Accepted Manuscript

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PII: S0301-679X(18)30302-5

DOI: 10.1016/j.triboint.2018.06.016

Reference: JTRI 5274

To appear in: *Tribology International*

Received Date: 17 March 2018

Revised Date: 14 May 2018

Accepted Date: 10 June 2018

Please cite this article as: Zhu Z, Nathan R, Wu Q, An experimental study of the lubrication theory for highly compressible porous media, with and without lateral leakage, *Tribology International* (2018), doi: 10.1016/j.triboint.2018.06.016.

An experimental study of the lubrication theory for highly compressible porous media, with and without lateral leakage

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Abstract

In this paper, we report a comprehensive, experimental study to examine the lubrication theory for highly compressible porous media. It is inspired by the frictionless motion of red cells in a tightly fitting capillary and a human skiing/snowboarding. A novel experimental setup was developed where lubrication pressure generated in a soft porous layer was measured as planar board glides over it. Both laterally confined (1-D) and unconfined (2-D) situations were examined. The results excellently agree with the theory by Feng & Weinbaum (J. Fluid Mech. 422 (2000), pp. 281-317) and Wu & Sun (Med. Sci. Sports Exerc., 43 (2011), pp. 1955-1963). The paper demonstrates the significant potential of applying soft porous media in lubrication with tremendously enhanced hydrodynamic lift.

Keywords: lubrication, soft porous media, lift generation, pressure

Nomenclatures

F1~F3	Load Cells
f_{air}	The percentage of air pressure in the overall lifting pressure.
h_2	The porous thickness under the leading edge of the planing plate
h_1	The porous thickness under the trialing edge of the planing plate
k	Compression ratio, h_2/h_1
K_p	Darcy permeability of the porous media
L	The length of the planing plate
P1~P12	Pressure sensors.
R	Coefficient of the Nogai Darcy permeability correlation