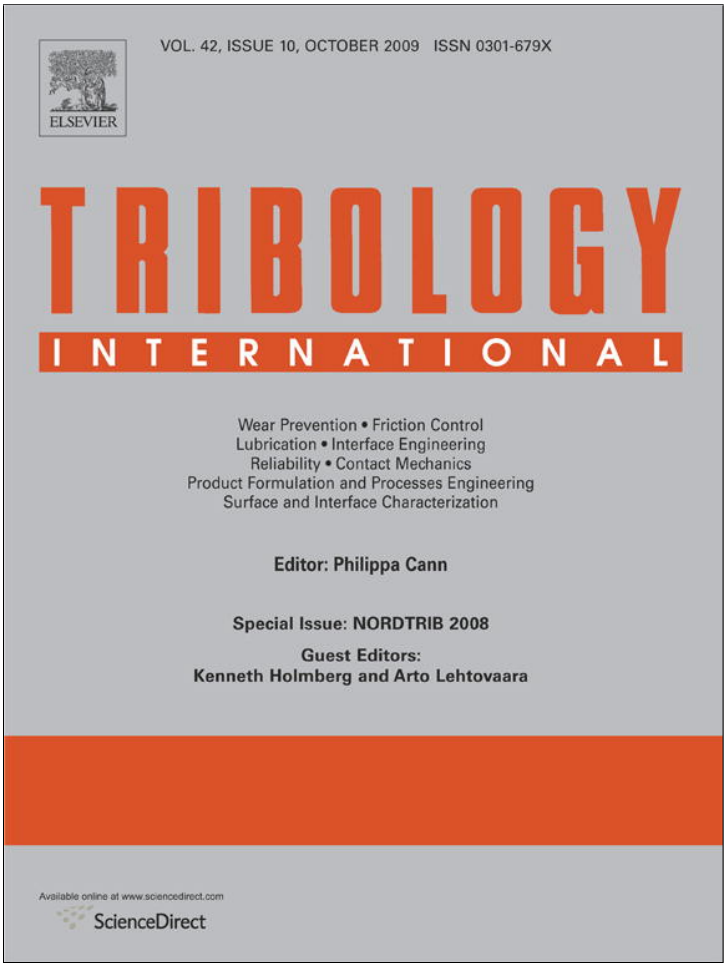
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Squeeze process under impact, in highly compressible porous layers, imbibed with liquids

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A B S T R A C T

The paper proposes a model for the squeeze process under impact for highly compressible porous layers imbibed with fluids (HCPL). It is assumed that the normal forces generated by elastic compression of the fibers comprising the solid phase are negligible compared to the pressure forces generated in the imbibed fluid, within the porous layer. The process, named ex-poro-hydrodynamic (XPHD) lubrication, is strongly dependent on porosity variation and consequently on permeability variation. Closed form analytical solutions are given for circular and rectangular contacts with various boundary conditions. Numerical applications show the existence of optimum initial compactity, σ_0, that minimizes the maximum impact force (i.e. the maximum damping effect). These interesting results can be useful for the design of squeeze dampers and shock absorbers based on XPHD lubrication.

1. Introduction

During the last 10–15 years, a new lubrication mechanism applicable to highly compressible porous layers imbibed with fluids (HCPL) acting as self-sustained films has been developed [1–4]. This new type of lubrication requires that the normal forces generated by elastic compression of the fibers comprising the solid phase are negligible compared to the pressure forces generated in the imbibed fluid, within the porous layer. The porous layer can be represented by

- the unwoven textile materials, as felt, or similar materials used as wash-cloth [1,5,6];
- the articular cartilage [1,7];
- the endothelial surface glycocolyx that coats the microvessels [6,9];
- the fresh powder snow [1,2];
- the goose down [4].

This type of lubrication is strongly dependent on porosity variation and consequently on permeability variation hence, the name of ex-poro-hydrodynamic (XPHD) lubrication was proposed [3].

The present paper analyzes the squeeze process under impact in XPHD conditions, for two different configurations: circular, respectively rectangular. The results suggest the possibility to use such processes for squeeze dampers and shock absorbers.

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2. Problem formulation and main assumptions

Fluid flow through a porous media can be approximated by Brinkman's (momentum) equation [10], which has the following general form:

$$\nabla p = \eta\left(\nabla^2 - \frac{1}{\phi}\right)u_m \tag{1}$$

where u_m is the mean fluid velocity through "the channels in porous media".

For low permeability, ϕ, this equation becomes an alternative of Darcy law [10]:

$$\nabla p = -\frac{\eta q_p}{\phi h} \tag{2}$$

where $q_p = u_m h$ is the rate of flow in a porous media of thickness h.

The geometry and kinematics of a friction joint containing HCPL determine a variation in space and/or in time of the thickness and porosity of the layer. This variation implies a variation of permeability, also in space and time. These variations are related essentially with the occurrence of a self-sustained pressure distribution, i.e. XPHD lubrication mode.

The analytical modeling of this self-sustained film requires the following assumptions:

1. The fluid imbibed in the porous layer is Newtonian and the flow is laminar and isothermal/isoviscous.
2. The porous layer is homogenous, isotropic and relatively thin; consequently the pressure across its thickness is constant.
3. The local deformation is produced only in the normal direction of the porous layer. For the sake of clarity the term of *local*