Jet Aeroacoustics

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Preface

Jet Aeroacoustics is a growing area, a function of the significant projected growth in global air transportation. With the era of widespread supersonic flight and the proliferation of general aviation aircraft on future horizons, the noise generated by the high speed flow from aircraft engine exhaust is of great concern for communities near airports, for passengers in the aircraft’s cabin, and for the structural integrity of the airframe. In addition, there are a number of industrial situations that desire lower noise from high pressure gas jets. Examples from industry include the noise from valves, burners, high pressure jets used in machining, miniature jets used for drying, and high pressure release situations in the power industry. Understanding the source of the noise itself is critical in the development of future noise reduction technologies. There are a number of groups around the world actively researching jet aeroacoustics. However, there is no single consolidated source that includes recent developments in the field. This book partly fills the gap by providing a collection of articles on jet aeroacoustics, which have been published in the International Journal of Aeroacoustics between 2002 and 2007. This resource includes developments in the area of jet aeroacoustics theory, computations and experiments. Topics include: jet noise theories, simulation methodologies, predicting noise from complex geometries, design of jet noise facilities and jet noise measurements.

In the history of human evolution noise has always accompanied new technology. Modern man invented pulleys, gears, ploughs, coaches and cars. All this certainly involved a lot of noise but it was overlooked when compared to the advantages. Then, over a century ago, when the Wright brothers invented the first heavier than air powered flying machine, our enthusiasm knew no bounds and we were overwhelmed with joy. Nobody bothered about noise! We are initially very proud to fly in larger planes like the four engine propeller aircraft such as the Vikings. Then came the jet propelled aircraft such as the Comets, Boeing 707 and the Douglas DC-8. It was prestigious to travel in the best of planes. We were not perturbed by the noise or the rattling of windows and some were proud to assert that they lived near a major airport. Early aircraft focused mainly on aerodynamics and propulsion. Noise, fuel consumption and emissions were secondary. Then came the era of environmental concern about noise pollution and, as time passed, designers became more and more conscious about reducing noise. First, they tried to reduce cabin noise by barriers and linings and only later did they try to understand and modify the source of the noise itself. The understanding began by empirical relationships until some elegance was provided by Lighthill’s theory of aerodynamically generated sound. Noise reduction efforts began with mixer-ejectors, multi-lobed nozzles, corrugated nozzles, vortex generating fins, chevrons, and now progress towards active flow control. There has also been a significant noise benefit in tailoring noise sources and by going to high by-pass engines. There is a lot of challenge
ahead because noise suppression has to occur without compromising thrust, speed or fuel economy. With recent advances in computational methods and computing power, computational jet aeroacoustics has emerged both as a tool to understand aerodynamically generated sound and as a predictive capability to assess various configurations.

Section I of the book includes both analytical and computational elements. The first few papers address theoretical aspects of jet noise. We begin with Goldstein’s views on a unified approach to some recent developments in jet noise theory. This is followed by Lilley’s description of the source of aerodynamic noise. The third article in this series is one by Kopiev et al. that addresses the formulation of theoretical approaches to studying the aeroacoustics of a supersonic jet from corrugated nozzles.

Computational jet aeroacoustics is considered in the next group of papers. We begin with Morris et al. describing simulations of supersonic jet noise. Uzun et al. tackle the problem of the coupling of integral acoustics methods with large eddy simulation (LES) for jet noise predictions. Next comes a series of papers by Shur et al. that provide comprehensive treatment to noise predictions from increasingly complex jets. Methods, tests and applications are considered in their first two papers. Their third paper considers analysis of jet noise-reduction concepts by LES. Piot et al. provide detailed comparisons with LES and linearized Euler equation results for the PSE approach. Vortex ring effects for subsonic noise are then considered by Kopiev et al. Freund & Fleischman report on a very interesting topic of ray traces through unsteady jet turbulence. The final paper is one on acoustic radiation from a semi-infinite duct with a subsonic jet by Zhang et al.

Section II of the book focuses on experimental research in jet aeroacoustics. This section begins with a piece by Ahuja that provides a detailed review of best practices for designing a clean jet noise facility and making accurate acoustics measurements. Next Bogey et al. describe an experimental study of the spectral properties of near-field and far-field jet noise. Coffiet et al. describe source mechanisms in subsonic jets and Ukeiley and Ponton discuss the near-field of a transonic axisymmetric jet. The effect of nozzle internal contour on jet aeroacoustics is highlighted by Viswanathan and Clark. A unique method of simulating hot jets by using helium-air jet mixtures is reported by Doty and McLaughlin. In the final paper Hileman and Samimy discuss the role of vortex generating tabs on noise sources in an ideally expanded supersonic jet.

The perspectives in both sections are provided by internationally recognized experts in the field. The book will provide a student, scientist or practicing engineer with a concise overview of developments in the field of jet aeroacoustics and a good starting point for further research.

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