14:00–202A+B

Steady granular flow: local and nonlocal approaches

*Ken Kamrin**,†, *Georg Koval***
**Dept of Mechanical Engineering, MIT, Cambridge, USA*
***Laboratory of Engineering Design, INSA, Strasbourg, France*

A general, three-dimensional law to predict granular flow in arbitrary geometries has remained an elusive challenge in engineering. Recently, an elasto-plastic continuum model has shown the ability to approximate steady flow and stress profiles in multiple inhomogeneous flow environments. However, the model does not capture some phenomena observed in the slow, creeping flow regime. As flow-rate decreases, granular stresses are observed to become largely rate-independent and a dominating length-scale emerges in the mechanics. This talk accounts for these effects using the notion of nonlocal fluidity, which has proven successful in treating nonlocal effects in emulsions. We augment the usual granular fluidity law with a diffusive second-order term scaled by the particle size that spreads flowing zones accordingly. Below the yield stress, the local contribution vanishes and the fluidity becomes rate-independent, as we require. We implement the modified law in multiple geometries and validate its predictions for velocity, shear-rate, and stress against discrete particle simulations.

kkamrin@mit.edu

14:20–202A+B

Dislocation-mechanics-based constitutive descriptions of crystal plasticity of metals: an overview

*Chongyang Gao**,†, *Liangchi Zhang***
**Department of Engineering Mechanics, Zhejiang University, Hangzhou, China*
***School of Mechanical and Manufacturing Engineering, The University of New South Wales, NSW, Australia*

A reliable constitutive model is crucial to the robust description of the dynamic response of a material under large deformation at high strain rates. Physics-based constitutive models for crystalline plasticity, such as Zerilli—Armstrong (ZA), Follansbee—Kocks (MTS), Nemat—Nasser—Li (NNL), Rusinek-Klepaczko (RK) and Voyiadjis-Abed (VA) models etc, have therefore been proposed to capture the microstructural characteristics and evolution of dislocation kinetics. Recently, the authors have developed a class of Gao—Zhang (GZ) models based on dislocation mechanics to reflect the thermo-viscoplastic behaviors of fcc, bcc and hcp metals. The applications of their models to OFHC copper, Tantalum, HSLA-65 steel, Titanium and Ti6Al4V alloy show that theirs give satisfactory predictions and are easier to use than the classical MTS model. Furthermore, the authors established a unified fcc model which can successfully describe the flow stress upturn phenomenon in fcc metals at extremely high strain rates by considering mobile dislocation density evolution.

lxgao@zju.edu.cn

14:40–202A+B

Strain hardening for steel under non-proportional loading

Frédéric Barlat†, *Jin Jin Ha, Myoung-Gyu Lee*
Graduate Institute of Ferrous Technology, Pohang University of Science and Technology, Pohang, Gyeongbuk, Republic of Korea

In this work, an approach is proposed for the description of the plastic behavior of materials subjected to multiple or continuous strain path changes. In particular, although it is not formulated with a kinematic hardening rule, it provides a reasonable description of the Bauschinger effect when loading is reversed. This description of anisotropic hardening is based on homogeneous yield functions combining a stable, isotropic hardening-type, component and a fluctuating component. The latter captures, in average, the effect of dislocation interactions during strain path changes. For monotonic loading, this approach is identical to isotropic hardening, with an expanding isotropic or anisotropic yield surface around the active stress state. The capability of this constitutive description is illustrated with applications on a number of steel sheet samples subjected to two-step tension tests with varying angles between the two loading directions.

f.barlat@postech.ac.kr

15:00–202A+B

A new elastic-plastic model for describing the nanoindentation size effects of surface-nanocrystalline materials

Shaoming Yu, Yueguang Wei†
LNM, Institute of Mechanics, Chinese Academy of Science, Beijing, China

Size effects of mechanical properties are found in experiments for nanostructured materials obviously. For a micro/nano-scale sample, surface and interface effects play an important role, and they will cause the obvious size effects of materials properties. In order to explain the influence of surface and interface effects, some researchers come up with a parameter of specific surface area. From author early work, for samples with different scales an approximate linear relationship between yield strength and specific surface area (or surface energy density) was obtained by order and dimensional analysis. This relationship explains the size dependence of single crystal nicke/gold in the experiments of uniform compression effectively. In the present research, authors extend the yield strength relationship to the case of surface-nanocrystalline (SNC) materials. Through finite element simulations based on the new model, the nanoindentation size effect of the surface-nanocrystalline materials is displayed clearly. The interface effect is also displayed, and result shows that the interface effect is an important contribution to the size effect of the mechanical properties of the nanocrystalline materials. Through comparison, finite element results agree well with the experimental results.

ywei@lnm.imech.ac.cn