ANCL - AEROACOUSTICS AND NOISE CONTROL LABORATORY AT UOIT

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Résumé

Ce document met en lumière quelques-unes des activités de recherche et de développement effectuées dans le laboratoire d'aéroacoustique et de contrôle du bruit (ANCL), qui est situé à *University of Ontario Institute of Technology* (UOIT) à Oshawa. L'ANCL mène des projets de recherches et développement de pointe dans les domaines de l'aéroacoustique, de l'interactions fluide-structure, des écoulements turbulents, des vibrations et du bruit induit par un écoulement, du contrôle de vibration et de bruit. En outre, le ANCL a la capacité d'effectuer des évaluations de produits et équipements acoustiques pour assurer le respect des différents codes et normes. Le but de cet article est de mettre en évidence l'expertise disponible à ANCL et de promouvoir de nouvelles collaborations et de nouveaux partenariats avec les industries au Canada et à l'étranger.

Mots-clés: aéroacoustique, intéractions structure-écoulement-bruit, contrôle du bruit et des vibrations

Abstract

This paper highlights some of the research and development activities performed in the Aeroacoustic and Noise Control Laboratory (ANCL), of the University of Ontario Institute Of Technology (UOIT) in Oshawa. ANCL conducts leading edge research and development in the fields of AeroAcoustics, Fluid-Structure Interactions, Turbulent Flows, Flow-Induced Vibrations and Noise, Noise and Vibration Control. Moreover, the ANCL has the capability to conduct assessments of acoustic products and facilities to ensure compliance with different codes and standards. The aim of this paper is to highlight the expertise at ANCL and to promote new collaborations and partnerships with industries in Canada and abroad.

Keywords: aeroacoustics, flow-sound-structure interactions, noise and vibration control

1 Introduction

The objective of the research team in the Aeroacoustics and Noise Control Laboratory (ANCL) is to contribute to the advancement of AeroAcoustics and Flow-Sound-Structure Interactions. The majority of our research projects address a wide range of practical engineering problems related to the design and operation of automotive, aerospace, and energy systems. Wall-bounded and free shear flows are inherently unstable. A small disturbance in the flow field, caused by a structural vibration and/or acoustic perturbation, can be strongly enhanced which often leads to the generation of acute noise problems and/or excessive vibration. Our research aims to understand the physics underlying the flow-sound-structural interaction mechanisms in order to develop innovative active and passive control techniques to eliminate these undesirable effects and produce more desirable effects such as enhanced mixing and drag reduction on motor vehicles. The research team at ANCL has contributed significantly to the knowledge transfer through successful collaborations with industrial partners such as; Ontario Power Generation, Bombardier Aerospace, Vibro-Acoustics, WEGU Manufacturing, and VertiGo Digital Displays. The ANCL is equipped with cutting edge experimental and numerical facilities for noise, vibration, and flow characterization. Some of the recent projects performed at ANCL are summarized below.

2 Flow-Sound Interaction Mechanisms

Flow-excited acoustic resonance is a design challenge in many engineering applications such as tube bundles in heat exchangers, boilers, turbomachines, and reactor vessels. The resonance can lead to acute noise problems and/or excessive vibrations. The research team at ANCL has been investigating the fundamental mechanisms of the flow-sound interaction in tube bundles with both bare and finned cylinders in cross-flow, as shown in figure 1. The first objective of this work is to develop design guidelines to predict the occurrence of acoustic resonance, expected noise level and the dynamic forces acting on heat exchanger tube bundles to ensure efficient, safe and reliable operation of the equipment. The second objective is to develop practical control strategies that can be used to alleviate the occurrence of acoustic resonance in tube bundles of heat exchangers [1].

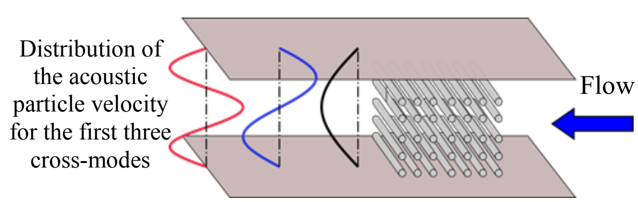

Figure 1: Flow-excited acoustic resonance in tube bundles.

3 Suppression of Flow-Induced Noise

The research team at ANCL has developed several passive control techniques for suppression of acoustic resonance excitation in shallow rectangular cavities, shown in figure 2. The first technique introduces secondary vortices generated by different spoilers located at the upstream cavity edge orthogonal to the main cavity shear layer. The second technique utilizes a high frequency vortex generator (i.e. control cylinder) placed in the vicinity of the upstream cavity edge. The last control technique introduces an upstream flow

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disturbance using wall mounted blocks. It is revealed from this work that the acoustic resonance is suppressed in the cavity due to either a reduction in the spanwise correlation of the free shear layer which, in turns, reduces its susceptibility to acoustic excitation, or an alteration in the impingement point at the downstream edge of the cavity, and thereby weakening the feedback cycle that controls the acoustic resonance excitation [2].

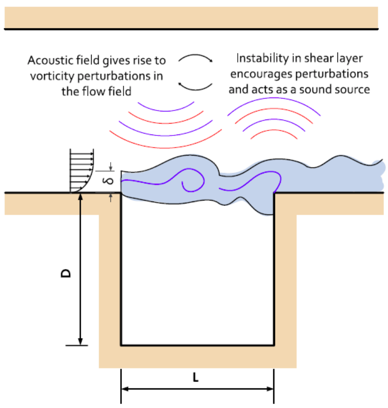

Figure 2: Fluid-resonant feedback mechanism in cavities.

4 Assessment of Test Facilities and Products

The ANCL Lab has the capabilities to test and characterize noise produced from industrial or residential facilities. Reverberation and anechoic chambers are essential facilities used for noise characterization. Figure 3 shows an on-site characterization of the reverberation time inside an industrial reverberation chamber using an impulse sound source. Moreover, the ANCL team performs full noise characterisation of industrial products and provides innovative solutions to eliminate noise problems. The tests are performed in state-of-the-art semi-anechoic chamber that has a background noise less than 29 dB.

5 Flow-Induced Vibration of Multi-Span U-Tubes

Steam generators in nuclear power plants have experienced tube failures caused by flow-induced vibrations. Two excitation mechanisms are responsible for such failures; random turbulence excitation and fluidelastic instability. The random turbulence excitation mechanism results in long-term failures due to fretting-wear damage at the tube supports, while fluidelastic instability results in short-term failures due to excessive vibration of the tubes. Such failures may require shutdowns, which result in production losses, and pose potential threats to human safety and the environment. Therefore, it is imperative to predict the nonlinear tube response and the associated fretting-wear damage to tubes due to fluid excitation. Strategic research collaboration between Prof. M. Hassan at the University of Guelph and ANCL has provided new insight into the dynamic response of loosely supported multi-span u-tubes, such as the one shown in figure 4, subjected to turbulence and fluidelastic instability forces. This work contributes significantly to the safety and reliability of tube bundles in nuclear steam generators [3].

Figure 3: On-site measurement of a reverberation time and noise characterization of a digital display unit in the semi-anechoic chamber.

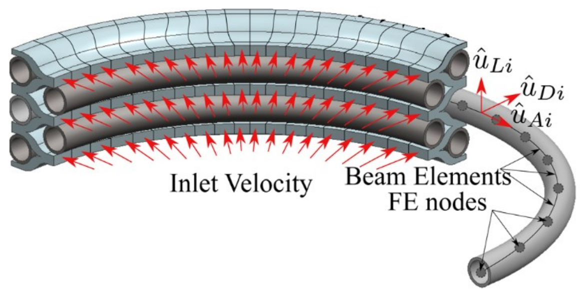

Figure 4: U-bend flow cell model.

6 Ergonomics and Dynamic Seat Comfort

Finally, the research team at ANCL has performed experimental and numerical characterization of the dynamic comfort in aircraft seats under different flight conditions using a multi-axis shaker table, shown in figure 5. Real flight data is used to assess the whole body vibration (WBV) exposures based on the international standard ISO-2631-1 and the British Standard BS-6841, thereby allowing for better development of aircraft seats at much lower costs and providing the customer with high quality products [4].

Figure 5: Evaluation of the aircraft seat comfort.

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