THE METHODOLOGY OF SLIDE MICRO-BEARINGS LUBRICATION

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Abstract

The core of the presented problem is to numerically and experimentally determine, or to indicate, the values of the optimum pressure and liquid velocity values appearing near the cells, of micro-bearing cooperating surfaces, and to find ways of controlling the friction forces between particles of the liquid and the cell of the micro-bearing cooperating bodies in the thin boundary layer.

Investigations of the physical and strength features are expected to be performed for various kinds of micro-bearing superficial layer and for efficient and damages micro-bearings.

In order to begin treating the surface structure of a superficial layer on the cooperating micro-bearing surfaces it is absolutely necessary to have at one's disposal the proper model of a liquid flow in the thin layer, and to obtain the proper values of friction forces. During presented research are realized the following tasks:

1. *The methodology of analytical and numerical efforts to obtain characteristics on the micro- and nano- level of pressure, liquid velocity and friction forces,*
2. *The methodology of experimental efforts on the nano- level to measure thin layer lubricant properties between cooperating micro-bearing surfaces.*
3. *The methodology of experimental research on the micro- and macro -level to measure cooperating surfaces in micro-bearing*

Keywords: *slide micro-bearings, lubrication, methodology*

1. Introduction

The presented paper describes the latest achievements of operating parameters for friction micro-pairs, friction micro-joints and especially friction forces of the conical, spherical, cylindrical, parabolic, hyperbolical micro-bearings particularly in HDD micro-bearings [1-10, 19-28].

The cooperating micro-bearing surfaces are covered by a very thin superficial layer of about 80 nm height with biological material additions. The superficial layer with biological additions contains genetic information which establishes the previously defined intelligent features prescribed in the genetic material. The means of registration of genetic DNA information inside the thin superficial layer with biological additions is called the genetic code. We can control genetic information and we can select such genetic information inside the thin biological layer so as to obtain proper carrying capacities and very small friction forces, as well as wear values during the exploitation period.

Authors have gained experiences in above research during the following realization:

- Wierzcholski Krzysztof, 2001-2004 GRANT KBN–8-T10B-061-21, "Theoretical and experimental investigations of thermodynamical and magnetical bearing materials properties in the field of exploitation problems in slide journal bearings",
- Wierzcholski Krzysztof, (project coordinator), GRANT (Deutsche Luft und Raumfahrt) Bonn DLR-198-96, "Computer optimization of slide bearing parameter",
- Wierzcholski Krzysztof, (project coordinator), GRANT UNII EU. GROWTH 2001-2003 NAS., "Computer aided optimization of newly developed bioreactor for tissue engineering"; G5RD-CT-2000-00282,

- Wierzcholski Krzysztof, (project coordinator), GRANT DLR-2002-00011 (Deutsche Luft und Raumfahrt) Bonn–Berlin, "Optimierung nicht Newtonscher Flüssigkeiten mit biologischen Eigenschaften aufgrund der Analogien zwischen den Strömungen des Schmiermittels im Reibkontakt in Lagern und in der Umgebung menschlicher Gelenke",
- Wierzcholski Krzysztof, (main investigator), 2003-20062 Grant KBN 4 T-11E030-25, "Non stationary models of human joints lubrication for deformed cartilage in magnetic field and computer aided optimization during tissue cultivation in bioreactor",
- Wierzcholski Krzysztof, (coordinator Transfer of Knowledge 2005-2008), GRANT UNI EU MTKD-CT-2004-517226, "Bio and Slide Bearings, their Lubrication by Non-Newtonian Oils and Applications in Non-Conventional Systems".

The asymmetric and symmetric grooves on the spherical micro-bearing surface are applied. The depth of the grooves amounts to about 25 nm. A whirling lubricant flow caused by the grooves lying either on the cooperating micro-brakes or clutch, or micro-bearing surfaces, consolidates the intelligent features.

The author indicates the similarity between the intelligent micro-bearing properties and the intelligent behaviour of human bio-bearings. In such investigations the adhesion forces in mechanical devices and bio-adhesion forces on living surfaces are taken into account [15].

Additionally very important are correlations between observed static friction force, adhesive force and calculate friction force characteristics vs. time. Rheological dependencies of visco-elastic material elasticity modulus vs. time for static friction and adhesion in micro-bearings are considered [14].

The process of transition from static to kinetic friction in rarely investigated [14]. The time of static contact of rubbing elements before sliding effects is very important on the static friction force during the transition to sliding.

It is worth noticing that the real molecular nano-technology which is observed in a biological cell is associated with a considerable change of the conformation of molecules in almost all the processes. For example, bacterial flagella motors constitute a manifestation of molecular nano-technology in the domain of nano-bearings. Thus, we can expect that the investigations related to the influence of the electronic structure on the decreasing in the resistance of the motion can have an important impact on the tribology in the case of small devices.

2. Lubrication of cells, micro-bearings and human joints

In this inter-section was presented the new model for determining the friction forces which act on surfaces of micro-bearings and human joint cartilages in the course of its growing and deforming in intelligent bearings. In the experimental investigations, were obtained the joint cartilage surface images taken by means of the AFM microscope in order to elaborate a computer model of contact zone between tissue outer layer and liquid boundary layer in micro- and nano-scale.

Many scientific research investigations in the field of micro- and nano-tribology for biobearing and mechanical micro-bearing, performed in recent years [11-18] show many new kinematics methods of lubrication as well as many new properties of lubricants and very new interesting dependencies between lubricants and material of bearing or human joint. Such models and features of lubrications for cultivated cells, cartilage surfaces in human joints and for cooperating micro- and nano- surfaces in micro-bearing and nano-bearing are illustrated in Fig. 1. Here are presented three research directions: cyto-bio-tribology, human joint-tribology, micro-nano-bearing-tribology. Common problems between above research directions are illustrated.

For examination of the mentioned problems of tribology is necessary knowledge in the field of cytology, histology and the fundamental knowledge of human joint lubrication, presented in [29] and [30], is necessary.

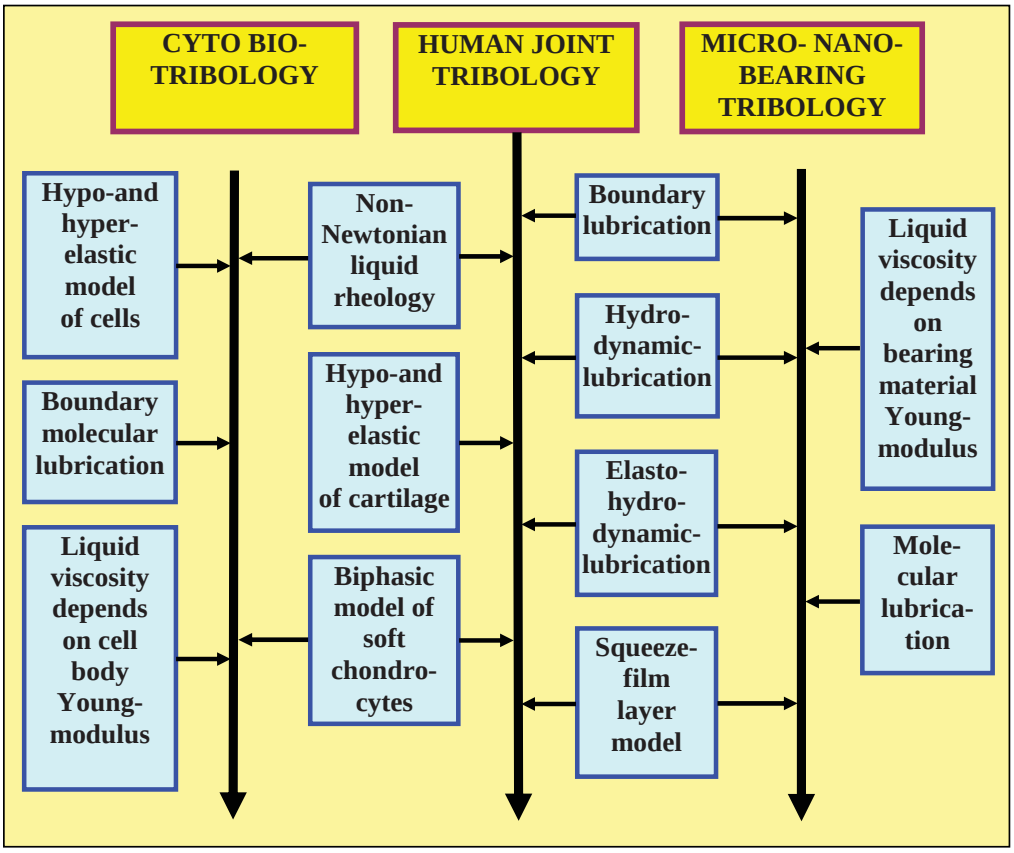

Fig. 1. Contact mechanics and tribology models of biological cells in bioreactor, of biobearing in human joints and nano- bearing in micro- devices

3. Methodology in detail including goals

The core of the presented problem is to numerically and experimentally determine, or to indicate, the values of the optimum pressure and liquid velocity values appearing near the cells, of micro-bearing cooperating surfaces, and to find ways of controlling the friction forces between particles of the liquid and the cell of the micro-bearing cooperating bodies in the thin boundary layer.

Investigations of the physical and strength features are expected to be performed for various kinds of micro-bearing superficial layer and for efficient and damages micro-bearings.

In order to begin treating the surface structure of a superficial layer on the cooperating micro-bearing surfaces it is absolutely necessary to have at one's disposal the proper model of a liquid flow in the thin layer, and to obtain the proper values of friction forces.

3.1. Analytical and numerical efforts to obtain characteristics on the micro- and nano-level of pressure, liquid velocity and friction forces, are realized by the search for the following results

- Optimum anticipated values of the hydrodynamic pressure, liquid velocity and friction forces in the nano-scale, which are admissible to avoid excessive wear values of micro-bearing surfaces,
- Desirable values of pressure, liquid velocity and friction forces in the nano-scale in micro-bearings for an optimization of the cultivation process for an optimization of the lubrication process,
- Real values of pressure, liquid velocity and friction forces in the nano-scale between given kinds of micro-bearing surfaces and the lubricant thin layer, considered in the qualitative, and
- quantitative sense, for cells lying on the cooperating surfaces to prepare a good lubrication process in the human joint.

3.2. Final effects of experimental efforts on the nano-level to measure thin layer lubricant properties between cooperating micro-bearing cells are completed by achieving the following results

- A geometrical structure of cooperating deformable micro-bearing surfaces, measured by means of the atomic force microscope (AFM), and its influence on further geometrical changes during unsteady micro-bearing lubrication and its influence on the lubricant properties, especially lubricant dynamic viscosity in the super thin boundary layer,
- Height values of the lubricant boundary layer just near and round the cell of micro-bearing cooperating surfaces during the lubrication process,
- Anisotropic properties of the micro-bearing material lying on the micro-bearing cooperating surfaces during the lubrication process and its influence on the lubricant dynamic viscosity in the super thin boundary layer,
- Isotropic properties of the micro-bearing material lying on the micro-bearing cooperating surfaces on the nano-level scale, and its influence on lubricant dynamic viscosity in the super thin boundary layer.

3.3. The final effects of experimental efforts on the micro- and macro-level to measure cooperating surfaces in micro-bearing are completed by achieving the following results

- A geometrical structure of cooperating deformable micro-bearing surfaces measured by means of the mechanical and laser sensors, and its influence on further geometrical changes during an unsteady cooperation,
- Anisotropic material coefficients describing the soft body of micro-bearing superficial layer including the organic additions with DNA information during the lubrication process,
- Inequalities of the roughness on the macro- and micro-level occurring on the micro-bearing during the lubrication,
- Measurement of the inequalities of roughness on the macro- and micro- level- occurring on the micro-bearing surfaces, caused by random changes during the hydrodynamic lubrication process with squeezing and weeping.

3.4. The final effects and results in the field of mechanical material engineering will be obtained in the form of analytical, numerical and experimental models to determine material coefficients of visco-elastic lubricants and non-Newtonian lubricants, which are applied in micro-bearings. The final effects lead to the following results

- The models describing the influence of the mechanical properties of the micro-bearing surfaces of the superficial layer on the lubricant apparent viscosity changes,
- The analytical, numerical and experimental models for determining the lubricant apparent viscosity to be applied in micro-bearings,
- The simulations of the apparent viscosity changes of the lubricants in micro-bearings caused by an external impulse,
- The determination of material coefficients for visco-elastic non-Newtonian liquids and lubricants by using analytical, numerical and experimental methods.

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