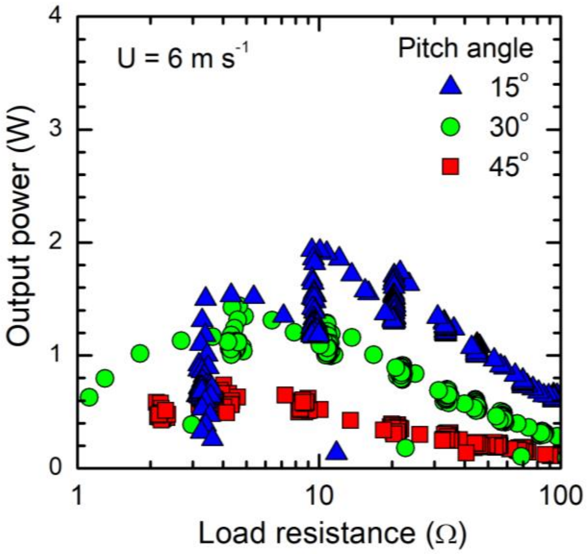

Fig. 10. Output power as a function of load resistance for different values of pitch angle. Inlet mean wind velocity equal to 6 m s^{-1}.

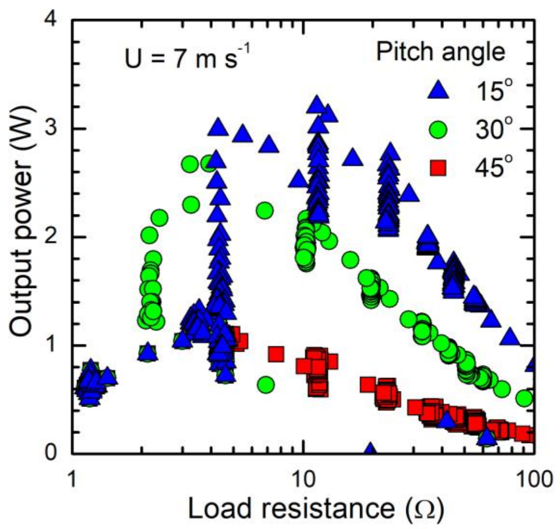

Fig. 11. Output power as a function of load resistance for different values of pitch angle. Inlet mean wind velocity equal to 7 m s^{-1}.

From Figures 10 and 11 we clearly observe that the pitch angle has a strong influence on the extracted output power. A 15º variation (pitch angle from 15º to 30º) slightly decreases the performance (-26% for U = 6 m s^{-1}; -16% for U = 7 m s^{-1}). However, a further 15º variation (pitch angle up to 45º) dramatically reduces the maximum output power (-49% and -56% for U = 6 m s^{-1} and 7 m s^{-1}, respectively). It is very remarkable that the change of maximum output power when changing the pitch angle from 15º to 30º angle is not so relevant for the case with higher wind speed (U = 7 m s^{-1}). In this case, the difference is only 16%, indicating that, as wind speed increases, the maximum output power may be attained when blades have a higher pitch angle value.

We also observe that the maximum output power at different pitch angles is achieved at different load resistance values. In comparison with the commercial model, the maximum values achieved at pitch angle 15º for U = 7 m s^{-1} is 3.2 W only, whereas the commercial unit was almost 15 W (see Fig. 2). As explained in Section 4, the reduction in the number of blades and the increase in size diameter have implied the decline in the performance.

All in all, the results indicate the interest of modifying the blade pitch angle even for small wind turbines and validate the technical feasibility of the proposed design of an active pitch control system.

6. Conclusions

We have designed an active pitch control for a horizontal-axis micro-wind turbine with the purposes of increasing its performance and of making the device more robust against gust and high winds. The mechanism is based on a Scoth Yoke, being simple, robust and economical. The smart control of the system is also carried out through simple and economical sensors and boards.

A proof of concept of the mechanism has been manufactured with 3D printing technology. The assembly has been tested in an open-circuit wind tunnel.

Results show the high influence of the pitch angle on the micro-wind turbine performance. Output power data obtained at different wind speed values and pitch angles suggest that an active pitch control may extract more energy than that obtained with fixed blades. Therefore, this technology applied to mini-wind turbines appears as a feasible candidate to improve the performance from current devices.

Acknowledgement

This work has been cofunded by the European Union through the European Regional Development Funds (FEDER). It has also been cofunded by the Secretaria d'Universitats i Recerca del Departament d'Empresa i Coneixement de la Generalitat de Catalunya through the Agència de Gestió d'Ajuts Universitaris i de Recerca under contract Ajut Llavor - 2019 LLAV 00003.

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