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風場內風機配置之最佳化研究
Layout Optimization of Turbines in a Wind Farm

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摘要

本文探討一定數量風力發電機如何配置於一既定風場，以減少尾流效應影響，獲得最佳發電效益。我們採用實際量測到的逐日平均風速，藉由尾流模型及風機發電功率模型，計算每一座風機的迎風速與發電量，再應用基因演算法與內點法，求得各風機在固定風場內的最佳排列方式。本研究分別以（一）固定風速下風場最大發電功率、（二）風場最大全年總發電量、（三）風場最小逐日與逐月發電量變異、以及（四）同時考慮最大發電量與最小逐月發電量變異之雙目標最佳化四種情境，建構最佳化分析的目標函數，並針對風場最大全年總發電量的最佳風場行驗證。也探討風機裝置數目對最佳化分析結果的影響。驗證與分析結果得知，若僅考慮目標函數為風場全年總發電量，則不同原始風速並不會影響演算法所求得的最佳風機配置結果；而在固定風場內，本研究可透過演算法求得最佳之風機裝置數目，使風場全年總發電量達到最大。

關鍵詞：風力發電、風機配置、尾流效應、基因演算法、最佳化。

Abstract

To avoid wake flow, the purpose of this study is to determine, among a given number of wind turbines in a small wind farm, the optimum plane layout of wind turbines in order to achieve the maximum efficiency of the wind farm. An analytical wake model and a power generation model are used to account for the velocity deficiency in the wake and the energy generated by a turbine, respectively. The complex nonlinear optimization problem is solved effectively by using a genetic algorithm and an interior point method to obtain the optimum placement of wind turbines. With regard to the optimization analysis, four objective functions representing different scenarios are considered in this study. They include (a) the maximum power generated by the wind farm, (b) the maximum energy generated by the wind farm in a whole year, (c) the minimum daily and monthly variations of the energy generated by the wind farm, and (d) the bi-objective optimization problem of maximizing the energy generated in a whole year and minimizing the monthly variation of the energy generated by the wind farm. The verification of the analysis is carried out for the above case (b). It is found that different ambient wind speeds do not affect the optimum layout of turbines for obtaining the maximum energy generated by the wind farm in a whole year. The optimum number of turbines to maximize the energy generated by the wind farm in a whole year within a fixed-size wind farm can also be determined accordingly.

Keywords: Wind energy, Wind farm, Wake effect, Genetic algorithm, Layout optimization.