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European Journal of Applied Engineering and Scientific Research, 2023, 11 (1):1-2
(http://scholarsresearchlibrary.com/archive.html)

ISSN: 2278-0041

Utilizing a Genetic Algorithm to Improve a Wind Turbines Operating Parameters

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***Received:** 01-Jan-2023, Manuscript No. EJASER -23-96127; **Editor assigned:** 03-Jan-2023, Pre QC No. EJASER-23- 96127 (PQ);**Reviewed:**18-Jan -2023, QC No EJASER-23-96127; **Revised:** 25-Jan -2023, Manuscript No. EJASER-23-96127 (R); **Published :** 31- Jan -2023, DOI: 10.36648/2278-0041.11.1.009*

DESCRIPTION

Wind turbines are devices that generate electricity by converting kinetic energy from the wind into electrical power. Wind power is a clean and renewable energy source, and it has the potential to provide a significant portion of the world's electricity needs. The efficiency of wind turbines can be increased by optimizing their operating parameters, such as blade pitch angle, rotor speed, and generator torque. However, optimizing the operating parameters of a wind turbine can be a challenging task due to the complex and nonlinear nature of the wind turbine system.

Genetic Algorithms (GAs) are a type of optimization algorithm inspired by the process of natural selection. GAs can be used to find the optimal values of the wind turbine operating parameters by generating a population of potential solutions and iteratively improving them through selection, crossover, and mutation. The first step in using GA to optimize wind turbine operating parameters is to define the objective function. The objective function is a mathematical function that quantifies the performance of the wind turbine. It is typically defined as the power output or efficiency of the wind turbine. The objective function is evaluated for each individual in the population, and the individuals with the highest fitness are selected for reproduction.

The next step is to define the parameters to be optimized. These parameters can include blade pitch angle, rotor speed, generator torque, and other variables that affect the performance of the wind turbine. Each individual in the population is represented as a set of values for these parameters, and the fitness of the individual is determined by evaluating the objective function for these parameter values.

Once the initial population is produced, the GA iteratively improves the population through selection, crossover, and mutation. Selection involves choosing the individuals with the highest fitness for reproduction. Crossover involves combining the parameter values of two individuals to produce a new individual. Mutation involves randomly changing the parameter values of an individual to introduce new genetic material into the population. The GA continues to iterate until a stopping criterion is met, such as a maximum number of iterations or a minimum improvement in the fitness of the population. The final individual in the population represents the optimal values of the wind turbine operating parameters.

One advantage of using GA for wind turbine optimization is that it can handle nonlinear and nonconvex objective functions. Wind turbine performance is affected by many factors, such as wind speed, wind direction, and blade design, which can lead to complex and nonlinear objective functions. GA can search through the space of possible solutions to find the global optimum, even when the objective function is nonconvex. Another advantage of using GA

Citation: *Okyay H. 2023. Utilizing a Genetic Algorithm to Improve a Wind Turbines Operating Parameters J Appl Eng Sci Res.11:009*

for wind turbine optimization is that it can handle multiple objectives. In many cases, wind turbine performance must be optimized with respect to multiple objectives, such as power output and cost. GA can handle multiple objectives by using a weighted sum approach, where each objective is given a weight that reflects its importance.

However, there are also some limitations of using GA for wind turbine optimization. One limitation is that GA can be computationally expensive, especially when the search space is large. Wind turbine optimization often involves a large number of parameters, which can increase the computational cost of the optimization process.

Another limitation of using GA for wind turbine optimization is that it can be sensitive to the choice of parameters, such as population size and mutation rate. These parameters can significantly affect the performance of the GA, and selecting the optimal values for these parameters can be challenging.

Using GA for wind turbine optimization is a promising approach to improve the performance of wind turbines. GA can handle nonlinear and nonconvex objective functions, and it can handle multiple objectives. However, the choice of parameters can significantly affect the performance of the GA, and the optimization process can be computationally expensive. Nevertheless, GA remains a powerful tool for wind turbine optimization, and it has the potential to play a significant role in the transition to a clean and renewable energy future.