Advances in Aeroacoustics – In Honor of Professor Geoffrey M. Lilley

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This special edition of the "International Journal of Aeroacoustics" is a collection of papers on current topics in the field. Geoffrey Lilley has been part of the aeroacoustics scene since the early days of jet noise and he and his colleagues/collaborators have made many significant contributions. In keeping with his many interests there is theory, measurement and innovation. The volume is about equally divided between theoretical aspects of flow noise and measurement, and some information about the career of Geoff Lilley.

Robert Westley provides a detailed and often humorous account of Lilley's early jet noise work. The lead article by Phil Morris fills in more recent highlights. Present day researchers will marvel at what now is considered primitive instrumentation that was used to measure jet noise. Nevertheless, with much ingenuity and no doubt uncanny insight, the first successful, that is airworthy, jet noise suppressors were developed.

Those who are intimidated by mathematics may be inclined to skip the papers on theoretical aspects of aerodynamic sound. However, this is a mistake, as the many the subtleties of the flow noise generation and propagation processes are examined and described in detail by some of the most eminent practitioners of the art. The 'theoretical' papers serve as an excellent starting point for those interested in the study of aeroacoustics. The references therein direct the reader to background material that bridges the gap between 'classical' and 'modern' aeroacoustics.

Marvin Goldstein describes how Lilley's contributions fit into a frame work of a generalized acoustic analogy. The idea of an acoustic analogy was first proposed by Lighthill, and has been expanded upon over the years by others. Goldstein's article shows how the so-called Lilley equation is obtained. He also offers an alternate approach that eliminates some of the difficulties associated with parallel flow analogies.

Tester and Morfey address the solution of Lilley's equation with quadrupole and dipole sources. These play central roles in sound generation of heated and high speed jets. The complexity of Lilley's equation precludes closed form solutions for all but a few specialized and unrealistic cases. The ever increasing capabilities of computers make possible numerical solutions. The suitability and relative performance of several solution schemes (e.g. direct vs. adjoint) are illustrated in many figures wherein predictions are compared.

The topic of sound generation by turbulent reacting flows is tackled by Bailly, Bogey, and Candel. They present several special wave-equations that serve as starting points for potential numerical studies. Khavaran, Kenzakowski, and Mielke-Fagan show how a theoretical model may be solved with a numerical simulation. They selected a RANS based prediction methodology. This and other comparable schemes are now capable of predicting the flow field in great detail, but can also be used to predict far field noise over a wide range of jet Mach numbers and jet temperature ratios. In particular the ability to quantify the relative contribution of the various sources to the overall spectrum levels is an extremely useful feature not only for theorist, but also for noise control engineers. Predictions match measured data quite well at 90^{o} to the jet axis, but there is some divergence (a few dB) closer to the jet axis.

The paper by Reba, Narayanan and Colonius has both theory and experiment. They combine measurements obtained with near-field and far-field microphone arrays to extract a model for large-scale mixing noise. The methodology is an extension of earlier efforts that was confined mostly to far-field measurements. These appear to have been largely overlooked, even though some of the results continue to be relevant.

Historically jet noise measurements have formed the basis of prediction methods. Marcus Harper-Bourne has examined 'past' and 'present' data. Following a review of major jet noise facilities, the measured data is normalized to permit comparison among the various data sets. The paper makes a convincing case that the differences cannot be attributed to spurious rig noise. Instead the area contraction ratio of the model jets appears to play a dominant role. Still, the paper concludes that further research is needed into fundamental aspects of jet noise, and indication that the field is like a magical onion, whose layers may be peeled back, only to reveal even more layers.

Viswanathan continues the theme of jet noise measurement by examining difference between heated and unheated jets. The paper establishes guidelines for minimum distances at which the far-field assumption is valid. These distances are about 40 times the jet diameter for hot and cold subsonic jets. This does not appear to hold for supersonic jets. The many graphs of source strength vs. downstream distance, normalized far-field spectra would permit one to generate an engineering jet noise prediction scheme that covers a wide range of operating conditions. The reader is also reminded of the importance of the directional characteristics of microphones when interpreting measured data.

McLaughlin, Bridges and Kuo discuss the scaling of experimental data to moderate size exhaust jets. The high speed jet noise facility at Penn State affords them with a means of simulating high speed jets by using controlled helium mixtures. Their data shows that the measurements compare well with measurements from larger jets up to Strouhal numbers of the order of 3. This is more than sufficient to capture the overall energy as well as features of the narrow band spectra. Their conclusions regarding near-field measurements are in line with those of Viswanathan.

The jet noise suppressors invented by Lilley, Westley and Young no doubt played a role in making jet passenger aircraft acceptable from the perspective a noise impact. So this volume would not be complete without mention of means of reducing noise. Khorrami and Lockard examine the effects of geometric details on slat noise. High lift systems are significant contributors to air-frame noise, a major component of noise during the landing approach. The paper illustrates the current capabilities and limitations of numerical simulation. The results suggest that coupling of a computational fluid dynamics (CFD) solution with a Ffowcs-Williams and Hawkings solver extends the frequency range by almost a decade. These discrepancies may diminish, as more powerful CFD schemes are developed and applied to complex geometries.

Plasma actuators have been shown to control flow and show some promise a potential noise control elements. The paper by Huang and Zhang is a timely primer on noise control via plasma actuators. Several actuators systems are discussed and their operation illustrated for controlling cavity noise and noise from flow over cylinders. Another practical application descried in some detail is the reduction of sound from cylinder-torque link model. The acoustic images are somewhat difficult to interpret, owing to the choice of gray-scale in the contour plots.

Advances in Aeroacoustics, bound as a 10”x7.5” soft cover with bright, crisp print, will certainly appeal to die-hard aero-acousticians. More importantly, it is an extremely useful reference of the state of the art, making it an invaluable starting point for those who want to know more about the subject, and perhaps consider further research. The analytical and experimental subjects presented in the articles also have relevance to other topics in acoustics.

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