POLITÉCNICA

BOLETÍN BIMENSUAL DE INVESTIGACIÓN DE LA ETSIDI

escuela técnica superior de ingeniería y diseño industrial

NÚMERO 13

# E T S I + D + I

**Este boletín informativo electrónico de periodicidad bimestral tiene como objetivo informar de las actividades de investigación desarrolladas en la ETS de Ingeniería y Diseño Industrial y recopilar los resúmenes de los artículos publicados en la Web of Science (WoS) de los que son autores o coautores investigadores de la Escuela.**

## SEMINARIOS

En el mes de febrero de 2020, ha tenido lugar en nuestra Escuela un Seminario impartido por un ponente de una Universidad extranjera.

En este caso, se trataba de un professor del Departamento de "Material Science and Manufacturing Technology", de la "Czech University of Life Sciences Prague".


SEMINARIO 6 DE FEBRERO DE 2020

**"Composites with natural fillers"**

Impartido por: Profesor Petr Valášek, Czech University of Life Sciences Prague (República Checa).


Slide 29. Green composites - Types of Fibers (fillers)


Slide 69. Palma oil as a source of renewable materials

Este boletín informativo electrónico de periodicidad bimestral tiene como objetivo informar de las actividades de investigación desarrolladas en la ETS de Ingeniería y Diseño Industrial y recopilar los resúmenes de los artículos publicados en la Web of Science (WoS) de los que son autores o coautores investigadores de la Escuela.

## PUBLICACIONES

### Numerical Simulation of Temperature and Pressure Changes due to Partial Discharges in Spherical Cavities Within Solid Dielectrics at Different Ageing Conditions.

Partial Discharges (PD) behavior during ageing of the insulation systems exhibits variations that depend on changes in gas filling characteristics and surface condition. In this article, numerical simulations of temperature and pressure behavior in an air-filled spherical cavity within a homogenous solid dielectric material due to PD activity are presented. An Analytical-Finite Element Analysis simulation approach was implemented in MATLAB and results exhibit reasonable agreement with experimental measurements reported by other authors. Simulation results allow concluding that pressure changes are directly related to variations in the PD behavior. In addition, affectations to cavity surface due to temperature increments can be discarded.

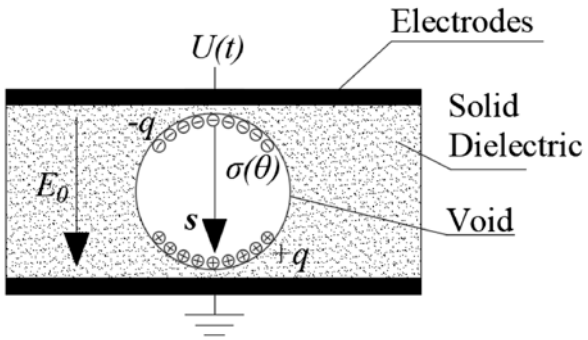


Fig. 1. Dipole moment, **s**, within the cavity due to surface charge distribution, σ(θ), after a Partial Discharge (PD) event.

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**DOI:** 10.3390/en12244771

*Rodríguez Serna, JM; Albarracín Sánchez, R. Numerical Simulation of Temperature and Pressure Changes due to Partial Discharges in Spherical Cavities Within Solid Dielectrics at Different Ageing Conditions. Energies, 12(24), 4771 (2019).*

**Efficient Multiaxial Shoulder-Motion Tracking Based on Flexible Resistive Sensors Applied to Exosuits.**

This article describes the performance of a flexible resistive sensor network to track shoulder motion. This system monitors every gesture of the human shoulder in its range of motion except rotations around the longitudinal axis of the arm. In this regard, the design considers the movement of the glenohumeral, acromioclavicular, sternoclavicular, and scapulothoracic joints. The solution presented in this work considers several sensor configurations and compares its performance with a set of inertial measurement units (IMUs). These devices have been put together in a shoulder suit with Optitrack visual markers in order to be used as pose ground truth. Optimal configurations of flexible resistive sensors, in terms of accuracy requirements and number of sensors, have been obtained by applying principal component analysis techniques. The data provided by each configuration are then mapped onto the shoulder pose by using neural network algorithms. According to the results shown in this article, a set of flexible resistive sensors can be an adequate alternative to IMUs for multiaxial shoulder pose tracking in open spaces. Furthermore, the system presented can be easily embedded in fabric or wearable devices without obstructing the user's motion.

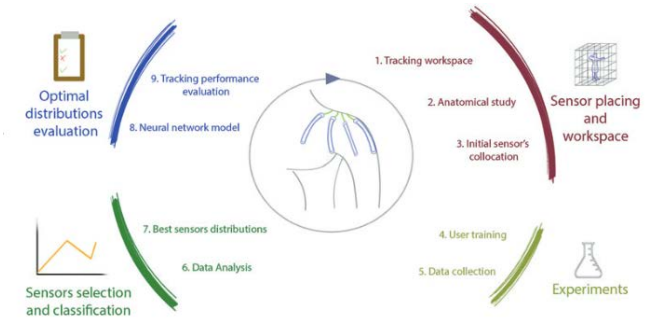


Fig. 1. Methodology applied to obtain optimal sensordistributions for measuringshoulder's multiaxial motion.Color images are availableonline.

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**DOI:** 10.1089/soro.2019.0040

*Samper Escudero, JL; Contreras González, AF; Ferre, M; Sánchez Urán, MA; Pont Esteban, D. Efficient Multiaxial Shoulder-Motion Tracking Based on Flexible Resistive Sensors Applied to Exosuits. SOFT ROBOTICS, Early Access Date: JAN 2020.*

**Analysis of the Improved Water-Resistant Properties of Plaster Compounds with the Addition of Plastic Waste.**

The aim of this article is to analyse the water-resistant properties of gypsum compounds with plastic cable waste added in order to determine the suitability of their use as an alternative to combat moisture problems in buildings. In the experimental process, test samples were made and subjected to capillary water absorption, water vapour permeability, wet chamber, water-stove cycle and total water absorption tests, and their porosimetry was also studied using the mercury porosimetry test. The results showed a significant decrease in water absorption and retention capacity. This is due in part to the reduced pore volume of the compounds that is achieved without affecting the hygrothermal properties of the gypsum products and keeping their mechanical properties above the minimum values indicated in the regulations. Thus, the material studied is a good alternative to the gypsums currently available on the market to be applied in the areas of buildings most exposed to water and it contributes to reduce environmental impacts.

Fig. 5. Prismatic test samples (Series V) submerged (left), prismatic test samples in the stove (right) during the water-stove cycle.

Fig. 7. Samples prepared for the mercury porosimetry test (Series VII).

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**DOI:** 10.1016/j.conbuildmat.2019.116956

*Vidales Barriguete, A; Atanes Sánchez, E; Del Río Merino, M; Pina Ramírez, C. Construction and Building Materials, Volume 230, UNSP 116956 (2020).*

**Hydrogen Storage for Off-Grid Power Supply Based on Solar PV and Electrochemical Reforming of Ethanol-Water Solutions.**

The hybridization of hydrogen and solar energy technologies is an interesting option to satisfy power demands in locations that are isolated from the electric grid. The main advantage of the photovoltaic (PV)-$H_2$ hybrid system is the possibility of power storage by means of an electrolyzer (EL) which transforms the electricity into hydrogen ($H_2$).

The work described here concerns a methodology to design PV- $H_2$ hybrid systems that considers the weather data and the electrical variables of the components to perform energy balances and to assess the system in terms of the load requirements, the levels of energy stored and the resulting costs. Two electrolytic systems (water splitting and ethanol electrochemical reforming) were studied in an attempt to find a best trade-off between the size and voltages of ELs. Ethanol reduced the energy requirements of EL at the expense of reagent consumption and lower current density. The energy supplied by these systems costs 0.28 (SIC)/kWh (i.e., roughly the same as power prices paid by domestic customers in Spain), but they have the merit of being autonomous and hydrogen has the capacity for seasonal energy storage - thus avoiding electrification constraints in off-grid locations and limitations of short-term electrical energy storages.

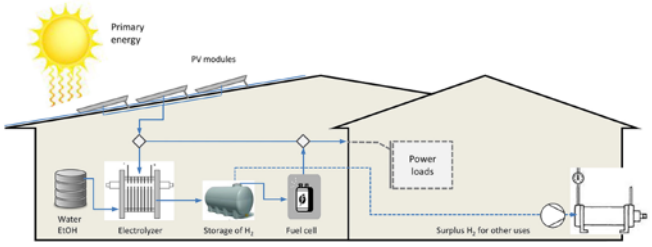


Fig. 1. Hybrid system for off-grid power supply based on solar PV and hydrogen storage.

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**DOI:** 10.1016/j.renene.2019.09.034

*Gutiérrez Martín, F; Calcerrada, AB; De Lucas Consuegra, A; Dorado, F. Hydrogen storage for off-grid power supply based on solar PV and electrochemical reforming of ethanol-water solutions. Renewable Energy, Volume 147, Part 1, Pages 639-649 (2020).*

**Streamer Simulation in Nano-based Dielectric Fluids at Different $Fe_3O_4$ Nanoparticle Concentrations.**

Nano-based dielectric fluids (NDF) seem to be a good alternative for improving dielectric and thermal characteristics of conventional liquid dielectric systems used in power transformers. $Fe_3O_4$ (magnetite) nanoparticles (NP) is one of the most investigated type of NP. Some experiments have shown that with its addition to mineral oil (MO) and ester, increases in breakdown voltage (BV) can be achieved applying both AC and DC voltages. This kind of NP have the advantage that can be handled and synthesized safely and easily using a two-steps method. Besides, streamer propagation can be reduced or avoided introducing $Fe_3O_4$ NP in dielectric fluids. These NP act as electronic traps and behave like slow-moving charged particles in the NDF. This behaviour as well as other dielectric characteristics such as resistivity, permittivity and loss tangent, depend on the type, size and concentration of NP. In this work, comparisons and analyses of thermal and dielectric performance of NDF with different $Fe_3O_4$ NP concentration are made taking into account the evolution and behaviour of streamers. It has been found that temperature in streamer tip, its length and speed depend on the $Fe_3O_4$ NP concentration and the BV is affected because of changes in streamer speed. The most adequate concentration for controlling the streamer has been obtained through simulations and comparisons with experimental results showing good agreement.

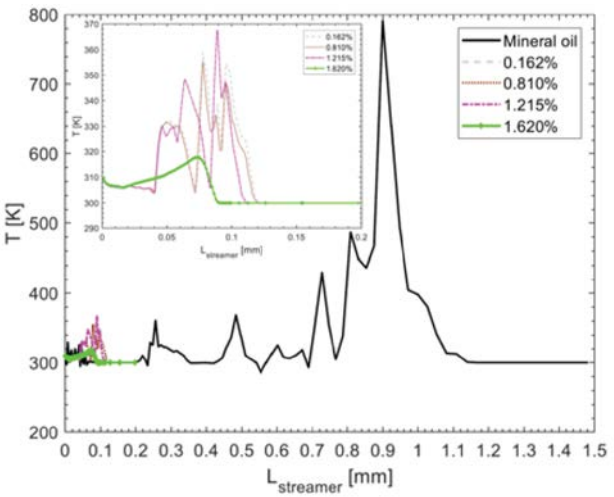


Fig. 2. Electric field distribution along the needle-sphere z-axis at 1000 ns for concentrations under 1.62 % w/v NP

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**Numerical Study of Particle Dispersion in the Turbulent Recirculation Zone of a Sudden Expansion Pipe using Stokes Numbers and Mean Drift Parameter.**

The dispersion of solid particles in zones of turbulent recirculation flow is of interest in various technological applications. Many experimental studies have been developed in order to know the contribution of Stokes numbers and mean drift parameter on the entering and dispersion of particles in the recirculation zone however to our knowledge there are not numerical studies reported about it. In this work, we made a numerical study of the incompressible turbulent flow laden with solid particles in sudden expansion pipes with different expansion ratios and different Reynolds number upstream of the pipe, using LES and Germano dynamic model with JetCode program for the continuous phase (air). The solid particles movement (different diameters were considered) was solved by using a Lagrangian tracking algorithm coupled to JetCode taking into account only drag and gravity forces supposing one way coupling. Finally, we calculated Stokes numbers based on the different fluid time scales and the mean drift parameter for all the solved cases and studied their isolated effect on the solid particle dispersion in the recirculation zones by computing the concentration by means of the particle number within the recirculation zones. Our results coincided with the experimental findings reported by others authors: the particle concentration exhibits a maximum value as the Reynolds number upstream in the pipe is decreased, the pipe expansion ratio is

Regarding the results obtained numerically about the solid particle dispersion within turbulent recirculation zones in terms of Stokes numbers and the mean drift parameters, coincided adequately with the experimental results.

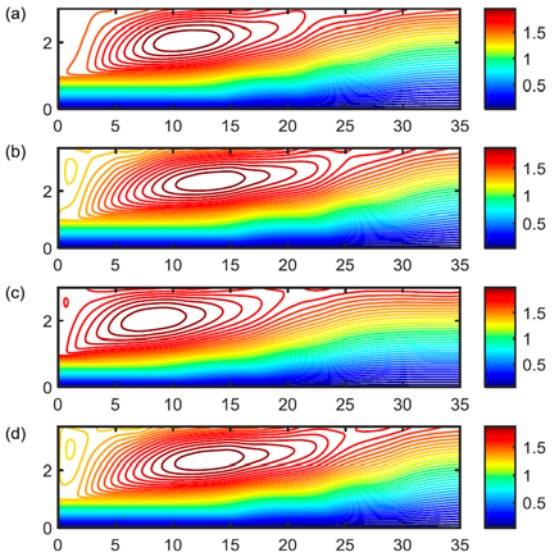


Fig. 4. Mean streamlines for a) $Re_{b1}H_1$; b) $Re_{b1}H_2$; c) $Re_{b2}H_1$; d)$Re_{b2}H_2$

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**DOI:** 10.29252/jafm.13.01.29777

*Torres, M.J.; García, J.; Doce Carrasco, Y.S. Numerical Study of Particle Dispersion in the Turbulent Recirculation Zone of a Sudden Expansion Pipe using Stokes Numbers and Mean. Journal of Applied Fluid Mechanics. Vol. 13, No. 1, pp. 15-23 (2020).*

**Characterization and Correction of the Geometric Errors Using a Confocal Microscope for Extended Topography Measurement, Part II: Experimental Study and Uncertainty Evaluation.**

This paper presents the experimental implementations of the mathematical models and algorithms developed in Part I. Two experiments are carried out. The first experiment determines the correction coefficients of the mathematical model. The dot grid target is measured, and the measurement data are processed by our developed and validated algorithms introduced in Part I. The values of the coefficients are indicated and analyzed. Uncertainties are evaluated using the Monte Carlo method. The second experiment measures a different area of the dot grid target. The measurement results are corrected according to the coefficients determined in the first experiment. The mean residual between the measured points and their corresponding certified values reduced 29.6% after the correction. The sum of squared errors reduced 47.7%. The methods and the algorithms for raw data processing, such as data partition, fittings of dots' centers, K-means clustering, etc., are the same for the two experiments. The experimental results demonstrate that our method for the correction of the errors produced by the movement of the lateral stage of a confocal microscope is meaningful and practicable.

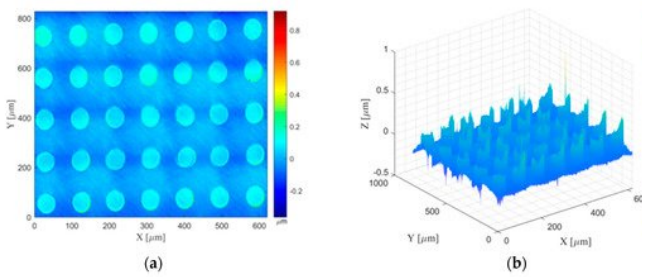


Fig. 3. Surface reconstruction after rotation of the raw measured surface: (a) 2D contour and (b) 3D surf.

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**DOI:** 10.3390/electronics8111217

*Wang, C.; Gómez García, E. Characterization and Correction of the Geometric Errors Using a Confocal Microscope for Extended Topography Measurement, Part II: Experimental Study and Uncertainty Evaluation. Electronics, 8(11), 1217 (2019).*

**Initial Plasticity Stages in Mg Alloys Containing Long-Period Stacking Ordered Phases Using High Resolution Digital Image Correlation (HRDIC) and in-situ Synchrotron Radiation.**

The development of strain incompatibilities between phases in an extruded $MgY_2Zn_1$(at.%) alloy during the initial stages of plastic deformation was studied using Synchrotron X-ray Diffraction experiment during in-situ tensile test and High-resolution Digital Image Correlation (HRDIC). The alloy microstructure is characterised by long LPSO fibers, crystalographically aligned non-DRXed grains with the basal plane parallel to the extrusion direction and randomly oriented fine DRXed grains. Localized transgranular shear bands form in DRXed grain areas first, just after yield. The total deformation is also accommodated by non-basal slip in the reinforcing microstructural components: non-DRXed and LPSO phases. The local deformation transmitted in these two phases is the main responsible of the appreciate ductility observed in Mg-Y-Zn alloys containing high volume fraction of LPSO phases.

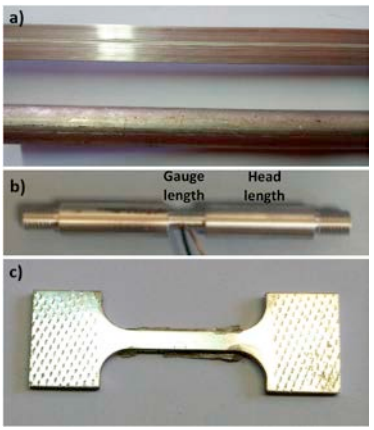


Fig. 1. a-c). a) Extruded bars used in this study. b) Tensile sample used for the in-situ synchrotron radiation diffraction experiment in P07 beamline. c) Tensile sample used for the HRDIC measurements.

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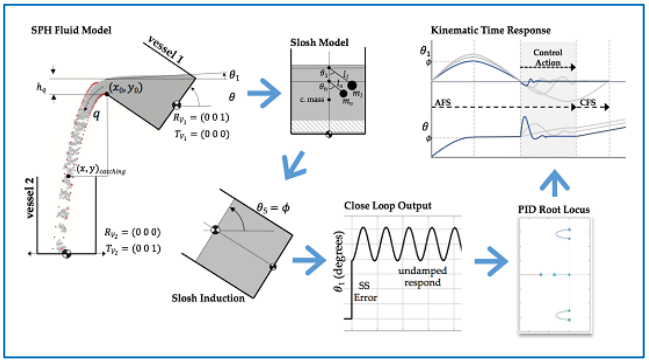
**DOI:** 10.1016/j.msea.2019.138716

*Garcés, G.; Orozco Caballero, A.; da Fonseca, J. Quinta; Pérez, P.; Medina, J.; Stark, A.; Schell, N.; Adeva, P. Initial Plasticity Stages In Mg Alloys Containing Long-Period Stacking Ordered Phases Using High Resolution Digital Image Correlation (HRDIC) And In-Situ Synchrotron Radiation. Materials Science and Engineering: A. Volume 772, Article 138716 (2020).*

**A Kinematic Controller for Liquid Pouring between Vessels Modelled with Smoothed Particle Hydrodynamics.**

In robotics, the task of pouring liquids into vessels in non-structured or domestic spaces is an open field of study. A real time, fluid dynamic simulation, based on smoothed particle hydrodynamics (SPH), together with solid motion kinematics, allow for a closed loop control of pouring. In the first place, a control criterion related with the behavior of the liquid free surface is established to handle sloshing, especially in the initial phase of pouring to prevent liquid adhesion over the vessel rim. A 2-D, free surface SPH simulation is implemented on a graphic processing unit (GPU) to predict the liquid motion with real-time capability. The pouring vessel has a single degree of freedom of rotation, while the catching vessel has a single degree of freedom of translation, and the control loop handles the tilting angle of the pouring vessel. In this work, a two-stage pouring method is proposed, differentiating an initial phase where sloshing is particularly relevant, and a nearly constant outflow phase. For control purposes, the free outflow trajectory was simplified and modelled as a free falling solid with an initial velocity at the vessel crest, as calculated by the SPH simulation. As the first stage of pouring is more delicate, a novel slosh induction method (SIM) is proposed to overcome spilling issues during initial tilting in full filled vessels. Both robotic control and fluid modelling showed good results at multiples initial vessel filling heights.




Graphical Abstract

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**DOI:** 10.3390/app9235007

*Camporredondo, G.; Barber, R.; Legrand, M.; Muñoz, L. A Kinematic Controller for Liquid Pouring between Vessels Modelled with Smoothed Particle Hydrodynamics. Applied Sciences 9(23), 5007 (2019).*

**The Discrete Element Method in Silo/Bin Research. Recent Advances and Future Trends.**

Silo research has been carried out since more than a century ago. However, many problems are still unresolved. Experiments have contributed to validate theoretical models and explain phenomena in silos, but since they usually involve a significant cost, numerical models have gained increasing attention by researchers. In this regard, the discrete element method is being used extensively to model the behavior of particulate systems such as those found within silos and bins. Initially, the main concern using this numerical method was focused on the validity of the models, since simplifications were usually introduced to reduce the computational cost. Over time, validation and calibration methods have been proposed in parallel with its use in different applications, obtaining consistent results comparing with experiments mainly at a laboratory scale. Nowadays, the combined use of DEM with other numerical methods is being continuously explored showing that it possesses a high potential for explaining phenomena in many different research fields. A review of its use in solids handling, more specifically in silos, together with a discussion on current limitations, and future trends will be presented in this article.

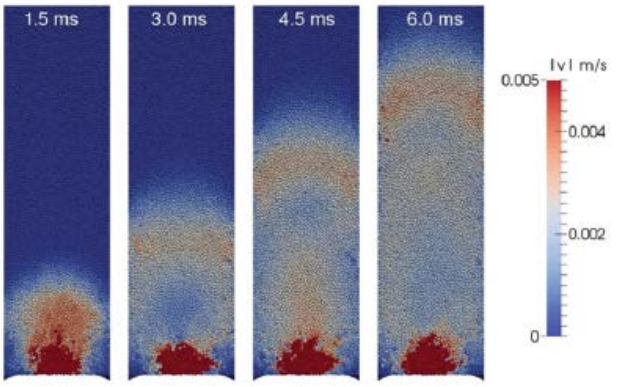


Figure 9. Visualization of the propagation of the rarefaction wave in a silo 0.12 m in diameter (Kobyłka, Horabik, and Molenda (2018)).

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*Ramírez Gómez, A. The discrete element method in silo/bin research. Recent advances and future trends. Particulate Science and Technology, volume 38, number 2, pages 210-227. (2020).*