MODELLING ORTHOTROPIC FRICTION WITH A NON-LINEAR BRISTLE MODEL

Adam Wijata[1], Michał Makowski[2], Bartosz Stańczyk[1], Jan Awrejcewicz[1]

[1] *Department of Automation, Biomechanics and Mechatronics, Lodz University of Technology, Stefanowskiego 1/15 St. 90-924 Łódź, e-mail:adam.wijata@edu.p.lodz.pl*

[2] *Institute of Vehicles, Warsaw University of Technology, Narbutta 84 St. 02-524 Warsaw*

Abstract

Friction is a phenomenon which occurs commonly in the nature and in mechanical constructions. One can find numerous mathematical models describing friction as a one-dimensional process. On the other hand, the number of models which take into account second dimension is significantly smaller. Such models should describe anisotropy besides well-known static and dynamic frictional effects.

In reference [1] we have proposed a 2D dynamic, bristle friction model which can be treated as an extension of the Reset Integrator Model [2]. The 2D bristle is defined with maximum strain z_0 and stiffness coefficients σ_1, σ_2 in two perpendicular directions. It is possible to introduce orthotropic type anisotropy in the model, but a way in which the model captures it can be improved by introducing *the maximum energy dissipation principle*, which bounds a direction of a friction force with a direction of a slip. In our improved model it is realised with non-linear stiffness of the bristle $\sigma_1^*(z)$, $\sigma_2^*(z)$ in a slip phase of motion. The non-linear stiffness is compared to the linear one in Fig.1 where $\delta = \sigma_1/\sigma_2$ denotes an orthotropy ratio.

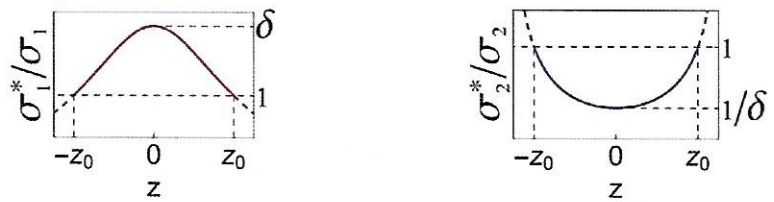

Fig.1. Non-linear to linear stiffness ratio for two perpendicular directions over a microsliding displacement

Improved model has been put into series of experiments to verify it qualitatively and quantitatively. One can observe in Fig. 2 how introduced non-linear stiffness influence a spiral-like trajectory of the planar oscillator moving over a surface with orthotropic friction.

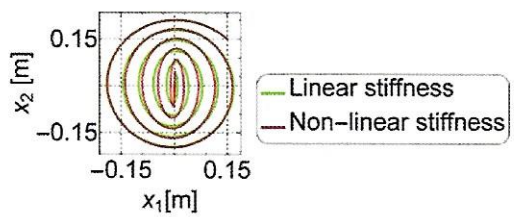

Fig.2. Planar oscillator trajectories comparison, $\delta = 1.5$

References

[1] Wijata A., Awrejcewicz J., Matej J., and Makowski M.: Mathematical model for two-dimensional dry friction modified by dither, Mathematics and Mechanics of Solids 22(10), 1936–1949, 2017.

[2] Haessig D. A., Friedland B.: On the modeling and simulation of friction, Journal of Dynamic Systems Measurement and Control 113(3), 354–362, 1991.