European Association for the Development of Renewable Energies, Environment and Power Quality (EA4EPQ)

International Conference on Renewable Energies and Power Quality (ICREPQ'10)
Granada (Spain), 23th to 25th March, 2010

Self-Powered Passive Adaptive Control of Pitch Angle and Betz-Shaped Wind Tunnel

S C Li
School of Engineering, University of Warwick, Coventry CV4 7AL, UK
E-mail: S.Li@warwick.ac.uk

ABSTRACT

For small turbines, the control of pitch angle is usually not a choice though it could keep turbine working in high efficiency zone while wind speed changes. The high cost and the complexity of this control system prevents its application in small turbines because it will further push up the already high costs of capital investment and maintenance, further worsening the bottle-neck problem of wind power generation.

In order to solve this technical issue, we have developed a conceptual design which employs a self-powered passive adaptive control system (SPACS) for pitch angle adjustment together with a Betz-shaped wind tunnel which can reduce the size and running cost significantly if compared with those of conventional wind tunnels. In this paper the main technical principles will be presented together with some conceptual sketches and initial results.

Fig. 1. Model wind turbine with the pitch control mechanism in the hub

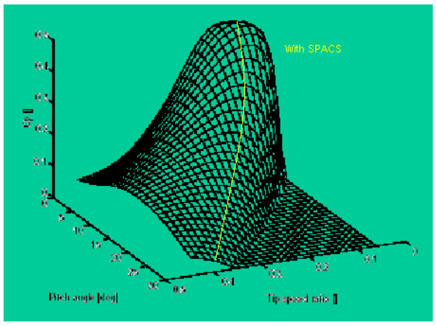

Fig.2 SPACS makes the turbine always operating at high performance

To test this concept, a model wind turbine was designed with an outer diameter of 700 mm for designed wind speed of 7.5 m/s as shown in Fig. 1.

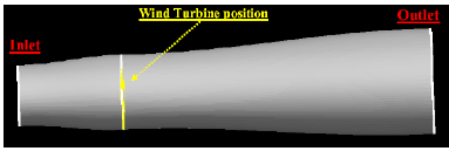

Fig.3. Sketch of the tunnel

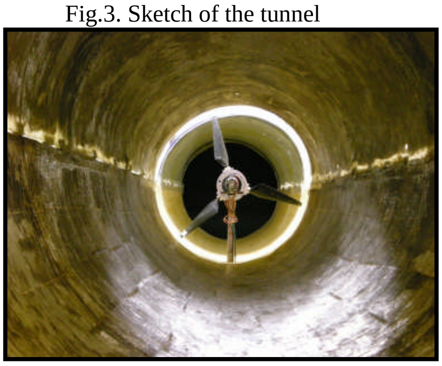

Fig.4. Internal view of the Betz tunnel with model turbine

The principle of the SPACS is as follows. The aerodynamic force acting upon on the blade is used as control power for adjusting the pitch angle with the variation of wind speed while the balance force is provided by a set of compression springs. The characteristics of the springs are such designed that makes the blade always maintain at the desired (high efficient) pitch angles while wind speed changes. That is, the operating points of the turbine are always on the ridge of the performance curves as shown schematically by Fig. 2.

The instability of SPACS is achieved by carefully choosing the rotating centre and controlling the mass centre as well as designing the aero-profile of the blade. That is, a delicate interplay of three centres: rotating centre, mass centre and aerodynamic centre will allow/ease the parameter selection of the control system such as the spring constant (characteristics), dashpot constant etc.

The Betz-shaped tunnel has been purposely developed to ensure that the test of turbine can be performed in a small wind tunnel (roughly in the same order of turbine diameter) but provide the data with same accuracy as those from large (4-5 times larger than the turbine diameter) tunnels which satisfying the infinite boundary conditions. Such a Betz-shaped test tunnel has been built up in the lab as shown in Fig.3. Figure 4 shows the tunnel mounted with the model turbine in the lab.

Acknowledgement:
The contributions from students working on MSc research projects and MEng group projects originating from this novel concept are highly appreciated.