УДК 631.313
Fisun M.A.[1], Lushchin S.P.[2]
[1]student of group E-411a NU “Zaporizhzhia Polytechnic”
[2]PhD (Phys.-math. sciences), associate professor NU “Zaporizhzhia Polytechnic”

**DETERMINATION OF THE WIND TURBINE POWER**

The development and use of renewable energy sources in Ukraine in recent years is becoming more widespread. One such source is wind energy, which uses the conversion of wind energy into electricity using wind turbines. Given that the average wind speed in the south-eastern part of Ukraine is 4,5 m/s, we can predict great prospects for the development of wind energy. An example is the construction and operation of the Botievo wind farm with a capacity of 200 MW. The average efficiency of modern wind turbines reaches values of 35…45 %.

The most common design is a horizontal-axial three-bladed wind turbine. The rotation of the windmill is due to the lifting force of the blades.

The power of the horizontal-axial wind turbine on the blades is calculated based on the formula of the kinetic energy of the air flow that passes through the area of the windmill [1]:

$$P = \frac{1}{2}\rho\pi R^2 V^3, \quad (1)$$

where ρ – the density of air; $R$ – the radius of the windmill; $V$ – air speed.

The amount of energy extracted in the wind by the rotor is proportional to the coefficient of use of wind energy $C_r$. The value of $C_r$ for a real windmill is in the range of 0,18…0,48. When transmitting energy through the transmission to the electric generator there are mechanical and electrical losses, so the power of the wind turbine will be less than the power of the rotor by the amount of losses taken into account by mechanical efficiency $\eta_{mech}$ and efficiency of the generator $\eta_{gen}$. Efficiency value $\eta_{mech}$ varies within 0,7…0,85, and $\eta_{gen}$ within 0,90…0,98 [1].

Taking into account these coefficients, the power of the wind turbine is determined by the following equation [1]:

$$P = \frac{1}{2}C_p\rho\pi R^2 V^3\eta_{mech}\eta_{gen}, \quad (2)$$

where $C_r$ – is the coefficient of wind energy utilization; $\eta_{mech}$ – efficiency of mechanical losses; $\eta_{gen}$ – efficiency of electrical losses of the generator.

Air density depends on pressure and temperature:

$$\rho = \frac{p}{R_\mu T}, \quad (3)$$

where $p$ – is the air pressure; $R_\mu$ – molar gas constant; $T$ – temperature.

The density of air also depends on its humidity. The relative content of water vapor in the atmosphere can vary in the range of 0…4%, and the air density will increase accordingly.

With increasing altitude, the air pressure decreases according to the barometric formula. Accordingly, the density of air decreases:

$$\rho = \rho_0 e^{-\frac{\mu g h}{RT}}. \qquad (4)$$

For example, for high-power wind turbines installed in coastal areas of the seas with a windmill blade axis height of 120 meters, the pressure change will be 1,32 %. Accordingly, the density of air will decrease by almost the same amount. Changing the temperature from -25 °C to + 25 °C will reduce the air density by almost 20 %. Therefore, the effect of temperature change on the power of wind turbines is much greater than the effect of changes in the height of its location.

The maximum output power of wind turbines depends on the radius of the windmill. This dependence is not quadratic, as increasing the radius of the wind turbine increases the height of the wind turbine and, accordingly, the wind speed.

Therefore, the power of the horizontal-axial wind turbine is determined by the following equation:

$$P = \frac{1}{2} C_p \frac{p}{R_\mu T} \pi R^2 V^3 \mu_{mech} \mu_{gen}. \qquad (5)$$

Thus, when calculating the capacity of a wind turbine, a number of factors must be taken into account, which are related to its design, as well as to the parameters of atmospheric air.

## REFERENCES

1. Основи вітроенергетики: підручник / Г. Півняк, Ф. Шкрабець, Н. Нойбергер та ін.; М-во освіти і науки України, Нац. гірн. ун-т. – Д.: НГУ, 2015. – 335 с.