streaming is very important from a scientific and practical point of view.

In this article, the acoustic streaming in a cylindrical cavity subjected to the vibration with constant frequency ω and constant amplitude A is investigated. The cavity is filled with a perfect viscous gas (air). The side surface of the cylinder and its ends are maintained at a constant temperature equal to the initial one. The gas motion is described using the gas dynamics equations in cylindrical coordinates (axisymmetric case). The Clapeyron ideal gas law is used as the equation of state. The system of equations is solved numerically. The calculations are executed with use of the implicit numerical scheme of first order of accuracy in both space and time. The method used for numerical simulation is described for the one-dimensional statement in [2]. The axial and radial streaming velocity components are calculated by averaging for the period of cavity vibration.

The results were obtained for three frequencies and different amplitudes of vibration. When amplitude increases, the nonlinear effects become significant and the acoustic streaming is changing. The period average temperature in nonlinear case differs substantially from the initial temperature. Additional vortices can appear. Nonlinear effects also are described in [3] for the case of big amplitude of vibration and frequencies much less resonance.

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THE LEGACY OF ANTONIO CASTELLANOS' WORK IN GRANULAR MATERIALS

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For about the last twenty years of its scientific career, Prof. Antonio Castellanos was deeply interested in the connection between the macroscopic behaviour of powders and the details of the contact between their constituent particles. Although his firsts works in the subject were motivated by the need to improve the transfer of toner particles, he made the problem of connecting the continuum description of granular materials to the particle-particle interactions the subject of a long term research program in which he investigated, among other things, the sources of the adhesion between particles, their relationship with the macroscopic cohesion, the mutual influence between microstructure and stresses in granular media, the stability of the fluidized state of granular media and the effect of the discrete nature of granular media on sound propagation. Many of his findings were reported in previous APM Conferences, in which he always enjoyed being a participant. This talk makes a summary of his works as a tribute to his memory.

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ELECTRO-CHEMO-MECHANICS OF SOLIDS AND ITS APPLICATIONS IN FUEL CELLS AND BATTERIES

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Materials used in energy conversion and storage devices are often subjected to multi-field driving forces (electrical, chemical, radiological, thermal, mechanical, etc.). In predicting the deformation and failure of these materials, conventional mechanics of material theories are no longer adequate, because these multi-field driving forces are typically coupled and produce synergetic effects that are not predicted by the classical theories. To fully understand how the different driving forces interact requires theories and models that are capable of accounting for the coupling of multi-field interaction processes.

In this talk, a theory for the mechanics of solids will be presented that accounts for the coupled effects of mechanical, electrical and chemical driving forces. The presentation will begin with an introduction of the general framework of the electro-chemo-mechanics [1, 2], followed by examples of its applications to solid oxide fuel cells [3] and Li-ion batteries [4 - 6]. Finally, path-independent integrals in electro-chemo-mechanics will be discussed [7].

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MODIFIED STRAIN GRADIENT THEORY AND TIMOSHENKO BEAM ASSUMPTIONS – A DIRECT APPROACH

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Materials with intrinsic micro- or nano-structure may show size-dependent material behavior, which is reflected by a stiffer elastic response to external forces when the size of the material body is reduced. In order to account for the so-called size effect strain gradient theories are applied, which involve higher gradients of displacements [1,2]. The additional introduction of a micro-rotation measure, which incorporates second gradients of displacements, leads to a Cosserat pseudo-continuum description [3,4]. Such a modified strain gradient theory of elasticity for isotropic materials [5] is investigated in this paper, discussing a higher order model for static beam bending. Since the analytical solution for the Bernoulli-Euler beam model is already known in the context of the modified strain gradient theory [5], we apply the Timoshenko beam assumptions [6] in the present work. This is useful in context with an inverse analysis: The corresponding additional material coefficients (a.k.a. material length scale parameters), which are involved in strain gradient continua, can be identified by means of deflection experiments [7]. These were carried out according to the method of size-effect, as described in [8]. In contrast to the results of a Bernoulli-Euler beam model, the independent rotations of the cross-sections of the beam are taken into account. It is aimed for an analytical solution of the Timoshenko beam model incorporating the terms of the extended theory. A system of coupled differential equations for the functions of beam deflections and rotations is derived. Timoshenko's shear coefficient and the shear modulus are involved. Non-dimensionalization of the functions and coefficients is provided and first numerical results are discussed. The system of coupled differential equations is solved and deflections and rotations are calculated for a straight beam with a unified load distribution.

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