Airco Wind Turbine Prototype Design and Development

N.A.Maidin, M.H.ARahman, M.N.Ahmad, M.H.Osman, M.K.Wahid, M.A.Latiff, S.H. Mazlan

ABSTRACT: The AIRco Wind Turbine is a new kind of product that can generate an electrical power from aerodynamic air flow that can be used to charge the phone. It is a green technology that used the wind as a source of energy to rotate the wind turbine and small electrical motor to generate an electrical power. This product is assembled and attached to the side of motorcycles basket in order to collect the wind energy to generate an electric power and also come with a gadget storage to place the phone when charging the battery. When travelling by riding the motorcycle, the energy from the aerodynamic air flow that occurs when increase the acceleration of the motorcycle can be converted to be an electrical power with adding few electrical components such as 12 volt DC electrical motor 5 volt voltage regulator and USB port which can used to charge our gadgets. It is an alternative way to generate the electrical power using the aerodynamic air flow as a free green energy. The objectives of this research are to analyze and propose the best blade design for wind flow, to design and develop functional prototype of AirCo Wind Turbine and to testing power generation from prototype.

KEYWORDS: Wind Turbine; Renewable energy; Prototype and AIRco

1. INTRODUCTION

In conventional energy are based on oil, coal, and natural gas have proven to be highly effective drivers of economic progress, but at the same time damaging to the environment and to human health [1].

N.A.Maidin, M.H.ARahman, M.N.Ahmad, M.H.Osman, M.K.Wahid, M.A.Latiff, S.H. Mazlan Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya,76100 Durian Tunggal, Melaka, Malaysia.

In order to save the environment and to human health the renewable energy is the best way to solve this problem. Hence, for this research, most suitable renewable energy than can be used is the wind energy because most energies produce occurs when the rider accelerates the motorcycles is the wind energy [2]. Wind energy is generated by converting the wind as the kinetic energy into other forms of energy using wind turbines [3].

Winds are generated by complex mechanisms involving the rotation of the earth, the heat capacity of the sun, the cooling effect of the oceans and polar ice caps, temperature gradients between land and sea, and the physical effects of mountains and other obstacles. In it function methodology, the wind turbines convert the kinetic force of the wind into a torque that is the rotational force, which is then used to propel an electric generator to create electricity [4]. Wind energy power stations that were known as wind farms, commonly aggregate the output of multiple wind turbines through a central connection point to the electricity grid. Across the world, there are both on-shore that is on land and off-shore that is out to sea wind energy projects [5]. In this research, the application of the wind turbine will be used on the motorcycles. So, aerodynamic air flow for motorcycles must be considered in this study.

The study of aerodynamics actually focuses on four thing that is the drag and lift of motorcycle, basic directional stability and also dynamic directional stability [6]. The aerodynamic usually concern with extolling the virtues of low drag and the accompanying effects on performance and fuel economy [7].

2. METHODOLOGY

Research methodology is a term that basically means the science of how research is done scientifically. It is a way to systematically and logically solve a problem, help people to understand the process of research being done, analyzes methods and the information obtained by them. In this section, it will cover up with explanation and planning about

the step and method being used to complete this research.

2.1 Detail Planning and Benchmarking

Detail planning is a crucial part in order to make sure research planning schedule went smooth as planned. Benchmarking is the process of comparing one's business processes and performance metrics to industry bests or best practices from other industries. The scope of the research becomes clearer from a feasibility standpoint. It was included its quality, cost and time. Besides, it also can see know the product are performing and it also can identify a gaps between an organization to others.

An analysis of competitive products is part of the process of establishing target specifications. Other products may exhibit successful design attributes that should be emulated or improved upon in the new product. By understanding the shortfalls of competitive products, a list of improvements can be developed that will make the new product clearly superior to those of others. In a broader sense, analysing competitive products can help orient designers and provide a starting point for design efforts rather than beginning from scratch and re-inventing. Traditionally, the evolution of design builds on the successes and failures of prior work.

2.2 Cad Drawing

At this stage, blade 1 and blade 2 suggested design will be created by using solidworkssoftware. The measurement data and sketches of concept is very important during cad drawing process, all the data and information needed is based on literature search findings as reference. The first step is to build the design part that start from the sketch and then after finish the sketch, create extrude, cut, revolve and etc. based on the desire shape. The figure 1, figure 2 below show the cad drawing in solidwork software.
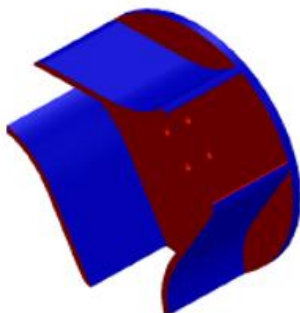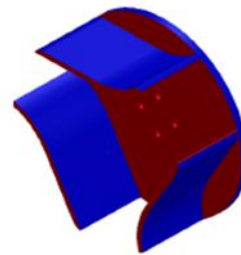

Figure1: Blade 1 cad drawing

2.4 Detail

2.5

2.6

2.7 Design

Figure2: Blade 2 cad drawing

2.3 Analysis

The analysis being carry out by using the Computational Fluid Dynamics Analysis (CFD) in the Solidwork software [8]. This Computational Fluid Dynamics Analysis (CFD) is used to analyse the air flow that generated the rotation of the wind turbine. It also will be used to analyse the air flow that passing through the path inside the wind turbine casing in order to choose the best blade design.

After finish analyse, it will proceed to the manufacturing process. Before doing the simulation, identify the parameter that need to be analyse. In this research, the velocity parameter will be used to analyse the air velocity that passing through the wind turbine blade. For this research, the wind turbine will be used at the motorcycle to collect the wind. The velocity of the motorcycle is equal to the velocity of the opposite direction (V = V terminal).

By using formula drag force, the aerodynamic force that occur when the motorcycle moving through air.Hence, for this analysis, three type of speed being used to analyse the air velocity and the turbulence intensity that passing through the wind turbine. The three type of speed is 100km/h (27.9 m/s), 90km/h (25m/s) and 80km/h (22.22m/s). For simulation, the parameter unit used is velocity (m/s) for the input velocity. Based on the design model, the position of turbine blade is at the inside the turbine casing and the analysis being built almost exact as the real design model. Both turbine blade 1 and turbine blade 2 will be analyse by using the same parameter.
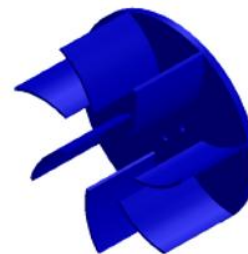
Detail design is an activity to produce a part, assembly and drawing together with the Bill of Material (B.O.M), actual material, weight, strength ratio, manufacturing requirements, easy to assemble, easy to maintenance etc. The software that will be used for CAD process is solidwork software.

The purpose to have detail design is as a technical reference which transform the sketches and data measurements into CAD drawings. By having the correct detail design, it can be used to develop analytical fabrication 2D-3D drawings for each part of the product. Once the database has been developed, prototype components can be rapidly built on computerized machines such as CNC mills, rapid prototyping, or stereo lithography systems.

ITEM NO.	PART NUMBER	QTY.
1	Left Side Casing	1
2	Right Side Casing	1
3	Front Motor Casing	1
4	Main Motor Casing	1
5	Bearing	1
6	Shaft	1
7	upper motor casing	1
8	Shaft Pin	1
9	Rear Hook Bracket	1
10	Front Hook Bracket	1
11	Washer M8	21
12	Hexagon Bolt M8x20	6
13	Hex Bolt Female	12
14	Hex Bolt M8x40	3
15	Rear Side Clamp	2
16	Front Side Clamp	2
17	Washer M4	8
18	Button Socket M4x20	4
19	Turbine Blade 1	1
20	Nut M4	4
21	B18.3.4M - 6 x 1.0 x 20 SBHCS --N	2
22	B18.2.4.1M - Hex nut, Style 1, M6 x 1 --D-N	2
23	B18.22M - Plain washer, 6 mm, regular	2

Figure4: Assembly detail design
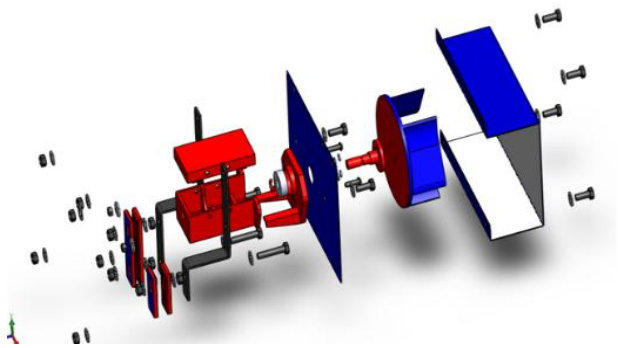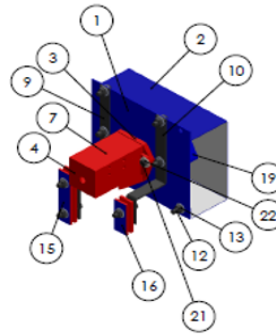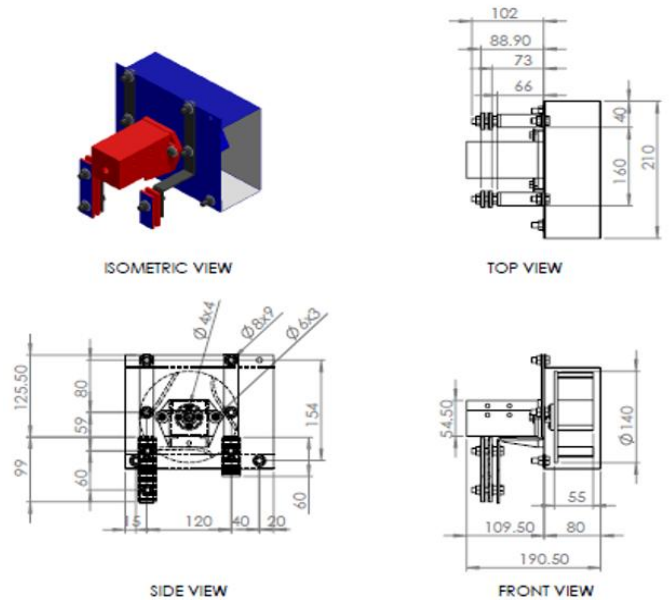
Figure3: Exploded view

Figure5: Assembly BOM

2.8 Prototype Development

During rapid prototyping process, The CAD detail drawing is save into STL file before transfer to the Rapid Prototyping Machine [9]. This STL file is the file that used by Rapid Prototyping Machine to read the CAD file and because of this, all the CAD file will be save into the STL file. But, before click to save the file, the output file format must be set in either Binary or ASCII file with fine resolution. For the 3D printer machine, there are few type of 3D printer that can be used to print the part. For this research, the PRUSA i3 Fused Deposition Modelling (FDM) 3D printer machine is used during printing the prototype. This 3D printer capable to print the material such as the ABS and PLA plastic material. This printer used a host software such as Rapetier-Host for printing setting.

The STL file component part is being open in this software. From this, some setting such as printing position for part, density of material, printing speed, temperature of bed and nozzle will be setup. Normally for the material such as ABS plastic, the temperature of the nozzle must be set in 235°C to 240°C and the bed temperature must be set to 70° to 90°C. Then by clicking the slice configuration setting, it will calculate printing time and also travel movement for printing. After finish the slice calculation, the file is save in gco format and then it can be transfer to the machine. The file will be read by machine and then it can be run for printing process. The figure 6 show the Rapetier-Host software.
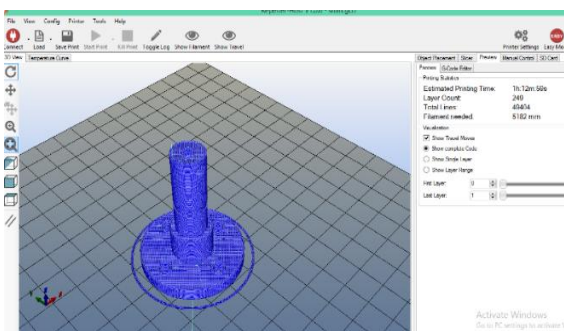

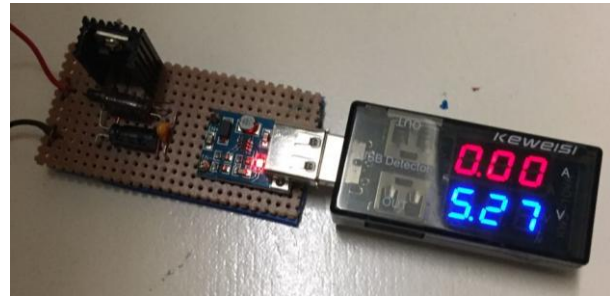Figure6: The rapetier-host software

Figure7: ABS juice glue

Figure8: Power regulator circuit diagram

Before running the printing process using this Prusa i3 printer, there are few thing that need to be set up. The first thing is the alignment between the nozzle and the bed. This can be set by using a piece of paper put between the surface of the nozzle and the bed. This setting must be set up at four corner of the bed. The second one is to set preheat ABS 1. This setting is to heat the bed at maximum temperature of 100°C and for the nozzle at maximum of 240°C before start to print.

After the bed is heated at the temperature between 60°C to70°C, an ABS juice glue is put on the bed surface in order to avoid the warping problem for the part. Figure 7 show the application of ABS juice glue on the bed. Then, by clicking the print part at the printer, the nozzle is automatically set up and start print. The screen view will show the percentage and the time of printing process. After finished printing all the part, all the part will be assemble together. This part contain the printed part, the electrical component, screw, bolt and nut. Finish assemble the part, then begin to run the testing. The AIRco Wind Turbine will be attach to the side of motorcycles basket using standard part such as the bolt, washer and nut.

2.9 Construction Model of Electrical Component

The most important part of this research is the structural of the electrical component model. DC Motor is used to generate electricity. The electricity is regulated to 5V by the voltage regulator. The figure 8 show the complete assembly of 5 Volt output circuit that being used in AIRco Wind Turbine complete with voltage measurement.

2.10 Assembly and Testing Process

The process begin from rapid prototyping development [10-11], the part assembly process together with the electrical component and then the prototype will be attach to the side of motorcycles basket using the bolt and nut. Then it is ready for testing. In testing process, the multimeter being used to evaluate the output current that be produce when we accelerate the motorcycles [12]. In order to test the wind turbine, it require the assembly at the basket. Then it will be test at the road follow the speed of 100km/h (27.9 m/s), 90km/h (25m/s) and 80km/h (22.22m/s). From this the wind turbine being test either it can be rotate or not and can it produce the voltage [13].
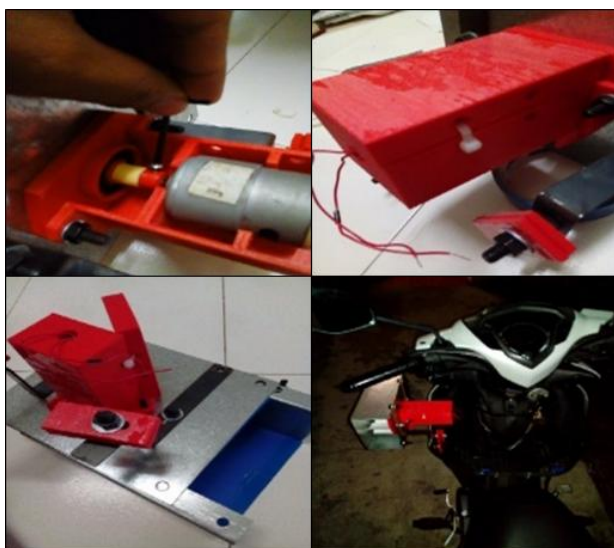

Figure9: Assembly process

Figure10: Testing process

3. RESULTS AND DISCUSSION

In this section, it will cover up with detail explanation about the output results obtained. Firstly, it begin with the simulation result [14] data that been analyse using Solidwork Flow Simulation. This is important to test the reaction of air flow that through the turbine blade proposed design and also finding the type or air flow that interact to the wind turbine. Secondly, for the actual testing, the prototype model being developed in order to test the concept and function of the prototype either it can be rotate and spinning well or not. It also to test either it can produce the objective output voltage that can charging the hand phone during riding the motorcycle. Both of this test were being conduct in parameter speed of motorcycle.

A. Turbine Blade Simulation Result

This analysis are using the Solidwork Flow Simulation. The velocity parameter that being used are 80km/h (22.22m/s). Each of blade (blade 1 & blade 2) being tested in 3D simulation model. The results obtained will be compared as shown in figure 11 below.

Name	Value	Avg. Value	Min. Value	Max. Value
Avg.Velocity (m/s)	32.428	32.394	32.327	32.434
Max.Velocity (m/s)	65.601	65.495	65.322	65.601
Min.Turbulence (%) Intensity	1.04	0.95	0.71	1.29
Avg.Turbulence (%) Intensity	8.96	8.98	8.89	9.15

②

Name	Value	Avg. Value	Min. Value	Max. Value
Avg.Velocity (m/s)	31.029	30.958	30.958	31.029
Max.Velocity (m/s)	60.025	59.966	59.813	60.120
Min.Turbulence (%) Intensity	0.98	0.98	0.94	1.01
Avg.Turbulence (%) Intensity	16.42	16.28	15.95	16.49

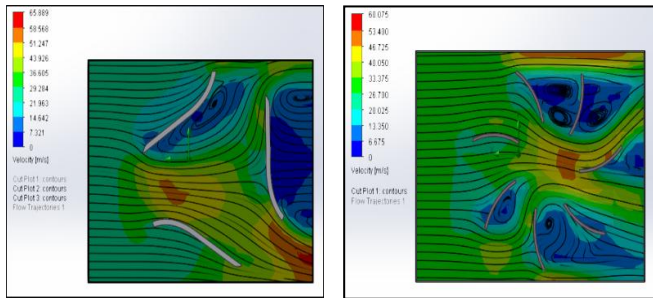Figure11: Result Data Turbine Blade 1 (1) & 2 (2) 80km/h (22.22m/s)

Figure12: Turbine Blade 1 & 2 Cut Plot Velocity (22.22m/s)

By comparing this two data of the Turbine Blade 1 and Turbine Blade 2, it find that the most different value between the two designs is the average of turbulence intensity value. The Turbine Blade 2 show the higher percentage value of the average turbulence intensity at 16.42% and the Turbine Blade 2 show the lower percentage value at 8.96%. The high percentage of the turbulence intensity mean higher inertia force that create. This inertia force can increase the speed of wind turbine. Base on this show that the turbine blade 2 can rotate in higher speed than the Turbine Blade 1. But for the average velocity show that the Turbine Blade 1 is more high then the Turbine Blade 2.

For further result, can see the cut plot of velocity. The figure 12 show the cut plot velocity result Turbine Blade 1 that appear during the analysis. Based on it show the contour colour that show the air velocity value that interact the wind blade. From this analysis show that in early entrance of the velocity flow at the state value. Then in the middle, the velocity begin to increase and continue flow until outlet. There is low velocity turbulance flow occor at the back of the turbine and also at the below side of the turbine blade.

This result show the high air velocity occur at the below center of the blade. This define that the high air velocity occor at the enterance does not give the hight inersia force to the blade instead it just release the high velocity to outlet.

Actual Testing

In actual testing, it being conducted on the road. The AIRco Wind Turbine being assemble properly at the motorcycle complete with the electrical component that used to generate electrical power that can charge the phone. The test that being conduct by riding the motorcycle by follow the parameter velocity of 80 km/h, 90km/h and 100 km/h. The figure 13 below show the output voltage in 80 km/h, 90km/h and 100 km/h. All this test were tested charging the phone during the test.

①

Speed(km/h)	Output Voltage (V)				Avg.
80	4.78	5.2	5.21	5.28	5.12
90	5.22	5.18	5.2	5.21	5.2
100	5.03	4.60	4.3	3.6	4.38

②

Speed(km/h)	Output Voltage (V)				Avg.
80	3.50	3.73	3.7	3.51	3.6
90	4.31	4.75	4.71	4.6	4.59
100	5.1	5.03	5.06	5.13	5.08

Figure13: Output Voltage (V) for Turbine blade 1 (1) & 2 (2)

In this research, one of the objective is to generate the 5 Volt current for charging the phone. Based on the table above, the result of the output data that being collected show the turbine blade 1 is quite inefficient to generating the current at the low speed of 80 km/h. But start at the 90 km/h show the voltage that been generate are almost achieve 5V.Refer to the analysis in flow simulation prove that the design of turbine blade 1 is not very suitable in collecting wind energy to generate electricity. For the design turbine blade 2, the result data that been collected show that the blade function very efficient in generating the electricity. It showing that in the speed of 80 km/h, it can generate average output of 5.12V. From this result, it prove the Turbine Blade 2 is efficient in generating the electricity for AIRco Wind Turbine.

4.   CONCLUSION

As a conclusion, in design and development a prototype was a big challenge to succeed. At the beginning, generating the concept Idea and design is more challenging because the design must meet the manufacturing capability. Mental and physical must strong enough. Otherwise, the thing designed will be just on the paper sketch. From this research a lots of new knowledge exploring and sharing contributes for the positive vibes for research especially about handling the 3D printer machine. Although, it capable in printing 3D model, sometime it quite difficult to handle because it have some error factor especially the material such as ABS plastic. This ABS plastic have the warped problem because it material properties that easy to warped when the material in cooling stage. This warping problem can easily defect the shape of the printing component. It also cause a waste material and time if the output doesn't meet the requirement. Finally everything went smooth as planned. The 3 main objective of this research are achieved.

ACKNOWLEDGEMENT

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