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OPTIMIZATION OF EFFICIENCY ENERGY THE WORK SURFACES WITH WORK ENVIRONMENT BY CREATING ASYMMETRIC SURFACE-ACTIVE STRUCTURES (INCLUDING SQUAMOSE-LIKE) WITH THE VECTOR DIRECTION GIVEN RESISTANCE, METHOD FOR DETERMINING INDIVIDUAL THE PROPERTIES, CLASSIFICATION OF SPECIES BY THE INTERACTION NATURE OF THE WORKING THE ENVIRONMENT AND OF GEOMETRY SURFACE - USING THE METHOD GORENKO

UDC 621

This article discusses and provides examples of the use the define of the resistance vector distribution function $f(\overrightarrow{a_{eff}})$ surface geometry at the implementation of the optimization method and increasing the efficiency of the working surfaces the method of formation of asymmetrical surface structures with a given geometry [1,2], the define of the resistance vector distribution function $f(\overrightarrow{a_{eff}})$ the surface geometry of the nano-, micro-, macro- dimensions - is performed according to the method Gorenko [1] with the help of specialized software a_{eff} [3] which is included in the software package **M3D^{G+}**, software a_{eff} it is intended to test the properties of the resulting surface geometry or primary geometry working surface, shows examples of the definition individual properties of the surface geometry, as well as the classification of types of calculated surface geometry on the nature of the interaction with the work medium.

Keywords: friction, resistance, friction reduction, resistance reduction, resistance vector, definition of the vector resistance, resistance vector distribution function, efficiency, effectiveness of energy metabolism, the effectiveness of the work surface, the efficiency of exchange energy the work surfaces, surface - active structure, types of surfaces, surface structuring, a method for increasing the energy efficiency of working surfaces, increase resource machine parts, increase the resource of friction units, method Gorenko, aeff, M3DG+, software, software aeff, software package M3DG+, determination of the amount of wear, wear, comparison of the geometric parameters of the surface, defect identification, to determine the stage of destruction.

Introduction

Using a method of increasing the efficiency of the working surfaces (fig. 1) by creating on them a surface structuring at the level of micro- and nanostructures (fig. 2) with given vector resistance in the working environment, when the surface is calculated for the given operating conditions [1, 2] – in tribosystems, hydraulic systems, steam and gas systems, it is necessary to determine the (less complex with fewer calculations more expeditious method) the resulting characteristics of the surface, that create on the basis of the basic roughness or if appropriate determining the characteristics and properties of the base roughness surface geometry, or worn out and modified under the influence of mechanically, thermal, chemical impacts the working environment during operation of the working surface, or perform a quick forecast properties geometry of 3D-models.

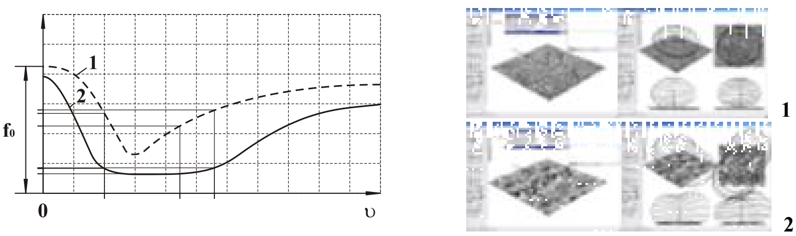


Fig. 1 – The dependence of the coefficient of sliding friction f_0 from speed υ for planar contact:
1 – surface standard roughness, her function $f(\overrightarrow{a_{eff}})$;
2 – the surface structuring the calculated for the specified operating conditions, function $f(\overrightarrow{a_{eff}})$, calculation is executed by a method increase the efficiency of energy exchange work surfaces in different environments work [1]

Existing methods of structuring [4, 5, 6, 7], that unlike the method of calculation of the surface geometry for the given operating conditions [1, 2] – they clearly define the type of structuring - do not give a method for determining the surface characteristics of individual geometry based on the distribution of resistance vector or comparison with other types of profiling and in particular with the surface a base roughness, and are characterized only individual cases by a statistically.

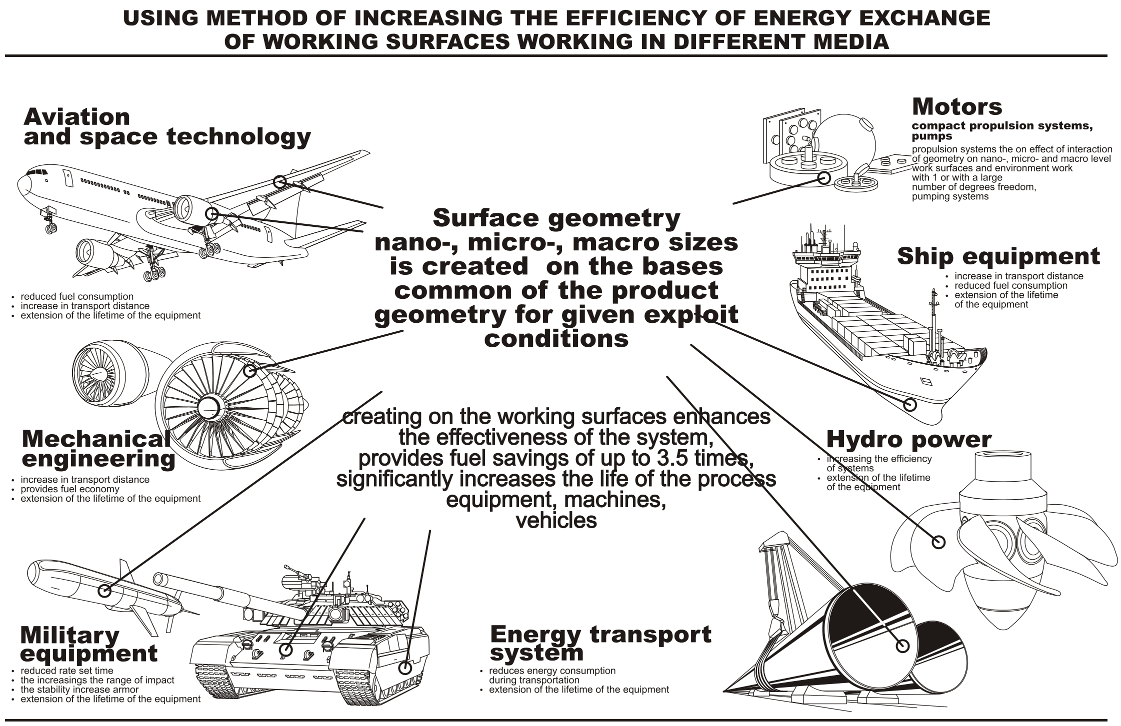


Fig. 2 – Using method increase the efficiency of energy exchange work surfaces in different environments work

Known sources [4, 5, 6, 7] do not give mathematical methods for identifying of individual features the structure of the surface geometry (their properties) based analyzing the distribution of the vector of the surface geometry resistance, so impossible a precise mathematical comparison and identification of their properties in comparison with other types of surfaces profiling.

This raises the question comparing the efficiency of energy exchange species surface profiling, determination of properties, determination of features and magnitude the operation characteristics for the surfaces profiling, the definition change the operation characteristics, determination of the decrease the efficiency of energy exchange work surface as a result of wear and tear, determination magnitude of wear of the working surface, definition of the basic characteristics of of base surface roughness, as well as the standardization of the complicated surfaces structuring, by interaction properties with the working medium - this would allow to reduce the time required to calculate surface geometry for the given operating conditions. For this proposed to use the method of directly construction of the resistance vector distribution function the working surface [1, 3] on based the analysis of the geometry surface the method Gorenko.

The purpose and task

In implementing the method of structuring surfaces (or surface), creating and combining macro-, micro- and nano- reliefs with the help of the analysis of the actual vectors the distribution of the velocity of movement of the medium and the necessary optimal gradient distribution of velocity vectors on surface in the maximum range of operating characteristics (fig. 2) – at the stage prior to the calculation of surface optimization - there is a need to define the basic characteristics of roughness (fig. 3) to determine as far as possible increase of energy efficiency on the basis of the basic geometry – for example as far as the increases the total area of the surface geometry in relation to the base, at the stage immediately after performing calculations of the synthesis of surface geometry - there is the need checking magnitude the values the efficiency of energy exchange in comparison with this value before the base geometry optimization, after the profiling on the primary surface geometry [8] (fig. 3) - it is necessary to determine the values of deviations [9] inconsistency of properties the created the geometry and to the mathematically calculated model, or at operating and when the wear the geometry surface (destruction, plastic deformation) necessary to determine the change in performance of work surfaces (fig. 3).

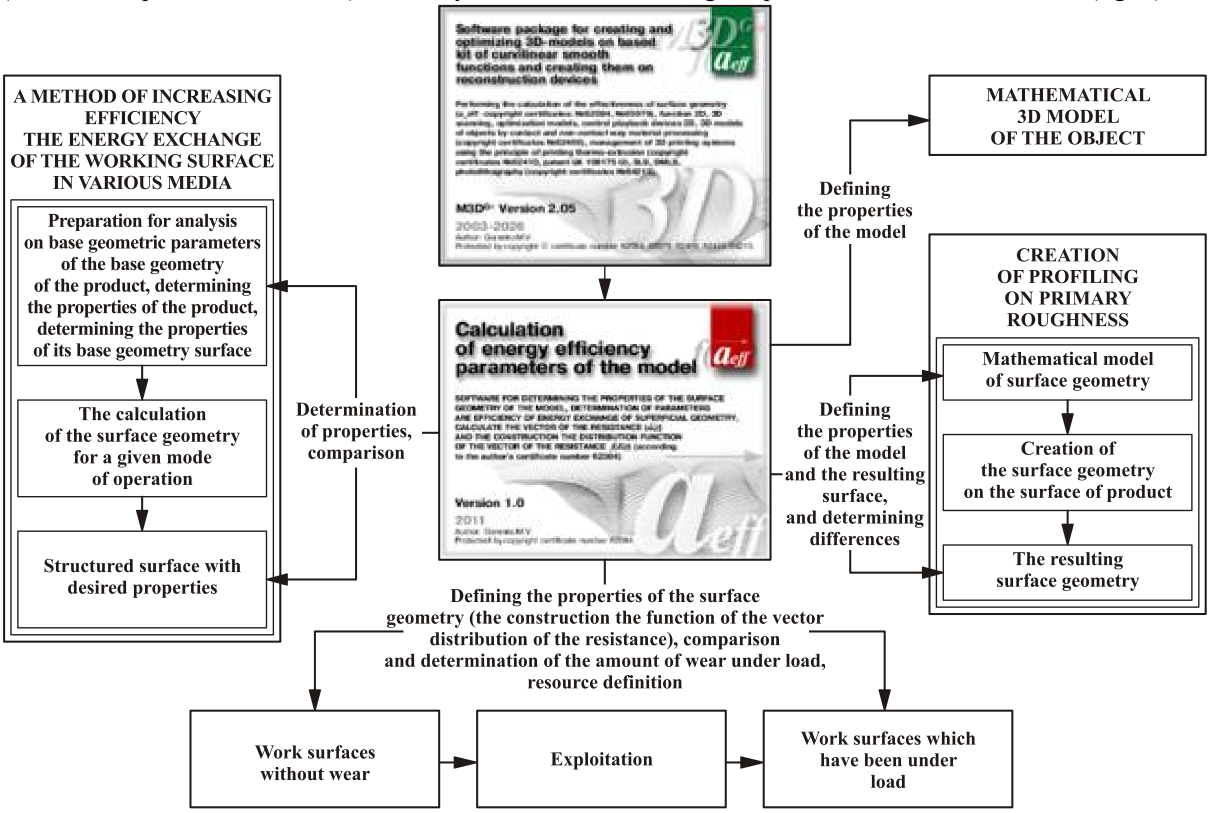


Fig. 3 – Using the method of constructing the resistance vector distribution function $f(\overrightarrow{a_{eff}})$ working surface [1] based on an analysis of its relief (surface geometry) method Gorenko through the software [3] which is included in the package CAD software package M3D^{G+}.

Results and their discussion

To determine the geometry surface properties, for determining and identification of the characteristic signs used method of calculating resistance vector distribution function [1], created software a_{eff} [3] which is included in the package CAD software package M3D^{G+} (fig. 3), and can be used independently for the analysis of surface geometry of the working surfaces.

Software [3] includes a module for analyzing the geometric parameters of the surface of the model, definition the area of the energy exchange, determining of the vector resistance [1] and of constructing the resistance vector distribution function $f(\overrightarrow{a_{eff}})$ [1] surface geometry – these parameters characterize the intensity of energy exchange work surfaces in different environments. Allows you to determine the change $f(\overrightarrow{a_{eff}})$ depending on wear and/or scaling surface geometry when creating on the working surfaces [8]. Areas of use: mechanics as tribosystem as well as hydro and steam-gas systems which are characterized by the interaction of the working surface with of the working environment, taking into account the features of the surface geometry of a given structuring, also used (fig. 3) to determine the structural changes in the growth process of plastic deformation in the material – this allows determine the interval before the stage of irreversible change, destruction, allows you to evaluate the effectiveness the interaction of the working surface with of the working environment (fig. 1,2), used to check the efficiency of energy exchange for the calculated surface geometry, respectively source materials [1] figures 2. The software works with a model files surfaces, surfaces are created by method of increase efficiency energy exchange of the working surfaces with of the working environment [1] – the file type has the extension *.aef.

Through the software a_{eff} done a comparison of 2 types of surface geometry - the standard (fig. 4) and (fig. 5) it is obtained by calculation respectively by a method increase the efficiency of energy exchange work surfaces in different environments work [1] (fig. 1).

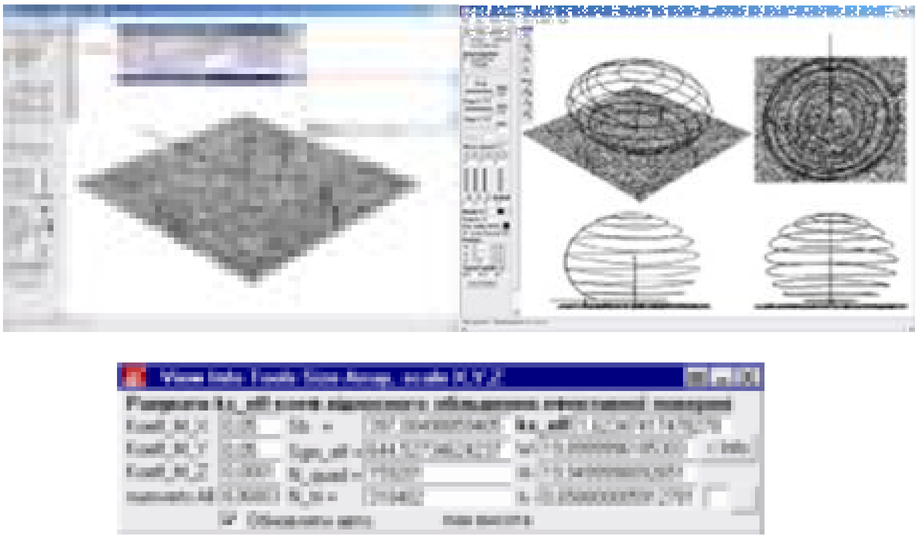


Fig. 4 – Calculation is of resistance vector distribution function $f(\overrightarrow{a_{eff}})$ surface geometry on the 3D model on the work surface the standard roughness

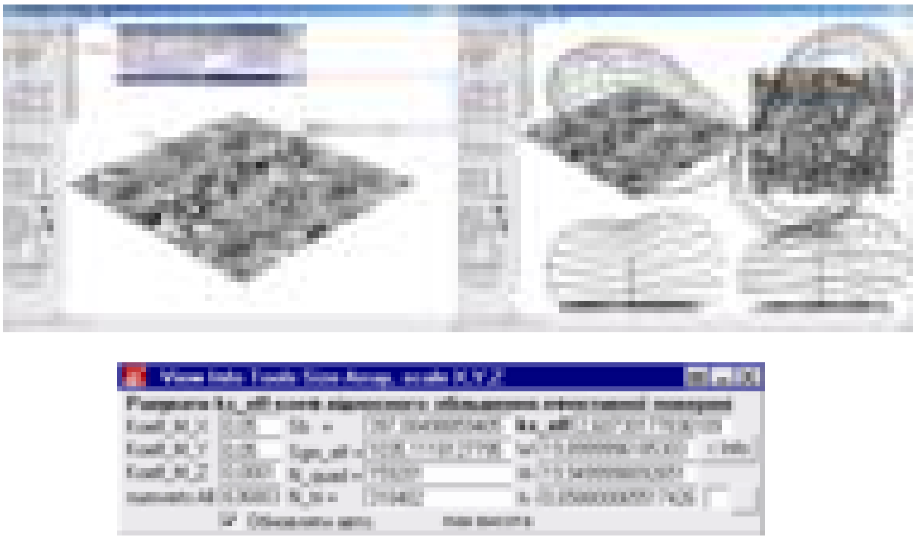


Fig. 5 – Calculation is of resistance vector distribution function $f(\overrightarrow{a_{eff}})$ surface geometry it is obtained by calculation respectively by a method increase the efficiency of energy exchange work surfaces in different environments work [1]

The results show, that when compared at relatively the same maximum height structuring h1=0,658800005912781 and h2=0,658800065517426, if standard roughness - area of the surface roughness in comparison to the base area - more in ks_eff1= 1,62347417478278 times, and increase in area in relation to the base surface obtained by means of calculation [1] more in ks_eff2= 2,60730177836109 times, this is provides for the sake of mode the fluid friction the optimal heat transfer and circulating the lubricant, resistance vector distribution function for the surface geometry for of the two surfaces of substantially different and in the case of standard roughness the function $f\left(\overrightarrow{a_{eff}}\right)$ it have view as the sphere - this is indicates the absence of a predetermined direction of circulation of the lubricant (unsystematic flow) unlike the calculated surface geometry (fig. 5), this is evidenced by the central constriction the volume the functions $f\left(\overrightarrow{a_{eff}}\right)$ (fig. 5).

Through the software a_{eff} for identifying of the resistance vector distribution function $f\left(\overrightarrow{a_{eff}}\right)$ surface geometry [3] was obtained the resistance vector distribution function the calculated for different types of the surfaces profiling (fig. 6), the resistance vector distribution function visualizes the characteristic differences between the properties of types of the profiling surface.

To confirm and for search matching between geometry the resistance vector distribution function and structuring the surfaces and her properties - calculation of this function was carried out for the verifying 3D models: for plane (fig. 7), linear structural element on a plane (fig. 8), for symmetric profiling - meander (fig. 9), for the profiling like saw (fig. 10), for asymmetric the profiling like saw (fig. 11), for symmetric structuring formed by an array of cones (fig. 12), done a comparison with the properties of a given surface geometry - variants which contains in the sources [4, 5, 6, 7].

CLASSIFICATION OF ASYMMETRIC SURFACTANT STRUCTURES SURFACES, WITH GIVENS THE VECTOR RESISTANCE WORKING ENVIRONMENT, THE DEFINITION OF

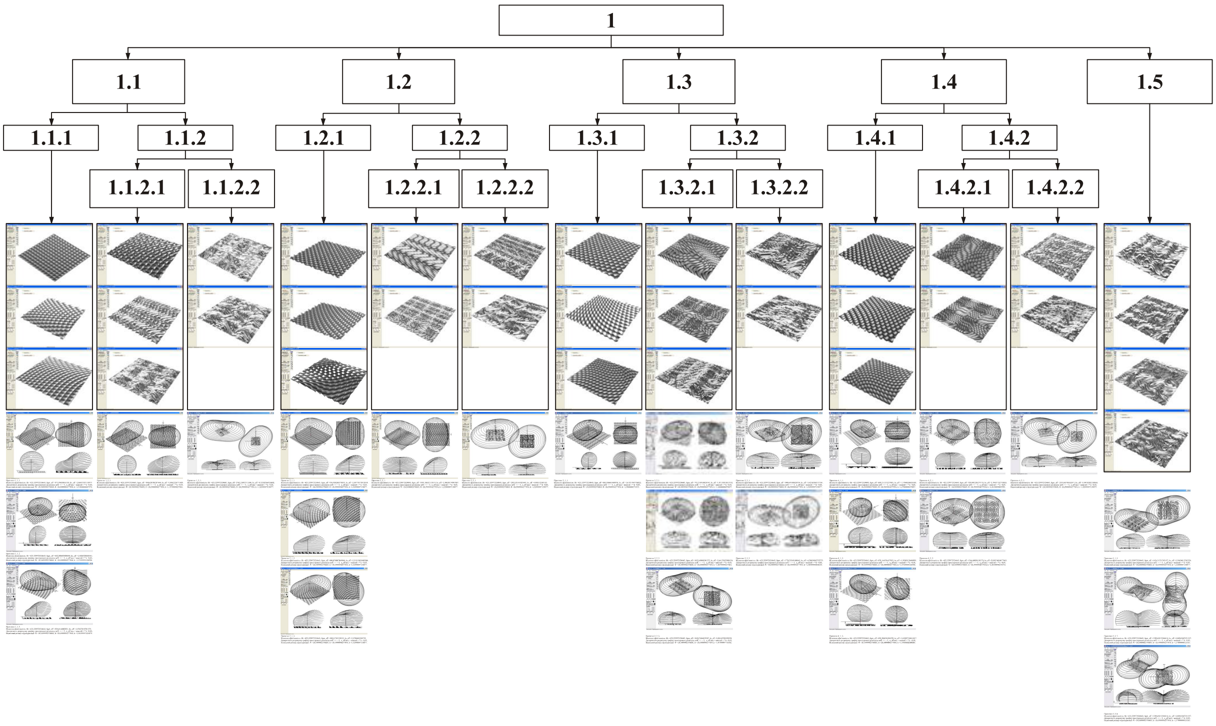


Fig. 6 – Classification of asymmetric surfactant structures surfaces, with givens the vector resistance working environment, the definition of, of resistance vector distribution function $f(a_{eff})$ characteristic for the type of structuring:

1 – types of asymmetric surface - active structures, with a given vector resistance of working environment;
1.1 – squamose - similar the surface structures formed of the squamose - similar of the asymmetric structural elements;
1.2 – saw - similar the surface structures formed from (saw - similar) of the asymmetric structural elements;
1.3 – drops - similar the surface structures formed of the drops - similar of the asymmetric structural elements;
1.4 – formed of the (droplets - similar) asymmetrically structural elements of the recesses on the surface;
1.5 – hybrid-amorphous surface structures that formed surface elements with complex the individual geometry of the peaks, slopes, valleys, the geometry of elements may be derived from all types of the surfactants structures;
1.1.1 – type: the simple the squamose - similar, formed from a the homogeneous asymmetrical elements;
1.1.2 – type: complex squamose - similar;
1.2.1 – type: simple interpolated of the saw - similar , formed from a homogeneous asymmetrical elements;
1.2.2 – type: the complicated interpolated of the saw - similar;
1.3.1 – type: simple interpolation of the drop - similar formed of homogeneous the asymmetrical elements;
1.3.2 – type: the complicated interpolated of the drop - similar);
1.4.1 – type: simple of the asymmetrically - perforated, formed from of the same type of the drop - similar of asymmetrical recesses elements;
1.4.2 – type: the complicated of the asymmetrically - perforated;
1.1.2.1 – formed from localized elements which are combined in groups, forming a common array of the surface structuring with given vector resistance in working environment;
1.1.2.2 – amorphous, educated from heterogeneous of the asymmetrical elements which are have individual geometry;
1.2.2.1 – formed from localized elements which are combined in groups,

forming a general array of surface structuring with given vector resistance in working environment;
1.2.2.2 – amorphous, educated from heterogeneous of the asymmetrical elements which are have individual geometry;
1.3.2.1 – formed from localized elements which are combined in groups, forming a general array of surface structuring with given vector resistance in working environment;
1.3.2.2 – amorphous, educated from heterogeneous of the asymmetrical elements which are have individual geometry;
1.4.2.1 – formed from localized elements which are combined in groups, forming a general array of surface structuring with given vector resistance in working environment;
1.4.2.2 – amorphous, educated from heterogeneous of the asymmetrical elements which are have individual geometry

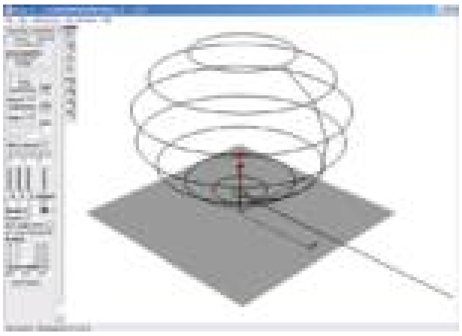


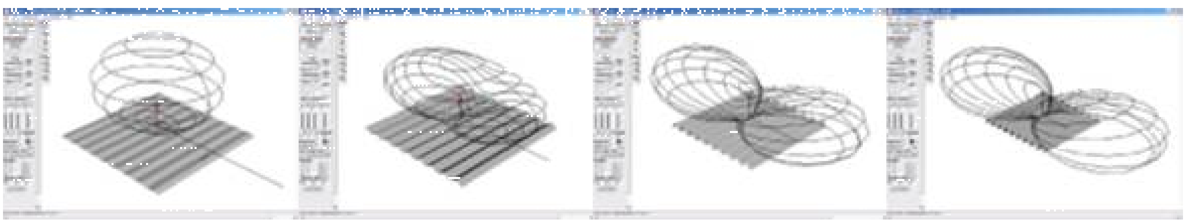
Fig. 7 – Function distribution of the vector resistance $f(\overrightarrow{a_{eff}})$ for plane, function distribution of the vector resistance have view as the sphere

a b c d

Fig. 8 – Function distribution of the vector resistance $f(\overrightarrow{a_{eff}})$ for linear the structural element on plane, its change depending on the height of the element of structural, the relative change in height: a – h_1 = 14; b – h_2 = 3; c – h_3 = 5; d – h_4 = 10, typical signs of the structural elements - they are determined by function distribution of the vector resistance $f(\overrightarrow{a_{eff}})$ and by changing the scale of the structural element - do not change, it does not change the geometric shape the function $f(\overrightarrow{a_{eff}})$, and only the scale

a b c d

Fig. 9 – Function distribution of the vector resistance $f(\overrightarrow{a_{eff}})$ symmetric meander, its variation depending on the structuring height, the relative change in height: a – h_1 = 1; b – h_2 = 3; c – h_3 = 10; d – h_4 = 20, at symmetry of structuring of the functions distribution of the vector resistance $f(\overrightarrow{a_{eff}})$ also it is symmetric

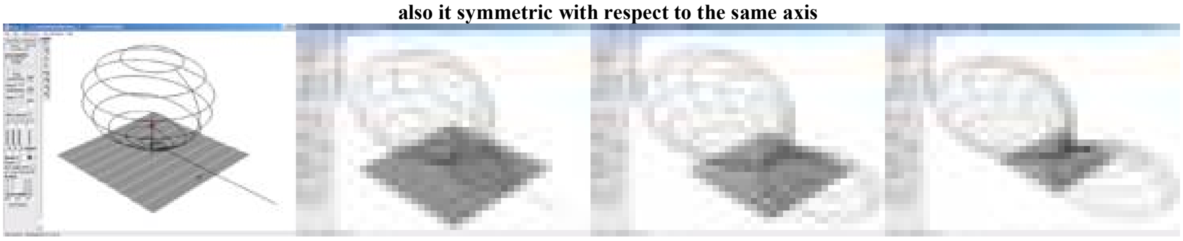


a b c d

Fig. 10 – Function distribution of the vector resistance $f(\overrightarrow{a_{eff}})$ for saw - similar profiling,

its variation depending on the structuring height, the relative change in height:
a – h_1 = 1; b – h_2 = 4; c – h_3 = 8; d - h_4 = 12,
if the structuring of the symmetric about the any axis – then and function distribution of the vector resistance $f(\overrightarrow{a_{eff}})$

also it symmetric with respect to the same axis



a b c d

Fig. 11 – Function distribution of the vector resistance $f(\overrightarrow{a_{eff}})$ for asymmetrical the saw - similar structuring,

its variation depending on the structuring height, the relative change in height:
a – h_1 = 1; b – h_4 = 4; c – h_8 = 8; d – h_{12} = 12,
at asymmetry of structuring - the function of distribution of the vector resistance $f(\overrightarrow{a_{eff}})$ also not symmetric

a b c d

e f

Fig. 12 – Function distribution of the vector resistance $f(\overrightarrow{a_{eff}})$ for symmetric structuring which is formed by an array of cones, its

variation depending on the structuring height, the relative change in height:
a – h_1 = 5; b – h_2 = 10; c – h_3 = 20; d – h_4 = 30; e – the view by axis *Z* function distribution
of the vector resistance for structure (4) with a height - h_4 = 30;
f – the view by axis X function distribution of the vector resistance for structure (4) with a height - h_4 = 30, function $f(\overrightarrow{a_{eff}})$

by axis *Z* it forms a reverse taper that can testify about the decrease head-on drag for a given type
of structuring, similar example is given in the source [5]

On the basis of geometry analysis for function distribution of the vector resistance of the geometry surface of verifying 3D models (fig. 7, 8, 9, 10, 11, 12) revealed the following patterns:

- function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ for symmetric profiling is symmetrical (fig. 8, 9, 10, 12);

- function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ for asymmetric profiling is asymmetrical (fig. 11);

- function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ for symmetric and asymmetric profiling is differ (fig. 10, 11);

- function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ for array cone - like elements that form a of the surface structure - the formed inverted cone recess unto of the tops of the cone (fig. 12), it has orientation by the axis of the cone - like of elements, comparing with the experimental data that provided in the source [5] revealed regularity - which indicates about depending such geometry of the function of distribution of the vector resistance, that characterizes the properties this structure and reduction of drag of this type of structuring the respectively source [5], this method allows us to identify, the presence of properties reduce drag in structuring;

- for plane - function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ it has the shape of a sphere (fig. 7), this property can be used as an evaluation standard benchmark of the deviation size from the plane of geometry of the what analyzed, determination of the dynamics of increasing strain and identify the start of the destruction process;

- any deviation from the plane of surface geometry - the surface of formed by of the function of distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ - deforms, changing volume the scope, this feature makes it possible to identify such deviations that may be caused by wear and tear, destruction, plastic deformation, allows the identification of development the defects;

- at the deformation of surface in a given basis plane (provided that the projection of surface on the plane base, that is analyzed is equal to the size the plane base) increases the surface area of the geometry - this causes an increase in volume which forms a surface of the function of distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ and causes deformation of the surface which is formed by the function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ surface geometry, which makes possible by of characteristic geometry of this feature - determine the type of surface geometry (fig. 6), determine the magnitude of the load that causes the deformation of the surface geometry and determine surface properties the geometry at interaction with the working medium.

Conclusions

1. Proved of connection the surface geometry function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ with properties interaction of the surface structuring with of the working environment - comparing the results of construction of the function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ for sets models surface structuring (fig. 7 - 12) and data which showing in sources [4, 5, 6, 7], and also based on the properties of the species of the surface geometry of calculated method increase the efficiency of energy exchange work surfaces in different environments work [1] and them of the function of distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ of surface geometry.

2. Any deviation of the surface geometry from of the basal plane - it causes a change of the vector resistance this the portion - this in turn displayed as deformation the surface of the function of distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ and an increase the volume which is formed of surface of the function the distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$. Such properties of the function the distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ the provide an opportunity:

- determination of deformation increase dynamics and the identification of the beginning of the process of destruction;

- identify deviations which are formed by wear and tear, destruction, plastic deformation, that is, it allows us to identify and explore the development of defects;

- it makes it possible to determine the type of surface geometry, determine the magnitude of the load that causes the deformation of the surface geometry and determine of properties at the interaction with the working medium;

- it allows you to identify the differences and features that can not be identified visually or whose identification is complicated by other mathematical methods.

3. The question of defining the limits of sensitivity of this method for determining the function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ and the dependence of the geometric parameters of function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ from the physical properties of the particular material requires further study.

4. The calculation results (fig. 4, 5, 6, 7, 8, 9, 10, 11, 12) obtained via software a_{eff} [3] they show the ability to identify surface geometry using define way of the function of distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$.

5. The deformation of the surface of function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ characterizes the properties of the surface geometry of the interaction with the work medium.

6. The using method of determining the characteristics of the surface geometry by defining function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ by method Gorenko when implementing the method increase the efficiency of energy exchange work surfaces in different environments [1] reduces the number of calculations and

the allow determine the properties of the surface geometry, both before and after optimization, and also allows determine difference changes surface characteristics in during operation.

7. Function distribution of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ for symmetric structuring what is formed by an the array of cones, at the height of structuring the more of a certain limit (an example is given for h = 30) noted marked reduction of drag in the interaction of the structuring this surface with of the work environment.

8. This method for determining characteristics the surface geometry by determining the distribution function of the vector resistance $f\left(\overrightarrow{a_{eff}}\right)$ and software [3] for this - offered for implementation and use in the production of. Using the software a_{eff} [3] in manufacturing at implementing the method to increase energy exchange of the working surfaces with of the working environment [1] significantly reduces the number of calculations, decreases labor intensity.

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Горенко М.В. **Оптимізація ефективності енергообміну робочих поверхонь з середовищем шляхом створення розрахованих асиметричних поверхнево - активних структур (зокрема чешуйноподібних) з векторно заданим напрямом опору, спосіб визначення індивідуальних властивостей, класифікація видів по характеру взаємодії робочого середовища і поверхневої геометрії - використовуючи спосіб Горенко.**

В роботі вперше запропоновано при реалізації способу підвищення енергообміну робочих поверхонь з середовищем і для визначення властивостей поверхневої геометрії використовувати спеціалізоване програмне забезпечення для автоматизації процесу визначення розподілу функції вектора опору $f(\overrightarrow{a_{eff}})$ поверхневої геометрії по способу Горенко, цей спосіб і програмне забезпечення пропонується використовувати для визначення стану матеріалів, визначення динаміки їх зношування, визначення початку руйнування. Дається загальне визначення видів поверхневої геометрії яка розрахована способом оптимізації і підвищення енергообміну робочих поверхонь з середовищем - в залежності від властивостей і особливостей геометричної будови. Програмне забезпечення a_{eff} самостійно і в складі програмного комплексу M3D^{G+} і спосіб підвищення ефективності енергообміну робочих поверхонь, обладнання для його реалізації пропонується для впровадження і використання в виробництві.

Ключові слова: тертя, опір, зменшення тертя, зменшення опору, вектор опору, визначення вектора опору, функція розподілу вектора опору, ефективність, ефективність енергообміну, ефективність робочих повер-

хонь, ефективність енергообміну робочих поверхонь, поверхнево-активні структури, види поверхні, поверхневі структуризації, спосіб підвищення енергоефективності робочих поверхонь, збільшення ресурсу деталей машин, збільшення ресурсу вузлів тертя, спосіб Горенко, aeff , M 3 DG +, програмне забезпечення, програмне забезпечення aeff , програмний комплекс M 3 DG +, визначення величини зносу, знос, порівняння геометричних параметрів поверхні, ідентифікація дефектів, визначення стадії руйнування.