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The Optimizational Pitch Control Strategy with the Clonal Selection on Quantum Genetic Algorithm

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Abstract: The development of the wind power generation is very fast, how to improve the efficiency of the generation is the research focus. The study analyses the control strategy of the wind power generation, optimizes the power output energy conversion factor of the optimal tip-speed ratio and the optimal tip-speed ratio using the clonal selection on quantum genetic algorithm, adjusts the control strategy and brings the optimal pitch control strategy. The comparison is the optimizational control strategy and the conventional control strategy with the simulation. The power output of the optimizational control strategy is more stable, the ability of the capturing wind is strong, cutting down the wave of the generation export power.

Key words: Control strategy, power output, power output speed ratio, capturing wind

INTRODUCTION

The wind power generation development is very fast, MW wind turbine has been the important product, the control technology of the wind turbine advances too (Xun-Wen and Zeng-Qiang, 2010). Economy and reliability is the important target. Variable pitch variable speed avoids the more load, gets the wind energy (Ye *et al.*, 2010; Jian-Zhong and Ming, 2010; Li *et al.*, 2010). So it can restrain the effect of the wave power about the power grid. The design of the control strategy of the variable pitch variable speed is utmost importance; power control strategy is the research focus of the running strategy. Conventional wind turbines control strategy is: when the wind speed is under the rated wind speed, it controls the output torque of the generator, the system can get the maximum rotor power coefficient; When the wind speed exceeds the rated wind speed, it can controls the pitch angle and the generator can generate the rated power (Guo, 2010; Muyeen *et al.*, 2010; Lin, and Hong, 2010). With the variable pitch variable speed technology development, the control of the wind turbine can be realized easily (Jie *et al.*, 2010; Wei *et al.*, 2010; Chen *et al.*, 2000). But how to get the wind power and generate the maximum wind power is the important research. The paper indicates that the clonal selection on quantum genetic algorithm optimizes and designs the variable pitch control strategy (Zhi-Jun *et al.*, 2010).

MODEL OF THE SYSTEM

The rotor power coefficient of the wind turbine is function about the tip speed ratio λ and the pitch angle:

$$\text{Angle} = \beta,\ cp\text{-}cp(\lambda,\beta),\ \lambda\text{-}\ \frac{\omega_r R}{v}\ t$$

where, ω is the wind rotor angular speed; R is the rotor semi diameter; v is the wind speed.

The wind power is:

$$P_r - \frac{1}{2}\rho s c_p(\lambda,\beta) v^3 \tag{1}$$

where, P_r is absorbed power, ρ is air volume mass, S is rotor swept area and C_p is rotor power coefficient.

C_p's empirical formula is:

$$Cp = (0.44 - 0.0167\beta)\sin\left[\frac{\pi(\lambda-3)}{15-0.3\beta}\right] - 0.00184(\lambda-3)\beta \tag{2}$$

The paper's fitting function is:

$$\begin{gathered} C_p(\lambda,\beta) = 0.22\left(\frac{116}{\lambda_i} - 0.4\beta - 5\right)e^{\frac{-12.5}{\lambda_i}} \\ \frac{1}{\lambda_i} = \frac{1}{\lambda_i + 0.08\beta} - 0.\frac{035}{\beta^3+1} \end{gathered} \tag{3}$$

The wind turbine power coefficient is the function of the tip speed ratio λ and the pitch angle β, when the pitch angle is fixed, the tip speed can get the maximum value, and the power coefficient is maximum. From the function: when the pitch angle is fixed, there is the optimal the speed ratio, the rotor power coefficient C_p is the maximum, the power is the maximum of the wind turbine. The wind turbine gets the optimal output power and then the optimal power's expression is:

$$P_{opt} = \frac{1}{2}\rho s c p_{max}\left(\frac{R}{\lambda_{opt}}\right)^3 \omega_r^3 \tag{4}$$

where, P_{opt} is the optimal output power; C_{pmax} is the optimal tip speed ratio energy conversion factor; λ_{opt} is the optimal tip speed ratio.

CLONAL SELECTION ON QUANTUM GENETIC ALGORITHM (CSQ)

In clonal proliferation, we adopt clonal function to control various antibodies' clonal scale:

$$n_c = \sum_{i=1}^{n} \text{round}\left(\frac{\gamma \times n}{i}\right) \tag{5}$$

where, In it, n_c is the scale of antibody group and γ is a the clonal coefficient for controlling the clonal scale and round (.) is integral function.

The existing intelligent calculation based on quantum calculation obtains the most optimized solution by the simple measurement on quantum amplitude. It requires huge calculation work because of the random search. Therefore, the variation can be realized by quantum non-gate:

$$\begin{bmatrix}\alpha' \\ \beta'\end{bmatrix} = G_{NOT}\begin{bmatrix}\alpha \\ \beta\end{bmatrix}|1\ 0|\begin{bmatrix}\alpha \\ \beta\end{bmatrix} \tag{6}$$

The interactive relations between quantum antibodies and observation in quantum algorithm will be established that could reduce its calculation amount.

The major steps of CSQ in combination of different backgrounds of quantum information handling mechanism and clonal selection can be described as follows:

- Initialization of initial aggregation. Confirming the size of population and the numbers
- According to the unit's amplitude in Q, the observation R of quantum superposition will be form $\{a_1, a_2, ..., a_{nc}\}$. In order to speed up convergence speed; we can take the output of traditional test instrument as one of the initial observation
- We should make appraisal to the adaptive results of all of the units in the population while calculating function and judge whether the algorithm could meet iteration termination conditions
- Choose operation to generate Q_b (t) and take the best observation unit as evolutionary target
- Setting the quantum rotation gate and make it to the amplitudes that need upgrading among the units in the population. Then upgrading $Q_b(t)$ and make quantum collapse to $Q_b(t)$. The observation $M_b(t)$ will form
- Clone $M_b(t)$ and $Q_b(t)$ to produce $M_c(t)$ and $Q_c(t)$. Variation in $M_c(t)$ to. M↓d (t) Quantum antibody set will be formed by quantum non-gate
- When evolution algebra increases 1, the algorithm will go to (3) for next calculation

In genetic quantum algorithm, the calculation amount results from the setting of rotation angle and the upgrading of quantum gates. To reduce calculation burden, we should cut the 32 conditions in quantum selection solutions to one particular formula. The clonal selection solution can expand to the whole population, which could further cut the calculation burdens. The evolution of observation will not only provide us with diversified quantum observation, but also form an interactive condition. The mutually influenced and advanced result will come into being, which will make algorithm realize fast iteration and best optimization.

In CSQ, we use the genes in the antibodies to stand for the adjustable propagation parameters in P_{opt}, C_{pmax} and λ_{opt}, the range of restoration factor to stand for spectrum regulations in particular locations and a group of adaptive fitness functions to stand for the multi-objective that need optimizing. Each of the adaptive fitness function stands for one objective. As the objectives are changing in accordance with the dynamic changes of channel conditions, CSQ also needs to select adaptive fitness functions dynamically according to the conditions.

RESULTS AND DISCUSSION

The paper simulates the three blades upwind 1.5 MW variable speed and variable pitch angle wind turbine, cut-in speed is 3.5 m sec^{-1} cut-out speed is 25 m sec^{-1} the rotor rated speed is 12 r•min^{-1}; The rotor semi diameter is 70 m.

Figure 1 is the curve of the variable wind speed with the time, if in the first 5 second the wind speed is 10 m sec^{-1}, the wind speed will increase from the fifth second, the wind speed will be about 16 m sec^{-1} at the

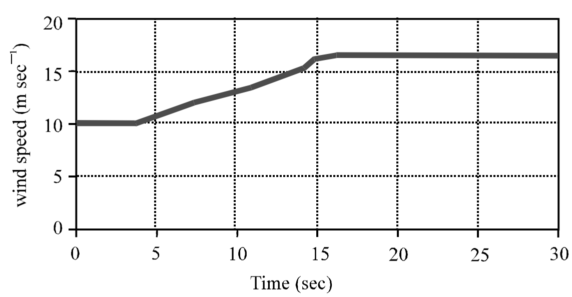

Fig. 1: The wind speed with different time

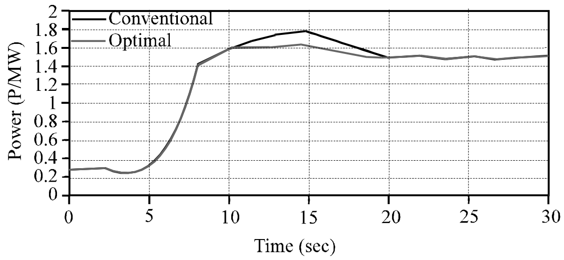

Fig. 2: The power with two control strategy

15 sec. Then it will hold to 30 sec. The simulation of the clonal strategies. selection on quantum genetic algorithm is better than the conventional control strategy, the output power is different. Figure 2 is the contrast of the two control.

The optimized control strategy can get the more wind energy in the Fig. 2 the optimized control strategy's output power is more stable than the conventional strategy. The output power of the is very stable from 10 sec to 20 sec, so the new strategy can decrease the influence to the grid, the power decreases from 1.79 to 1.62 MW the reduced wave percent is 9.497%.

CONCLUSION

The modified strategy can restrain the wave of the output power in the simulated result. The satisfaction simulation can be used in the system control strategy; however the wind speed is high or low. The output power of the generator is stable; it can improve the speed of the control system's response. The scheme of the rotor speed and the pitch angle is improved. The wind generator can run stably and reliably. The paper brings out the multivariable control strategy, is the research of the variable speed and pitch angle wind turbine. The wind turbine adopts the non-linear torque specialty pitch control strategy, optimizes the system of the wind turbine.

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