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Aerodynamics Analysis of Helical Wind Turbine Rotor High Speed Train

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Abstract: This project involves the design and fabrication of wind turbine system. The research is then continued to study the voltage and current produce by the fabricated wind turbine. It is used to calculate power from the wind turbine. Besides, it also shows the fabrication process of propeller by 3D printing. Then, optimal design to hold propeller. Test is conducted in a wind tunnel to evaluate the voltage and current reading at their speed limitation. Results show that power from the wind turbine is directly proportional to the speed of motor. Each condition takes one hour to finish. For each condition it have five speed to be recorded and each speed are recorded for three time with five minutes duration. Since it uses DC motor, the current generation is quite small due to reverse current which revert the current. The power generated for the system on longitudinal for design A is 0.30 watt and 10.12 watt at 29.54 km/h and 44 km/h while for design B is0.07 watts and 2.19 watts at 45.12 km/h to 59.60 km/h respectively. For transverse condition design A is 0.41 watts and 3.94 watts at 41.44 km/h and 55.79 km/h respectively but for design B there is no reading from the turbine due to need on high speed.

Keywords: *High Speed Train, High Speed Railway, Wind Turbine, HAWT*

1. Introduction

Wind energy is one of the most efficient renewable energy around the world since it is easy to be utilize and it can be found easily. Even though to get the wind energy is quite costing at first but the result after the setup it will bring more goodness toward the consumer [1-5]. As of now, there are a lot of company are interest toward this wind energy and a lot of exertion is made to create the power from this source of energy. The world is now trying to get to learn more about using the wind energy as the source for their electrical generation. As for that, high speed train should provide with their service by having a wind turbine system as the source for their power generation. Therefore, the high-speed train and wind turbine power system is the main concept for development in this project as it can be sa more precisely on the design of the propeller that can be more effective on the electric generation. As for that with designing and remodeling the optimum model of the wind turbine to be implemented on the high-speed train, the evaluation is going to be done in the wind tunnel to make it more realistic with the condition [6-9].

2. Introduction

For this project, the literature review focuses on the general information on wind turbine. This is because wind turbine just needs good air flow to rotate the propeller and generate the energy. As for the application of wind turbine in vehicle, there are number of researches have been carried out to evaluate and design the wind turbine system for land vehicles as well as for aircraft [9-11]. However, there is limited research focusing on high speed train.

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Wind energy is important as it will give some effect on economical energy supplies and would deliver issue identified with worldwide environmental change. Since year 2000, renewable energy has been the fifth key component for Malaysia to make an improvement.

Next, research about high speed train that are known as *maglev* which is stand for magnetic levitation. Magnetic levitation train or maglev is a train that use the electromagnetic system which is very power. The magnetic field that are created from the wire and battery experiment is the simple idea of maglev train rail system.

On getting the development of this power production by a moving train, once we can have a simple concept which is having a wind turbine as the kinetic mechanism that are going to make a movement.[12-13] The generation of power from the rail coach, it can still use the concept of power production from moving train but there have a few designs have been proposed. From previous study, the researchers show that his concept of invention (Fig. 1) is by using the wind pressure. By having a compressed air then it can rotate the turbine and will generate the electricity [14-15].

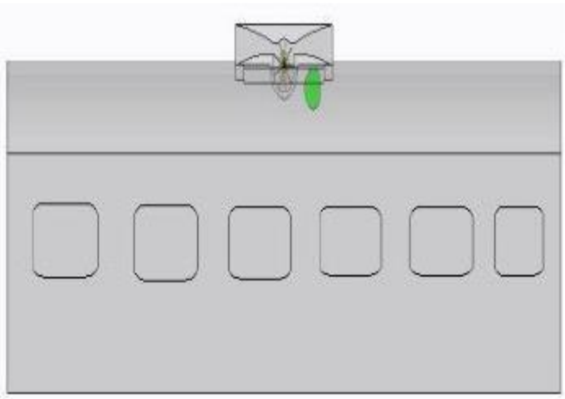

Fig. 1: The conceptual invention (Srinivasan and Engineering, n.d.)

Wind turbine power generation is the convert of kinetic energy of wind into electrical energy without making any serious environmental damages. It can be said to be the most promising distributed energy resources in the world [11]. The innovation in electronic power has enhanced on the installation and most give good efficiency (Coefficient, Coefficient, and Coefficient, n.d.).

3. Research Methodology

Research flow for this project can be presented as Fig. 2.

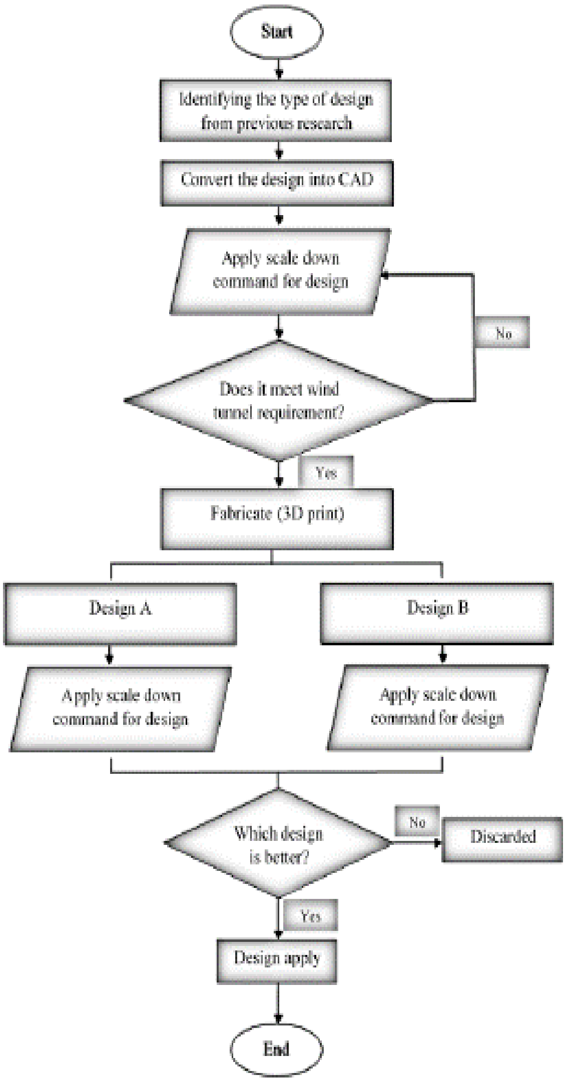

Fig. 2: Flowchart for research methodology

3.1 Design Process

The design process is a process which editing drawing so it do fit for 3D printing and meet the wind tunnel spec. At this stage, two software are used to edit the design and scale the design.

Solidworks is a software which designer use to take out their ideas into reality by drawing into solid modelling and make it to 3D dimensional shape which can make them see better before start fabricating the projects. *Bachelor's Degree Project (BDP)*

Cura is a software that need to be used after done the editing using the solidworks software. Cura is used (3-1) for slicing the object after editing process is done. Slicing means to check the internal condition of the object before it is proceed to 3D printing.

3.2 Fabrication

Fabrication process consist of three process which is 3D printing, shaft and stand/holder of propeller and testing:

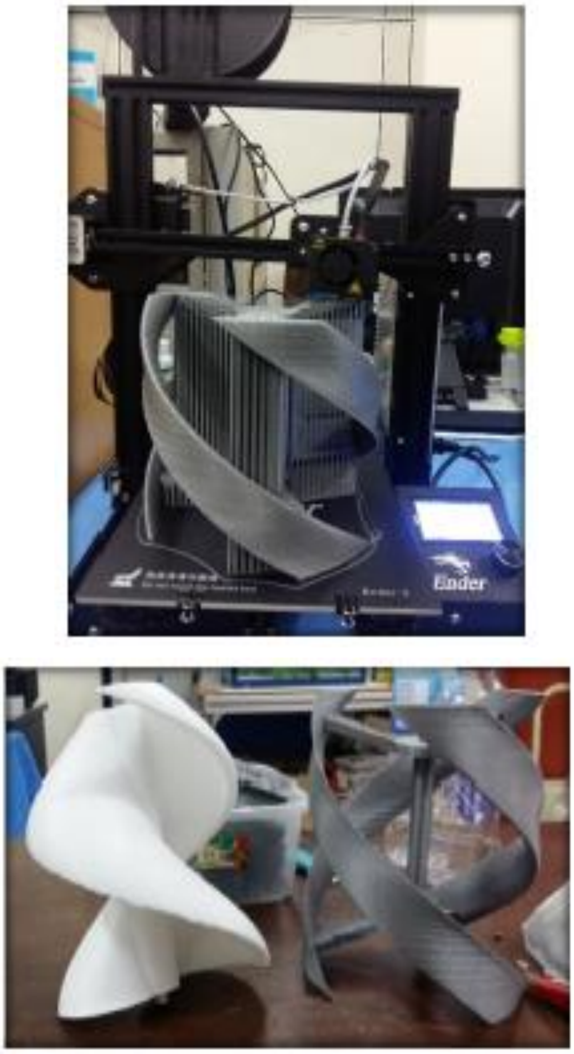

Fig 3: 3D printing process (top), fabricated product (down)

3D printing process is a type of rapid printing process. For design A, it takes about 16 hours and design B 25 hours to completed. For shaft, it uses a long shaft instead of short shaft because the different in their angle will effects the rotation of the propeller. For the holder, it is basically made from recycle material which is basically plank and wood block. For testing it have been done for two condition. Which is transverse and longitudinal condition.

Fig 4: Longitudinal Condition(top), Transverse Condition (down)

For measuring the speed of wind in m/s pitot tube is used. Pitot tube are attached to the wind tunnel and place in the front of the wind turbine.

Fig 5: Pitot tube installation

4. Results

After the fabrication process, the test has been done for all condition for both design and condition. Therefore, the results obtain from the test is recorded but for design B transverse condition there is no data obtain due to the wind turbine need higher speed to

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rotate the motor. Figure below show the full assembly of the wind turbine for design A.

Fig 6: Full Assemble

Thus, the results for each condition as shown in table below.

Table 1: Design A result Longitudinal Condition

Wind Turbine Speed (km/h)	Torque (Nm)	Voltage (V)	Current (I)	Power (W)
29.54	2.95	1.53	0.19	0.3
32.70	3.27	3.22	0.34	1.09
36.58	3.66	6.65	0.57	3.91
40.14	4.01	8.02	0.73	5.83
44.24	4.42	10.09	1.00	10.12

Table 2: Design A result Transverse Condition

Wind Turbine Speed (km/h)	Torque (Nm)	Voltage (V)	Current (I)	Power (W)
41.44	4.14	1.85	0.22	0.41
45.30	4.53	2.75	0.35	0.95
48.71	4.87	3.74	0.47	1.77
52.25	5.22	4.46	0.56	2.50
55.79	5.58	5.31	0.74	3.94

Table 3: Design B result Longitudinal Condition

Wind Turbine Speed (km/h)	Torque (Nm)	Voltage (V)	Current (I)	Power (W)
45.12	4.51	0.92	0.08	0.07
48.61	4.86	2.06	0.14	0.28
52.22	5.22	3.36	0.22	0.73
55.92	5.59	4.60	0.30	1.39
59.60	5.96	5.76	0.38	2.19

As stated before, for design B with transverse condition, there is no result obtain as the speed of the wind tunnel is at the highest speed yet the turbine is still not rotating.

Based on the result, it can be said that design A with transverse condition will be most effective as the turbine produce more stable power compare to the other designs.

On the other hand, Design A with longitudinal condition, shows undesirable results when the turbine is at high speed as it may fail due to high vibration and the speed of rotation.

Design B is not to be choose because the speed needed to rotate the turbine is very high and the power production is very low.

5. Conclusion

In conclusion, all the objectives had been achieved as the best design has been determined with the most optimum condition of turbine that are suitable to use for high speed train.

6. Recommendations

For further development of wind turbine for high speed train, there are several aspects that can be improvised:

a) The smoothness of fabricating the product which do affect the air flow of the product.
b) To have a suitable wind tunnel so that the prototype can be easily fitted into it.
c) A better enhancement on design B as it is slightly design for vertical axis wind turbine.
d) Find a better solution on make the model less friction due to material use.
e) Decide on type of motor usage. As recommended to try on AC motor which is slightly good for charging and electric supply.

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