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Development and Utilization of Wind Energy Resources and Analysis of New Utilization Methods Based on Fuzzy Control

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Abstract: The rapid development of wind energy has formed a huge industry, which has driven the development of a number of related industries and products, and is of great significance to promoting the development of my country's national economy. If it can be used to generate electricity, it will be very beneficial to the life and production of the local people. Therefore, it is very important to continuously improve the wind power generation control system and improve the utilization rate of wind power and the quality of power supply. The purpose of this paper is to study the development and utilization of wind energy resources and new ways of utilization based on fuzzy control. In this paper, the research work is carried out from the two aspects of control strategy and fuzzy controller design, and the design method of fuzzy controller is emphatically studied. Finally, the simulation model of wind turbine is constructed by MALAB, and the simulation experiment of the proposed fuzzy control method is completed. The results show that the fuzzy controller can achieve better control performance.

1. Introduction

Energy is not only a key resource related to economic development and social progress, but also an important strategic resource related to national economic life and national security [1]. In order to ensure the security of energy supply, promote sustainable economic development, develop and utilize new renewable energy, improve technical standards, and promote industrial development, the implementation of sustainable energy strategies has become an inevitable choice [2]. Renewable energy mainly refers to natural resources such as hydropower, solar energy, wind energy, biomass energy, geothermal energy and ocean energy [3]. Among them, wind power generation is the most mature and most forward-looking commercialized development of new power generation

technologies, which can be off-grid or grid-connected. The development of wind energy is not only a short-term supplementary energy source, but also one of the foundations of the future energy system. Wind energy is a clean energy that does not generate greenhouse gases, and has had a positive impact on the protection of the environment that cannot be ignored [4-5].

Along with the historical process of manufacturing, energy development plays an important role in countries around the world. Heffron R reviews 72 countries and their introduction of energy laws in solar development. Their analysis shows that (new) legislation in some developing countries is not associated with a significant increase in the share of solar energy in the energy mix. They then highlight how solar development can be achieved through laws that can provide certainty for investment. Furthermore, they emphasize the importance of flexibility, which allows the full potential of solar energy to be realized in the energy system [6]. Sidortsov R explores how and to what extent government policies designed to support the oil and gas industry influence the outcome of the decision-making process for new hydrocarbon projects. Based on the case study of the Russian Arctic and sub-Arctic. Utilize records of key presidential meetings and speeches, as well as applicable program policy statements, laws, and administrative regulations. Data are subject to discourse and legal analysis that is supplemented and corroborated. The advantage that the benefits outweigh the risks in the policy discourse is particularly influential in the decision-making process of new oil and gas development in Russia [7]. In the long run, energy development is one of the most important issues facing economic development.

The specific work of this paper is as follows: The importance of developing wind energy resources is expounded, the Weibull distribution function is used to fit the model of wind power, and then the model of hydropower is established. The model of the controller. After the model is established, the wind power is simulated in the Simulink toolbox in MATLAB software, and the dispatching of the wind power system is effectively implemented by setting fuzzy rules and fuzzy reasoning.

2. Development and Utilization of Wind Energy Resources Based on Fuzzy Control

2.1. Development of Wind Energy Resources

(1) Cleanliness

The use of wind energy to convert mechanical energy into electrical energy is clean and pollution-free, and will not produce greenhouse gases and pollutants. Compared with traditional conventional thermal power generation through coal-fired power generation, wind power can reduce greenhouse gas and pollution emissions, and has positive environmental benefits [8-9].

(2) Low requirements on land for wind farm construction

Wind power plants can be built on land that is difficult to use in agriculture, such as the Gobi desert, grasslands, beaches and waters, with low land use costs [10].

(3) The operation of the equipment consumes less resources

Except for the manufacture and installation of wind power equipment, wind turbines do not require additional equipment to provide power during operation and do not consume other resources [11].

(4) The wind power industry can promote local economic development

Wind energy development can create clean energy industries and boost economic growth in less developed regions. The large-scale wind power industry will also create a unique cultural landscape and tourism development for tourists [12].

2.2. Suggestions on Ways to Develop Wind Energy Resources

(1) Reasonable assessment of wind energy resources

Fully understand the long-term and complex nature of changes in the energy system, and conduct comprehensive planning and design for the development and utilization of wind energy. Focus on the mid- and long-term energy demand of the renewable energy strategy, fully evaluate the development potential, cost and good growth rate of wind energy resources, and formulate a mid- and long-term scientific development plan for wind power [13]. Driven by green growth, it will pave the way for the transformation of the energy system, increase the wind energy of the energy system, and realize the transformation from auxiliary to dominant.

(2) Actively promote technological innovation in energy transition

The problems that need to be overcome in the near future are: in low wind speed areas, research and development of wind turbine products with longer blades and higher towers will bring more wind energy and expand the scope of wind power use; according to the characteristics of low wind power density and wide distribution, Develop a small, independent power supply system that integrates multiple power sources and energy storage production, and flexibly interacts with the public power grid. Through smart microgrids, wind energy resources are maximized and technological innovation is promoted [14-15].

2.3. The Basic Principle of Fuzzy Control

An important part of fuzzy control is the fuzzy manager. A fuzzy controller usually has the following characteristics: input and feedback, fuzzy input, language control rules, fuzzy logic and defuzzification of output. The input value of the controller is generally not a complete number, so the process of fuzzification is to change the input value in the fuzzy quantity [16-17]. Language control rules and fuzzy logic are the control points. According to the introduction and control rules of speech, fuzzy reference logic describes the distribution of activities. The defuzzification process transforms the output of the P output into a normal output. Finally, the controller changes the output value and the output value (i.e. the control value) to control the system [18].

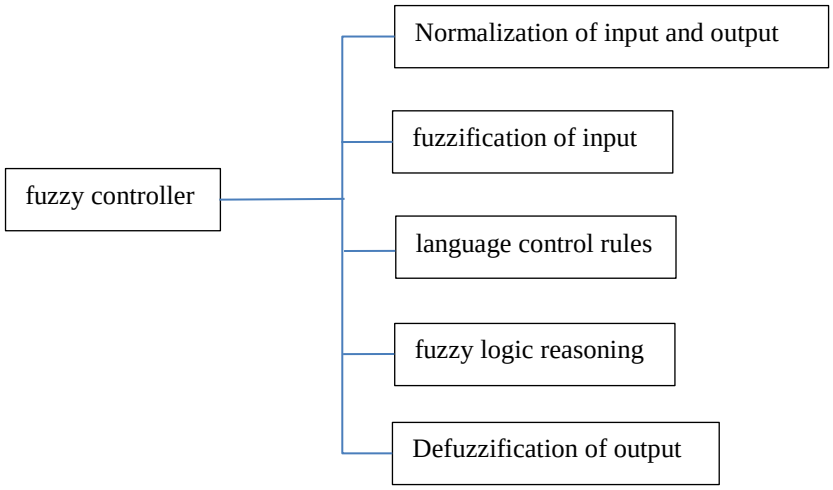

Figure 1. The composition of the fuzzy controller

Fuzzy control system has many advantages, which are briefly summarized as follows:

There is no requirement for an accurate mathematical model, and its fuzziness can be used to solve the control of complex systems and fuzzy objects.

The theoretical foundations of fuzzy control, such as fuzzy rules, fuzzy reasoning and fuzzy representation, are established on the basis of mature experience and can be updated continuously. In this way, fuzzy control has intelligence.

The core of fuzzy control system - fuzzy controller is computer-based, so it also has some advantages of computer control, such as precise digital control and soft software programming. Although the fuzzy control system has many advantages and has been widely used in many fields, both theoretical research and practical application need to be explored and developed.

3. Application of MATLAB and Simulink

3.1. Fuzzy Controller Modeling

In this paper, the FIS Editor in the MATLAB toolbox is used to design the fuzzy controller, so it is only necessary to set the value range of the universe of discourse of each language variable, and other conversion tasks are automatically completed by the tool. During the simulation, take the wind power Pf∈[0, 50], store the wind energy Ws∈[300, 2100], and output the wind energy P∈[0, 13.5], the above value ranges can be regarded as the normalized results, do not care about them The unit.

The rule base includes a certain number of control rules. Usually, people summarise them according to the actual experience of some authorities in related fields, and express them in the form of if…is…and…is…then…is…. According to the relationship between wind power, stored wind energy and output wind energy, combined with practical experience, this paper formulates 49 control rules, which are input into FIS Editor for fuzzy control.

Since MATLAB's toolbox, FIS Editor, integrates algorithms for fuzzy reasoning and clear interface, the two parts of the work do not need user control, so the design introduction of these two parts is omitted here. The FIS Editor tool can generate a " .fis " file from the above design parameters for subsequent simulation.

3.2. Simulink Model of Wind Power Generation

In this paper, wind energy and wind turbines are modeled by using Simulink software. In the MATLAB library, we have a function wblrnd(A, B) that generates Weibull-distributed random numbers, where A is the scale parameter c and B is the average wind speed k. In Simulink technology, the longest-used block building technique is the S-function. This paper uses the MATLAB language to write the S-function that can realize the random number that obeys the Weibull distribution, finds the Clock module and the S-Function module in Simulink, and connects them, as shown in Figure 2. The Clock module provides the running sequence for the S-Function module. Under each clock, the S-function will be triggered to generate a random number that obeys the Weibull distribution. Double-click the S-Function1 module, and we can set the parameters of the Weibull distribution module.

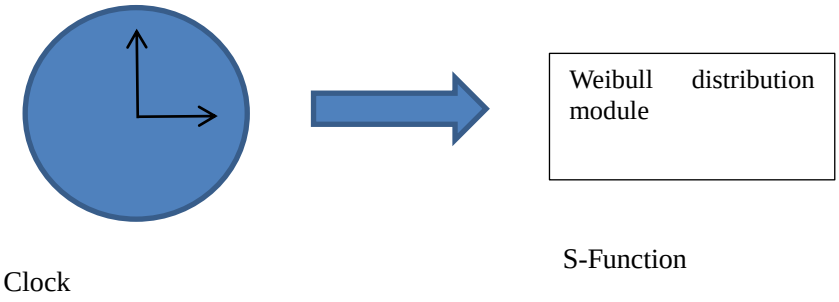

Figure 2. Simulink program to simulate wind energy using the Weibull distribution

4. Model Building and Simulation

4.1. Establishment of Wind Turbine Model

The subject of this design study is a 1.25MW variable speed turbine. It is assumed that the wind turbine used consists of a horizontally pitched rotor connected to a generator through a speed increaser. The system block diagram is shown in 3:

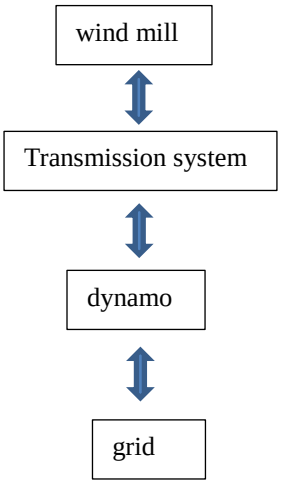

Figure 3. Block diagram of wind turbine

In order to design a good controller, it is important to build an accurate wind turbine power model. From the point of view of the control system, the wind turbine can be divided into three systems: the aerodynamic characteristics of the wind turbine, the power characteristics of the transmission system and the generator model. The wind efficiency coefficient C is a function of the tip speed ratio n and the pitch angle β, namely:

$$C_p = C_p(\lambda, \beta) \tag{1}$$

The useful power output that the wind turbine can actually get from capturing the wind is:

$$P_r = \frac{1}{2}\rho S C_p(\lambda,\beta)v^3 \quad (2)$$

in:
Pr: power absorbed by the wind rotor, (W);
ρ: air density, (Kg/m/3);
V: wind speed, (m/s);
The generator involved in this design is a wound three-phase asynchronous generator, so by changing the stator voltage, changing the reaction torque and speed of the generator to achieve variable speed.

$$T_e = \frac{pm_1U_1^2r_2}{(\omega_g-\omega_1)\left[(r_1-\frac{C_1r_2\omega_1}{\omega_g-\omega_1})^2+(x_1-C_1x_2)^2\right]} \quad (3)$$

Among them: p is the number of pole pairs of the generator; m1 is the number of stator phases of the motor; ω_1 generator synchronous speed, the unit is rad/s.

4.2. Simulation Research

Table 1 shows the simulation results of output power under various wind conditions when no controller is added, the blade pitch angle is initially set to $0°$ and the fuzzy controller is used to control the system; Table 2 shows the output power under various wind conditions Simulation results of generator speed.

Table 1. Comparison of output power overshoot at different wind speeds

Wind speed(m/s)	No controller(%)	Fuzzy control(%)
5	2	0.005
10	25	0.006
15	177	0.007
20	102	0.009

Table 2. Comparison of generator speed overshoot at different wind speeds

Wind speed(m/s)	No controller(%)	Fuzzy control(%)
5	0.85	0.01
10	1.56	0.02
15	1.58	0.02
20	2.23	0.03

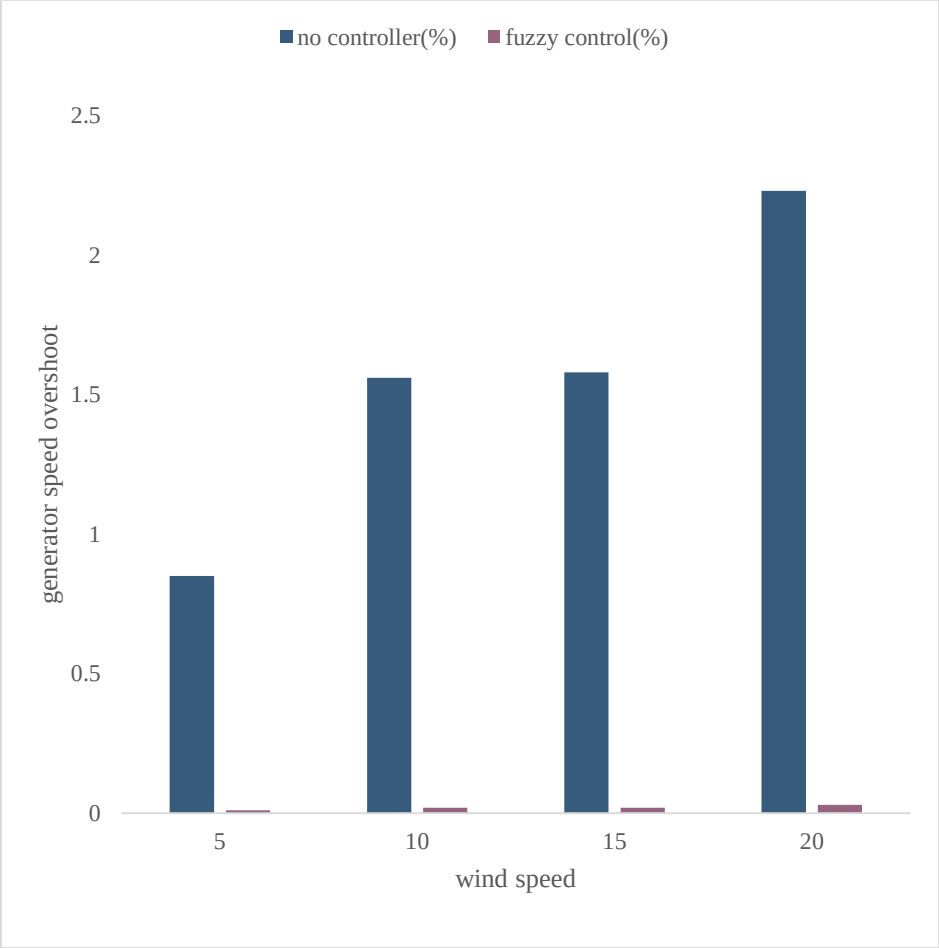

Figure 4. Generator speed comparison simulation results

From the simulation results in Fig. 4, it can be seen that compared with no controller, at low wind speed, fuzzy control can obtain stable power output and lightning speed; when running at high wind speed, due to the blade guidance of the wind turbine, the A delay, so that the output power and generator speed have small fluctuations around the desired value, but the controller's illusion can reduce the fluctuations, and the output and generator speed fluctuations are small.

5. Conclusion

When developing the economy, we only pay attention to economic growth unilaterally, and use resources uncontrollably, making the ecological environment unbalanced and exceeding the environmental carrying capacity, resulting in the failure of the ecosystem to restore its original stable state, resulting in the outbreak of various environmental problems. Therefore, on the basis of my country's national conditions, while pursuing rapid economic development, how to properly handle the relationship between man and land, rationally use resources, and not destroy the environment has become the top priority of my country's economic development. This paper mainly analyzes the operation and control process of the variable speed turbine of the new wind power generation system, and designs an intelligent controller for its control system, that is, the wind turbine of the fuzzy controller. Through MATLAB simulation programming, the control

performance of the controller is analyzed.

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Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

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