UNCOUPLED DISSIPATION ASSUMPTION TO CONTROL ELASTIC GAPS IN GURTIN-TYPE STRAIN GRADIENT MODELS

Mohamed Jebahi*, Lei Cai*, Farid Abed-Meraim*

***Arts et Metiers Institute of Technology, CNRS, Université de Lorraine, LEM3, F-57000 Metz, France**
mohamed.jebahi@ensam.eu

ABSTRACT- Thanks to their capabilities in capturing size effects, strain gradient plasticity theories have received a strong scientific interest in the last two decades. However, despite the great scientific effort on these theories, several challenging issues related to them remain to be addressed.

One of these issues is concerned with the description of the dissipative processes due to plastic strains and plastic strain gradients. In almost all existing strain gradient works, such processes are described using generalized effective plastic strain measures, which imply plastic strains and their gradients in a coupled manner. This kind of (coupled) measures makes the issue of proposing robust and flexible dissipation formulations and the control of important dissipative effects difficult. Using such measures, it is not easy to control, for example, the elastic gaps at initial yield or under non-proportional loading. However, in most cases, the coupling between dissipative processes is only used by assumption. Its consistency with the current understanding of small scale plasticity is not confirmed in the literature.

In spirit of multi-criterion approaches available in the literature, the present work proposes a flexible uncoupled dissipation assumption to describe dissipative processes. These processes are assumed to be derived from a pseudo-potential that is a sum of two independent functions of plastic strains and plastic strain gradients. Using this assumption, a new Gurtin-type strain gradient crystal plasticity (SGCP) model is developed and applied to simulate various two-dimensional plane-strain tests under proportional and non-proportional loading conditions.

Results associated with these tests show the great flexibility of the proposed model in controlling some major dissipative effects, such as elastic gaps. A simple way to remove these gaps under certain non-proportional loading conditions is provided. Application of the proposed uncoupling assumption to simulate the mechanical response of a sheared strip has led to accurate prediction of the plastic strain distributions, which compare very favorably with those predicted using discrete dislocation mechanics.