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Experiments No. (4)

Effect of Rotor Blade Shape and Number of Blade on Wind Turbine Power Generation

Power from the wind has become an increasingly popular option for electricity generation. Unlike traditional energy sources such as coal, oil, and gas that contribute large quantities of carbon dioxide to the atmosphere, wind power relies on a non-polluting, renewable, ever-present resource the wind. In recent years, the cost of harnessing energy from the wind has become more affordable making it a viable alternative for many communities.

A wind turbine generally consists of a two- or three-bladed propeller made of aluminum or fiberglass mounted on the top of a tall tower. It converts energy from the mechanical energy of moving air to electrical energy by means of a generator. The wind causes the shaft of the turbine to spin which in turn causes a generator to produce electricity.

In this experiment, will measure the power output of a wind turbine with sum Investigation:-

1- The relationship between power output and rotor plate shape.

2- The relationship between power output and number of rotor plate.

It will use a small DC motor wind mill as a generator and a pin wheel as the turbine. The power output of the pin wheel can be determined by measuring the current and voltage produced by the motor.

Power is determined using the relationship

$$P_{Electrical} = V \times I_{Electrical}$$

Power = voltage x current

The power from the wind calculated from the relationship

$$P_{wind} = \frac{1}{2} \rho_a A_T V_T^3$$

Power from the wind$=\frac{1}{2} *$ air density $*$ Turbine area $*$ turbine velocity ^{3}

Assume: $\rho_a = 1.226\ \text{kg/m}^3$

$$V_{T=}\frac{V+V^-}{2}$$

$$\text{Turbine velocity}_{=} \frac{Air\ speed\ infront\ of\ the\ tubine + Air\ speed\ rear\ the\ tubine}{2}$$

And, turbine efficiency can be calculated from:

$$\%\eta_T = \frac{P_{Electrical}}{P_{\text{wind}}} \text{ X } 100$$

OBJECTIVES

In this experiment will

• Use a Current Probe to measure current output.

• Use a Voltage Probe to measure voltage output.

• Calculate power output(Electrical & from the wind).

• Determine the relationship between power output and rotor blade shape.

• Determine the relationship between power output and number of rotor blade at constant win speed.

• Determine the turbine efficiency for each case.

MATERIALS

1- Small DC wind generator.

2- Voltage Probe.

3- Current Probe.

4-Multi speed blower.

5- Square & helical blade shape.

6- (1) hole punch.

7-(3) wire leads with alligator clips.

8- Anemometer.

PRE-LAB QUESTIONS

1. In Part (A) of this experiment, you will change the shape of your rotor blade with different wind speed. What effect do you think this will have on the power output of your wind turbine?

3. In Part (B) of this experiment, you will change the number of your rotor blade while keeping the wind speed constant. What effect do you think this will have on the power output of your wind turbine?

PROCEDURE

Part (A) Effect of Rotor blade Shape

1. Use the square ore concave shape blade with Small DC wind generator.
2. Connect the Current Probe to Channel 1 and the Voltage Probe to Channel 2
3. Connect the motor, wires, and clips as shown in Figure 2. Take care that the red lead from the motor and the red terminal of the Current Probe are connected.

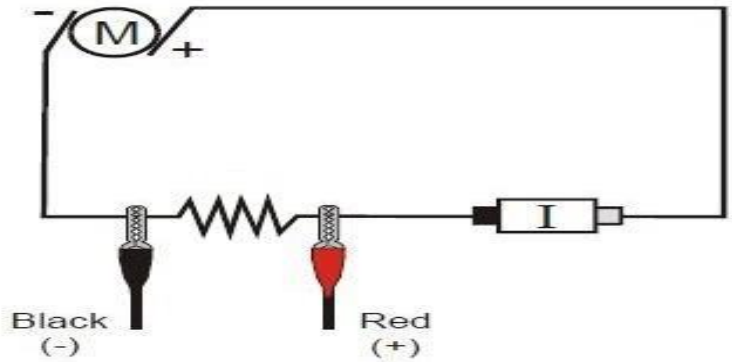

Figure 2

4-Place the pinwheel about 15 cm in front of the blower. Turn on the blower to the high setting. Wait for60 seconds until the fan reaches a constant velocity.

4. Use an anemometer to measure the wind speed.
6. If the current reading is negative, disconnect the alligator clips from the

wires on the motor and switch them.

7.If the voltage reading is negative or zero, unclip the voltage probe clips and switch them.

8.Record the current and voltage value in the data table.

9.Repeat the Steps with the use concave shape blade with Small DC wind generator.

Be careful not to change the location of the pinwheel or blower between trials.

Part (B) Effect the Number of Rotor blade

1. Use one blade of the square ore concave shape with Small DC wind generator.
2. Connect the Current Probe to Channel 1 and the Voltage Probe to Channel 2
3. Connect the motor, wires, and clips as shown in Figure 2. Take care that the red lead from the motor and the red terminal of the Current Probe are connected.
4. Place the pinwheel about 15 cm in front of the blower. Turn on the blower to the high setting. Wait for60 seconds until the fan reaches a constant velocity.

5. Use an anemometer to measure the wind speed.
6. If the current reading is negative, disconnect the alligator clips from the wires on the motor and switch them.
7. If the voltage reading is negative or zero, unclip the voltage probe clips and switch them.
8. Record the current and voltage value in the data table.
9. Repeat the Steps with the use two blades with Small DC wind generator.
10. Repeat the Steps with the use three blades with Small DC wind generator.
11. Repeat the Steps with the use four blades with Small DC wind generator.

Be careful not to change the blower speed & location of the pinwheel or blower between trials.

DATA

Part (A) Effect of Rotor Plate Shape

No.	Square Rotor blade							
				P_{wind}(W)	I(amb)	V(volt)	$P_{Elec.}$(W)	$\%\eta_T$
1								
2								
3								
4								
No.	Concave Rotor blade							
				P_{wind}(W)	I(amb)	V(volt)	$P_{Elec.}$(W)	$\%\eta_T$
1								
2								
3								
4								

Part (B) Effect the Number of Rotor blade

No.	Cncave Rotor blade							
				P_{wind}(W)	I(amb)	V(volt)	$P_{Elec.}$(W)	$\%\eta_T$
1 Blade								
2 Blades								
3 Blades								
4 Blades								

PROCESSING THE DATA

1. In the space provided in the data table, multiply current and voltage to determine the power output of the turbine.
2. What is the relationship between power output and rotor blade shape in part (A)?
3. What is the relationship between power output and rotor blade number in part (B)?
4. What are some characteristics of an ideal location to build a wind farm, a grouping of many wind turbines? What make these characteristics ideal?
5. What are some advantages of using wind power over power from traditional means such as fossil fuels? What are some disadvantages?
6. In your mind, why the wind speeds after the turbine is less than the wind speeds before the turbine? Discuss that.

EXTENSIONS

1. Plot the relationship between wind speed and turbine efficiency in part (A).
2. Investigate the effect of rotor blade shape on power output of other rotor shapes of the same diameter as the ones in this experiment in part (B)
3. Plot the relationship between number of rotor blade and turbine efficiency in part (B).