ABSTRACT

Wind turbines benefit from decades of technological developments and are currently close to the Betz limit of maximal efficiency. However the starting of these turbines is still a challenging issue. Optimizing for high efficiency and having an early start (a low starting wind velocity) leads to contradictory calibrations of the turbine. At startup the angle of attack of the wind on the blade is much higher than 45 degrees. Increasing the fluid torque around the rotor in order to lower the starting wind velocity means increasing the pitch angle. Conversely, high efficiencies are characterised by low pitch angles. In this case some wind turbines are even unable to start by themselves.

Concerning small wind turbines, nearly all have neither engine for starting nor variable pitch angle because it would not be cost effective. In addition they are often located near places of energy consumption and do not experience optimal wind conditions. Thus in these areas of low and unstationnary wind velocities, it is vital to have a low starting velocity and a fast transitional regime, to avoid frequent and long "idling periods" or down periods. Finally because the fluid torque scales as the radius R^3 whereas the swept area scales as R^2, it is all the more difficult to start wind turbines as they are small.

A solution to that issue, currently more and more studied, is to replace active tip, active twist, active flap and trailing edge flaps by passive variable pitch angles using flexible blades along the chord. This idea is mostly inspired by studies on fish swimming, insect flight and plants reconfiguration. For exemple flexibility of insects wings is a way to redirect the aerodynamic force and to increase the thrust. In the same line of thought, reconfiguration reduces the drag force on plants.

In this talk we explore experimentally and theoretically how flexible blades improve starting performance of a wind turbine without damaging the efficiency in operation. The criteria to evaluate the starting of the turbine are the starting wind velocity U_S and the acceleration during the transient regime. Experiments show that a moderate blade flexibility improves significantly the starting performance of the wind turbine: a larger fluid moment applied on the rotor, (ie a smaller starting velocity U_S and cut-off velocity U_{CO}), and a larger initial acceleration. We discuss these results in details, pointing out the scaling laws at stake for moderate blade flexibilities.