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Non-local and numerical formulations for dry sliding friction and wear at high velocities

A. Lodygowski [a], G.Z. Voyiadjis [b,*], B. Deliktas [c], A. Palazotto [d]

[a] Department of Civil and Environmental Engineering, Poznan University of Technology, Piotrowo 5, 60-965 Poznan, Poland
[b] Department of Civil and Environmental Engineering, Louisiana State University, Baton Rouge, LA 70803, USA
[c] Department of Civil Engineering, Mustafa Kemal University, Iskenderun, Hatay 31200, Turkey
[d] Department of Aeronautics and Astronautics, Air Force Institute of Technology, Wright–Patterson AFB, OH 45433, USA

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ABSTRACT

Severe contact stress problems generate high temperature and create thermomechanical gouging and wear due to high velocity sliding between two materials staying in contact. In order to improve the facilitation of the design of particular components and improve performance of these engineering applications, it is necessary to better understand the physical behavior of high speed environment. As presented here this environment is made up of two components in contact. Therefore, basing on the experimental approach (Lodygowski, 2010; Lodygowski et al., submitted for publication) the major consideration of this paper is aimed to develop an experimental/theoretical model for the material constitutive behavior in order to better characterize and predict the internal failure surrounding the gouging and wear events.

This research is to be carried out in two stages. First, by investigating the phenomenon of wear and later it will be extended to incorporate gauging problems. The principle of virtual power is used by introducing the contributions from damage and its corresponding gradients as a measure of micro motion of damage within the bulk. In addition two internal state variables are introduced on the frictional contact interface, one measuring the tangential slip and another measuring the wear. By using these internal state variables together with displacement and temperature, the constitutive model is formulated with state laws based on the free energies and the complimentary laws based on the dissipation potentials. The proposed theoretical model is implemented as user defined subroutine VUMAT in the explicit finite element code ABAQUS to analyze the structural response of the ultra high speed sliding experiment between Steel and VascoMax steel at Ecole de'Nationale Institut der Mechanic, at Metz France.

This model provides a potential feature for enabling one to relate the non-local continuum plasticity and damage of the bulk material to friction and wear at the contact interfaces. The findings of this research effort is invaluable in providing a multiscale material model and numerical procedure that will be used within a hydrocode to better facilitate the design components of the severe contact stress applications.

* Corresponding author.
E-mail address: voyiadjis@eng.lsu.edu (G.Z. Voyiadjis).

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