Virtual and Intensive Course Developing Practical Skills of Future Engineers

VIPSKILLS

Erasmus+ 2016-1-PL01-KA203-026152

PROJECT TITLE	Wind Energy Laboratory class
OBJECT	Investigation of the power generated by the aero-generator depending on the number of blades
NAME AND SURNAME	
DATE	2018

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1. Introduction

Since the inception of the wind energy technology, machines of several types and shapes have been designed and developed around different parts of the world. Some of these are innovative designs which are not commercially accepted. Although there are several ways to categorize wind turbines, they are broadly classified into horizontal axis machines and vertical axis machines, based on their axis of rotation [1].

Horizontal axis wind turbines (HAWT) have their axis of rotation horizontal to the ground and almost parallel to the wind stream. Most of the commercial wind turbines fall under this category. Horizontal axis machines have some distinct advantages such as low cut-in wind speed and easy furling. In general, they show relatively high power coefficient. However, the generator and gearbox of these turbines are to be placed over the tower which makes its design more complex and expensive. Another disadvantage is the need for the tail or yaw drive to orient the turbine towards wind [1].

Fig. 1.1. Three bladed horizontal axis wind turbines

Fig. 1.2. Two bladed horizontal axis wind turbines

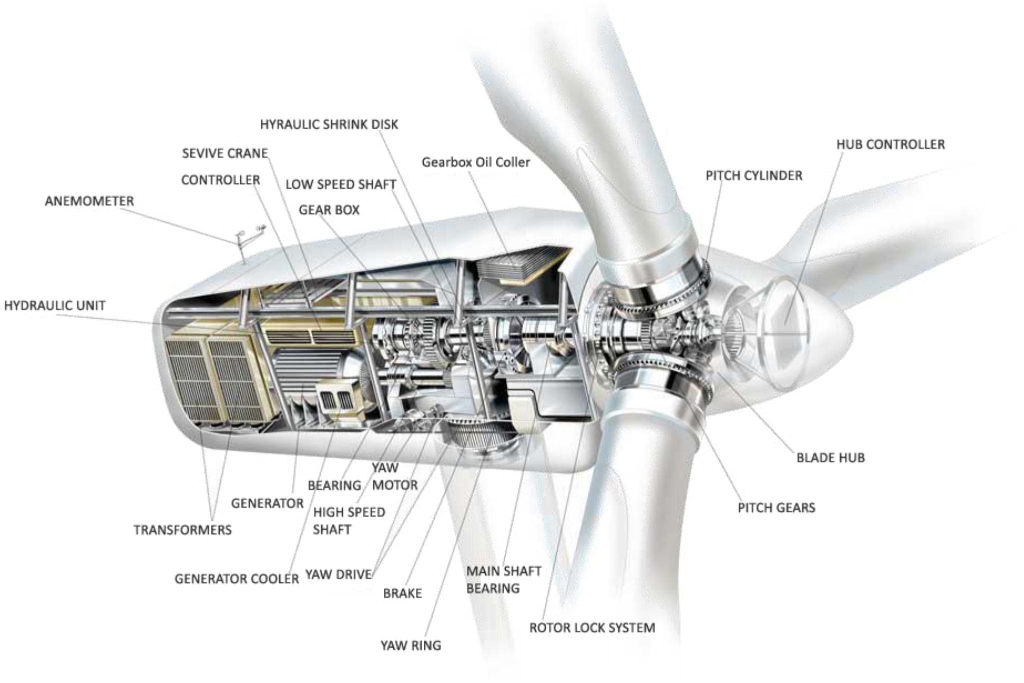


Fig. 1.3. Components of a wind electric generator[2]

Depending on the number of blades, horizontal axis wind turbines are further classified into (Fig.1.4):
- single-bladed,
- two-bladed,
- three-bladed,
- multi-bladed

Single-bladed turbines are cheaper due to savings on blade materials. The drag losses are also minimum for these turbines. However, to balance the blade, a counter weight has to be placed opposite to the hub. Single-bladed designs are not very popular due to problems in balancing and visual acceptability. Two-bladed rotors also have these drawbacks, but to a lesser extent. Most of the present commercial turbines used for electricity generation have three blades [1].

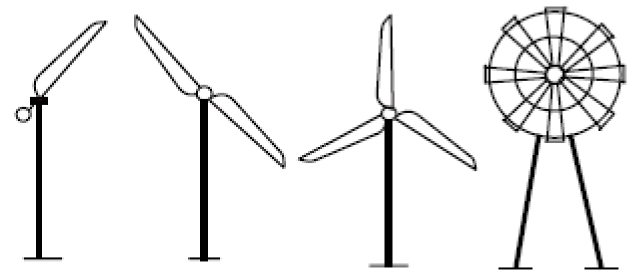


Fig. 1.4. Classification of wind turbines [1]

They are more stable as the aerodynamic loading will be relatively uniform. Machines with bigger number of blades (6, 8, 12, 18 or even more) are also available. The ratio between the actual blade area to the swept area of a rotor is termed as the solidity. Hence, multi-bladed rotors are also called high solidity rotors. These rotors can start easily as more rotor area interacts with the wind initially. Some low solidity designs may require external starting.

Now consider two rotors, both of the same diameter, but different in the number of blades; say one with 3 blades and the other with 12 blades. As the rotor swept area and velocity are the same, theoretically both rotors should produce the same power. However aerodynamic losses are bigger in case of the rotor with a larger number of blades. Hence, for the same rotor size and wind velocity, we can expect more power from the three bladed rotor. Then why do we need turbines with more blades? Some applications like water pumping require high starting torque. For such systems, the torque required for starting goes up to 3-4 times the running torque. Starting torque increases with the solidity. Hence to develop high starting torque, water pumping wind mills are made with multi-bladed rotors. [1]

Based on the direction of receiving the wind, HAWT can be classified as upwind and down wind turbines as shown in Fig. 1.5 Upwind turbines have their rotors facing the wind directly. As the wind stream passes the rotor first, they do not have the problem of tower shadow. However, yaw mechanism is essential for such designs to keep the rotor always facing the wind. On the other hand, downwind machines are more flexible and may not require a yaw mechanism. But, as the rotors are placed at the lee side of the tower, there may be uneven loading on the blades as it passes through the shadow of the tower [1].

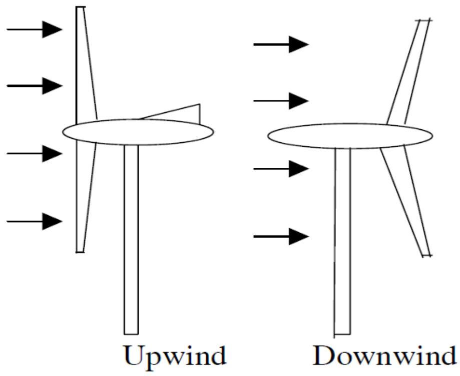
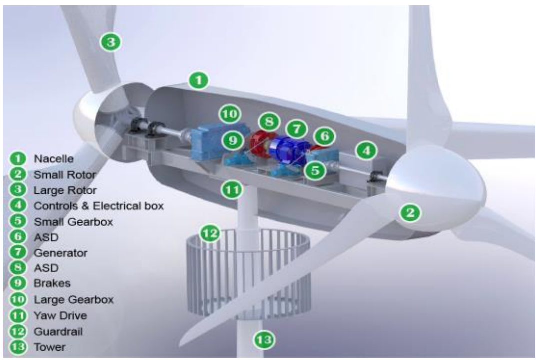


Fig. 1.5. Upwind and downwind turbines. [1]



Rys. 1.6 Mixed construction of turbines (Dual Rotor Contra-Rotating) [3].

2. Objective

As seen before, one of the factors which has more influence in the available wind power is the speed. For this reason, we will study the influence of this factor in a practical way. It is desired to demonstrate how the speed of the wind influences on the working of the rotor depending on the number of blades.

3. Required elements

a) required elements

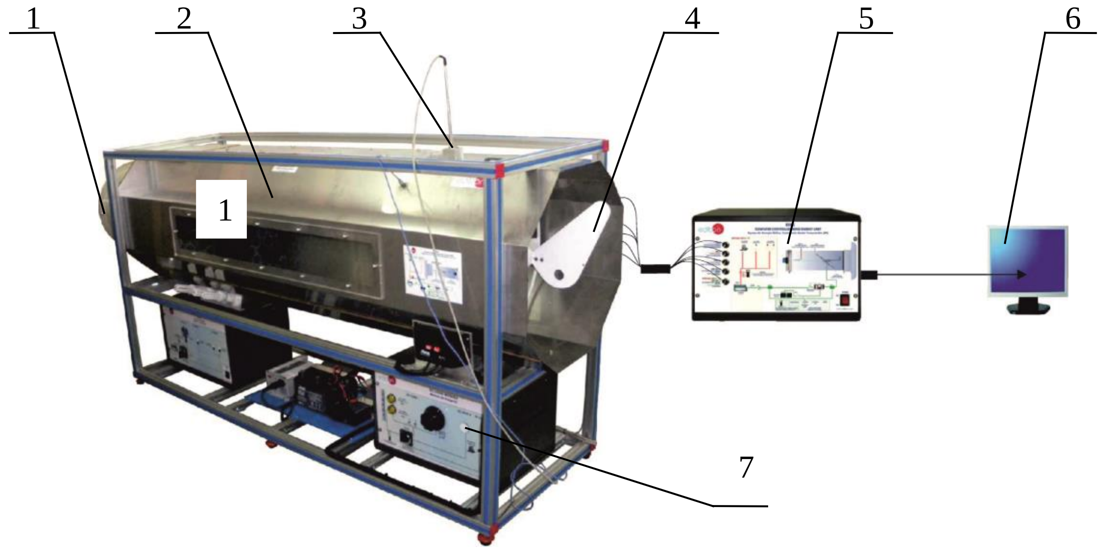


Fig. 2 Required elements: 1-fan, 2-wind tunnel, 3-anemometer, 4- rotor of three blades, 5-loads module, 6 – computer, 7 – Control System (SCADA) INIT1.

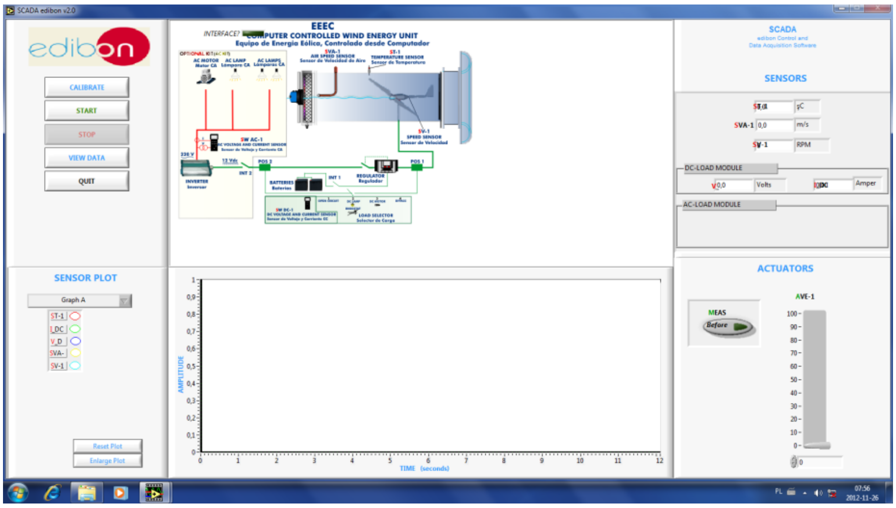


Fig. 3 Control System (SCADA)

b) practical task (fig. 3)

In order to study the power as a function of the wind speed and the number of blades, we will try to keep the density and the area of the rotor constant.

Make sure the fan is turned off before starting the task. Afterwards, follow the steps described below:

1) Turn on the main interface.
2) Set the selector of the DC module to “lamp”.
3) Turn on the DC module.
4) Run the SCADA, eeec.exe. Make sure that the PC is connected to the main interface via the SCASI cable.
5) Set MEAS selector to BEFORE.
6) Turn on the fan.
7) Fix the first fan speed (10%), it will be gradually increased.
8) Take speed values (AVE-1: 10%). Write down the voltage, current and rotation speed given by the software in the table.
9) Increase the fan speed.
10) Repeat steps 8 and 9 for 20%-100% AVE-1 position for 2 and 3 blades.
11) Write results in table 1.
12) Turn off the fan.

c) results and tables

The power output of a wind turbine:

$$P = U \cdot I \quad W \tag{1}$$

where:
U - voltage [V],
I - current [A].

Put all measured and calculated data into Tables 1 and 2.
Draw function: P=f(v), n=f(v) for 1, 2 and 3 blades.
Comment on how the wind speed influences the captured power.

d) comment:

How does the number of blades wind speed influence the captured power and the speed of the rotor?

Table 1. Results of the experiment.

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1 blade

AVE-1	v	I	U	P	n
[%]	[m/s]	[A]	[V]	[W]	[rpm]
10					
20					
30					
40					
50					
60					
70					
80					
90					
100					

2 blade

AVE-1	v	I	U	P	n
[%]	[m/s]	[A]	[V]	[W]	[rpm]
10					
20					
30					
40					
50					
60					
70					
80					
90					
100					

Student's name:

Date:

Reference list

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2. www.renewableenergyhub.co.uk
3. http://www.zecwindpower.com
4. www.edibon.com/