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Renewable Energy

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Experiments No. (3) Effect of Wind Speed 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 wind speed. 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



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$$P_{\text{Electrical}} = V \times I$$

Electrical Power = voltage x current

The power from the wind calculated from the relationship

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

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

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

$$V_T = \frac{V + V^-}{2}$$

$$\text{Turbine velocity} = \frac{\text{Air speed in front of the turbine} + \text{Air speed rear the turbine}}{2}$$

And, turbine efficiency can be calculated from:

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

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 wind speed.
- Determine the turbine efficiency.

MATERIALS



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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.

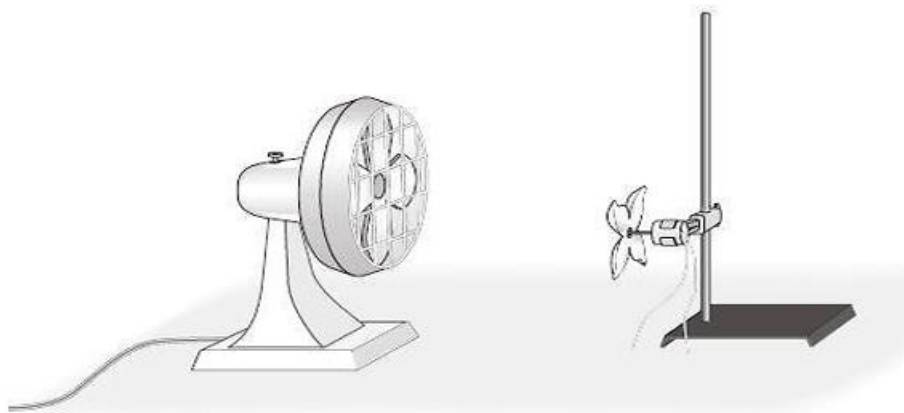


Figure 1

PRE-LAB QUESTIONS

In this experiment, it will increase the wind speed while keeping the number of rotor blade constant. What effect do you think this will have on the power output of your wind turbine?

PROCEDURE

1. Use the square shape blade with Small DC wind generator.
2. Connect the Current Probe to Channel 1 and the Voltage Probe to Channel 2



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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 for 60 seconds until the fan reaches a constant velocity.

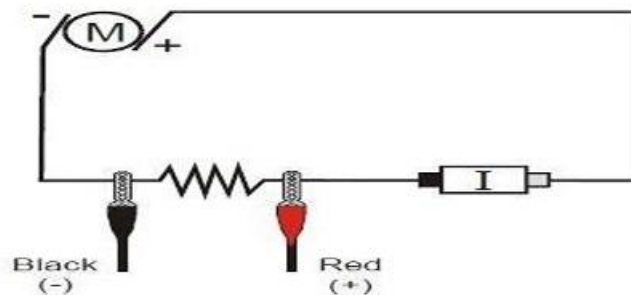


Figure 2

1. Use an anemometer to measure the wind speed in front and rear the wind mill.
2. If the current reading is negative, disconnect the alligator clips from the wires on the motor and switch them.
3. If the voltage reading is negative or zero, unclip the voltage probe clips and switch them.
4. Record the current and voltage value in the data table.
5. Repeat the Steps with the fan on the medium setting and then again on the low setting.

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



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DATA

No.	Square Rotor blade							
				$P_{wind}(W)$	$I(amb)$	$V(volt)$	$P_{Elec.}(W)$	$\% \eta_T$
1								
2								
3								
4								
5								
6								
7								
8								

PROCESSING THE DATA

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

EXTENSIONS

Plot the relationship between wind speed and power output.