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Editorial

Advances in Vibroacoustics and Aeroacustics of Marine, Aerospace and Automotive Systems

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1. Introduction

The purpose of this Special Issue was to highlight the latest enhancements in vibroacoustics and aeroacustics of marine, aerospace, and automotive systems. This Special Issue can be seen as a further step ahead from two previous Special Issues covered by some of the Authors, see [1,2].

In proposing this wide topic, we wanted to give scientists and engineers the opportunity to publish their current studies, both in the theoretical and experimental fields of vibration, sound generation and radiation, and passive and active noise control systems, which can be of interest for assessing vibroacoustics and aeroacustics characteristics of marine, aerospace, and automotive systems. This issue provides access to several articles encompassing the aforementioned themes.

In the following, a brief summary on the content of the papers included in this Special Issue will be presented.

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2. The Present Issue

We are deeply honored to be the guest editors of this thematic issue, which includes original articles and reviews of interest for the scientific community working on these subjects, as well as for industrial R&D departments. We are particularly grateful to the several leaders in these areas who decided to honor us with their valuable contributions. We want to thank them and their collaborators for the effort they have accomplished for publishing their works in this issue of *Applied Sciences*. We are equally thankful to many colleagues who have helped us evaluating and reviewing these manuscripts with substantial improvements.

This Special Issue highlighted the latest studies on vibroacoustics and aeroacustics problems and aimed at analyzing specific industrial problems. Many similar contributions can already be found in the literature, underlining the relevant efforts provided by scientists and researchers in tackling these critical designing aspects (see [3,4]).

In the work of [5], the dynamic stiffness method (DSM) was formulated to study the out-of-plane natural vibration of thin orthotropic plates using the classical plate theory (CPT). Hamilton's principle was implemented to derive the governing differential equation of motion for free vibration, whereas the Wittrick–Williams (W–W) algorithm was used as a solution technique to compute the natural frequencies. The complete procedure was implemented in a computer program using a combination of MATLAB and ANSYS. This enabled the calculation of any natural frequency and a validation against finite element method results was provided finally. The newly dataset of natural frequencies obtained by the DSM for different geometries and materials represented a benchmark for future comparison purposes.

In the work of [6], the structural vibration response of a re-entry vehicle during a ballistic flight was simulated numerically. Once the pressure fluctuations on the outer surface were modelled, the vibroacoustic response was derived for the re-entry vehicle metallic aeroshell. Similarly to the work of [7], the low-frequency response was simulated through a FEM–BEM model, whereas the Statistical Energy Analysis was used to compute the high-frequency behavior. A validation of these models was provided through a comparison with ground experimental data under a diffuse-field acoustic loading provided by loudspeakers in a dedicated reverberation chamber. In the full-frequency range provided by both deterministic and statistical modelling procedures, the models were proven to be complementary in simulating the whole full-frequency vibroacoustic response.

The work proposed in [8] reported a further simulation investigation based on BEM to perform passive noise control (PNC) assessments for passenger aircraft headrests. In particular, two PNC improvements of headrests were designed to reduce the sound pressure level (SPL) at the passengers' ears in an aircraft cabin during flight; the first was based on the optimization of the headrest shape, whereas the second consisted of partially or fully covering the headrest surface with a new highly sound-absorbing nanofibrous textile. An experimental validation campaign was conducted in a semi-anechoic chamber to provide a comparison. An acceptable correlation between experimental and numerical results was obtained and, based on these findings, general guidelines were proposed for the acoustical design of advanced headrests.

Document [9] presented a comparison among FEM simulation procedures for the modelling of the numerous bolt connections of a four-stroke, four-cylinder petrol engine. A full 3D modelling of the bolts was preliminarily validated through a comparison with experimental test data available for the whole engine. Two further modelling approaches, a 1D approach and a contact-based (0D) approach, were benchmarked considering their influence on the accuracy for the dynamic analysis of an engine. The results were compared in terms of preprocessing time and accuracy, showing that each of the three modelling procedures presented pros and cons, whereas the 1D modelling could be considered as the recommended one in most of cases.

Localization and quantification of noise sources are important to fulfill customer and regulation requirements in a such competitive sector such as automotive manufacturing. Wind tunnel testing and acoustic mapping techniques based on microphone arrays can provide accurate information on these aspects. In the investigation presented in [10], an inverse method tailored to a volumetric approach was presented with the aim to investigate wind tunnel testing for the automotive industry. Two different kinds of problem were tackled: on the one hand, the results of inverse methods are strongly influenced by the problem definition and, on the other hand, experimental conditions very often mandatory to improve accuracy of results. These aspects were studied making use of simulated experiments. Finally, a set of scores was defined to evaluate the resulting maps with objective metrics.

Currently, it is a hot research topic to retrieve the wave parameters by using X-band marine radar. However, non-negligible rainfall noise usually exists in the collected marine radar images, which seriously interferes with the extraction of the wave parameters. To reduce the influence of rainfall noise, the zero-pixel percentage (ZPP) method can be used to detect rainfall in radar images, but the detection accuracy is limited, and the selection of the threshold needs to be further studied. Based on the ZPP method, the ratio of zero intensity to echo (RZE) method for rainfall detection was proposed in [11]. The detection threshold is determined by statistical analysis of a large amount of radar data. Additionally, the rainfall intensity level was retrieved from X-band marine radar images directly. The data obtained from the experimental data measured in Fujian Province, China, were used to verify the effectiveness of the proposed method, showing that the detection accuracy of the proposed method was 11.7% higher than that of the traditional method.

In [12], the numerical simulation of the vibroacoustics evaluation of an innovative material for a sports car roof was performed. The objective was to evaluate the feasibility of the newly designed roof against the traditional one made of fiberglass. Similarly to [13], the evaluation was carried out using numerical and experimental analysis techniques, with cross-comparison between the corresponding results. An accurate model of the car roof of the Alfa Romeo 4C car, made with the new material, was implemented and analyzed from the vibroacoustic point of view. The mere switch to the new material, with no changes in the geometry/structure of the car roof, did not allow for the preserving of the original performances and, therefore, a geometric/structural optimization of the component was also performed. The excellent damping capacity of the proposed material led to an improvement in the vibroacoustic transfer functions and to a reduction in the weight of the pavilion. The low density of the new material and the geometric optimization led to a 14% weight reduction compared to the previous design, but also to a reduction of the transfer functions peaks of these functions across the whole frequency range of interest (50 to 400 Hz).

Understanding local phenomena connected with airflow around road vehicles allows to reduce the negative impact of transportation on the environment. The work presented in [14] used numerical tools for computational fluid dynamics (CFD) and computational aeroacoustic (CAA) calculations. The simplified car geometry "Ahmed body" was used for two different purposes: a validation process and a CAA analysis using the Ffowcs Williams–Hawkings (FW-H) analogy. The research was performed using the $k-\omega$ Shear Stress Transport (SST) and the Large Eddy Simulation (LES) turbulence model. Three different comparison criteria were introduced for comparison purposes, showing that the adopted method allowed visualizing the acoustic field around reference geometry and determining the frequency range for which the A-weighted sound pressure level was the highest.

The work reported in [15] represented a further step ahead of what experimentally observed in [7]. Namely, the PNC improvements for aircraft headrests were studied now through BEM models with the aim of comparing them in terms of the pressure levels at passengers' ears. A numerical-experimental comparison was also provided against the data reported in [7]. A spherical distribution of monopole sources surrounding the headrests was considered as the acoustic load (in such a way to recreate a diffuse acoustic field simulating the cabin noise perceived by passengers during cruise conditions). The electro spun mat made of PVP plus silica inclusions was adopted as headrest covering material and turned out to be advantageous, and even more promising if used in combination with a proper headrest shape.

Low-speed axial cooling fans are frequently used to manage engine temperature by ensuring that adequate quantities of air pass through heat exchangers, even at low vehicle speeds or in idle conditions. The study in [16] aims to provide a better understanding of the unsteady flow behavior around an automotive axial cooling fan with seven blades and its impact on the aerodynamic noise generation. LES near the near-field region and the FW-H method were performed to analyze the flow characteristics around the fan and to predict the aerodynamic noise emitted from the fan at a constant speed of 2100 rpm. The simulation results for the velocity distributions and aerodynamic noise were compared with the experimental data showing a comparatively good agreement upstream and downstream from the fan. The findings of this research provided important insights into the design of axial fans with lower noise and higher performances.

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