I/ We declare that had read this work and in my/ our opinion which the project was adequate from the scope and quality for the award of the Degree of the Bachelor in Mechanical Engineering (Thermal Fluids).

Signature : ....

Supervisor Name : Mr. Nazri Bin Md Daud

Date : 14th May 2010

DEVELOPMENT OF SIMPLE WIND TURBINE

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This report is submitted as partial requirement for the fulfillment of the Degree of the Bachelor in Mechanical Engineering (Thermal Fluids).

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APRIL 2010

DECLARATION

"I declare that this thesis entitled 'Development of Simple Wind Turbine' is the result of my own research except as cited in the references"

Signature : ....

Author's Name : Mohd Firdaus Bin Mohd Nordin

Date : 14th May 2010

Specially Dedicated to My Beloved Family, Friends and Companion

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ABSTRACT

A wind turbine is a rotating machine which converts the kinetic energy of wind into mechanical energy. If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill. If the mechanical energy is instead converted to electricity, the machine is called a wind generator, or more commonly called a wind turbine. This study presents in designing and fabrication of the development of a simple wind turbine. The project is to analyze the characteristic of wind turbine design and producing a horizontal axis wind turbine that can operate properly. Besides that, the wind turbine should generate electricity as it function. For this process, after the design is finish fabricated, an experiment was undergone to determine the output power which is the electricity and also to check whether the prototype operates properly. Actually the experiment was undergone using actual wind velocity that can be gain around us but because the wind velocity is too slow and not windy, the laboratory fan was act as the alternative method to undergo the experiment. The wind velocities used were 65, 70 and 75 m/s. The wind turbine was set with the angle of 30° for its blade because this is the most efficient angle. The 75 m/s showed the maximum result where the voltage is 0.319 V, the current is 2.94 x 10^{-3} A and the power is 937.86 x 10^{-6} watt. So to make sure that all the objectives for the Projek Sarjana Muda is achieved, the experiment and procedure must be done properly and also by referring the scope of the project.

ABSTRAK

Sebuah turbin angin ialah sebuah mesin yang berputar di mana menukar tenaga kinetik daripada angin kepada tenaga mekanikal. Jika tenaga mekanikal itu digunakan secara langsung daripada mesin, seperti pam atau batu-batu pengisaran, mesin adalah biasanya dipanggil sebuah kincir angin. Jika tenaga mekanikal adalah sebaliknya bertukar kepada bekalan elektrik, mesin itu dipanggil sebuah penjana kuasa angin, atau lebih lazimnya dipanggil sebuah turbin angin. Kajian ini dikemukakan dalam mereka dan pembuatan dalam pembangunan sebuah turbin angin yang mudah. Projek ini adalah untuk menganalisis ciri-ciri rekaan turbin angin dan menghasilkan sebuah turbin angin yang berpaksi mendatar yang dapat beroperasi dengan betul. Selain itu, turbin angin ini perlu menjana bekalan elektrik sambil ia berfungsi. Untuk proses ini, selepas rekabentuk itu selesai dibuat, ujkaji dijalankan bagi menentukan pengeluaran tenaga elektrik dan juga untuk memeriksa sama ada prototaip beroperasi dengan baik. Sebenarnya eksperimen dijalankan menggunakan halaju angin yang sebenar yang boleh diperolehi sekitar kita tetapi kerana halaju angin adalah terlalu perlahan dan tidak berangin, kipas makmal bertindak sebagai kaedah alternatif untuk menjalankan eksperimen. Halaju angin yang dipakai ialah 65, 70 dan 75 m/s. Turbin angin telah ditetapkan dengan sudut 30° untuk bilahnya kerana ini adalah sudut yang paling cekap. Halaju 75 m/s menunjukkan keputusan yang maksimum di mana voltannya ialah 0.319 V, arusnya ialah 2.94 x 10^{-3} A dan kuasanya ialah 937.86 x 10^{-6} watt. Jadi untuk pastikan yang semua objektif-objektif untuk Projek Sarjana Muda dicapai, eksperimen dan prosedur mesti dibuat dengan betul dan juga dengan merujuk skop projek ini.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

P	=	wind power, watts
ρ	=	air density at sea level, kg/m^3
A	=	area swept by rotor blades, m^2
v	=	wind velocity, m/s
I	=	wind current, A
V	=	wind voltage, V
P	=	wind pressure, pa
h	=	height, m

CHAPTER I

INTRODUCTION

1.1 Overview

A wind turbine is a rotating machine which converts the kinetic energy of wind into mechanical energy. If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill. If the mechanical energy is instead converted to electricity, the machine is called a wind generator, or more commonly a wind turbine.

Horizontal axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator. Since a tower produces turbulence behind it, the turbine is usually pointed upwind of the tower. Turbine blades are made stiff to prevent the blades from being pushed into the tower by high winds. Additionally, the blades are placed a considerable distance in front of the tower and are sometimes tilted up a small amount.

Wind turbines are designed to exploit the wind energy that exists at a location. Aerodynamic modeling is used to determine the optimum tower height, control systems, number of blades and blade shape. Wind turbines convert wind energy to electricity for distribution. Conventional horizontal axis turbines can be divided into three components.

1.2 Problem Statement

Nowadays, the people that live in Malaysia are getting increase time by time due to the increasing of foreigners who come here for working, studying and also residing, besides increasing of new born child and Malaysian people itself. There are more buildings such as house, office, shop, factory and etc, which keep growing due to the increasing of people for their accommodation, work and life. Indirectly, this will affect the usage of electricity and the electricity will keep increasing. There are many sources for the production of the electricity such as from the dam and power plant and wind energy is one of the alternatives that can be use for producing electricity. Besides that, wind energy is easy to gain because it is around us and it is actually a natural and renewable energy and because of that, it is a great alternative. So this experiment will be undergoing as a preparation for seeking another way to produce electric.

1.3 Objective of the Project

The project is to analyze the characteristic of wind turbine design and produce a horizontal axis wind turbine that can work properly. Besides that, the wind turbine should generate electricity as it function. The main objectives in this project study are as following:

a) To fabricate a prototype of a horizontal axis wind turbine.
b) To gain the output power from a prototype of a horizontal axis wind turbine.

1.4 Scope of the Project

The project is involved in development and production of a prototype of a horizontal axis wind turbine. Thus, the scopes are listed as following:

a) Literature review and study of wind turbine.
b) Modeling a horizontal axis wind turbine by using Solidwork (3D).
c) Fabricate a prototype of a horizontal axis wind turbine.

CHAPTER II

LITERATURE REVIEW

2.1 Experiment

S.V.R. Wilson and P.D. Clausen (2007) had modified the blade for wind turbine and measured the blade response. The structural design of the composite blade was modified from the original design to reduce its stiffness in flapwise bending. Signals from 10 strain gauges attached to the blade were acquired every 45° in the azimuthal domain and at a fixed rate 140Hz in the time domain. The test turbine was located at a highly turbulent site with the intensity between 0.3 and 0.5 at all wind speeds. Cyclic variation in the root bending moment was nearly sinusoidal, with a small plateau in the peak possibly due to effected of large yaw angle on the blade bending moment. The blade's response to yaw was investigated for both normal yaw events which during typical day and also for extreme yaw events which occurred infrequently.

F. Wang, L. Bai, J. Fletcher, J. Whiteford, and D. Cullen (2007) studied on a small domestic wind turbine with scoop. The aim of this study is to investigate the possibility of improving wind energy capture, under low wind speed conditions, in a built-up area, and the design of a small wind generator for domestic use in such areas. The activities reported in this paper are optimization of a scoop design and validation of the CFD model. The final design of scoop boosts the air flow speed by a factor of 1.5 times equivalent to an increase in power output of 2.2 times with the same swept area. Wind tunnel tests show that the scoop increases the output power of the wind turbine. The results also indicate that, by using a scoop, energy capture can be improved at lower wind speeds. The power generation of such a new wind turbine is expected to be increased, particularly at locations where average wind speed is lower and more turbulent.

A.K. Wright and D.H. Wood (2007) analyze that the magnitude of gyroscopic rotor shaft and blade bending moments on a free yaw wind turbine rotor are proportional to the product of rotor speed and yaw rate. An analysis is presented of the relationship between two variables and wind speed, based on field test data from a 2 m diameter wind turbine with a tail-fin furling system, and in reference to the recent revision of the International Electrotechnical Commision standard for small wind turbine design. Examples are given of fast yaw rates caused by furling, and by large wind direction changes at relatively small wind and rotor speeds. Analyses of data showed that reducing turbine yaw moment of inertia increases the magnitude of maximum yaw rate for a given rotor speed, and that yaw rate is highly influenced by tail fin aerodynamics

2.2 Theoretical Analysis

Kamoun Badreddinne, Helali Ali, and Afungchui David (2005) developed an efficient numerical code, for the optimization of the aerodynamic characteristics of horizontal axis wind turbines. A vortex model has been treated based on the lifting line theory. The circulation at the trailing edge is obtained by resolving the variation problem; consisting in find the optimal circulation on the lifting line of the wind turbine, by minimizing the losses due to the induced velocities. The value of the circulation is further updated by virtue of a multiplicative factor obtained by maximizing the torque. Confrontation of the results obtained with those of Maekawa, Sharpe, a Glauert's blade element momentum theory calculations and a developed simplified model, have revealed the potential of the optimum project in predicting improved and higher rotor performances.

S. Roy (1997) studied on optimal planning of wind energy conversion systems over an energy scenario. The wind power system design must optimize the annual energy capture at a given site. The only operating mode for extracting the maximum energy is to vary the turbine speed with varying wind speed such that at all times the TSR is continuously equal to that required for the maximum power coefficient. The theory and field experience indicate that the variable-speed operation yields 20 to 30% more power than with the fixed-speed operation. In the system design, this trade-off between energy increase and cost increase has to be optimized. In the past, the added costs of designing the variable pitch rotor, or the speed control with power electronics, outweighed the benefit of the increased energy capture. However, the falling prices of power electronics for speed control and the availability of high-strength fiber composites for constructing high-speed rotors have made it economical to capture more energy when the speed is high.

J.S. Rohatgi and V. Nelson (1994) present the analysis for the generation of wind power. Power regulation and control issues must be addressed in a modern HAWT. When the wind speed increases to a value at which the generator is producing rated power, some control action must occur so that the generator does not exceed its rated capacity and overheat. Typical methods of power regulation at rated wind speed are pitch regulation, stall regulation, and yaw control or furling. Pitch regulation is accomplished by providing rotating bearings at the blade root and actively changing the blade pitch angle relative to the wind, thus regulating power. Stall control is accomplished by designing the rotor so that aerodynamic stall is reached at rated wind speed and the rotor power is limited by airfoil stall. Yaw control or furling turns the entire rotor out of the wind either vertically or horizontally at rated wind speed and regulates power by reducing the rotor area exposed to the wind. The latter approach is generally only employed on small wind turbines.

Taylor & Francis Group (2006) present the study of wind speed and energy. The available wind energy at any time depends on the wind speed at that time, which is a random variable, knowing the average annual energy potential of a site is one thing and the ability to accurately predict when the wind will blow is quite another thing. For the wind farm operator, this poses difficulties in system. Scheduling and energy dispatching as the schedule of wind power availability is not known in advance. However, a reliable forecast of wind speed several hours in advance can give the benefits like can efficiently accommodate wind generation in a timely manner, allows the grid-connected wind farm to commit to power purchase contracts in advance for a better price and also allows investors to proceed with new wind farms and avoid the penalties they must pay if they do not meet their hourly generation targets.

2.3 Programming and Simulation

M. Jureczko, M. Pawlak, and A. Mezyk (2005) had studied in developed a computer program package that would enable optimization of wind turbine blades with regard to a number of criteria. When designing a wind turbine, the goal is to attain the highest possible power output under specified atmospheric conditions. From the technical point of view, this depends on the shape of the blade. The change of the shape of blade is one of the methods to modify stiffness and stability, but it may influence aerodynamic efficiency of wind turbine. Other method to change dynamic and mechanical properties of wind turbine is modifying the composite material, which the blade is made of. The problem of determining the optimal shape of blade and determining the optimal composite material is a complex one, as the mathematical description of aerodynamic load is complex and a number of constraints and objectives have to be satisfied.

C. Nichita, M. El Mokadem and B. Dakyo (2006) doing researched on the simulation procedures for wind turbine. The main goal of the work is to develop specific procedures for implementation in wind turbine simulators designed especially for small machines. Using blade element methodology, they established procedures for the torque and power characteristics of a small wind turbine, where some physical construction parameters are known. The algorithm is developed for two simulations, which differ by the parameter used for the set of characteristics (wind speed or pitch angle).

Chen yan, Zhang Zhinceng and Ze Zhiquan (2006) had analyse simulation of a turbulent wind field for horizontal axis wind turbine. For the structural design and dynamic performance analysis of a winf turbine, a wind field model is useful to simulate the turbulent wind. Taking the turbulent flow as a stochastic process, a practical turbulent wind field model based on Veers's Fourier synthesis method is presented, and the corresponding numerical algorithm is described.

CHAPTER III

PRINCIPLE OF OPERATION AND DESIGN

3.1 Introduction

A wind turbine is a rotating machine which converts the kinetic energy of wind into mechanical energy. If the mechanical energy is used directly by machinery, such as a pump or grinding stones, the machine is usually called a windmill. If the mechanical energy is instead converted to electricity, the machine is called a wind generator, or more commonly a wind turbine.

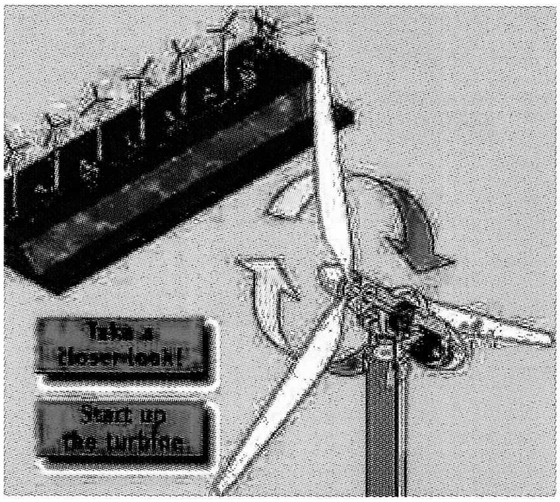

Figure 3.1: How Wind Turbine Work
(Source: http://en.wikipedia.org/wiki/Wind_turbine)

This aerial view of a wind power plant as shown in Figure 3.1 shows how a group of wind turbines can make electricity for the utility grid. The electricity is sent through transmission and distribution lines to houses, businesses, schools and so on.

The three-bladed wind turbines are operated upwind, with the blades facing into the wind and the close up for the turbine is showed in Figure 3.2. The other common wind turbine type is the two-bladed downwind turbine.

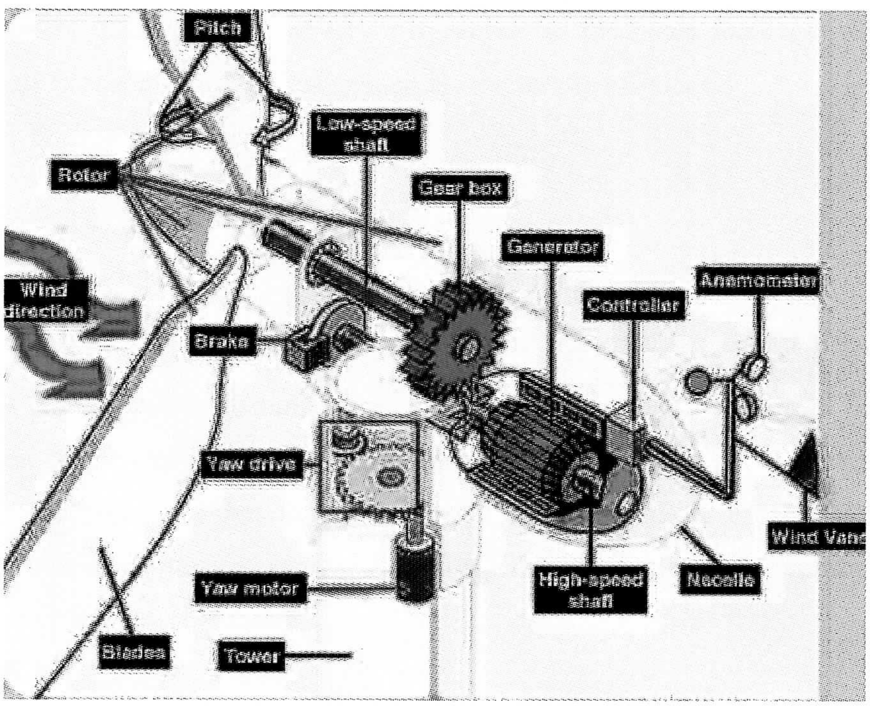

Figure 3.2: Wind Turbine Close Up
(Source: http://en.wikipedia.org/wiki/Wind_turbine)