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On the impact of anemometer size on the velocity field in a closed wind tunnel

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ABSTRACT

In the present paper, experimental and numerical investigations of the flow around different types and sizes of anemometers are presented and discussed.

The measurements of the flow field at different distances upstream of the anemometer are performed with a laser Doppler Anemometer. The computational results are in good agreement with the experimental ones since the observed deviations are of the same order of magnitude. These results show that anemometers may induce a strong distortion of the velocity field, even far upstream of the anemometer. This distortion has to be taken into account in the anemometer calibration field to yield reliable and consistent measurements.

1. Introduction

The effects of the distortions of the velocity field by a body introduced in a wind tunnel are even now not fully explained. Some investigations have already been led, mainly related to aeronautical research [1,2] and wind energy [3]. In these cases, wind tunnels are used as experimental tools to help in the design of aircraft or wind turbine parts. However, because of its finite size, the flow conditions are slightly different in a wind tunnel compared to those in an unbounded flow field where the bodies under test are found. Empirical equations are often established to correct the effects of buoyancy, solid and wake blockages on the results but some theoretical corrections based on potential flow computations can also be established.

In the industrial field, anemometers are used more and more often to measure a flow rate in ducts for efficiency and/or safety-related subjects. Industry now requires reliable and accurate measurements. This involves taking into account the effect of anemometer intrusion in the duct during the measurement process as well as improving the calibration methods of anemometers in wind tunnels.

Comparisons between National Metrology Institutes or calibration laboratories are good tools for demonstrating if the intrusion effect of the anemometers is taken into account in a suitable way. H. Mueller [4] has shown for example in EURAMET 827 comparison that the deviations which may be observed between the National Metrology Institutes could be due to the transfer standard itself and more specifically to the interaction between them and the wind tunnel where the calibration is performed.

As a contribution to the understanding of the phenomenon, EDF R&D and LNE-CETIAT have together led a study to evaluate the impact of an anemometer on the velocity field in a wind tunnel. Experimental measurements in a closed wind tunnel and numerical simulations have been performed simultaneously, for different types and sizes of anemometers (from Pitot tube to large vane anemometer).

The interest of the simultaneous experimental and numerical investigation is the possibility of directly validating the numerical results by the mean of the experimental ones. Once the numerical model has been validated, numerical experiments are easier to run than experimental ones to investigate further the blockage effect of anemometers when geometrical parameters are varying.

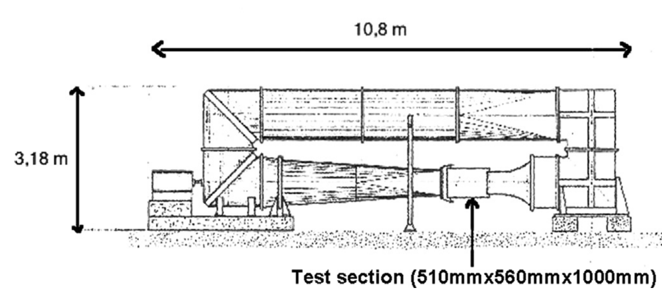

Fig. 1. Closed wind tunnel at LNE-CETIAT used for the experimental investigations.

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Fig. 2. The tested anemometers.

2. Experimental setup

Experimental investigations are carried out in a closed wind tunnel. The objectives are to highlight the disturbing effect of the anemometer on a velocity field and to record experimental data to validate the numerical investigations.

2.1. The experimental setup

The tests are performed in a closed wind tunnel (Fig. 1) used for the calibration of anemometers at LNE-CETIAT. The test section is rectangular. The top and bottom walls are parallel and the side walls diverge slightly from the inlet to the outlet of the test section. This feature reduces the effect of the increase of the boundary layer between the inlet and the outlet of the test section.

The wind tunnel is characterized by a velocity field homogeneous in space and stable in time. These characteristics are quantified and taken into account in the uncertainty budget. The

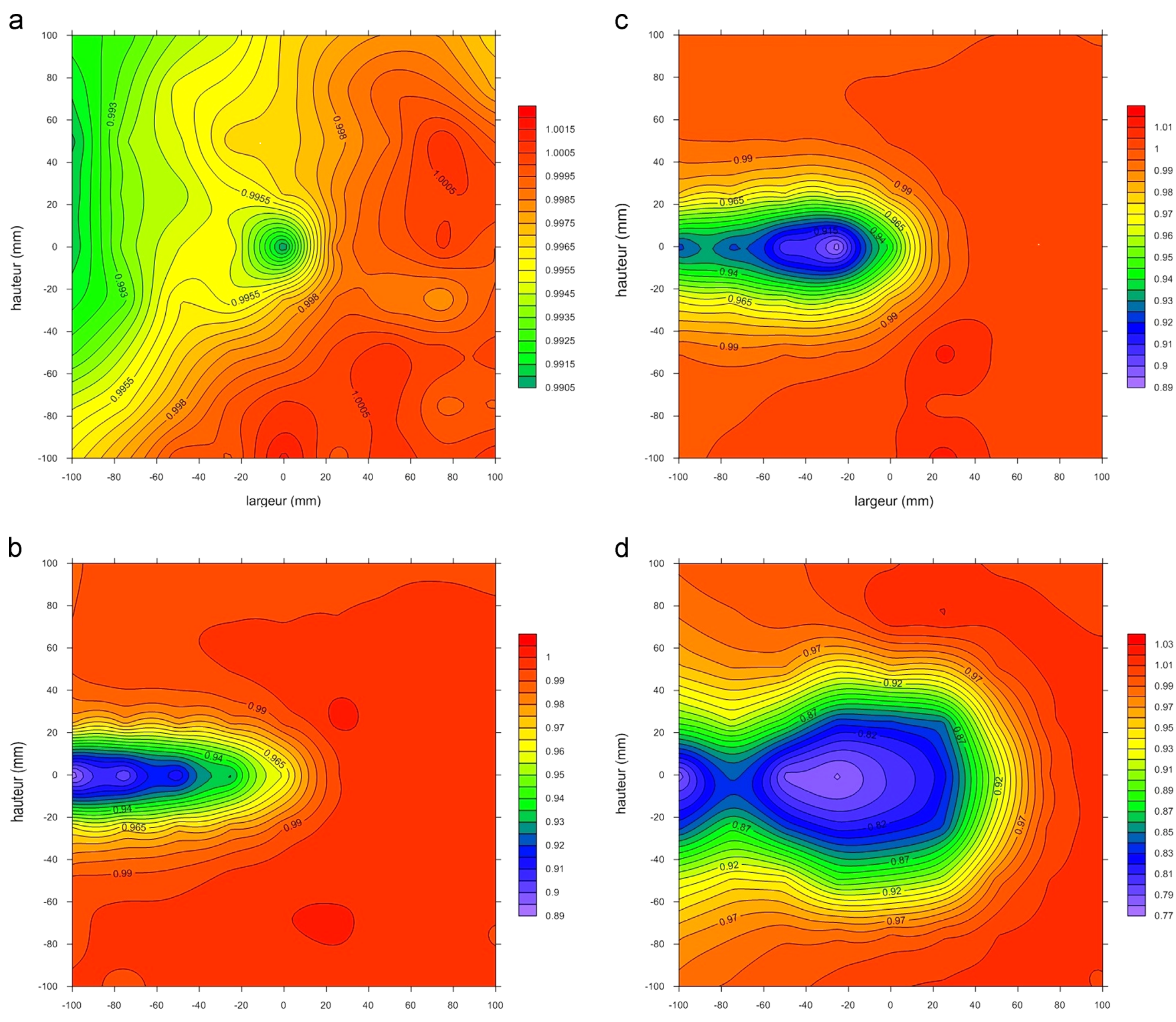

Fig. 3. Axial dimensionless velocity fields at 20 mm upstream of the anemometer (a) Pitot tube, (b) thermal anemometer, (c) 14 mm vane anemometer, and (d) 100 mm vane anemometer.

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