Consiglio Nazionale delle Ricerche
Istituto per l'Energetica e le Interfasi
U.O.S. di Milano

SEMINARIO

Non-isothermal cyclic fatigue in oscillating elasto-plastic structures with hysteresis

Michela Eleuteri
Dipartimento di Matematica "F. Enriques" - Università degli Studi di Milano

5 giugno 2013 - ore 11:00
CNR IENI - sala Q4 P1 16 - via R. Cozzi 53 - 20125 Milano

The theory of hysteresis operators developed in the recent years has proved to be a powerful tool for solving mathematical problems in various branches of applications, such as solid mechanics, material fatigue, ferromagnetism, phase transitions. In a series of recent papers [2, 3, 4, 5, 6], we developed a model for thermo-elasto-plastic oscillations of beams and plates with hysteresis and material fatigue. It is well known that plastic deformations lead to energy dissipation and material fatigue, which is in turn manifested by material softening, heat release and material failure in finite time.
The aim of this seminar is to present this model and discuss its thermodynamic consistency.
After a short introduction about hysteresis and the main hysteresis operators used in elasto-plasticity (the *stop* and the *Prandt-Ishlinskii* model) we will focus our attention to the main assumption for our model: there exists a qualitative and *quantitative relation between accumulated fatigue and dissipation rate*. This is motivated by the so called *rainflow method* for cyclic fatigue accumulation in uniaxial processes [1] and by experimentally documented strong heat release at the point of material failure which manifests an energy dissipation peak. So our approach turns to be different from other situations, see for instance [7], where the analysis of damage increase in visco-elastic solids is carried on assuming that the damage is driven by large deformations, rather than by energy dissipation.
In particular, in the papers [3, 4] the influence of the energy dissipation due to the material softening on the damage increase was taken into account; this assumption accelerates the fatigue accumulation to such an extent that a singularity (material failure) may develop in finite time. We will discuss about this possibility and present a proposal for the evolution equation for the fatigue parameter m which is consistent from the thermodynamic viewpoint.
In the last part of the seminar we plan to discuss about the possibility of accounting also decreasing fatigue rate in the model, i.e. partial damage recovery, by the effects of heat induced phase transitions (local melting), so that the time of failure of the material can be shifted. This will be done by introducing, together with the fatigue parameter m, also a new parameter of phase transition, a phase variable χ, taking values in the interval [0, 1] and describing the degree of melting of the material; when $\chi = 0$ the material is in the solid phase, whereas when $\chi = 1$ is completely melted. This recovery mechanism is activated by the heating due to dissipation and the external source. Also in this case the thermodynamic consistency of the model problem can be shown under similar considerations as before [6].
We conclude the seminar with some open problems and perspectives in the numerical treatment of this model, a topic that turns to be as challenging as (for the moment) difficult.

References

[1] M. Brokate, K. Dressler and P. Krejci: Rainflow counting and energy dissipation for hysteresis models in elastoplasticity, Euro. J. Mech. A/Solids, 15 (1996), 705-735.
[2] M. Eleuteri, J. Kopfova' and P. Krejci: A thermodynamic model for material fatigue under cyclic loading, Physica B: Condensed Matter, 407, no. 9 (2012), 1415-1416.
[3] M. Eleuteri, J. Kopfova' and P. Krejci: Fatigue accumulation in an oscillating plate, Discrete Cont. Dynam. Syst., Ser. S, 6 No. 4., (2013), 909-923.
[4] M. Eleuteri, J. Kopfova' and P. Krejci: Non-isothermal cyclic fatigue in an oscillating elastoplastic beam, Comm. Pure Appl. Anal., to appear.
[5] M. Eleuteri, J. Kopfova' and P. Krejci: Fatigue accumulation in a thermo-visco-elastoplastic plate, submitted.
[6] S. Bosia, M. Eleuteri, J. Kopfova' and P. Krejci: Fatigue and phase in an oscillating plate, submitted.
[7] E. Rocca and R. Rossi: A degenerating PDE system for phase transitions and damage, preprint arXiv:1205.3578v1 (2012), 1-53.

Informazioni

dr. Stefano Zapperi - +39 02 66173 385 - stefano.zapperi@ieni.cnr.it
Su richiesta, si rilascia attestato di partecipazione