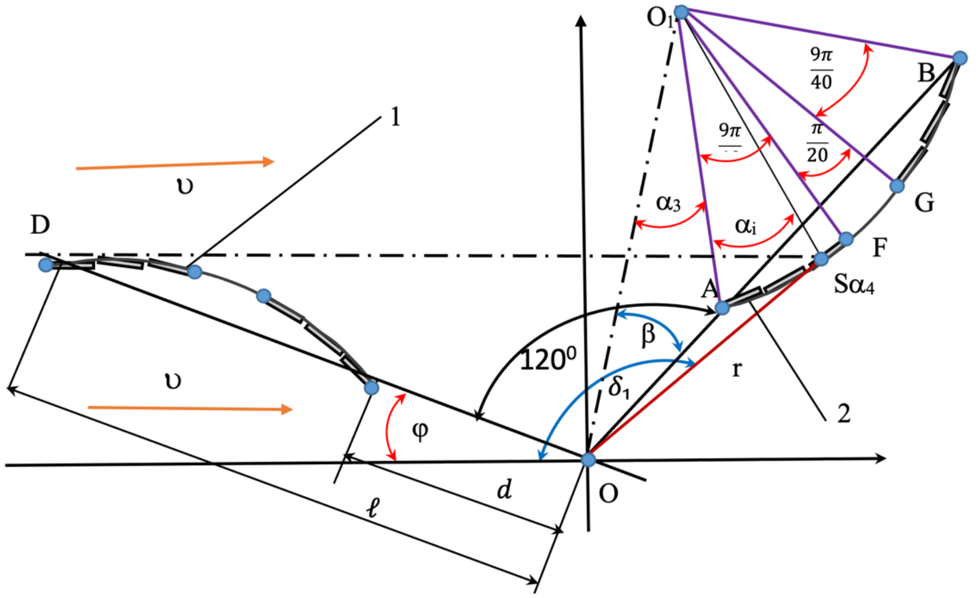

Fig. 1. Regarding the calculation of the torque of the Rotor 2nd wing in position 2

from the drawing $\frac{R}{\sin(\angle O_1 O S_{\alpha 4})} = \frac{R}{\sin(\angle O_1 \mathrm{OA} + \angle \mathrm{AOS}_{\alpha 4})} = \frac{r}{\sin(\angle O O_1 S_{\alpha 4})}$ or $\frac{R}{\sin\left(\beta+\delta_1-\left(\varphi+\frac{2\pi}{3}\right)\right)} = \frac{r}{\sin(\alpha_3+\alpha_{s4})}$ and in this $\delta_1 = \delta + \frac{2\pi}{3}$ considering that

$$\sin(\alpha_3 + \alpha_{s4}) = \frac{r}{\mathrm{R}} \sin(\delta + \beta - \varphi)$$

and from it we find the final equation:

$$\alpha_{S4} = \alpha_3 - \ arc\sin\left(\frac{r}{\mathrm{R}} \sin(\delta + \beta - \varphi)\right)$$

Where it is known that expressions r,α_3,δ and β are represented by the following equations[6], [7], [8], [9]:

$$r = \sqrt{R^2 + |OO_1|^2 - 2 \cdot |OO_1| \cdot \cos[\alpha + \alpha_3]}$$

$$\alpha_3 = arc\cos\left(\frac{|O_1 O|^2 + R^2 - d^2}{2 \cdot R \cdot |O_1 O|}\right)$$

$$\delta = 2 \cdot arctg \frac{-B1 \pm \sqrt{B1^2 - 4 \cdot A1 \cdot C1}}{2 \cdot A1}$$

$$\beta = arctg \frac{|O_1 C|}{\lambda \cdot k + a}$$

Ushbu tenglama and shakilga bazlanib 2-wing for holding events based on the conditions of izamiz [10], [11], [12], [13],:

$0 \leq \alpha_{S4} \leq \alpha_F$

$$\mathrm{M}_2 = \frac{1}{2} \cdot \mathrm{c} \cdot \rho \cdot \mathrm{h} \cdot \left[\left(\int_{\alpha_{S4}}^{\frac{9 \cdot \pi}{40}} (\upsilon \cdot sin\delta_1 - \omega \cdot \mathrm{r})^2\right) \cdot r \cdot d\alpha + \left(\int_{\frac{11 \cdot \pi}{40}}^{\frac{\pi}{2}} (\upsilon \cdot sin\delta_1 - \omega \cdot \mathrm{r})^2\right) \cdot r \cdot d\alpha\right]$$

$\alpha_F < \alpha_{S4} < \alpha_G$

$$\mathrm{M}_2 = \frac{1}{2} \cdot \mathrm{c} \cdot \rho \cdot \mathrm{h} \cdot \left[\left(\int_{\frac{11 \cdot \pi}{40}}^{\frac{\pi}{2}} (\upsilon \cdot sin\delta_1 - \omega \cdot \mathrm{r})^2\right) \cdot r \cdot d\alpha\right]$$

$\alpha_G \leq \alpha_{S4} \leq \alpha_B$

$$\mathrm{M}_2 = \frac{1}{2} \cdot \mathrm{c} \cdot \rho \cdot \mathrm{h} \cdot \left[\left(\int_{\alpha_{S4}}^{\frac{\pi}{2}} (\upsilon \cdot sin\delta_1 - \omega \cdot \mathrm{r})^2\right) \cdot r \cdot d\alpha\right]$$

Here are the values derived from rotor design α_F, α_G and α_B: [14]. [15] and [16]. Based on the number of equations, it can be concluded that the second-stage wing undergoes three homogeneous dynamic transformations during its second position.

The driving moment of the rotor tier wing in position 3:

Once the tier 2 fan advances behind wing 1, modification φ transfers it to position 3. At the same moment, wing 2 begins to expand again in the direction of the wind from point A, which is its bottom section.

$d \cdot sin\varphi \geq r \cdot \sin(180^0 - \delta_1)$ marks the start of state 3 of the limitations. Even in this instance, it will seem homogenous with the following equation:

$$\alpha_{S5} = \alpha_3 - arc\sin\left(\frac{r}{R}\sin(\delta + \beta - \varphi)\right)$$

The arc-shaped surface formed on the angular base α_{S5} enters an active functioning state, whereas the surface built on the angular basis α_{S4} remains passive. This is critical for determining the limit of the integral.

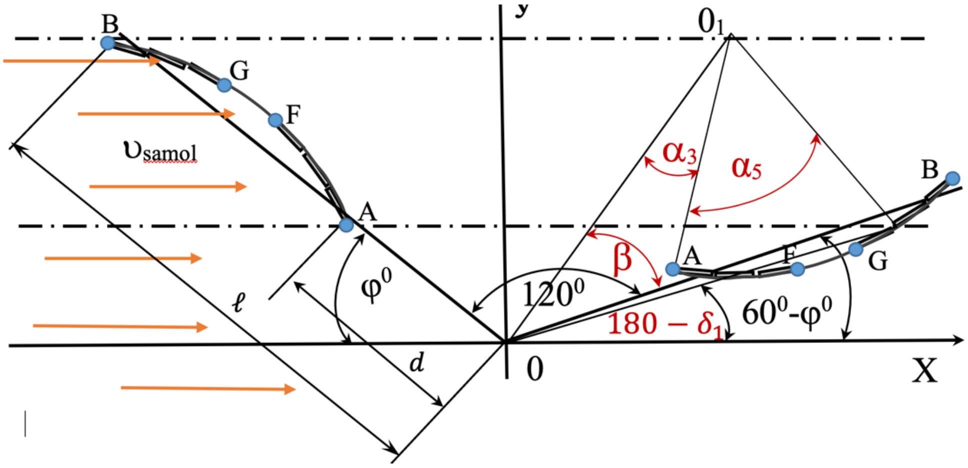

Fig. 2, we calculate the torque of rotor wing 2 in position 3 using the following conditions:

$0 \leq \alpha_{S5} \leq \alpha_F$, $\alpha_F \leq \alpha_{S5} \leq \alpha_G$ in the past

$$M_2 = \frac{1}{2} \cdot c \cdot \rho \cdot h \cdot \left[\left(\int_0^{\alpha_{S5}} (\upsilon \cdot sin\delta_1 - \omega \cdot r)^2\right) \cdot r \cdot d\alpha\right]$$

And in the range $\alpha_G \leq \alpha_{S5} \leq \alpha_B$ to

$$M_2 = \frac{1}{2} \cdot c \cdot \rho \cdot h \cdot \left[\left(\int_{\alpha_G}^{\alpha_{S5}} (\upsilon \cdot sin\delta_1 - \omega \cdot r)^2\right) \cdot r \cdot d\alpha\right]$$

The equations will be suitable. It is worth noting that in scenario 2, angle α_{S5} will represent the integral's beginning coordinate, α_{S5} as well as its end coordinate. However, in the $\alpha_G \leq \alpha_{S5} \leq \alpha_B$ range, the surface moment caused by the wing autofocus arc will be relatively tiny, because the surface is nearly parallel to the wind direction. The result is that the second wing undergoes two homogenous dynamic changes at the third position of the tier. The term "tier" indicates that the rotor is divided into two tiers. We studied the second wing of one tier here. The second wing of the second tier will have the same characteristics, but with a 60^0 delay [17], [18], [19] [20]. These equations do not require answers in engineering calculations; instead, they allow you to calculate with the required precision utilizing computer-based approximate solution methods [21], [22].

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