Scientific Report: Serration Technology on Airfoil: Unsteady Aerodynamics and Aeroacoustics

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Description and aims

As wind turbine blades move through the air, they produce noise. To protect residents, maximum noise levels are set that may not be exceeded. To stay within the noise limit, wind turbines often need to operate at reduced speed, which makes wind energy effectively more expensive. Reduction of noise without reducing the rotor speed would therefore make wind energy cheaper and, hence, a more attractive alternative for fossil energy.

Wind turbine airfoil noise can be generated at the leading edges of the blades, through interaction with the atmospheric turbulence, or at the trailing edges, where turbulence in the boundary layer that develops on the blade surface scatters into sound. Interestingly, the same mechanisms are also responsible for a major source of noise in modern aircraft engines.

Airfoil noise can be reduced by serrating the edges like saw teeth, inducing destructive interference and loss of spanwise coherence. Other types of serrations, like brushes, pins, wavy or porous edges, are possible too. All these blade modifications are inspired by the wings of owls, who can fly without being heard. A vast amount of research on airfoil serrations, both theoretical and experimental, has been performed over the past 20 years, at universities and research establishments and by the industry. But still there is no complete understanding of the mechanisms.

The aim of this workshop was to bring together senior experts and a new generation of researchers from universities, research establishments, wind turbine and aircraft engine industry: aerodynamicists, acousticians, experimentalists, numerical experts and mathematicians. The idea was to assess the state-of-the-art of the prediction methods and the experimental capabilities, to identify challenges and to investigate possibilities for future co-operations.

The following challenges were identified:

(a) The aerodynamic performance must be maintained while reducing noise.
(b) Trailing edge serrations should be flexible, but what is the optimum stiffness?
(c) There is significant difference in experimental results from different facilities.
(d) Improvements of large-scale experimental facilities are necessary to account for the full range of relevant frequencies.

Format

In separate discussion groups the possibilities for joint future activities were discussed, for example measurements on a benchmark airfoil in several facilities. All participants were invited to join a COST action.

Scientific developments

Highlights of the workshop were the presentations about the rapid developments in “Particle Image Velocimetry” for unsteady flow measurements and “Lattice-Boltzmann” for CFD/CAA. Furthermore, a new serration type, a combination of saw tooth wedges and pins, showed to have high potential. The researchers were pleased to hear, from a wind turbine industry representative, that 1 dB noise reduction already leads to significant increase in wind energy production. In other words, this type of noise research is absolutely worthwhile.

The participants were all positively surprised by the venue and the workshop format.