An Evaluation of the Needed Dimples Spacing and Roughness of Hip Joint Prosthesis Articulating Surfaces at Partially Regular Surface Texture

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1. Introduction

Currently in the field of technology of processing of a surface with formation of partially regular surface texture is reached essential progress. Creation of artificial lubricant pockets (dimples), as a rule, prevents the bonding of articulated surfaces of tribo-pair, promotes removal of products of wear process into dimples from a contact place, feeds the frictional contact by portion of lubricant in process of its operation, that all essentially improve tribological properties.

The objective of this work is to regulate the dimples spacing of partially regular surface texture on a ball head of hip joint prosthesis depending on the nominal contact pressure and to define a class of a roughness to which it is necessary to process a ball head surface for metal/metal and metal/polymer friction pairs.

2. Materials and methods

The problem of optimisation of a surface texture from a position of the molecular mechanical theory of a dry and boundary friction and a hypothesis of "film starvation», developed by Kragelsky [1], taking into account criterion of a minimum of coefficient of friction, is considered. According to a hypothesis of "film starvation» on two contacting surfaces in a sliding direction the protective layers of an intermediate layer simultaneously are formed and destroyed and probability of contact through an lubricant layer increases owing to an optimum relationship of speeds of destruction and restoration of a boundary film, and also a relationship $S/(S-d)$ is an average distance between dimples S and their average extent $S-d$, where d is a size of dimple on a surface. The contacting prosthesis elements (a ball head and an insert) have the area of interaction where the contact process is also influenced by a surface waviness.The nominal contact pressure depends on contour pressure, therefore at definition of contour pressure the two forms of a wave – cylindrical and spherical were considered and comparison of their influence was performed. The actual nominal pressure was defined by a simulation method with use of software ANSYS. The metal/metal (CoCrMo alloy) and the metal/UHMWPE (ultra-high-molacular-weight polyethylene GUR 1020) friction pairs were simulated.

Taking into account the noted above criteria the roughness characteristic of a ball head surface Δ was defined by which then the main roughness parameter R_a – the mean arithmetic deviation of the profile, was obtained.

3. Results and discussions

In a range of nominal contact pressure 2…20 MPa the condition of "film starvation» absence is the defining one that gives the optimum relationship $S/(S-d) = 1.01\ldots7.0$. The coefficient of friction at this relationship does not reach the minimum and is not therefore the defining criterion.

To the higher surface roughness class it is necessary to process a ball head surface: for the metal/metal tribo-pair in comparison with the same of the metal/UHMWPE, also in the case of a spherical waviness in comparison with cylindrical one, and at increase in magnitude of ratio $S/(S-d)$ and of a nominal contact pressure, but the latest factor provides a weak influence. There is the interesting result which shows that considerable variability of initial parameters at the definition of ratio $S/(S-d)$ leads to the maximum change of a surface roughness class no more than in one unit.

4. Conclusion

The obtained results allow providing the engineering well-founded approach at designing of the spherical joint of hip prosthesis with partially regular surface texture, and also other joints which structure includes the spherical joint. Besides, it allows generating initial data at the formulation and solution of the further problem by the definition of wear rate in the joint to be designed.

5. Acknowledgements

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6. References

[1] Kragelsky, I.V., Dobychin, M.N., and Kombalov, V.S., “Friction and Wear”. New York: Pergamon Press; 1982.