Editorial

Advances in Mechanical Engineering

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2022, Vol. 14(10) 1–3
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DOI: 10.1177/16878132221125578
journals.sagepub.com/home/ade
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Special Collection on advanced practices in aerospace and energy engineering

Numerous significant and interdisciplinary technological advances happen in aerospace end energy engineering nowadays. They span the increased use of computers in every stage of product design, over different modeling, computation, optimization, and artificial intelligence methods, to contemporary (unconventional, non-invasive) experimental techniques and enhanced measuring equipment, alongside dramatic breakthroughs in material science as well as high-precision and additive manufacturing methods. Not to mention the idea of electrification of flow machines together with the increased use of unconventional fuels.

Stringent requirements for prolonged working life at optimal performance and smallest environmental impact call for enhanced, innovative, and multidisciplinary approaches in the areas of aerospace and energy engineering. This special collection covers a wide range of topics related to the state-of-the-art numerical and experimental research conducted worldwide with the main purposes of: encouraging further excellent research and industrial advancement, enabling scientific collaboration and knowledge exchange as well as pointing to future trends in aerospace and energy engineering.

Even though this SC was open for submission in the second half of 2021, while the pandemic was still raging, the authors found strength and willingness to present their research for which we are truly grateful. It includes 12 papers by more than 35 authors affiliated to 10 different scientific institutions (universities and research institutes worldwide). The journal AiME performed the complete, rigorous review processes and provided great support to the authors. All the papers were selected on the basis of quality and scientific excellence of their topics and content.

This collection aims to provide a fundament for the most contemporary research in mechanical engineering and beyond. In particular, problems addressed come from the areas of microfluidics, flow measurements (including both measuring techniques and equipment), turbomachinery, aircraft propulsion, supersonics, flow control, multiphase flows, additive manufacturing, and engineering design. Methods used in presented research studies encompass analytical, numerical, and experimental approaches. Furthermore, strong relations and comparison to real applications and operation are made.

For instance, incompressible and compressible flow through microtubes, that also takes into account gas rarefication, applicable in bioengineering and MEMS (that is being increasingly employed), is investigated analytically in Guranov et al.[1] and Milićev and Stevanović.[2] The presented results (pressure, velocity, and temperature profiles) match well with other results from literature and are easily applicable. On the other hand, Bikić et al.[3] numerically and experimentally investigates the benefits (mostly visible in lower energy consumption) of a novel design of flow meters, typically employed in industry due to their simplicity, reliability, and ease of maintenance. Another industrial application, a transient analysis of hydropower plants, is presented in Svrkota et al.[4] From a data analysis performed on 270 hydropower plants with crossflow turbines, a simple mathematical model that estimates the turbine performance characteristics is formed. Its accuracy of 5%–10% is demonstrated on three case studies. On a more abstract level, this study also illustrates how important it actually is to relate empirical and theoretical data, and constantly improve our starting assumptions. That is where high-quality, reliable experimental studies also come into play, particularly in the field of fluid mechanics that is very hard to describe purely theoretically and where the governing equations are not yet closed and many flow phenomena remain unresolved, turbulence being just one of them. Experimental investigation of the turbulent swirl flow in a piping system, a highly complex transient, 3D flow, is presented in Čantrak and Janković[5] It was performed by PIV, a contemporary, noninvasive measuring technique, and it provides insight into the turbulence structure as well as abundant validation data. A special kind of turbomachinery, a jet engine, or more precisely, its core part is investigated in Davidović et al.[6] Four different configurations of a tubular combustion chamber were

experimentally tested to establish the range of its operability. The proposed design and experimental methodology can easily be applied to similar structures. Another example of combined numerical and experimental studies of a multifunctional bulkhead separating the cold (compressor) and hot (turbine) sections of a gas generator can be found in Kolarević et al.[7] Through coupled flow and thermo-structural analyses, a novel, innovative gas generator bulkhead design is proposed and validated. Although every experiment poses some difficulties, both in preparing and conducting, measuring the quantities of supersonic flows is particularly challenging, due to highly sensitive flow field, extremely high pressures and temperatures, and very small timescales. A novel technique suitable for wind tunnel measurements, with additional points of contact between the model and the support sting, is proposed in Vuković et al.[8] It is reported that transient starting and stopping loads can be reduced by more than 50%, which enables achieving higher Mach numbers in the working section. Another interesting example of an enhanced wind tunnel measuring technique is described in Xue et al.[9] on a case of a jet controlled air vehicles. The peculiarities here are that the model is completely free, not constrained by any additional support, because a small volume high-pressure gas cylinder is incorporated directly into the model of the air vehicle, which enables the investigation of changes in model's attitude and orientation with jet both on and off. Further possibilities of different kinds of flow control (both passive and active, in both low- and high-speed flows), and various benefits that can be achieved in terms of increased efficiency, lift-to-drag ratio, stabilization of the boundary layer, separation or stall delay, even aircraft control, etc. are covered in Svorcan et al.[10] The paper also points to some directions of further development and references numerous computational and experimental studies alike. On the other hand, this collection also addresses multiphase flows. Density, thermal conductivity, and viscosity of dispersions of agricultural biomass particles in ionic liquid are experimentally investigated in Radojčin et al.[11] Dispersions with different mass concentration of particles were studied at different temperatures to investigate the possibility of creating a new, enhanced heat transfer fluid. Continuing onto novel structural materials, research presented in Vorkapić et al.[12] investigates the possibilities of enhancing mechanical properties of 3D printed thermoplastic polymers. The starting material is widely available and affordable, but with poor mechanical properties partially due to the anisotropy that accompanies additive manufacturing. In other to employ 3D printed structures in energy and aerospace applications, their characteristics must be improved and made more reliable.

It may be observed that this special collection, as it is focused on flow machines, covers numerous and diverse fluid dynamics topics, but also some structural ones. All possible investigative approaches (analytical, numerical, experimental) are employed and their usability and importance are once again demonstrated, particularly their combination and comparative analyses. State-of-the-art research directions in natural and technical sciences, such as: increased reliability and capabilities of numerical simulations that greatly shorten and economize the design process, novel materials and manufacturing methods, data analysis in aerospace and energy engineering, efficiency improvement, novel and unconventional technical solutions, environmentally friendly materials and processes, etc. are pursued. At the same time, the importance as well as complexity and high cost of experimental research in aerospace and energy engineering is accentuated and a special focus is given to the most contemporary measurement methods that provide (usually so scarce and unavailable) usable experimental data.

This collection aimed to join together, intertwine but also compare/contrast:

- numerical and experimental methods, together with all their respective advantages and disadvantages,
- established, well-proven versus novel, contemporary practices and research trends,
- conventional versus renewable energy sources,
- engineers and scientists specializing in fields of mechanical, aerospace, energy, electrical and civil engineering and technology, and provide them a place to present, discuss, and improve their ideas and achievements,

and the Editors believe these goals have been achieved. The explored topics are multidisciplinary and current. They stimulate further research and incite international collaboration. In the end, they propose ways to efficiently answer to the growing energy demands and increase the quality of everyday life in the best possible way. We hope the readers will feel the same way.

It has been our pleasure and honor to organize and participate in this SC. We are sincerely grateful to all the authors as well as the managing office of the journal that has been very helpful during the entire submission and publication process. We are also grateful to the Ministry of Education, Science, and Technological Development of Republic of Serbia that supports most of the presented research studies.

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