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Metals exhibit so-called "size effect" when intrinsic (e.g., grain) or extrinsic (sample) dimensions are reduced to the nanoscale. An open question is whether this size effect extends to fracture behavior, and whether phenomena like flaw tolerance are observed. We explore mechanical strength and fracture of nanocrystalline platinum pillars containing pre-cracks in the context of linear elastic and elastic-plastic fracture mechanics. We present the synthesis of rectangular sub-micron sized platinum pillars with few-nm grain sizes through electroplating and e-beam lithography. Notches of varying length and crack tip radius are formed at pillar edges using a focused ion beam. In-situ uniaxial tensile tests are performed in SEMentor, a custom-built instrument made of a scanning electron microscope and a nanoindentation module, at elevated and cryogenic temperatures (77 K) to elucidate the influence of thermally activated processes on deformation and fracture. Large-scale molecular dynamics simulations are performed to understand size effects, flaw sensitivity, and deformation mechanisms.

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11:40–207

The effects of residual surface stress on the elastic fields of half-plane problems

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Based on Fourier integral transforms techniques, this short paper investigates the elastic stress fields of semi-plane problems with surface stress effects. Surface constitutive relations and generalized Young–Laplace equations, expressed in the reference configuration, are used to describe the elastic behaviour of the material surface. Due to the existence of residual surface stress, the Lagrangian expressions of surface stresses will have out-plane terms. The solutions with out-plane terms and without out-plane terms are analyzed. Numerical results show that in consequence of residual surface stress, the out-plane terms of surface stress have significant effects on the shear stress of a vertical concentrated loading case, but have little effects on the shear stress of a horizontal concentrated loading case.

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12:00–207

Mechanical behavior of graphene using atomic-scale finite element method and molecular dynamics

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Graphene has attracted significant attention due to its unique electronic and mechanical properties. Researchers have used a number of computationally efficient continuum models to analyze nanostructures. However, nanostructures such as graphene are essentially discrete, and continuum models can not account for such discreteness. Based on two case studies of graphene, we demonstrate that the atomic-scale finite element method (AFEM) is computationally efficient and can be used to model both global and local behavior with high degree of accuracy. The first case is a comparison of the force-strain curves obtained from AFEM and molecular dynamics (MD). It is shown that AFEM captures the global behavior of a graphene sheet quite accurately. The second case is a comparison of the equilibrium configurations of a narrow graphene sheet obtained from AFEM and MD. It is found that AFEM can also capture the local behavior at atomic level.

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12:20–207

The flexing of locally isostatic periodic structures

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Many natural crystal structures, in particular zeolites, can be modelled as simple pin-jointed structures which are locally isostatic, where the number of structural constraints are equal to the number of structural freedoms. Guest and Hutchinson showed that such structures must have at least one mechanism that will allow the structure to deform, and it is conjectured that these mechanisms are responsible for some of the unexpected properties of zeolites, for instance having a negative coefficient of thermal expansion. In fact, many repetitive locally isostatic structures have many additional mechanisms beyond those predicted by Guest and Hutchinson. This paper will explore the infinitesimal mechanisms associated with some simple two-dimensional structures, such as the kagome and roman mosaic structures. In particular, the paper will examine which of the mechanisms extend to finite mechanisms that might lead to the large-scale deformation of the structure.

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FS09: Mechanics of materials processing
13:40–13:49, Thursday, 23 August
Gabor Csernak, Hungary, Chair
Room: 207

13:40–207

The effect of substrate on powder concentration distribution in coaxial laser cladding

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A steady numerical 3D model of coaxial laser cladding has been developed to predict powder concentration distribution from coaxial nozzle to substrate. Powder concentration distribution has been investigated without and with considering the substrate. A low-velocity and high-pressure gas mass is formed by substrate, resulting in the change of powder concentration distribution. According to the results, though the thermal exchange between melt pool and gas flow can be ignored, the size of melt pool deeply influences the powder concentration distribution. And when the size of melt pool is large enough, gas flow field becomes a key factor to determine the powder concentration distribution. The research indicates that substrate plays an important role in powder concentration distribution.

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13:43–207

The effect of runout on the stability of milling with variable helix tools

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Chatter vibrations in milling processes cause noise, poor surface finish and increased tool wear. They occur due to an unstable self-excited mechanism. Time-delayed vibrations at the previous cut on the outer surface of the chip affect current vibrations at the present cut. Variable helix tools are characterized by different helix angles at different teeth of the cutter. In particular, due to a distributed time delay between two subsequent cuts delay differential equations with distributed delay are models for the tool vibrations. In the present contribution the stability analysis is done in the frequency domain by an extended version of the multifrequency approach. A typical example of a milling process with a variable helix tool is used to study the effect of runout on the stability of chatter vibrations by considering a nonlinear cutting force law and the dynamics in three spatial dimensions. It turns out, that the effect of runout on the stability of regenerative chatter is much larger for variable helix tools than for regular tools with uniform pitch and uniform helix angles.

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13:46–207

Advances in nonlinear model reduction and parametric modelling using the proper generalized decomposition

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In this work, we present recent advances and promising developments in the application of the model order reduction (MOR) method known as proper generalized decomposition (PGD) to the simulation of nonlinear thermo-mechanical problems and the construction of parametric solutions. The PGD is a powerful a priori model reduction technique based on the separation of the problem variable that is particularly well suited for computing parametric solutions. Its direct application to nonlinear problems is however difficult reducing thereby the attractiveness of the method for non-academic applications. We investigate the potential of the asymptotic numerical method coupled to the PGD for the efficient solution of non-linear parametric models. A particular emphasis is put on real-time and optimization applications.

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FS10: Porous media
13:55–14:19, Thursday, 23 August
Kaixin Liu, China, Chair
Changfu Wei, China, Chair
Room: 207

13:55–207

Singularity of the energy propagation in anisotropic fluid-filled porous materials

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In this paper, the energy singular propagation in open-cell anisotropic porous solids is studied with the aim to provide a reference in the energy design and application of porous materials. Based on Biot's theory, the perturbed eigenvalue problem that arises when the nearly pure modes are propagated is firstly considered. Then, by using the obtained perturbed eigenvalues, the evolution conditions on the elastic parameters are established for the existence of various systems of folds in the ray surface. The emphasis is placed on the slow wave, which is particular for the porous material with the pore fluids. The critical conditions for the pattern transformation in the parameter space are given. At last, the special situation (zero porosity) is discussed and the results show that the situation in the pure solids is a degenerated case of the present discussion.

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13:58–207

Phase change in porous media under constant heat flux

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This paper introduces a one-dimensional analytical solution capable of predicting the temporal evolution of solid-liquid phase