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STRUCTURED SURFACES A NEW PERSPECTIVE FOR TRIBOLOGICAL BEHAVIOR OF LUBRICATION CONTACTS

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Abstract: Structured surfaces means the achievement of a rate, or controlled micro–geometry for one or both friction surfaces. These surface profiles are used to guarantee lubrication functions of transport, hoarding and spread of the oil and to collect the wear products for maintaining the uprightness of the friction couple surfaces. The first textured surfaces where obtained by plateau–honing. Effectively structured or textured surfaces are done by processing dimples and channels forms on the active surfaces of the friction couples. In these micro–geometry forms the lubrication oil is guarded in starvation times, during the transition periods.

1. INTRODUCTION

A new concept in the field of tribology has been the development of contact surfaces which are designed for improved lubrication capability. This can vary from simple control of the surface roughness of two mating surfaces, to the more complex formation of regular structures which serve the double purpose of retaining lubricant and trapping debris particles. For increasing efficiency, trying not to have a random character of the micro–geometry, after the 60's people began the texturing of the surfaces, [1,8,9]. The first forerunners of textured surfaces where obtained by plateau–honing.

Structured surfaces are done by processing dimple and channels forms on the active surfaces of the friction couples. In these micro–geometry forms the lubrication oil is guarded in starvation times, for example in the transition periods. In the present article will be presented the advantages of these surfaces, the technological processes used to accomplish these surfaces and the main machine elements fields where these are used.

Structured surfaces create a lubrication film, which produces a load carrying capacity when there is no condition for the wedge effect. This kind of surface engineering produce:

- continuous and discrete textures, for friction control;
- thin and soft lubrication films;
- thin hard films for durability of fluid lubrication;
- surfaces chemistry protecting films, for reliability.

The general motivation is the same: to reduce friction and increase durability and energy transmission components and engines, [1,8,9].

Texture and topography of surfaces has a very strong influence on the tribological properties. In many experiments and real application it has been shown that the friction can be dramatically reduced if the contacting surfaces are given a texture comprising a pattern of small recesses. It is generally believed that the beneficial effect of these recesses in boundary lubricated conditions is twofold; they act as a local containers of lubricants capable of feeding the lubricant directly between the two contacting surfaces and they can bury wear debris and contaminants, thereby keeping the interface flat and clean which minimizes the amount of deformation in the sliding process and this reduces the friction.

For a number of years, textured surfaces have been used in applications ranging

from cylinder bores to rolls for steel sheet rolling. However, the adopted texturing techniques do not allow high definition and micron scale of the areas of real contacts. New texturing techniques are introduced for improving mechanisms of textured surfaces.

2. STRUCTURED SURFACES PROPERTIES

The applications of structured surfaces are connected with large area flat – surfaces contacts as sliding bearings and seals. The main function of the structure procedure is on one way the transport and the spread of the lubricant into the contact area and on the other way to remove and collect the wear products obtained in the tribological processes.

These functions defined above can be obtained by three kinds of structured surfaces:

- stochastic surfaces structures, represented in Figure 1,[5]; in this structure the microchannels spread the lubricant all over the surface, without discriminated senses; these stochastic structures warrant the remove of the wear products from the contact area; but they have also the drawback spreading and ousting the lubricant from the contact area too, so the couple goes into lubrication starvation process;
- deterministic surfaces structures, with lubrication closed pockets, represented in Figure 2, [5]; these kind of structures assure the presence of the lubricant in the contact area, unconnected with the feed pressure; the spread of the lubricant out of these pockets is possible only by the increment of hydrostatical pressure; as drawback is the fact that the lubricant affects by his physical and chemical properties the behavior of the friction couple;

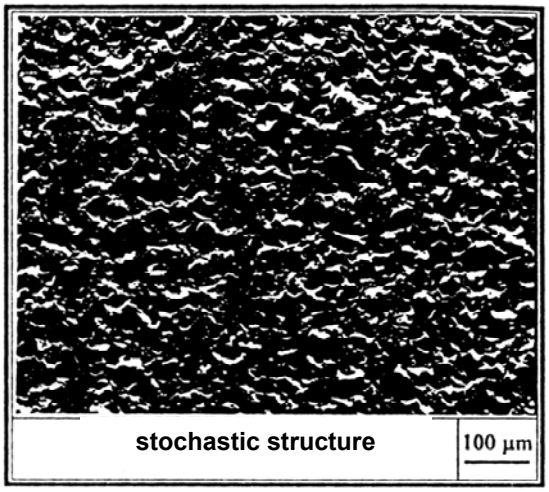


Fig. 1
Stochastic structure obtained by electron – microscopy

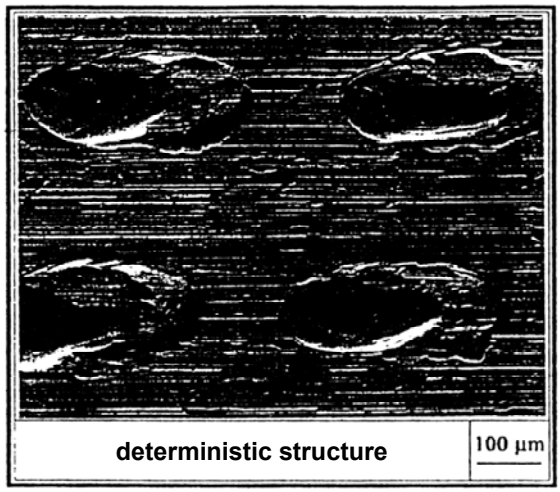


Fig. 2
Deterministic structure obtained by electron – microscopy

- mixed surfaces structures, or determinist – stochastic surfaces structures, represented in Figures 3, 4, 5, [5]; they join the advantage of deterministic structures referring to the use of the effects of lubrication pockets, that means the permanent presence of the lubricant in the contact area, with the undertake of the transportation and remove of the wear products out of the contact area, from the stochastic structures.

3. USED TECHNOLOGIES TO ACHIEVE STRUCTURED SURFACES

There are many technologies to obtain structured surfaces:

- the process of plateau–honing; in conditions of optimal manufacture, the honing using super–abrasives for hard steel processing leads to uniform textures with well outlined asperities; these asperities assure surfaces formation type plateau; Figure 6, [7], presents a plateau surface processed by horning technologie;
- surface chemical pickling, by photogravure, like in Figure 5, [5];
- surface laser processing (LBM) of micro–dimples all over the active area of the friction couples; the process is presented in Figure 7b, [5];
- surface abrasive–jet processing (AJM) of micro–dimples all over the active area of the friction couples; the process is presented in Figure 7a, [5].

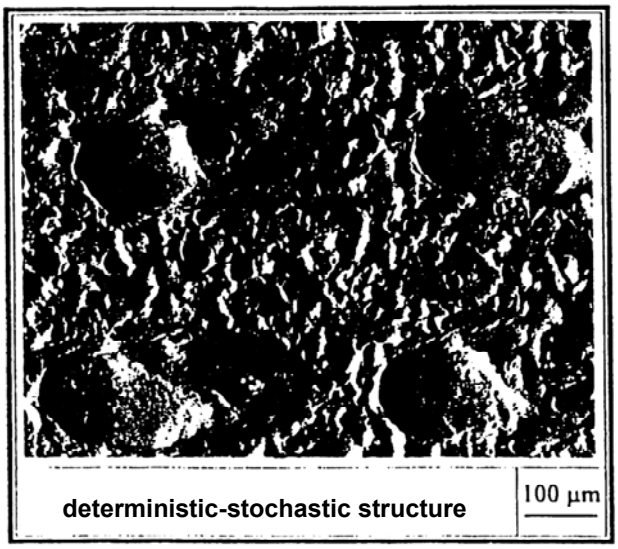


Fig. 3
Deterministic - stochastic structure
obtained by electron – microscopy

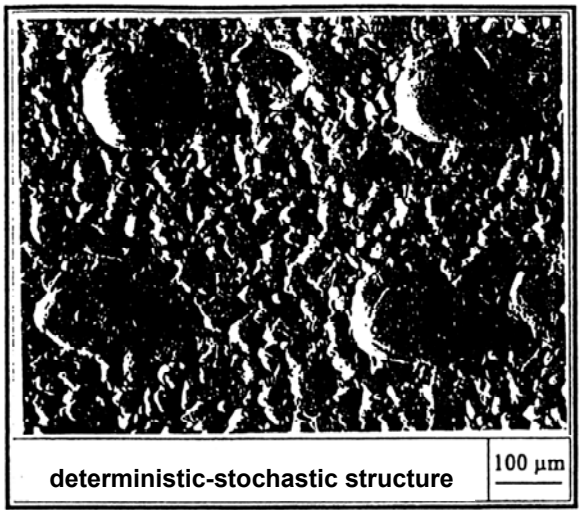


Fig. 4
Deterministic - stochastic structure of a fine structure surface without bourne asperities

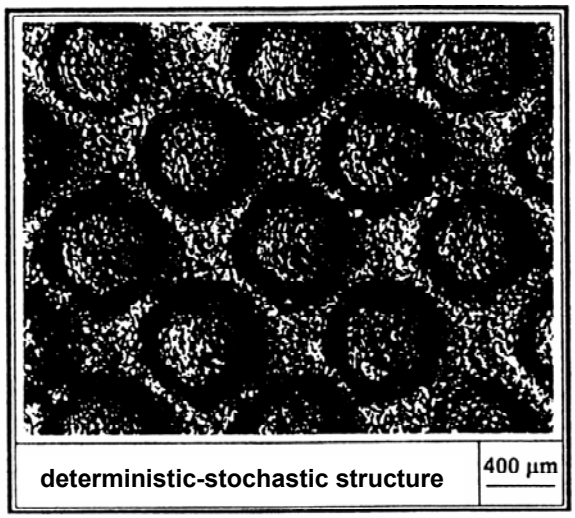


Fig. 5
Deterministic - stochastic structure
obtained by surface chemical pickling

Technological aspects for the processes of manufacture of structured surfaces:

- the manufacture procedures are used for different kind of surface dimples geometries, as shown in Figure 9, [3];
- some technologies to create dimpled surfaces can produce bourne asperities around the dimples performed into the manufactured surface, as it is shown in Figure 10, [3]; these asperities have a negative impact on the lubrication of the active surfaces lubrication; it can be used a process of polishing or lapping to remove these asperities;
- the profile of dimples differs in connection of the technological process used to produce

these structured surfaces; Figure 8a, [6] shows that the AJM process let to obtain dimples with soft tapered form, in opposition with the cillindrical one, Figure 8b, [6] obtained by the LBM process;

Some papers presents optimization for structural manufacture of the surface using the deterministic–stochastic procedure, in three steps, [5]:

- the first step can be obtained by superposition of the two procedure, the deterministic and the stochastic technologies;
- the second step is to remove the asperities produced in the process of manufacturing of deterministic dimples on the surfaces;
- the third step is to realize and improve the stochastic structure in order to spread it on the entire processed surface; this can be obtained by deforming procedures.

Fig. 6
Plateau–honing structured surface

Fig. 7
Micro–dimples surface manufacture:
a. abrasive–jet machining (AJM),
b. laser–beam machining (LBM)

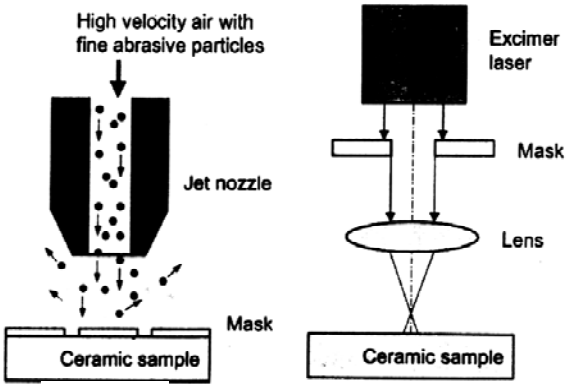
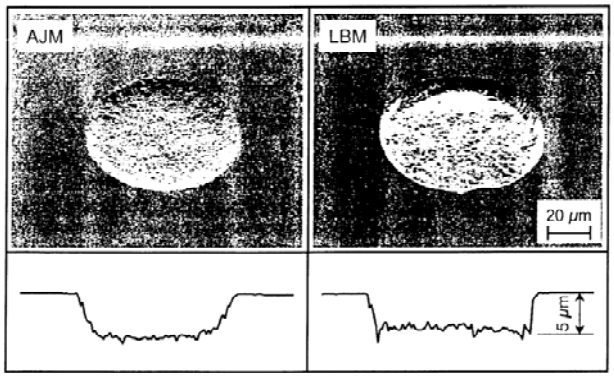


Fig. 8
Geometry of micro–dimples manufactured by:
a. jet abraziv–jet (AJM), b. laser–beam (LBM)



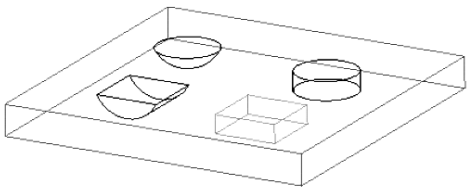


Fig. 9
Different forms for the geometry of dimples

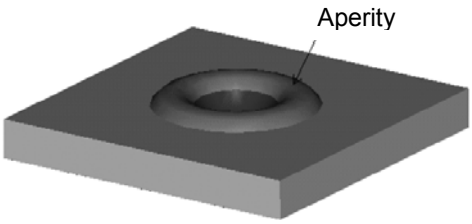


Fig. 10
Asperity obtained by manufacturing dimpled surfaces

4. MACHINE ELEMENTS USING STRUCTURED SURFACES

Structured or textured surfaces are used for different kind of machine elements:

- mechanical seals; scientific studies and articles show the impact that the using of structured surfaces can produce to improve tribological properties of these machine

elements; the presence of this structured geometries leads to assure a lubrication film, and avoids premature wear of the of the active surfaces; Figure 11, [3] presents a seal textured ring; the surface structure is a cheaper mean to realize carrying capacity, comparatively with other procedures for manufacture the surfaces: channels, buckles, skewed areas;

- thrust sliding bearings, where only one part of the bearing is structured, in order to obtain a joint effect of the dimpled zones, like the one obtained in the step thrust bearing; Figure 12, [3] shows the principle of this bearing; the gain of carrying capacity is less then the one obtained in a step bearing, but the friction is smaller as the friction of the pure step bearing, and they have the advantage of a smaller required precision in the manufacture process;
- contact between piston ring–cylinder layer in combustion engines, where the friction forces are in direct relation with the amount of fuel used by the engine and the performances of the car; Figure 13, [3,4] presents a textured ring, because this the part of the friction couple with structured surface; the use of these structured surfaces has positive followers: reducing the friction coefficient and good working in starvation conditions;
- big roller bearings; for these machine elements it can be used for the roller cage, in order to avoid the bearing failure in case of cage miss alignment; Figure 14 presents the use of textured surfaces for roller bearings;

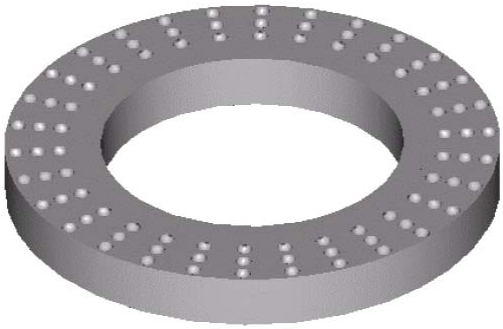


Fig. 11
Mechanical seal ring with structured surface

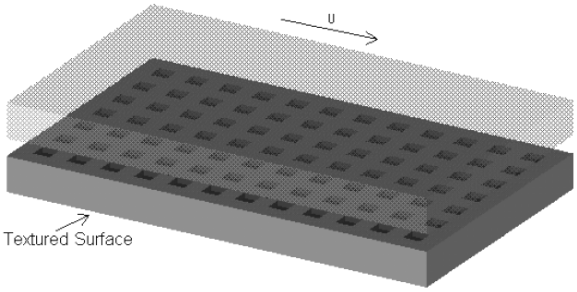


Fig. 12
Textured segment of a thrust slide bearing

Fig. 13
Piston ring with textured surface

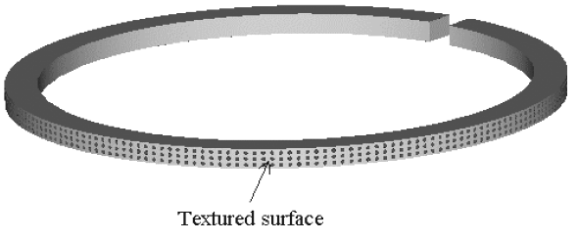
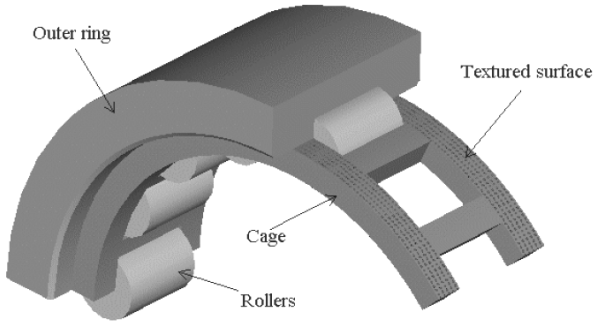


Fig. 14
Roller bearing with textured surface cage



The structured surfaces are used in the process of plastic deformation of thin or thick metal plates, to reduce the friction in the process and to avoid the damage of the manufactured elements and of the deformation tools. The paper [5] presents some aspects of these use of structured surfaces.

5. CONCLUSIONS

Structured surfaces are very important challenge for sliding couples using large contact areas and they are already in use. The research branch approaches the subject since the last decade. The first time in an article some researchers approaches the problem in the 60's. But only in the 90's the subject of structured surfaces was carefully studied by the tribology specialist researchers.

Probably there will be a growth of the area of machine elements using structured surfaces. The main problem remains in computing the boundary lubrication regime using this kind of surfaces. Another problem is the tribological research and detect the most important friction characteristics for many variants of surface geometry and establishing some optimum variants.

Bibliography:

1. Iliuc,I. – *Tribology of thin layers,* Editura Academiei R.S.R. şi Elsevier, Amsterdam–Oxford–New York–Tokyo, 1980*;*
2. Marian, V.- *Contribuţii privind lubrificaţia cuplelor de frecare cu suprafeţe texturate*, rezumatul Tezei de Doctorat, Bucureşti, 2006, Universitatea Politehnica din Bucureşti, Romania
3. Marian, V. – *Lubrication of the textured surfaces*, Depart. Of Machine Elements and Tribology, University Politehnica of Bucharest, Romania
4. Pettersson, U. – *Surfaces Designed for High and Low Friction*, Acta Universitatis Upsaliensis, Uppsala, 2005
5. Steinhoff E., Rasp W.,Pawelsky O. – *Entwicklung von tribologisch optimierten Oberflächenstrukturen für die Blech–und Massivumformung*, The XIIth International Coloqium Tribology 2000+, January 11 – 13, 2000, Technische Akademie Esslingen, Germany
6. Wakuda M., Yamauchi Y., Kanzaki S., Yasuda Y. – *Effect of surface texturing on friction reduction between ceramic and steel materials under lubricated sliding contact*, Wear, Volume 254, 2003, Elsevier Science S.A.
7. Bardac D. – *Contribuţii privind creşterea preciziei şi îmbunătăţirii calităţii alezajelor utilizate în industria motoarelor cu reacţie prelucrate prin superfinisare* – Teza de Doctorat, Universitatea Politehnica Bucureşti – Facultatea Inginerie Aeronautică, Bucureşti,1996
8. Pavelescu D., Muşat M.,Tudor A. – *Tribologie, frecare, uzare, ungere (Tribotehnică)* – Editura Didactică şi Pedagogică, Bucureşti, 1977
9. Pavelescu, D., – *Tribotehnica*, Ed. Tehnica, Bucuresti, 1983.