DESIGN A WIND VENTILATOR TURBINE FOR DOMESTIC APPLICATION USING ANSYS

MOHD AZRIE BIN SUMED

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DECLARATION

I declare that this project report entitled "Design a Wind Ventilator Turbine for Domestic Application Using ANSYS" is the result of my own work except as cited in the references

Signature :
Name : MOHD AZRIE BIN SUMED
Date : 16 / 6 / 2017

APPROVAL

I hereby declare that I have read this project report and in my opinion this report is sufficient in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering (Thermal-Fluid).

Signature :

Name of Supervisor : PM Ir. Dr. ABDUL TALIB DIN

Date : 16/6/2017.

DEDICATION

To my beloved mother and father

ABSTRACT

Performance of an engineering device are mainly depends on its ability to adapt and functional at the most extreme conditions. This project mainly highlight on the design of wind ventilator turbine with and without tubercles added. The objective of this report is to to compare the CFD analysis result of drag and lift coefficient among three blade design. The blade with 15, 8 and without tubercle was put on a test. The geometry of the blade was generate using SOLIDWORK software before transferred to ANSYS software by changing the file to IGES format. The geometry was then edited to satisfy the real situation condition. Mesh was generated and the boundary condition of the model was set to avoid any error occur. The simulation was made using standard k-epsilon model. Inlet velocity of the test section was set for four different values and the calculated solution result of ANSYS was recorded and plotted. The result shows that the blade that having more tubercles are more likely to have a better input on lift coefficient. Meanwhile the drag coefficient resulted an increase pattern of graph for all simulation test conducted with different maximum values. Ratio of lift and drag force also be considered in order to compare the best blades design. By using calculation method, it is also shows that the more tubercles present on the blade edge, the higher and consistent the ratio would be which affect the effectiveness of the device.

ABSTRAK

Prestasi peralatan yang menggunakan prinsip kejuruteraan bergantung kepada kebolehan alat tersebut berfungsi walaupun dalam keadaan yang ekstreme. Projek ini khususnya mengkaji rekabentuk bilah ventilator angin turbine. Objektif kajian ini ialah untuk membandingkan keputusan analisis CFD bagi pekali heret dan naik antara tiga jenis bilah yang berbeza. Bilah yang mempunyai 15, 8 dan tanpa tuberkel telah diuji. Geometri bilah tersebut telah dijanakan menggunakan perisian SOLIDWORK sebelum dipindahkan ke perisian ANSYS dengan mengubah fail kepada format IGES. Geometri tersebut di edit bagi memenuhi kehendak pada keadaan yang sebenar. Jaringan dan keadaan garis sempadan model tersebut telah ditetapkan bagi mengelakkan sebarang kesilapan berlaku.simulasi telah dibuat menggunakan model k-epsilon piawai. Kelajuan masuk kajian tersebut telah ditetapkan kepada empat nilai yang berbeza dan keputusan kiraan solusi ANSYS telah direkod dan diplot. Keputusan menunjukkan bilah yang mempunyai teberkel yang lebih banyak lebih berpotensi mendapatkan keputusan akhir yang lebih baik berdasarkan nilai pekali naik. Sementara itu, pekali heret menunjukkan keputusan menaik dalam graph bagi kesemua simulasi. Nisbah heret dan naik juga patut diambil kira untuk membandingkan bilah yang lebih bagus.dengan menggunakan kaedah kiraan, ia menunjukkan bahawa kehadiran teberkel yang lebih banyak , lebih tinggi dan konsisten nisbah akan terhasil dimana mampu memberi kesan kepada keberkesanan alat tersebut.

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ABBREVIATIONS

mm	Millimeter
m	Meter
pa	Pascal
m/sec	Meter per Second
Fmin	Minimum Force
Nb	Number of Blades
Nu	Number of Electroactive Material
Vw	Wind Speed
km/h	Kilometer per Hour
l/s	Litter per Second
cm	Centimeter
mph	Meter per Hour
RPM	Rotation per Minutes
rad/s	Radian per Seconds
kg/m^3	Kilogram per Meter Cube

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

As a country that experienced low average of annual rainfall with 50.0 mm to 350.0 mm (Meteorological Department Malaysia), Malaysian populations prefer to install air conditioning for human comfort. Which resulted the increase of chlorine gas released into atmosphere. Therefore, wind ventilator turbine was designed as alternative to reduce global warming and provide humidity comfort as well.

This device is also known as air driven fan which mean it is free energy consumption device. Equipped with a numbers of blade, the wind ventilator turbine is said to be able to operate in low-wind velocity condition at least 5 mph. This device is super light since it is made from galvanized steel or aluminum construction in 12-inch and 14-inch sizes. These vents use the natural force of wind and air pressure to spin and vent out stale attic air.

Before any product come across the market, it need to be fully tested to prevent any malfunction which may lead to a disaster. To avoid any loss of time and virtue, a software named ANSYS was created that make these engineers job become more interesting and easier. This software can be used to simulate interactions of all disciplines of physic, structural, vibration, fluid dynamics, heat transfer and electromagnetic for engineers. Besides that, determining and improving weak points, computing life and foreseeing probable problems are possible by 3D simulations in virtual environment.

1.2 Problem Statement

The rooftop turbine ventilator now is not only widely accepted as industrial ventilation, but also has become a common ventilation feature used in other types of buildings including institutional, commercial and residential as an alternative to air-conditioning systems. This device quality basically assessed by its performance on controlling temperature in a building by transmitting hot air from the attic. To be more specifically, its performance depends on the design of the wind ventilator turbine itself. Although it is often thought to be very effective even in the lightest wind conditions, but many scientific studies found that its actual performance in the real building is not very promising due to some outdoor climatic constraints and the weaknesses of the device's configuration itself. Based on this problem, this report aim is to design a better wind turbine ventilator in order to describe its full characteristics, reliability and limitations of the device. Future turbine ventilator criteria which is not only ventilate well in high-wind speed region, but also could be an effective multifunction device even in low wind velocity region is also considered.

1.3 Objective

The objective of this project are as follow:

i. To review the mechanical mechanism used on wind ventilator turbine.

ii. Design an improvement feature on wind ventilator turbine for domestic application based on the three different blades design.

iii. Compare the CFD analysis result of drag and lift coefficient of the three blades design.

1.4 Scope of Project

The scopes of this project are:

i. Calculation and analysis of wind ventilator turbine using CFD software (ANSYS).

ii. Indicate the different of drag and lift coefficient result and data based on three different blades with different number of tubercles.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

Literature review is focused on previous study in the related field which includes the current knowledge including substantive findings, as well as theoretical and methodological contributions to a particular topic. In this chapter, journal and technical report from other researchers are reviewed and summarize.

2.2 Analysis and Design of Roof Turbine Ventilator for Wind Energy Harvest by Yung Ting et al. (2010)

This study analyzed the effect of number of blade used and the blade angle on the performance of a vertical axis roof turbine ventilator. According to the previous studies, electroactive material had already been verified its capacity for energy harvest. Roof turbine ventilator with gear mechanism that attached on the bottom side is considered to achieve that purpose. The electroactive materials employed around the ventilator will be impacted and vibrated by the rotation of gear teeth.

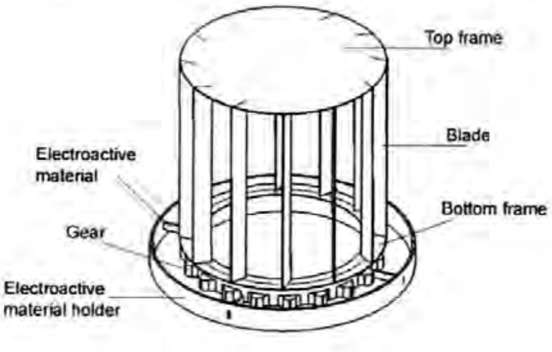

Figure 2.1.1: Roof Turbine Ventilator

2.2.1 Methodology

The experiment was carried out by testing 3 main aspect of roof turbine ventilator which are number of blade, blade angle and number of electroactive material attached. For better efficiency, straight type of blade was used in this experiment. 12 and 18 number of blade was chosen to examine the performance with various combinations of blade angle (β = 30°, 45°, 60°, and 90°). Diameter of the roof turbine used in this study is 250mm. Different number of pieces of electroactive materials (Nu=I, 2, 3, 6) are also assigned. In order to closely emulate the real environment, the wind speeds are assumed to be 3, 4 and 5m/sec.

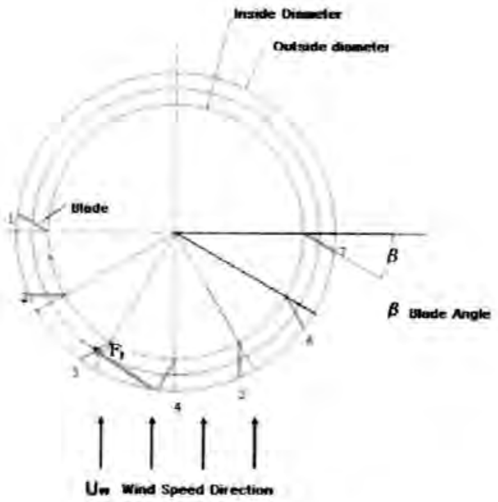

Figure 2.1.2: Top view of roof turbine and wind flow

2.2.2 Result and Discussion

i. Minimum Requirement Force for Rotation

Wind power should provide enough force to overcome the inertial of roof turbine ventilator and the deflection of electroactive material. Therefore, the minimum force to rotate the turbine blade was calculated as Table 2.1 below.

N_U (piece)	F_{min} (N)	
	N_b= 12	N_b= 18
1	0.44	0.46
2	0.84	0.86
3	1.24	1.26
6	2.44	2.46

Table 2.1: Fmin for different Nu

The force for 1 piece of electroactive material is about 0.04N and 0.06N for Nb=12 and 18 respectively. Number of electroactive material (Nu = 1, 2, 3 and 6) in this case study with 5mm vibration displacement generated in each of them. Therefore, the minimum force Fmin is calculated for Nb=12 and 18 respectively.

ii. Angle and Number of Blade Effect

From the result of experiment, its show that higher wind speed could generate more wind power so that larger driving force is obtained. At the same time the wider the blade angle, possibility to generate larger driving force is high based on Figure 2.1.3. For example, with Nu = 3 and blade angle of 90°, number of blade Nb=12 at wind speed 5m/sec is the only condition that can rotate the turbine and Nb=18 wind speed Vw=4 and 5m/sec can rotate the turbine.

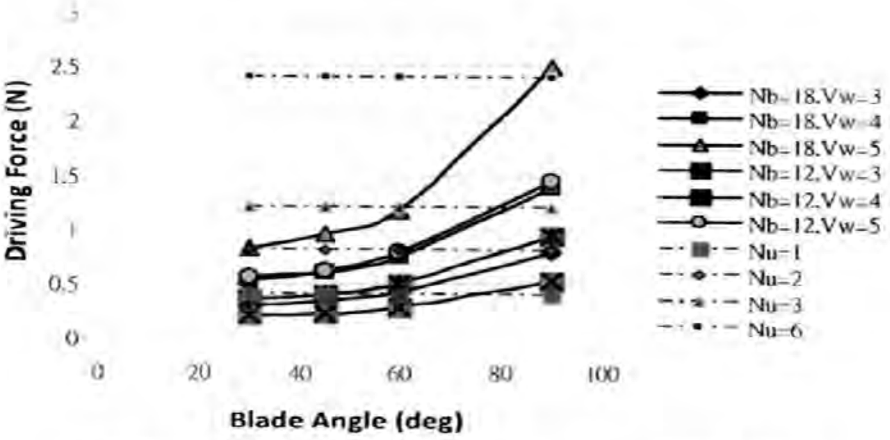

Figure 2.1.3: Graph of Driving Force against Blade Angle

Note that: Nb = number of blade

Nu = number of electroactive material

Vw = wind velocity

2.2.3 Conclusion

The roof turbine ventilator blade seem to be important for its better effectiveness in giving human comfort. It can be conclude that, the efficiency of the roof turbine can be improved by adding more blades and wider blade angle to ensure the turbine can rotate even with minimum wind speed.

2.3 Rooftop Turbine Ventilator: A Review and Update by Mazran Ismail & Abdul Malek Abdul Rahman (2012)

In order to describe rooftop turbine ventilator full characteristics, reliability, limitations and possible improvement of the device, this study discusses the current development and future prospects of the turbine ventilator by elaborating the results of some experimental and analytical work that have been done in various aspects of its application and performance. The analysis and summarized findings presented in this study also recommend some criteria that should be considered in designing future turbine ventilator which is not only ventilate well in high-wind speed region, but also could be an effective multifunction device even in low wind velocity region.

2.3.1 Methodology

Some important design aspect for a rooftop turbine ventilator have been focused in this study such as turbine diameter (size), blade height, blade configuration, openings and duct/throat diameter. The referred blade height in this study are 170, 250 and 340 mm at a fixed wind speed of 12 km/h. For blade design, 300mm straight vane turbine, 300mm curved vane turbine, 250mm straight vane turbine, 250mm straight vane turbine were tested. Besides that, throat diameter and opening of rooftop turbine ventilator also tested on 4 different design as shown on Figure 2.1.6.

2.3.2 Result and Discussion

i. Turbine Diameter

Based on previous study, Lai (2003) confirmed the consumer beliefs that the bigger size of turbine ventilator would induce higher ventilation rate. However, it was found that the ventilation rate induced by more commonly used ventilators of 14" (360mm) and 20" (500mm) are more or less the same, meaning that the rate can be considered equal when it comes to the application in engineering.

ii. Blade Height

When turbine ventilator of different vane heights of 170, 250 and 340 mm shown in Figure 2.1.4 were tested at a fixed wind speed of 12 km/h. The study found that 13.5% improvement in flow rate could be achieved if the vane/blade height is increased by 50%. This percentage can be related by increasing airflow rates of 65, 70 and 75 l /s for all 3 model respectively.

Figure 2.1.4: Variable blade height

iii. Blade Design

In terms of vertical vane or blade design, it was found that for the same size of 300mm (12") turbine ventilator, the curved vane type of ventilator had about 25% larger flow rate than the straight vane ventilator at the same wind speeds. Besides, the study on the different types and forms of turbines ventilator as shown in Figure 2.1.5 also revealed that the fabrication material of the device also affect the ventilator's capacity to induce airflow.

Figure 2.1.5: Different types of turbine ventilators under test

iv. Throat Diameter and Opening

The results of a single performance curve (embodying air extraction rates, wind speeds, throat size and pressure differentials across the devices) confirmed that the turbine ventilator with bigger throat of 300mm (12") is perform better than turbine ventilator with 250mm (10") diameter throat. The study also indicated that the simple open stub (without turbine ventilator) performed best in air extraction, thus recommended the type to be a base-line model for improving conventional turbine ventilator as shown in Figure 2.1.6.