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WIND TURBINE MODEL IN MATLAB/SIMULINK ENVIRONMENT

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ABSTRACT*:* *The purpose of the report is to create an neuron network that can provide information on the levels of electromagnetic fields created around conductors of an alternating current power line. The simulated is made byMatlab/Simulink, the received results are shown graphically*.

KEYWORDS- *wind turbine, model, simulation, Matlab/Simulink*

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I. INTRODUCTION

Wind turbines are an integral part of renewable energy sources and have been widely used in recent years. The advantages of using wind turbines are related to their high productivity and environmental friendliness, which is why wind energy has shown remarkable growth in terms of installed capacity and energy production.

Wind power plants convert the kinetic energy of the wind into electricity. The majority of plants form so-called wind farms, which are connected to the electricity grid. These facilities usually operate in adverse weather conditions: strong winds, icing, rain, lightning [1].

Wind direction and speed vary significantly in different locations, seasons and over time. Thus, even slight changes in wind speed or direction can lead to significant and unpredictable differences in the output power of wind turbines.

Increasing wind speed usually also increases the output power. To achieve optimal conversion efficiency, a certain, constant, wind speed is required. The design and shape of the turbines is designed so that it is possible to limit the nominal power to a maximum allowable level, in order to protect and protect the turbine from breakage or failure.

Wind farms are characterized by nonlinear characteristics, due to the dynamics of the wind. This greatly complicates the preparation of operating graphs in their various operating modes. However, testing and analyzing wind energy systems is a challenge in laboratory conditions due to the complex equipment and environmental conditions. One of the possible engineering solutions to this issue is to build a software model for simulating a wind turbine in the Matlab/Simulink environment. The advantages of this approach are that it is possible to simulate and analyze various critical and emergency modes that are difficult or impossible in real conditions.

Research in this area covers various aspects of wind turbines [3], [4], [5], [6]. Wind energy can be collected as long as the blades are facing the wind direction. Horizontal axis wind turbines (HAWTs) typically have a taller tower, which allows the turbine to withstand higher winds as wind speed increases with height [2].

A horizontal axis wind turbine (HAWT) rotates on an axis parallel to the wind direction. In this paper, HAWTs are the subject of study, as they are more efficient [7].

II. WIND TURBINE MODEL EQUATION

The growing demand for renewable energy worldwide has positioned wind power as a leading green energy solution. Essentially, a wind turbine converts the kinetic energy of the wind into mechanical energy (1).

(1)

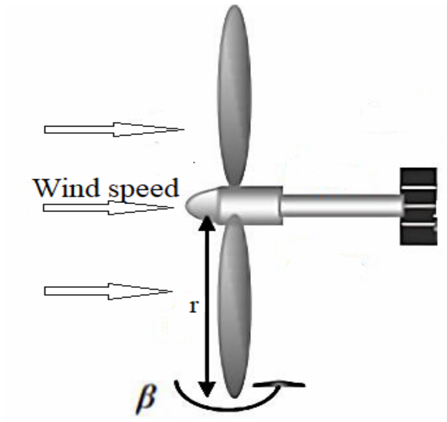

Fig. 1 Model of wind turbine

The amount converted mechanical energy depends on wind speed and air density. According to a number of studies [3], [4], [5], the power generated by a wind turbine is described by equation (2).

P = (2)

where,
P – power turbine (W)
- power factor
ρ - air density, (1,25kg/m^2)
A - the surface of the blades
v – wind speed (m/s)

The wind speed coefficient λ is calculated using the equation (3).

λ = , (3)

where,

W_t – turbine speed (rad/sec)
r - rotor blade radius (m)

The power factor Cp (λ,β) is determined according to equation (4).

(4)

After mathematical transformations, we arrive at the final equation (5) for determining the constant . , , , , ,

(5)

where,

λ – wind speed coefficient
– constant
the angle of inclination of the blades (°)

The turbine rotor torque Tr can be calculated by the equation (6).

T_r = (6)

III. NUMERICAL ANALYSIS AND SIMULATION

The simulation was performed in the MatLab Simulink environment. For this purpose, the block diagrams found in the accompanying library were used. For each of the elements, a customized individual block was selected and parameterized for the studied case. Fig. 3 shows the Master Subsystem of the modeled wind generator.

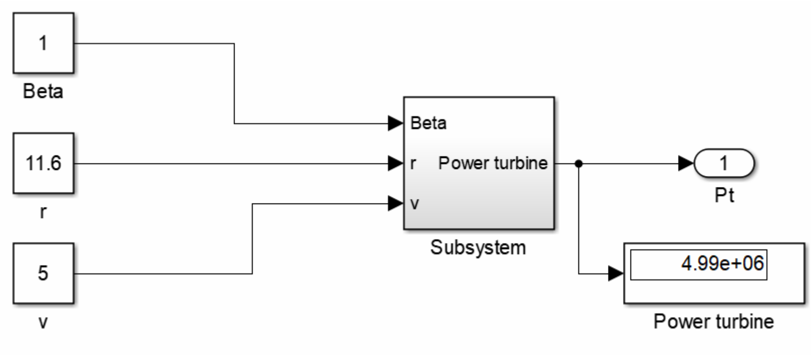

Fig. 3 Master Subsystem of Wind Generator Modeling

In this work, two operating modes of the wind turbine have been studied, for which a different wind speed has been set. The simulation model of the wind turbine is shown in Fig. 4. The input parameters that describe the modeled turbine have been introduced. r - 11.6 m, v – 5m/s and β, which in this case is a variable value. The model has been parameterized for the needs of the study. For this purpose, all the interconnections between the block elements have been implemented, some of which are shown in Fig. 4.

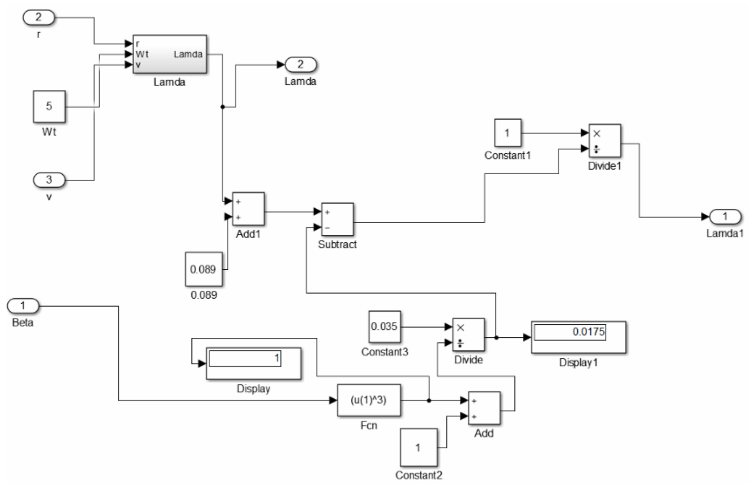

Fig. 4 Subsistem determining λ and λ_1

At v = 5 m/s, simulation values for the generated power of the turbine were obtained, which are shown graphically in Fig. 5. Analysis of the results shows that the highest turbine performance is expected at a blade pitch angle of β = 2°. The study ends at β = 10°, because the power values begin to decrease, and this is not the desired effect. It is noted that at different pitch angles of the turbine blades, different power is generated. As a result, it can be concluded that the pitch angle of the wind turbine blades has a direct impact on the final generated power.

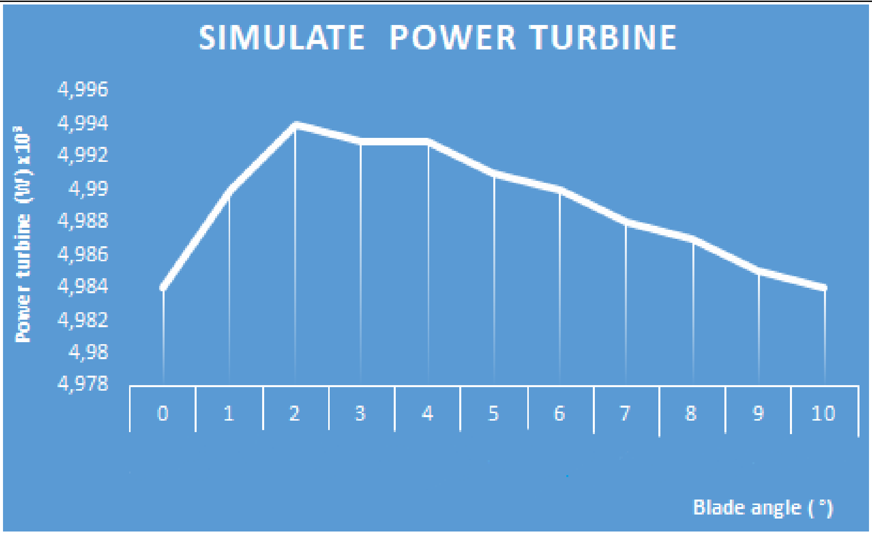

Fig. 5. Simulation values for the generated power of the turbine at v = 5 m/s

When simulating the second operating mode, when the wind speed is set to v = 10 m/s, similar results are observed, shown in Fig. 6. The analysis shows that changing the blade pitch angle β has an impact on the final energy generated by the wind turbine. Again, the critical moment is observed when changing the blade angle between 2 and 3 degrees. It is noted that after these values of β, the power generated by the turbine begins to decrease smoothly.

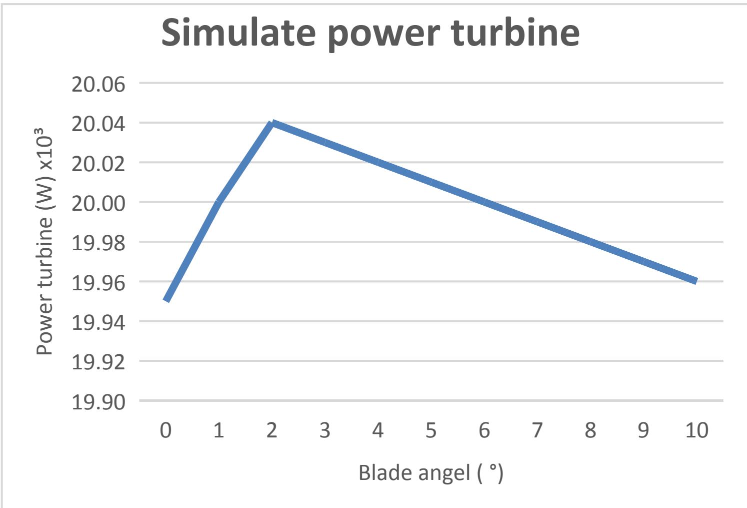

Fig. 6. Simulation values for the generated power of the turbine at v = 10 m/s

IV. CONCLUSION

A system for converting wind energy into electricity has been modeled. For this purpose, user-friendly icons and dialog windows in the Matlab/Simulink environment have been used.

In order to test the effectiveness of the proposed model, different operating modes of the wind turbine have been simulated, the main one being the change in the angle of inclination of the blades. The proposed model gives an idea of the energy generated by the simulated wind turbine. It is observed that the produced power increases with the wind speed, which confirms the need for power control. The model shows that with increasing the angle of inclination of the blades, the aerodynamic power decreases.

By increasing or decreasing the angle of inclination of the blades, the maximum amount of extracted wind energy is possible

This model is suitable and applicable for similar studies in this area.

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