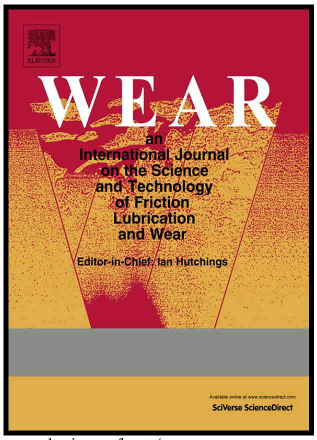
Author's Accepted Manuscript



www.elsevier.com/locate/wear

Can a "pre-worn" bearing surface geometry reduce the wear of metal-on-metal hip replacements? --- a numerical wear simulation study

Leiming Gao, Zikai Hua, Robert Hewson

PII: S0043-1648(17)31504-1
DOI: https://doi.org/10.1016/j.wear.2018.03.010
Reference: WEA102380

To appear in: *Wear*

Received date: 12 October 2017
Revised date: 6 February 2018
Accepted date: 18 March 2018

Cite this article as: Leiming Gao, Zikai Hua and Robert Hewson, Can a "pre-worn" bearing surface geometry reduce the wear of metal-on-metal hip replacements? --- a numerical wear simulation study, *Wear,* https://doi.org/10.1016/j.wear.2018.03.010

Can a "pre-worn" bearing surface geometry reduce the wear of metal-on-metal hip replacements? --- a numerical wear simulation study

Leiming Gao[1)]*, Zikai Hua[2)], Robert Hewson[1)]

1) Department of Aeronautics, Imperial College London, London, UK, SW7 2AZ

2)School of Mechatronics Engineering and Automation, Shanghai University, Shanghai, China, 200444

*leiming.gao@imperial.ac.uk

Key words: Total Hip Replacement (THR); metal-on-metal; non-spherical; worn geometry; wear simulation; EHL

Abstract:

Total Hip Replacement (THR) is generally a highly successful treatment for late stage hip joint diseases and wear, however, wear continues to be one of the major causes of metal-on-metal THR's failure. Hip replacements typically experience a two-stage wear; a higher initial wear rate in the beginning followed by a lower steady-state one with the surface profile changed. This alludes to the potential use of a cup with a non-spherical interior cavity with an initial geometry similar to a worn surface which may benefit from lower wear rate. In this paper wear is numerically simulated with a cup having a non-spherical geometry inspired by the initial stage of wear.

A wear model was recently developed by the authors for the THR, which considered the lubricated contact in both elastohydrodynamic lubrication (EHL) and mixed lubrication regime, rather than a dry contact used in most of other studies of wear modelling in the academic literature. In this study the wear model has been updated by introducing the 'λ ratio' (the ratio of film thickness to surface roughness) and addressing the non-Newtonian shear-thinning properties of the synovial fluid. This wear model was able to describe the non-linear wear evolution process due to the change of worn profiles. Firstly the wear of a spherical hip joint was simulated until a steady-state wear rate is achieved. Then a non-spherical joint was proposed in which the cup bearing geometry was generated by the previously predicted worn profile from the spherical joint. At last the wear of this "pre-worn" hip bearing was simulated and compared to the spherical one. Approximately 40% reduction in the steady-state wear rate and 50% in the total accumulated wear has been observed in the non-spherical hip joint. This study presented a full numerical analysis of the relationship between lubrication, wear reduction and the geometry change, and quantitatively suggested the optimal geometry to reduce running-in wear.