Design of an active pitch control for small horizontal-axis wind turbine

J. Vilà[1], N. Luo[1], L. Pacheco[1], T. Pujol[2], J.R. Gonzalez[2], I. Ferrer[1], A. Massaguer[2], E. Massaguer[2]

[1] Department of Electrical Engineering, Electronics and Automation, University of Girona, Campus Montilivi, 17003 Girona (Spain)
[2] Department of Mechanical Engineering and Industrial Construction, University of Girona, Campus Montilivi, 17003 Girona (Span)

Phone number:+0034 686 750 724, e-mail: joaquim.vilab@udg.edu; ningsu.luo@udg.edu

1. Introduction

- State-of-the-art micro-wind turbines (< 5 kWp) use passive pitch control technologies.
- An active pitch control implemented in a micro-wind turbine may improve both performance and safety [1].
- A simple, robust and economical active pitch control mechanism is designed, manufactured and tested in a open-circuit wind tunnel.
- The active pitch control mechanism is controlled by low cost electronic elements.

2. Laboratory facilities

- Original micro-wind turbine of 6 blades with rated power of 90 W at 12 m/s (M-300, Guangmang, see Figure 1).
- Laboratory tests in an open-circuit wind tunnel (Figure 1). Fan of 18.5 kW (TFT/2, Solé-Palau). Variable speed drive (Altivar Process 600, Schneider Electric) to control the fan.
- Data acquired: wind speed, load resistance, current, voltage and power generated by the wind turbine.

Fig. 1. Open-circuit wind tunnel at the Energies laboratory at the University of Girona.

3. Active pitch control design

- Mechanism designed for wind turbines with 3 blades (see Figure 2a).
- Pitch rotation based on the Scotch Yoke mechanism. Central prismatic element with three slits acting as slider guides for the heads of the rods connected to the blades (see Figure 2b).
- A linear actuator, connected to a thrust ball bearing, linearly moves the prismatic element through sliding guides (see Figure 2c)
- Sensors and economical 8 bits PICs are used to control the system (Figure 3).

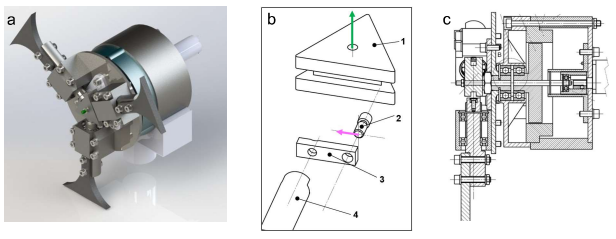

Fig. 2. General view of the mechanism (a); detail of the Socth Yoke mechanism for the pitch rotation (b); cross-sectional view of the mechanism (c).

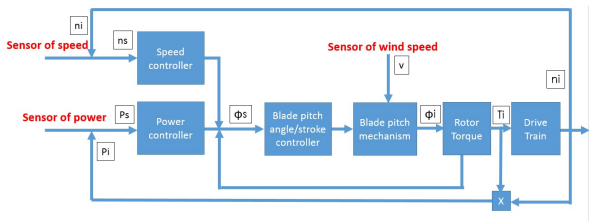

Fig. 3. Block diagram of the working mode for the pitch electronic control.

4. Modified micro-wind turbine

- Non-standard elements manufactured with 3D printing technology (Figure 4).

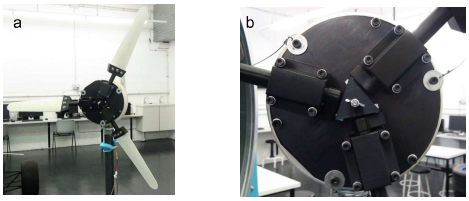

Fig. 4. Final assembly of the modified micro-wind turbine with active pitch control (a) and detail of the mechanism (b).

5. Experimental results

Fig. 5. Prototype installed at the exit of the open-circuit wind tunnel ready to be tested

- Output power as a function of the load resistance tested in the open-circuit wind tunnel (Figure 5).
- Pitch angle has a strong influence on the extracted output power (Figures 6-7).
- Load resistance that maximizes power output changes with pitch angle value (Figures 6-7).
- The mechanism is robust and reliable.

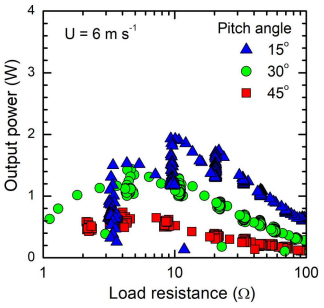

Fig. 6. Output power as a function of load resistance for different values of pitch angle. Inlet mean wind velocity equal to 6 m s^{-1}.

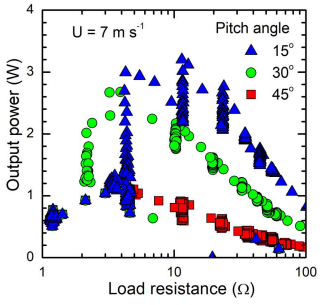

Fig. 7. Output power as a function of load resistance for different values of pitch angle. Inlet mean wind velocity equal to 7 m s^{-1}.

6 Conclusions

- An active pitch control mechanism for a horizontal-axis micro-wind turbine has been designed.
- A proof of concept of the mechanism has been manufactured and tested in an open-circuit wind tunnel.
- Results show a high influence of the pitch angle on the micro-wind turbine performance.
- Further studies are required to set up the control system so as to increase the power output in comparison with commercial micro-wind turbines.

References:

[1] Pozo, F.; Vidal, Y.; Acho, L.; Luo, N.; Zapateiro, M. Power regulation of wind turbines using torque and pitch control. *American Control Conference*, Washington DC, USA. June 17-19, **2013**.

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