Preface

The first international symposium on **Fl**ow **I**nduced **N**oise and **Vi**bration Issues and **A**spects (flinovia) was held in November 2013 over 3 days in Rome, hosted by our friends at the Italian Consiglio Nazionale delle Ricerche (CNR). This book contains the recent work of 17 contributors from Italy, France, United States of America, Canada, and China.

The proceedings of the conference truly span most issues and aspects of flow-induced vibration and noise. Several authors describe experimental and numerical methods for characterizing fluctuating wall pressures induced by turbulent fluid flows, focusing primarily on turbulent boundary layers. Several other authors examine the resulting vibrations of flow-excited structures. Finally, some authors use structural vibrations to infer the behavior of the exciting flow.

The volume consists of 16 full chapters and a single extended abstract that summarizes the interactions among the presenters and attendees and the mutual refinements gained through oral presentations and discussions. That summary succinctly reflects a shared vision of the field and its specific topics.

The following are the main areas in which the presentations can be categorized, even if only for the sake of convenience, since most of the papers are largely interdisciplinary. Only the last name of the first author of each chapter is used for identification in this listing.

Opening Lecture

The flinovia keynote speaker, Dr. William Blake, opened the symposium with a survey of papers by several authors who have examined the nature of TBL flow over rough surfaces. Blake summarized both experimental and numerical studies, including the use of time-accurate Large Eddy Simulation (LES) techniques.

Source Characterization

Many authors have investigated TBL wall pressures over the past 50 years.

Juvé provides an overview of previous attempts to compute wall pressure auto- and cross-spectra using computational fluid dynamics (CFD) methods. He also emphasizes the importance of considering pressure gradients, which decelerate or accelerate the flow, altering the boundary layer shape and resulting wall pressures.

Moeller also address pressure gradient effects, providing new measurements that demonstrate the significant effects of adverse pressure gradients on boundary layer shape, and therefore on the wall pressures. Their measurements also show the dispersive nature of low frequency convecting wall pressures, establishing that group velocities, not phase velocities, should be used in TBL wall pressure models.

Camussi provides a summary of both experimental and numerical investigations of supersonic TBL flow wall pressures. While supersonic wall pressure autospectra seem to scale similarly to subsonic spectra, there is still a need for more investigations into the cross-spectra of TBL wall pressures, which span the shock cells that appear in supersonic flow.

Using LES to simulate large-scale turbulent eddies, combined with Reynolds Averaged Navier–Stokes (RANS) modeling for smaller turbulence, is becoming quite common.

Juvé shows that these methods, as well as rigorous Direct Numerical Simulation (DNS), are able to simulate accurate wall pressure spectra beneath simple TBL flows.

Caro describes how time-accurate CFD combined with RANS, commonly called Hybrid RANS-LES methods, are applied using the commercial software Star-CD to simulate complex flows around automobiles. Caro shows that simply applying boundary layer parameters in empirical models (such as that of Chase) to estimate TBL wall pressure models, does not work well in complicated flows.

De Luca presents a simulation of the turbulent synthetic jets, which can have important industrial applications in designing specific actuators.

Direct and Inverse Methods

Along with direct measurement and simulation methods, some authors are pursuing inverse methods to either infer or synthesize TBL wall pressure fluctuations using traversing microphones and panel vibrations. The goal is to synthesize the effective TBL wall pressures in a test facility without moving fluid, usually using wave-number filtering and an assumed field of partially correlated plane wave sources.

Aucejo and Robin describe approaches for simulating TBL wall pressures with a single traversing source, using the acoustic holography technique or surface plane wave decomposition. Different techniques were used demonstrating that the main difficulty lies in the use of a large array of sensors. The decisive advantage of the proposed methods is associated with the synthetic antenna concept where one moving sensor is used instead of an array.

Totaro attempts to use vibration measurements to identify the wall pressure fluctuations responsible for a panel's vibration. The method gives good results for deterministic excitation even if the ill-conditioning, common in inverse methods, must be corrected through regularization. For random excitation like TBL, the method must still be improved to overcome limitations due to acoustic background noise in test facilities.

Structural Vibration and Noise

Once turbulent sources are characterized, they must be applied to models of underlying structures so that vibration, stresses, and radiated noise may be simulated.

Chevalier outlined the importance of flow-induced noise for underwater structures, and by other authors, including Ichchou, for aerospace structures.

Several frequency-domain approaches for modeling flow-induced vibration are summarized by Maxit, who also shows the effects of structural ribs on the resulting vibration.

While the usual structural modeling approach is to use finite elements (FE), FE becomes computationally infeasible for large structures excited by slowly moving fluid due to the exorbitant mesh sizes required.

Ichchou suggests using energy methods to allow for coarser meshes, while still providing sufficient spatial distribution of the results to visualize structural vibration and energy distribution.

The overall structural response to TBL flow can also be used to infer equivalent distributed source forcing functions. Similar in some extent to the synthetic array methods described earlier, De Rosa pursues reconstructing the effective structural forcing functions based on structural vibrations. The approach requires the underlying modal response functions to be represented properly. The underlying response functions, combined with the spatial cross-correlation of the wall pressure fluctuations, form the well-known joint acceptance functions of a structure and a source; this latter can be approximated by using equivalent pseudo deterministic excitation.

Ciappi uses dimensional analysis with flow and structural variables to collapse a large series of disparate structural vibration measurements into a somewhat universal curve. Her proposed scaling function normalizes structural response by the autospectrum of the wall pressures, effectively providing the integration of the joint acceptance functions.

While most investigators analyze flow-induced vibration and noise in the frequency domain, sometimes time-domain analyses are required, particularly for flows that are not statistically stationary or ergodic, or for cases where the acoustic and/or structural waves couple with the flow.

Leung describes the interaction of duct flow with liner vibration and acoustic waveguide propagation, as he tries to explain experimental observations of reduced duct silencer performance.

Finally, Hambric shows that time-domain calculations of fluctuating stress, along with mean stresses, are required when assessing fatigue damage of structural materials.

In the appendix, one more abstract is reported involving a contribution whose full paper was not available to be included in this book. It belongs to Ceccio, who investigated TBL flow under varying pressure gradients, but on the suction side of lifting surfaces at very high Reynolds numbers. The lifting surface flows separate from the trailing edge, generating another important turbulent source—shed vortices.

Summary

The first flinovia was a great opportunity to gather together a diverse group of international investigators of flow-induced vibrations and noise in an intimate setting, with a single continuous session. This workshop model allowed for lively discussion among all participants, both during the presentations, and during breaks and social events.

Several authors mentioned ongoing efforts in flow-induced vibrations and noise, showing that this field is still being investigated, and remains of great importance to an impressive number of crucial communities, including the world's navies, the automotive industry, and the air and space industries.

We, the organizers, are hopeful that future flinovias will be held so that the state of the art will continue to be discussed, and that we all may benefit from mutual exchanges of discoveries and ideas. We want also to recognize and thank all the CNR-INSEAN persons who greatly collaborated before, during, and after the symposium to attain its best outcome.

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