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NUMERICAL SIMULATION AND EXPERIMENTS WITH THE PROFILE NACA 0012

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Abstract: *This paper introduces the new model of the airfoil and describes both aeroelastic experiments and numerical simulation with the prof le NACA 0012. Mathematical description of the f uid-structure interaction has to involve both the equations of the f uid dynamic and the equations of motion of the solid body. The f rst results will be presented.*

Keywords: ***Aeroelastic, flow-structure interaction, identification***

1 Introduction

The interaction of the airfoil and f uid f ow belongs to a large group of f uid-structure interaction. This interaction takes place in many technical disciplines, e.g. from civil engineering to human vocal tract computation, see Dowell (1995). It is desirable to be able to describe and compute this f eld of study. The paper describes f rst steps with the new model of the airfoil which is used both for numerical simulation and for the experiments.

2 Structural design

The model of the airfoil NACA 0012 is a symmetrical prof le with the length of the chord 100 mm with two degrees of freedom. In this new stand both degrees of freedom are realized by vertically movement. The combination of two vertical displacement gives the f nal rotation and translation.

The mathematical model of the prof le consists of system of ordinary differential equations of motion. They are generally nonlinear, but for small motions they can be linearized.

3 Dynamic properties of the wing

The aim of the measurement in the laboratory of dynamics and vibration is to gain both the basic idea about the system properties and the data for the system identif cation.

This measurement gives an idea about the model properties. The values of natural frequencies and damping ratios from the experiment are presented in Table 1.

The complex frequency transfers have been measured for the identif cation process. From the transfers were computed the eigenvalues of the model, for more information see Horacek (2005). The eigenvalues of the system are listed in Table 1. Further, it was changed the position among the airfoil and the leaf springs and it was measured the natural frequencies of the system. The results are shown in the Figure 1.

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Tab. 1: Dynamic characteristics of the model from the experiment and from the identif cation

Mode No./Eigenvalue	Damping ratio [%]	Natural frequency $[Hz]$	Real part	Imag. part
1/s1	2.04	31.75	-2.55	201.4
2/s2	1.74	40	-1.72	250

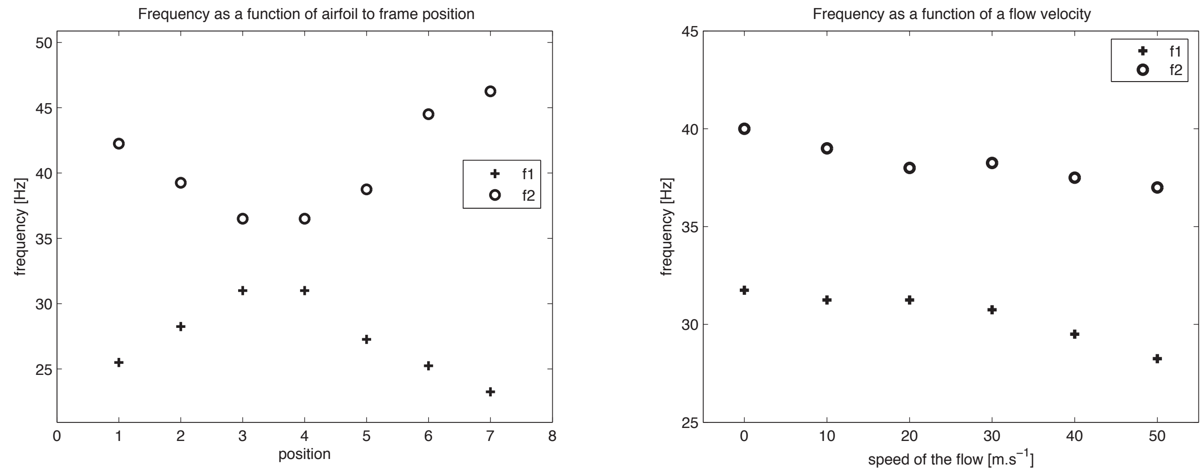

Fig. 1: Natural frequencies of the airfoil as a function of the airfoil to frame position (on the left) and as a function of the flow speed (on the right)

4 Measurement in the wind tunnel

It has been measured in the wind tunnel in the Institute of Thermomechanics with this prof le. This measurement has prooved also a feasibility of the experiment. During the f rst experiment it has been measured the frequency of the prof le as a function of the f ow speed. The angle among the f ow and the airfoil was set to $\alpha = 0\,rad$. The f ow speed has been changed with the difference $\Delta v = 10\,m.s{-1}$ in the range $v \in (0,\,50)\,m.s{-1}$. The results are shown in the Figure 1.

5 Conclusions

There are two parallel parts of research, one focuses on the experiments, the second one concentrates on the numerical simulation. The aim of the experimental branch is to set up self-feeding oscillation (f utter) and to measure the transient f ow f eld during this motion. The numerical part consists of correct identif cation and f uid-structure interaction problem solution. The mathematical model of the wing is in good agreement with the measurement.

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