Special Issue “Aeroacoustics and Noise Mitigation” (EditoriAL)

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Editorial

Special Issue "Aeroacoustics and Noise Mitigation"

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Aerospace, an open access journal operated by MDPI, recently released a Special Issue entitled "Aeroacoustics and Noise Mitigation". Dr. Hua-Dong Yao from Chalmers University of Technology in Sweden served as the Guest Editor for this edition. In this Special Issue, readers can explore a collection of 11 articles that encompass various subjects, ranging from fundamental research to practical applications in the real world.

As the study of sound increasingly incorporates multidisciplinary physics, today, aeroacoustics has been expanded from the study of sound generation alone to a process that partially or completely combines sound generation, propagation, and mapping at receivers. Moreover, aeroacoustics is not limited to flows such as external noise pollution, footprint, and indoor environment quality, but also deals with flow–structure interaction (FSI), aero-vibro-acoustics, and damage detection and health monitoring of structures, etc. Due to the common basis of mathematical algorithms and physics, theories and methods developed for aeroacoustics with air as the medium have been applied to other fluid media such as water. The application scenarios are also not limited to aircraft, but extend to, for example, ground vehicles, HVAC (heating, ventilation and air conditioning) systems, wind turbines, ship propellers, and underwater vehicles. According to the instructions provided by ICAO (the International Civil Aviation Organization), aircraft noise mitigation can be achieved by noise source controlling, air traffic management, operating procedures, land-use planning, and relevant regulations and policies. However, with the emergence of clean-energy air vehicles such as flying cars and drones, available technologies and policies should be updated to meet the new demands and situations of rural/urban air mobility.

To promote aircraft electrification, propellers have been widely considered for propulsion due to their high aerodynamic efficiency, ease of maneuverability, and resilience and compatibility in complex operational situations. However, noise emissions from propellers cause environmental impacts, which can be particularly severe for flights at low altitudes in rural and urban areas. In response to this challenge, the current Special Issue collects articles on the design and optimization of propellers. Xue et al. [1] proposed a multidisciplinary design optimization (MDO) algorithm to design propellers emitting low noise and also possessing high aerodynamic efficiency and structural strength. The MDO algorithm integrates the vortex-lattice method for aerodynamic force computation and Hanson's frequency-domain method for sound computation. The study by Xue et al. [1] paves the way for aeroelastics optimization, which will be required in a later stage of the design process. Moreover, their algorithm in general can be applied to any propellers. Specifically for a short-regional electric aircraft carrying 19 passengers, Yao et al. [2] investigated a dual-blade propeller concept with joint blade tips termed a boxprop, a classical propeller with three blades, and another classical propeller with six blades. All of these propeller designs were optimized using an optimization platform for both aerodynamics and aeroacoustics. The platform integrates the computational fluid dynamics (CFD) method of the Reynolds-averaged Navier–Stokes equations (RANS) and the acoustic analogy of the Ffowcs-Williams–Hawkings (FW–H) equation. The effects of the propeller geometric parameters, including the number of blades, on the noise generation from blade-tip vortices were addressed in the work by Yao et al. [2] Regarding propellers for unmanned aerial

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vehicles (UAV), Witold Klimczyk and Adam Sieradzki [3] proposed a global MDO algorithm to synchronize the aerodynamics and aeroacoustics optimization based on RANS and FW–H acoustic analogy. The k-ω shear stress transport (SST) model was adopted for turbulence modelling in RANS. In their work, important geometric parameters were outlined to establish a parametric model for the blade geometry. The twist distributed along the radial direction is more sensitive than the camber and chord of the blade sectional profile, and the sweep shows a negligible effect in the scenarios studied by Klimczyk and Adam Sieradzki [3].

New low-noise airfoil designs [4,5] and elastic cavities [6] were explored in terms of the fundamental mechanisms of noise generation and mitigation. A foil with a wavy leading edge and a blunt trailing edge designed based on the NACA0012 profile was investigated by Xing et al. [4]. The method of improved delayed detached eddy simulation (IDDES) and the FW–H equation were adopted to simulate this foil at the angle of attack of zero degree. This wavy foil was found to be effective in reducing tonal noise at certain frequencies and broadband noise. Zhang et al. [5] proposed a concept that air is passively sucked into a long passage, the inlet of which is on the pressure side of the flap near the side edge and the outlet of which is on the side edge. Through numerical simulations, it was demonstrated that this passive blowing air concept suppresses vortex formation and consequently reduces the noise generation from side-edge vortices. This passive concept is simpler than active air-controlling devices, since it makes only simple changes to the existing flap structure. To understand the influences of the aeroelasticity on the noise generation in transonic cavity flows, Nilsson et al. [6] directly simulated turbulent flow and its noise for the generic M219 cavity, using an FSI solver that couples the IDDES method with a finite-element model. The Spalart–Allmaras (SA) turbulence model was adopted in the IDDES. The analysis based on the spectral proper orthogonal decomposition (SPOD) showed that flexible cavity walls react to the flow characteristic frequencies and contribute to the generation of the far-field noise.

Devices for mitigating engine noise were developed by Yan et al. [7] and Cican et al. [8]. A seamless acoustic liner made from composites, which can be added to nacelle intakes or exhaust nozzles to reduce engine noise, was designed by Yan et al. [7] This seamless liner exhibits better acoustic absorption at multiple modes and frequencies as compared to traditional liners that are made by assembling several pieces with different structural properties. Cican et al. [8] put forward to incorporate an exhaust nozzle ejector into a micro turbojet engine. By adjusting the ejector geometry, experiments and numerical simulations showed that the thrust was increased, but the specific fuel consumption and noise emissions were reduced. In addition to the above works, Ottersten et al. [9] found a new mechanism that triggers turbulence in a voluteless fan, which is a benchmark configuration for HVAC air units. A region of relatively small flow velocity rotates within the fan clearance passage, and turbulence commences downstream of this region. The characteristic rotation frequency of the region is distinct and small, leading to a tonal sound at this small frequency.

Numerical and experimental methods for noise prediction and measurement are collected in this Special Issue. Zhang et al. [10] introduced a nonlinear acoustic solver and successfully applied it to predicting noise from a variety of sources, including airframe components and jets, for aircraft at supersonic speeds. Turbulence at sub-grid scales was synthesized in this method, and the accuracy of the method was validated. Zhou et al. [11] proposed a mass-conserved formulation for the FW–H acoustic analogy in the frequency domain. The formulation is valid at very low Mach numbers where flow is assumed to be incompressible. The advantage of this formulation is that the noise generated by spurious mass flux is excluded by taking into account higher-order derivatives of Green's function. Aside from the development of the numerical methods, experimental techniques for measuring acoustic impedances for liners were developed by Yan et al. [7] An in situ method and a direct method were compared. Both methods are accurate and applicable at medium frequencies but less accurate at high frequencies, and the accuracy of the in situ method is better than that of the other method at low frequencies. The in situ method also shows better reliability at high frequencies. A generator of acoustic spinning modes was constructed to produce a single mode or a group of modes based on a phase array control method. This generator was validated and applied to testing full-size acoustic liners.

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