

Special Issue: Feature Papers in *Eng* 2021

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The aim of this first *Eng* Special Issue is to collect experimental and theoretical research relating to engineering science and technology. The general topics of *Eng* are as follows: Electrical, Electronic and Information Engineering; Chemical and Materials Engineering; Energy Engineering; Mechanical and Automotive Engineering; Industrial and Manufacturing Engineering; Civil and Structural Engineering; Aerospace Engineering; Biomedical Engineering; Geotechnical Engineering and Engineering Geology; Ocean and Environmental Engineering. Therefore, the following editorial is a selection of representative works of these topics.

This book contains up to 14 papers, including 3 paper reviews, published by several authors interested in new cutting-edge developments in the field of engineering. Solid oxide fuel cells (SOFC) are considered as one of the most promising fuel cell types for application as high-efficiency power generators by Tonekabonimoghaddam and Shamiri [1]. In this interesting work, the authors review the use of computational fluid dynamics (CFD) to maximize SOFC performance and life and minimize cost by considering numerous configurations and designs. A critical analysis of available literature proves that detailed research on the simulation of thermal stress and its damaging impact on the SOFC is still in its early stage of development. Numerical simulation is expected to help optimize the design, operating parameters and fuel cell materials. Therefore, sensitivity analysis of fuel cell parameters using simulation models is analyzed to address the issue. Finally, the present status of the SOFC optimization efforts is summarized by the authors so that unresolved problems can be identified and solved.

Aras and Diaconeasa [2] report that Probabilistic Risk Assessment (PRA) is one of the technologies that is used to inform the design, licensing, operation and maintenance activities of nuclear power plants (NPP). They indicate that PRA can be performed by considering the single hazard (e.g., earthquake, flood, high wind, landslide) or by considering multi-hazards (e.g., earthquake and tsunami, high wind and internal fire). Single-hazard PRA was thought sufficient to cover the analysis of a severe accident until the Fukushima Daiichi NPP accident in 2011. Since then, efforts were made to consider multi-hazards as well; thus, multi-hazard PRA are starting to be seen as being indispensable for NPP. However, a general framework for multi-hazard PRA is still missing. In this paper, the authors argue that the starting point for any multi-hazard PRA general framework should be the Advanced Non-LWR Licensing Basis Event Selection (LBE) Approach and Probabilistic Risk Assessment Standard for Non-LightWater Reactor (non-LWR) Nuclear Power Plants. For Probabilistic Risk Assessment (PRA), history has shown the path forward before, with the Three Mile Accident being seen as one milestone to understand the necessity of PRA. The Fukushima Daiichi NPP Accident is another milestone in the development of PRA, showing the need for performing multi-hazard PRA for the current and future NPP.

Metal phosphates represent an important group of materials with established industrial applications that are still attracting special scientific interest, owing to their outstanding physical and chemical properties. In this review, Amghouz et al. [3] provide an account on the synthetic routes and applications of zirconium and titanium phosphates, with a special focus on their application in the medicinal field. While zirconium phosphate has been extensively studied and explored with several reported industrial and medicinal applications,



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especially for drug delivery applications, titanium phosphates have not yet attracted the deserved attention regarding their established applications. However, titanium phosphates have been the focus of several structural studies with their different polymorphic forms, varied chemical structures, and morphologies. These variations introduce titanium phosphates as a strong candidate for technological and, particularly, biomedical applications.

In the following work, El Sheshtawy et al. [4] develop a method to perform shape optimization of a tidal stream turbine hydrofoil using a multi-objective genetic algorithm. A Bezier curve parameterized the reference hydrofoil profile NACA 63815. Shape optimization of this hydrofoil maximized its lift-to-drag ratio and minimized its pressure coefficient, thereby increasing the turbines power output power and improving its cavitation characteristics. The Elitist Non-dominated Sorting Genetic Algorithm (NSGA-II) is employed by the authors to perform the shape optimization. A comparative study of two- and three-dimensional optimizations is carried out. The effect of varying the angle of attack on the quality of optimized results is also studied. Predictions based on the two-dimensional panel method results are also performed. Predictions based on a two-dimensional panel method and on a computational fluid dynamics code are compared to experimental measurements.

Non-carbonated fruit juices often tend to foam over during bottling. The resulting foam height corresponds to the equilibrium of foam formation and decay. Therefore, the foam unexpectedly occupies more space in the bottle and carries parts of the juice out of the bottle, resulting in product loss under filled containers and hygienic problems in the plant. Recent ultrasonic defoamers are effective but only capable outside the container and after the filling. In this article, a lateral ultrasonication through the bottle wall with frequencies between 42 and 168 kHz is used in-line by the authors [5] for non-invasive foam prevention during filling. The comparably high frequencies have a particular effect on the fresh foams, where a large fraction of small resonant bubbles is still present. Foam volume reductions of up to 50% are reached in these experiments. A low power of 15 W was sufficient for changing the rise of entrained bubbles and minimizing the foam development from the start. The half-life of the remaining foam could be reduced by up to 45% from the reference case. The authors indicate that the main observed effects were a changed rise of entrained bubbles and an increased drainage.

Aziz et al. [6] experimentally studied the surface roughening (Ra), martensitic phase transformation (MPT) and grain misorientation (GMO) behavior of stainless steel 304 and 316 in various grain sizes (Dg), including five cycles of sequential uniaxial tensile stress testing and Scanning Electron Microscope-Electron Back Scattered Diffraction (SEM-EBSD) investigation. The MPT and GMO characteristics were sequentially investigated by the authors using tensile testing and SEM-EBSD analysis. The correlation between MPT, GMO, martensitic volume fraction (Mf) and Ra behavior were also investigated. The experimental results showed that increasing the total strain from 5.0 to 25.0% increased the MPT, GMO, and Mf, which were transformed from the metastable austenitic phase in stainless steel (SUS) 304.

Sand control screens (SCD) have been widely installed in wells producing bitumen from unconsolidated formations. The screens are typically designed using general rules-of-thumb. The sand retention testing (SRT) technique has gained attention from the industry for the custom design and performance assessment of SCD. However, the success of SRT experimentation highly depends on the accuracy of the experimental design and variables. In this work, the authors examine the impact of the setup design, sample preparation, near-wellbore stress conditions, fluid flow rates, and brine chemistry on the testing results and, accordingly, screen design [7]. The SRT experiments were carried out using the replicated samples from the McMurray Formation at Long Lake Field. The results were compared with the test results on the original reservoir samples presented in the literature. Subsequently, a parametric study was performed by the authors changing one testing parameter at a test, gradually making the conditions more comparable to the actual wellbore conditions. The results indicated that the fluid flow rate is the most influential parameter on sand production, followed by the packing technique, stress magnitude and brine salinity level.

The next study involves the use of food-grade chemicals in the integrated pest management of dry-cured ham through the use of 100% polyester weft knitted mesh nets. Tubular mesh nets that are used to contain dry-ageing hams, commonly referred to as ham nets, were treated with a patent-pending food-grade chemical solution (40% Propylene Glycol + 1% Propylene Glycol Alginate + 1% Carrageenan) to control ham mites. Both treated and untreated ham nets were compared by the authors [8] for mechanical performance characteristics based on the following standards: abrasion resistance (ASTM D4966), elastic recovery (BS EN 14704-1:2005), breaking strength (ASTM D5034-09) and bursting strength (ASTM D3786). The results indicate that the chemical treatment had minimal to no impact on the mechanical performance characteristics of ham nets. The findings support the use of treated ham nets to increase the end-use functionality and provide ham producers an option for integrated pest management without compromising mechanical performance needs.

A compact artificial magnetic conductor (AMC) structure for the application of specific absorption rate (SAR) reduction is presented in this work by Karimian et al. [9]. A magneto-dielectric (MD) structure as a host of AMC substrate is used to miniaturize the AMC size. The magneto-dielectric has been designed with a low-profile spiral loop in a way to have a high permittivity and permeability for the desired center frequency of 3.5 GHz. Simulation results confirm the zero-degree reflection phase of the proposed AMC unit cell. Moreover, a 70% reduction has been achieved by the authors in comparison to the conventional AMC. To validate the simulation results, a prototype of the board is fabricated and measured with a coplanar waveguide (CPW) antenna for the reflection coefficient. The measurement results display an excellent agreement with the simulation ones.

Optical multi-band (OMB) systems exploit the low-loss spectrum of the single mode fiber (SMF) and are key enablers to increase the transportation capacity and node connectivity of already deployed systems. The realization of OMB systems is mainly based on the technological advances on the component and system level, and for this purpose, a broad gamut of various structural elements, such as transceivers, amplifiers, filters, etc. have been commercialized already or are close to commercialization. This wide range of options, which aid in unlocking the concurrent transmission in all amplification bands, is reviewed here by Uzunidis et al. [10] for the first time, whilst their pros and cons, as well as their limitations, are discussed. Furthermore, the needs for additional components in order to fully exploit the 390 nm low-loss wavelength range of SMF, which spans from 1260 to 1650 nm, are highlighted by the authors. Finally, based on a physical layer formalism, which incorporates the impact of the most important physical layer constraints for an OMB system, the attainable capacity and transparent reach of each amplification band are quantified.

Power electronics converters are traditionally designed regarding efficiency, power density, cost, and reliability figures of merit. Today, with the extreme spread of power electronic applications in our modern societies, together with the Earth's limits in terms of materials resources, it is important to consider the ecological impact of the converter not only during its usage but over its whole life cycle. In this article, de Freitas Lima et al. [11] introduce an eco-dimensioning methodology for analyzing and accounting for the energy consumption over the entire converter life. The analysis is applied on a small DC–DC converter considering the main components dual active bridge (DAB) converter. The planar transform is one of the key elements modeled in this article, including material and manufacturing conditions. The traditional and eco-dimensioning approaches are carried out and compared in order to emphasize the possible consequences on total energy cost.

Most commercially available hybrid electric vehicle (HEV) drivetrains are made of small internal combustion (IC) engines and large electric drives to improve fuel economy. They usually have higher cost than the conventional IC-engine-based vehicles because of the high costs of the electric drives. In this paper, Hu et al. [12] propose a hybridized powertrain composed of the original full-size engine of the vehicle and a universally optimum size parallel electric drive. The dynamic programming (DP) algorithm was used to obtain the sensitivity of the maximum miles per gallon (MPG) values versus

the power rating of the electric drive. This sensitivity was then analyzed by the authors to determine the optimal window of the electric drive power ratings. This was proven to be universal for all passenger cars of various masses and engine powers. The fuel economy and vehicle performance of this HEV was compared with those of the 2019 Toyota Corolla, a conventional IC-engine-based vehicle, and the 2019 Toyota Prius, a commercially available HEV. The results showed that the proposed universally optimized HEV powertrain achieved better fuel economy and vehicle performance than both the original ICE and HEV vehicles, at low additional vehicle cost.

When the concentration of a gas exceeds the equilibrium concentration in a liquid, the gas–liquid system is referred to as a supersaturated system. Supersaturation can be achieved by either changing the pressure and/or temperature of the system. The gas from a supersaturated liquid escapes either through bubble nucleation that usually occurs on solid surface and/or gas diffusion through the gas–liquid interface. The bubble nucleation requires a minimum threshold supersaturation. A waiting time is required to observe whether the applied supersaturation is sufficient to initiate bubble nucleation. When the supersaturation is not sufficient to cause bubble nucleation, some or all of the supersaturated gas may diffuse out from the liquid through the gas–liquid interface before further reducing the pressure in order to increase the supersaturation. In this work, using Fick’s second law of diffusion and Henry’s law, an analytical method is proposed by Pradhan and Bikkina [13] to estimate the level of supersaturations generated in three gas–liquid systems at several step-down pressures. Characteristic times of the gas–liquid systems were estimated by the authors to validate whether the waiting times used in this study are in accordance with the semi-infinite diffusion model used to estimate the supersaturations generated.

In the last manuscript, Zengerle et al. [14] investigate the damping phenomena acting on piezoelectrically driven MEMS oscillators. Three geometrical shapes of MEMS oscillators are presented, including cantilevers, bending oscillators and paddle oscillators. An analytical model for their resonance frequencies is derived. The bending modes of these micro-oscillator structures are characterized regarding their resonance frequency and their quality factor as a function of the ambient pressure in a nitrogen atmosphere as well as the dependence on the distance to a neighboring plate representing a geometrical boundary (e.g., to the package or to the mounting). The investigations cover a pressure range from 10^{-3} mbar up to 900 mbar and a gap width from 150 μm to 3500 μm . Consequently, a Knudsen number range over 6 orders of magnitude from 100 to 10^{-4} is covered. The measurement data are evaluated with a generalized damping model consisting of four parts representing the individual damping mechanisms (intrinsic, molecular, transitional and viscous). The evaluated parameters are analyzed as a function of the resonance frequency and the gap width. From the results found, the authors gain fundamental insights on the viscous and transitional damping mechanisms as well as on the intrinsic losses. In conclusion, a basic concept is provided to reduce the damping of micro-oscillator bending modes and thus increase the quality factor. Additionally, the results are supported by finite element simulations, revealing the temperature and pressure distribution within the gap.

Conflicts of Interest: The author declares no conflict of interest.

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Short Biography of Author

Antonio Gil Bravo (Full Professor of Chemical Engineering, Universidad Pública de Navarra, Spain): Professor Gil earned his BS and MS in Chemistry at University of Basque Country (San Sebastián), and his PhD in Chemical Engineering at University of Basque Country (San Sebastián). He did postdoctoral research at the Université catholique de Louvain (Belgium) working on Spillover and Mobility of Species on Catalyst Surfaces. The research interests of Professor Gil can be summarized as: Evaluation of the porous and surface properties of solids. Pillared clays. Gas adsorption. Energy and CO₂ storage. Pollutants adsorption. Environmental technologies. Environmental management. Preparation, characterization and catalytic performance of metal supported nanocatalysts. Industrial waste valorization.