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ANALYSIS OF THE PROBLEM OF WIND POWER SYSTEMS WITH COUNTER-ROTATING WIND TURBINES

In the energy market, characterized by a steady increase in electricity demand, as well as environmental constraints, research in search of new and improved renewable energy conversion systems is a priority. In wind energy, a promising solution to this problem is the use of counter-rotating wind turbines (CRWT) in the construction of wind power system (WPS). The advantage of a WPS with a CRWT over the classical design of a WPS is that, with the same nominal power values of electric machines, the generator of the CRWT system has smaller dimensions through a large angular speed of rotation of the field.

A CRWT system consists of two windwheels, one of which rotates clockwise, the other - counterclockwise. Each wind wheel is connected to one of two rotors. The CRWT system generator combines the rotation of both rotors. Wind turbines can be located in 3 positions: both in front of the generator, both behind the generator or one in front of the generator and the other behind. In various existing studies in the literature, the front wind wheel is also called the main wind wheel or wind wheel, located against the wind; similarly, the rear wind wheel is called a secondary wind wheel or a wind wheel operating at reduced wind.

The starting point in the research and development of CRWT systems is represented by the results of the theoretical research performed by Newman in 1983 [1], who further analyzed and developed Betz's theory. According to Betz's law, a wind turbine can theoretically capture about 59.3% of the airflow energy. The parameter expressing the ability of the turbine to extract energy from the wind, Betz called the power coefficient. In real conditions, the power coefficient is lower than the theoretical value, since the aerodynamic and mechanical losses of the turbine are taken into account. In the works of Newman [1,2] it was shown that the theoretical maximum power coefficient of a wind turbine can be increased with a very high gear ratio from 59% to 64% if the second wind wheel with the same radius is located downstream from the first. This theoretical result has led to various theoretical and experimental studies aimed at determining the conditions that provide for more efficient extraction of wind flow energy.

In [3], a theoretical model was proposed in which two coaxial wind turbines were considered, with the secondary wind wheel smaller than the primary wind wheel. The central part of the primary wind wheel (76.2% of the diameter of the wind wheel) does not extract wind energy, since it does not have blades. The calculations given in [3] showed that such a WPS design makes it possible to obtain a maximum power factor of 0.814.

In the early 2000s, research and development of CRWT prototypes intensified [4]. So, in 2003 in California (USA) tests of a prototype with a capacity of 6 kW were carried out for 4 months under various meteorological conditions [5]. It was found that the CRWT system is more efficient at low rotational speeds (16 - 60 rpm), the energy extracted from the wind flow can increase by 40% compared with the classical WPS design.

Despite the valuable results found within the studies, since the performance of the turbine system depends on multiple parameters (such as blade type, solidity of the two rotors, area swept by the blades, diameter ratio of the front and rear rotor, distance between the two rotors, movement transmission system, control system). There is still need of extensive studies of this type of wind kinetic energy conversion system. Also, the counter rotating wind turbines have to prove their reliability in real operating conditions.

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