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PROPOSITION DE POST-DOCTORAT

Intitulé : Experimental analysis of the shock buffet airfoil aeroelastic coupling

Référence : **PDOC-DAAA-202*3-3***
(à rappeler dans toute correspondance)

Début du contrat : 1/1/2023	**Date limite de candidature :** 30/11/2022

Durée : 12 mois, renouvelable pour 6 mois sous conditions- Salaire net : environ 25 k€ annuel

Mots clés

Aeroelasticity, buffet, transonic flow, wind tunnel, PIV measurements, data analysis, instability, LCO

Profil et compétences recherchées

PhD in Fluid & Structure Mechanics, Aerodynamics

Strong background in Compressible flows, data analysis, measurement techniques

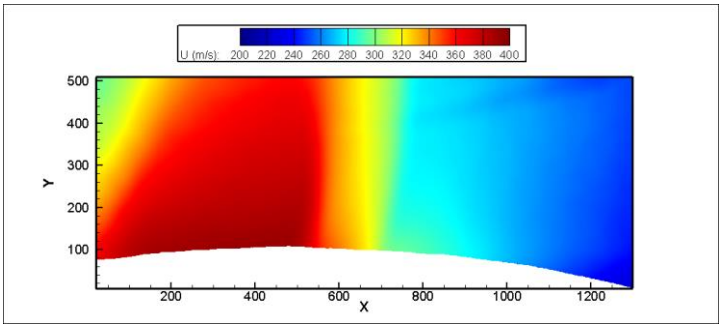
Knowledge on simulation and stability analysis methods is most welcomed

Présentation du projet post-doctoral, contexte et objectif

Within the transonic regime, the aeroelastic behavior of a wing can be modified due to the occurrence of the shock buffet phenomenon. Gao [1] describes different mechanisms that can occur when an airfoil features an elastic structure, namely lowering of the buffet threshold, either in the form of the fluid or structure mode, a resonance between the structural and buffet frequency and a coupling of the fluid and structure modes resulting in a buffet related flutter dynamics.

Although much research has been conducted in this field through numerical simulations (Giannelis [2]) and theoretical analysis (Gao [3]), only few experiments have been realized, leaving much uncertainty about the flexible airfoil dynamics in a realistic environment. Hartmann [4] brought some useful information though, as he used a pitch free airfoil under shock buffet condition and found the resonance dynamics when approaching the pitch frequency close to buffet. However, for instance, no experiment seems to have found the coupling mechanism of flutter in a transonic stream identified by Gao [1].

In the EU HOMER project dedicated to the investigation and measurement techniques for aeroelastic problems, ONERA carried out experiment in the transonic S3Ch wind tunnel to analyze experimentally the aeroelastic behavior of an airfoil with pitch and plunge degrees of freedom, in a transonic flow. In the past, this wind tunnel served to explore the aerodynamic buffet phenomenon using a rigidly mounted airfoil and a half wing (Jacquin [5], Brion [6], Dandois [7]). In the context of the HOMER project, the airfoil was subjected to different conditions of pitch and plunge stiffnesses and the flow was varied in Mach and angle of attack to produce buffet conditions. Illustrations of the tests are shown in the figure 1. When setting the airfoil free in pitch during the HOMER tests, an unsteady coupling between shock buffet and pitch was found at a frequency higher than that of the shock oscillations that corresponds to the bending structural frequency of the model, indicating the lock-in of the buffet mode to the structure mode. After a short amplification the dynamics reaches Limit Cycle Oscillations (LCO) of rather large amplitude.



The post-doctoral project aims at performing an in-depth processing of the database obtained during these tests and at carrying out physical analyses in order to explain this coupled dynamics.

Furthermore we also observed a modification of the buffet threshold that remains unexplained at the moment.

The database comprises accelerometer and optical displacement sensors data to evaluate the structural behavior of the model, wall pressure information, and PIV measurements to evaluate the behavior of the flow as well as of the structure (thanks to the airfoil that is visible in the PIV raw images). The processing of the PIV data in particular requires automatic processing of the individual images for masking (the airfoil), determination of instantaneous shock position and shape, and airfoil position, that the postdoctoral project will work out. An entire set of other methodologies will also need to be developed to allow for the evaluation of the fluid / structure interaction using the entire set of data.

The goal of the post-doctoral project is thus to describe at the same time the fluid and structure behaviors. The final objective will then be to clarify the physics at stake in the unsteady “lock-in” dynamics that was obtained during these experiments.

A supporting activity in modeling and simulation will also be developed to help identify the physical mechanisms at stake and the influence of parameters in a range wider than that accessed through the experiment. This part will be a follow-up of activities that were already engaged to prepare the experiment.

In the framework of this project, the fellow researcher will interact with the partners of the HOMER consortium who were involved in the transonic work package of the project. These partners are TUDelft University, Bundeswehr Munich and DLR Gottingen. They are among the best teams working on the problem of aeroelasticity for transonic flows.

The postdoctoral project provides a unique opportunity to publish a series of breakthrough articles in the scientific journal of the community (Journal of Fluid Mechanics, Fluid and Structure, Experiments in Fluids, AIAA Journal) in this field of aeroelasticity at transonic speeds. One of the articles will be detailing global results obtained with the partners in the HOMER project.

[1] GAO, Chuanqiang et ZHANG, Weiwei. Transonic aeroelasticity: A new perspective from the fluid mode. Progress in Aerospace Sciences, 2020, vol. 113, p. 100596.

[2] Giannelis, Nicholas F., and Gareth A. Vio. "Investigation of frequency lock-in phenomena on a supercritical aerofoil in the presence of transonic shock oscillations." Proceedings of the 17th International Forum on Aeroelasticity and Structural Dynamics, Como, Italy. 2017.

[3] Gao, Chuanqiang, et al. "Mechanism of frequency lock-in in transonic buffeting flow." Journal of Fluid Mechanics 818 (2017): 528-561.

[4] Hartmann, Axel, Michael Klaas, and Wolfgang Schröder. "Coupled airfoil heave/pitch oscillations at buffet flow." AIAA journal 51.7 (2013): 1542-1552.

[5] Jacquin, Laurent, et al. "Experimental study of shock oscillation over a transonic supercritical profile." AIAA journal 47.9 (2009): 1985-1994.

[6] Brion, Vincent, et al. "Laminar buffet and flow control." Proceedings of the Institution of Mechanical Engineers, Part G: Journal of Aerospace Engineering 234.1 (2020): 124-139.

[7] Dandois, Julien. "Experimental study of transonic buffet phenomenon on a 3D swept wing." Physics of Fluids 28.1 (2016): 016101.

Collaborations extérieures

HOMER consortium (TU DELFT, UNIBW, DLR GOTTINGEN)

Laboratoire d’accueil à l’ONERA

Département : Department of Aerodynamics, Aeroelasticity, Acoustics

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