Dynamic measurements on an airfoil using acoustic forcing

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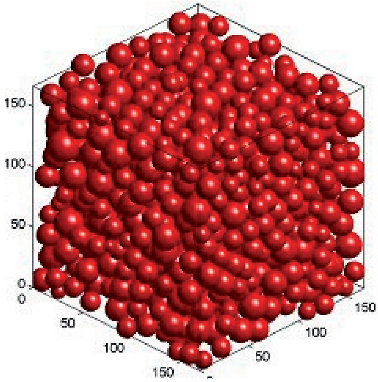

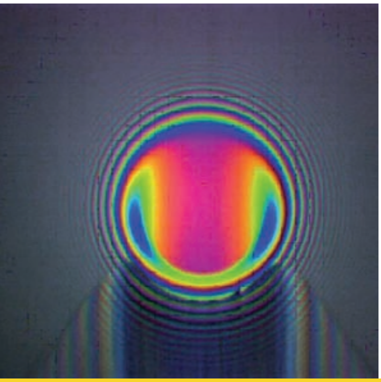

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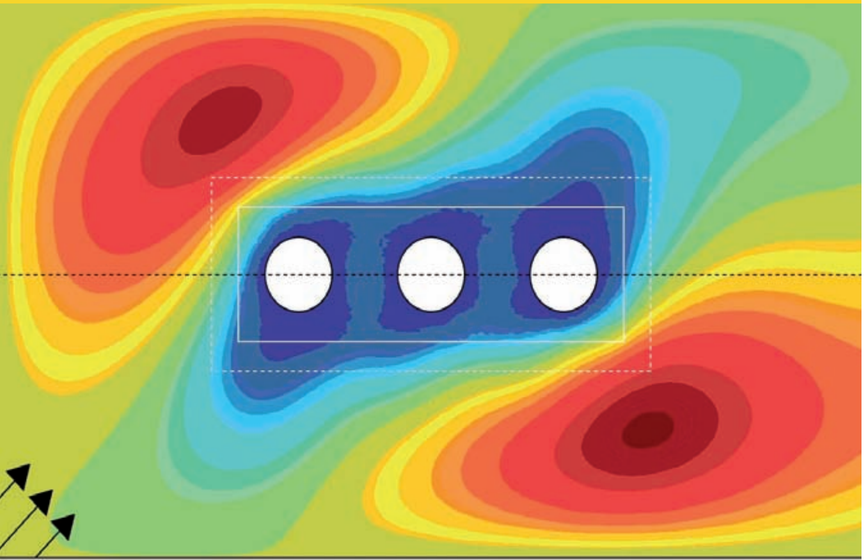

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Dynamic Measurements on an Airfoil Using Acoustic Forcing

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Introduction

Knowledge of the unsteady forces on a wing is crucial for successful wing design. For conventional profiles the unsteady linearized potential theory of Theodorsen & Sears has been successful in predicting the unsteady forces on a two dimensional thin airfoil in subsonic flow. Our current research effort is focused on predicting and measuring the influence of a cavity on the unsteady forces for a thick airfoil (NACA0018), see fig. 1. The work is part of the European project VortexCell2050 (www.vortexcell2050.org).

Fig. 1. NACA0018 airfoil with a cavity and transducers [▌].

Measurements of the unsteady forces on an airfoil are typically carried out using complex mechanical systems to displace the airfoil with respect to the main flow. We present a new method where the airfoil is fixed with respect to the wind tunnel and we displace the flow rather than the airfoil.

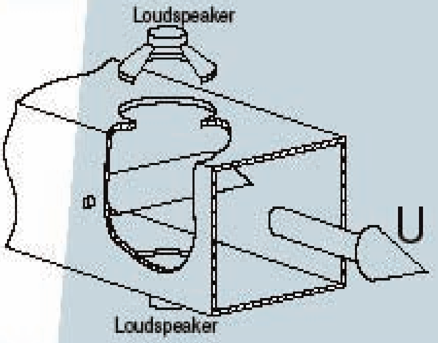

Fig. 2. Schematic drawing of the experimental setup with loudspeakers and NACA0018 airfoil.

Experimental Setup

A drawing of the experimental setup is shown in fig. 2. Two dynamic pressure transducers are placed on the airfoil surface at 15% of the chord from the leading edge on the upper and lower surface, see fig. 1. The speakers are tuned to the first eigen-frequency of the wind tunnel to create a transversal standing acoustic wave. The acoustic field is determined using two pressure transducers in the side wall of the wind tunnel. The main reason for using this method is to avoid a complex mechanical system.

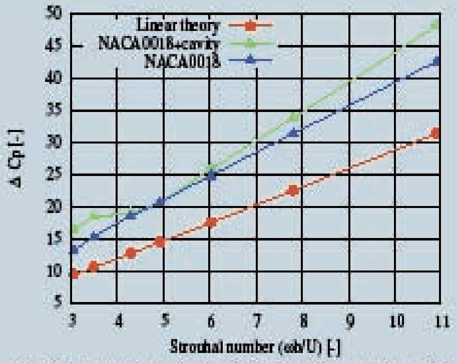

Fig. 3. Measured amplitude of ΔCp for different values of the Strouhal number compared with linear theory.

Results

In fig. 3 we compare the measured difference in pressure coefficient $\Delta Cp = 2\Delta p/\rho U v'$ with linear theory of Theodorsen & Sears as function of the Strouhal number ($St=2\pi fb/U$) for the two transducers at 15% of the chord. Here Δp is the actual measured pressure difference, ρ the density, U the free stream velocity, v' the amplitude of the acoustic velocity fluctuation in the center of the wind tunnel, f the frequency in *Hz* and b is the semi chord. We observe that both with and without cavity the experimental values are consistent higher than the theory. We furthermore observe a deviation in the data with and without cavity around $St = 3.5$.

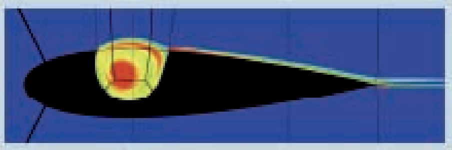

Fig. 4. Result of Euler simulation, vorticity in the cavity.

Conclusions

A new method for performing unsteady measurements on an airfoil in a wind tunnel has been presented. The results show that indeed the airfoil sees an unsteady flow. The measurements are consistently above the results of the unsteady linearized potential theory for a flat plate. We will compare these experimental results with 2D numerical Euler simulations see fig. 4, using the Euler code of S.J. Hulshoff [EIA: an Euler code for Internal Aeroacoustics. T.R. R-1530-D, Eindhoven University of Technology, 2000].

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