摘 要

本研究的重點分成兩部分，第一部分為 2003 至 2005 年澎湖中屯風力發電機運轉資料分析，第二部分為風力發電機氣動性能之模擬。

由分析澎湖中屯風力發電機運轉資料的結果顯示韋伯和伽馬分佈不能完全適合地代表澎湖的風速分佈，但在全年、春、秋、冬仍以韋伯分佈代表最適合，夏天則以伽馬分佈最適合。同時也找出此型機台風速、轉速和輸出三者的關係，對於未來預測發電量或模擬風機性能上有重要的幫助。浪費百分比的分析上，現有機台並沒有充份利用澎湖當地具有的風能，未來設置的風力發電機可選用更大額定輸出功率的機台。發電量與容量因數的分析上，由發電量觀察，可看出風力發電在台灣的困境，夏天用電量最高，但發電量卻最少。另外也新定義一種容量因數，用於觀察年和年之間發電量的差異，且對於風機機械效能有較好的評估。風能輸出的預測分析上，驗證了韋伯分佈在預測風能輸出上是較準確的。

風力發電機氣動性能的模擬上，初步以 NACA-4412 翼剖面當作葉片的設計。分析的案例有兩種，第一種為給定不同風速、不同轉速下找最大輸出，第二種為固定轉速 72rpm 下，不同風速所產生的輸出。利用 Spalart-Allmaras 和 K-Epsilon 兩種紊流模式分析，得到此風機在不同條件下運轉的基本性能。靈敏度分析上顯示 Spalart-Allmaras 紊流模式比 K-Epsilon 紊流模式輸出值稍大。由速度場可看出滑流(Slip Stream)及渦流(Vortex Stream)的成份，而滑流與渦流所有之動能也是來自於空氣流動能之減少，這證明了真正的風力機是無法達到貝茲(Betz)中最大功率係數。由於目前只做到初步嘗試的階段，驗證 STAR-CD 可適用於風機性能的模擬上。後續的工作可驗證美國能源署再生能源實驗室(NREL)的實驗值，得到比較精確的模擬模式，最後再以澎湖實際機台的外型做設計，模擬整體風機的性能，和實際的運轉資料做比較。

Abstract

The paper includes two parts. The first part is the analysis of the operating data of wind turbines in Penghu from 2003 to 2005. The second part is the simulation of the aerodynamic characteristics of a wind turbine using STAR-CD computational fluid dynamic (CFD) code.

In the first part of analysis, the operating data of Penghu wind turbines are analyzed using Excel. The relations of power, wind velocity, and rotational speed of wind turbines are displayed graphically. From these relations, the performance of these turbines in a particular year can be observed qualitatively. From the results of the analysis of first part, based on the statistical chi-square test, it can be concluded that neither the Weibull nor the Gamma probability mode can be used to represent the annular distribution of wind velocity. Nevertheless, the Weibull probability provides a better fit of the wind velocity of whole year, spring , autumn and winter. The Gamma distribution gives a better result for the wind velocity distribution during summer. We also find that the power generation of the wind turbines can be reasonably predicted when the wind velocity is represented by the Weibull probability model. Based on the Weibull probability distribution of wind velocity, and the characteristics of these wind turbines, it can be concluded that part of the wind energy of the site is wasted. The percentage of wind power that is wasted is calculated. Based on the Weibull probability model of wind distribution, we can define a factor to represent the variation of wind energy in different year. Based on the new factor, we can have a better assessment of the mechanical performance of the wind turbines.

In the second part of the analysis , the aerodynamic behavior of NACA-4412 wind blade is simulated using SRAR-CD code. The results are displayed as the relation between the power vs wind velocity under different rotational speed of turbine, and power vs wind velocity with a specific rotational speed. Two different turbulent models are used in the study. These two models are K-Epsilon and Spalart-Allmaras turburlence model. The results of these two models are very similar. The wind power predicted by Spalart-Allmaras turburlence model is more than the power as predicted by K-Epsilon turburlence model. The study has demonstrated that the STAR-CD CFD code can be used to simulate the aerodynamic behavior of wind turbine.