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NEW ASPECTS OF PITTING PHENOMENON AT THE ANTIFRICTION ALLOYS

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Abstract: *This paper presents some particularity and specifies aspects of pitting at the antifriction alloys. The paper presents the theoretical aspects and observations about these phenomena.*
Key words*: sliding bearings, pitting. antifriction alloys*

1. GENERAL ASPECTS

This paper embosses on a basis of theoretical and experimental results extracted from authors’ works and from the special literature the pitting phenomenon, especially in the antifriction alloys case, used in constructing and fabricating of bearings with multilayer bushings

Physics, the phenomena consists in the appearance, on the contact surfaces of a type of alveolus of different dimensions looking like some pinches, made by the detaching of small particles from the superficial layer. The particularity is given by the fact that these alloys are characterized by high plasticity and tenacity and a very low hardness. The pitting phenomenon (tiredness) at a macro structural level of antifriction alloys used in construction of bearings with multilayer bushings takes place in three stages.

The first stage is characterized by the appearance of microcraks, uneven disposed which radically penetrates the antifriction layer of the alloy, especially in the practicing area of maximum efforts.

In the second stage, due to the interaction between the microcraks and the lubricant film, in which it is developed the pressure which determines the variable carrying force (hydrodynamic or hydrostatical), takes place an evolution of these following the maximum directions of tangent tensions, disposed under an 45° angle towards directions of maximum axial tensions, or the principle of minimum material strength.

The phenomena increases at variable local pressure, which in time generates associations of faults and discontinuities facilitating, then, the appearance and the development of macro cracks called „material tiredness”. Meeting the strengthen material on which has been applied the antifriction layer, the macro-crakes are developing across this separating area. This is the third stage, when a part of the layer comes of the basic layer which leads to the appearance of pinching.

2. MICROCRAK SOURCES

For explaining the first stage, which makes the subject of this paper, the author considered useful a gradual and short analysis of the appearance way of these microcraks, which stay at the basis of this phenomenon. The author has, synthesized in two groups these sources: structural and dates of plastic deformation, which will forward be describe.

The imperfections of crystalline structures, constitutes the first source. According to the theory concerning the crystalline structure, the atoms can be considered by aproximation as spheres.

By uniting the spheres’ center with lines, elementary cells are obtained having different parallelepiped forms. **The compact arrangement,** has in view the obtaining of holes as smaller as they can be as part of the network, the atoms from the upper layer lay in the holes of the spheres from the lower layer, characteristic for the compact hexagonal network which does not takes part of the Brava’s networks.

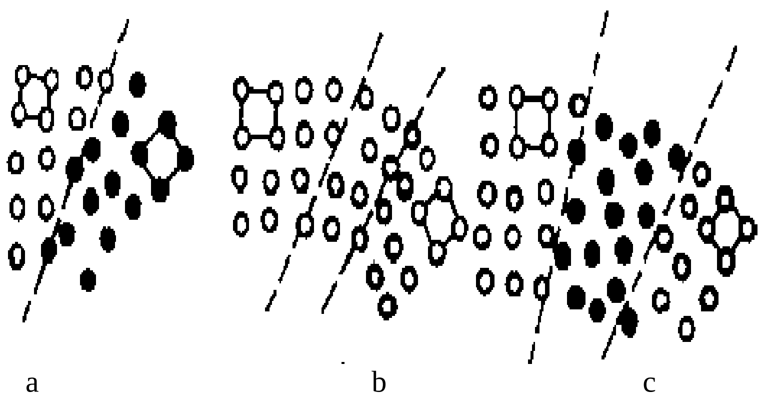

Fig.1. Types of structures which can be found at the boundary between seeds

The less compact arrangement has the interstice’s size bigger laying on vertical axis. Any impurity represents different dimensional spheres which produces structural distortions and discontinuities, a bigger phenomenon in the case of alloys. By their adjoining and agglomeration, these structural distortions can be considered the most fine and elementary future sources of microcraks. A relatively large number of atoms different from the base ones, grouped, can generate structural discontinuities.

Relying on the geometrical criteria **crystals imperfection** or **of network** can be **punctual,** under the shape of **vacant spots (**atoms missing from the structure**) interstitial atoms** (atoms of the same kind with the ones in the network but occupying interstitial positions in the structure), **foreign atoms.** When the simple punctual imperfections interact, they can form relatively small vacant spots agglomerations or interstitial atoms, which don't entirely destroy the network's frame, known as the designation of "clusters" or bigger congestions named colonies.

Linear imperfections or the dislocations are bigger dimension imperfections, which consist of a row of atoms of a crystal with a unnatural coordination. Due to the crystal's tendency of purification during the crystallization of the fusion, the unknown atoms are pushed towards the exterior of the crystal, thus generating surface imperfections. These imperfections represents surfaces which separates, in the material's mass, different portions from chrysalis's structure point of view (regarding the crystalline structure),of the crystallographic orientation or the spontaneous magnetically orientation etc...Regarding the crystalline structure, surface defects may be considered separation limits (boundary) between phases, between grains or sublimit, defined as separation surfaces between macles, packing defects, etc, being able to take different forms. **Grain boundries**, are transition regions from a grain to another. These adjacent grains are distinguished by their crystalline orientation fig.1

It was proven by experiments that limits' energy increases as the angle increases, reaching maximum value at angles of approximately 20º. Limits' energy at large angles is about 600 erg/cm^2 by comparing with the limit of a macle of only 25 erg/cm^2[2]. This large amount of energy encourages a succession of reactions in solid form as: diffusion, fall-outs or phase transformations [2].

Also in these regions the concentration of unknown atoms is bigger than in the rest of the material.

Sublimits, are also surface imperfections which appear inside the same crystalline grain, due to purification tendency.

One of building-up methods of a sublimity network named substructure consists' in cold deformation with low deformation degrees (1-10%) followed by low temperature annealing with the pursuit of avoiding the formation of a new generation of grains after crystallization [1]. During cold deformation a high number of marginal dislocation is formed which owing to the annealing is arranged one above the other. This phenomenon is called polygonalization or annealing in SITU (owen), because sublimates building is determined by the appearance by bending of some slippage plane packages. Those contains same sign dislocations, which by one above the other arrangement make a fragmentation of slippage planes at low angle forming almost a polygon sides. The composition and design of physic-chemical of alloy phases is another important source of discontinuities. The alloy are metallic materials made by two or more atomic species which will constitute in alloy components, generally metallic elements, it can also be nonmetallic, conditioned by metallic character domination.

The homogeneous part of an alloy, divided by another homogeneous parts by fine determinate surfaces forms a phase. Alloy s properties will be affected by composition, quantity, form and phase distribution which compose them. By percentage modification between components is obtained an alloy system. Solid solutions, results as sequel of atom immersions of alloy component (solution component) in crystalline network of basic component (solvent). After lay-out mode of those two atom components can result: solid solutions of substitution or interstice solution. Some alloy systems as Cu-Zn, Fe- Al at high temperatures when the entropy has an important role, shows irregular solutions which under certain temperature it's organist adopting an low entropy estate, of low intern energy and a low blank energy.

Inter metallic compounds, are caracterizeited by chemical compositions fine determined: A_mB_n, $A_mB_nC_p$. Their crystalline network is different then the one of compounds, mostly been very complex, and mechanical properties, their thermo stability is higher then the compounds. At their time those compounds can show various intermediary phases being able to be grouped in: electro-chemical compounds, which are normal valence, geometrical compounds are formed by ratio criterion between atom component dimensions. The Laves phases belong to one of the following crystalline structures in slippage axle domain: $MgCu_2$, $MgZn_2$, $MgNi_2$. is powerful plastic distortions contains approximately 10^{12} traps/cm^3.

Electro-chemical compounds are formed on basis electronically concentration defined with the ratio between valance number and the number of atoms they belong. Beside those sources due to their imperfections shown in and after raw elaboration, second important source are cold and hot plastically deformation effects of **those materials. The sliding** on the maximum atomic density planes leads to the forming of variation in levels at the surface of the crystal witch, on the microscope appear like belts (fig.2).

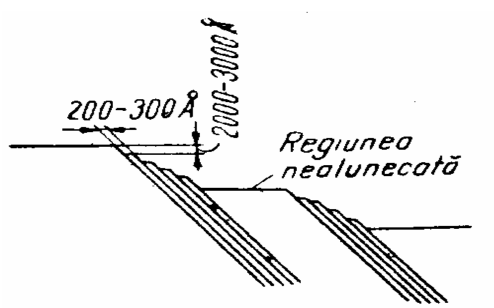

Fig.2. Sliding muvement in monocrystals

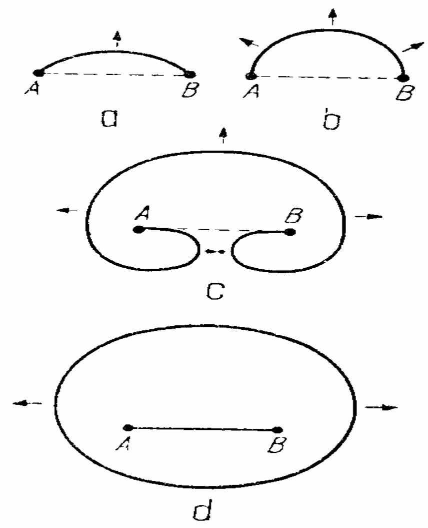

Fig.3. New dislocation closed curl forming

Metallic materials used in industry are olycrystalline, made from grains (crystals) separated by grains limits, Necessary stresses for deforming polycrystalline are stronger then deforming of a monocrystals. The experiments shown and theoretical proved that cold deforming take place harder near the grain limit then inside the crystal, so the limit has a higher resistance then the rest of the crystal. For explaining the plastic deformation of dislocation mechanicals

In a sliding belt the notion of dislocation source must be considerate. The principle of a dislocation source debated for the first time by Frank and Read it is illustrated in fig 4.

The process can repeat new curls being generated each curl producing a single movement through the sliding plan. In general dislocation multiplication while plastic deforming leads to the increasing of necessary tension for their movement. Cold hardened is due to mobile dislocation crossings, encounter of mobile dislocations with no mobile dislocations, with hurried or other obstacles in the way of movements, network tensions created by the dislocation agglomerations, etc. The most important manifestation of the cold hardening is the strength increasing of the later distortions, accompanied by the adequate plasticity dropping of the material.

This phenomenon depends on the type of the crystal lattice, on the nature of the metallic phase which deforms, on the presence and distribution of other phases or compounds, on the temperature, etc. The link between the cold plastic distortion and the distortion amount is presently fully elucidated. While an annealed metal contains $10^6 \ldots 10^8$ traps/cm^3, the same metal subdued to some The enhancement of the traps quantity, due to plastic deformation, presently explains, in the best way, the cold hardening phenomenon of the metals and alloys. The traps density **ρ** determines the necessary tension **σ** for generating the deformation, like in the relation:

$$\sigma = \sigma_0 + \alpha G b \sqrt{\rho} \qquad (1)$$

in which :

$\boldsymbol{\sigma_0}$ is the friction tension within the crystal,

α a constant which depends structure and properties of the material, G the transversal elasticity module, b the Burgers vector. So, as the dislocation density becomes bigger, the necessary tension for producing the deformation gets bigger. The dislocation role in the cold hardening results not only from density influence on a certain surface, but from their distribution mode in the material. The medium relative deformation ε depends on the dislocation density **ρ**

According to [2] wherein b and p keep's the signification and X represents the distance along entire angle of slip plan at upside crystal good-sized Bruges vector. Cold tempering by plastic deformation it's explained by (appear) of internal tensions very strong generated by dislocation's (for example near grain limit's or faze limit),by intersection of dislocation forest, by immobile steps created on mobile dislocation's or from dislocation's circumvolution whit the fitted head. Near those tension's at the crystal network system (third order) in cold-hardness' steel appears macroscopic tensions (First order) and microscopic tensions (Second order).The importance of grain limit's in (cruisers) process are indicated by hi-level of tension necessary for deformation of the polycristals comparing to monocrystals.

For many metallic materials it can be used the Hall-Patch [3]

$$\Gamma = \Gamma_0 + k / \sqrt{d} \qquad (2)$$

Γ-yield strength at one appointed deformation, the medium diameter of the grain, Γ_0-the tension give by the friction at the movement of dislocation, k- constant.

The anisotropy of properties give by the raised of preferred orientation it is overlapped by the anisotropy produced by the modification of shape and the phases deformed distribution and the composites. By plastic deformation the metallic material grain, at first having the same axis, they get longer proportionally with raise of deformation degree.

Once with the slipping of grains the grains limits become less smoother and the metallographic structure gets a microform. The pieces' anisotropy with microform is more pronounced proportionally with the impurity degree. At the pieces design work, in especially from magnesium alloys it is necessary to heed by the appearance of microform because the lines of inclusions represent fragile areas and with smaller resistance.

Ageing, represents another effect of plastic deformation at cold rest in the atom's alloys precipitation during the suprasatureitidd solid solutions aging. The suprasatureitid solid solutions durification take place in three stages: the solid solution durification; the durification through deformation of coherent precipitation (agglomerations of outsiders atoms, which are fitting with the basic metal net) called and "areas"; durification through the forming of precipitations (new phases which are breaking the coherent connections with the basic metal net). In each case the mobile dislocations must by-passing or getting through this barricades, and the homogeneous suprasatureitidd solid solutions, tougher than pure metal, heightening the hardness once with the coherent precipitation’s separation. Maximum durification it is reached at a critical dimension of the particles which permits to the dislocations to get curved arround the individual particles.

3. CONCLUSIONS

During crystallization of atoms which constitutes the crystalline structure produce discontinuous of structure under the shape of vacancy or interstitials atoms. During generations with aliens atoms are pushed at grains’ margin generating surface imperfections and sublimity. This constitutes the base of forming a superstructure which gives special properties to the resulting structure, compared to the basic material properties. The chemical-physical nature and construction of phases from the alloys, through the different compounds and phases and the resulting solutions, constitutes another important source of discontinuitys.

All these elements it’s states of equilibrium. Any parameters’ modification which have established this equilibrium generates obvious structural modifications.

These modifications often appear during the machine work (chip removal operations, warm and cold deformations, thermo treatments, etc) resulting from the blank(bar strip) the final pieces are obtained, followed by the ones generated by the tasks that are being taken by these pieces, during the process of exploitation, one of the effects being the studied pitting phenomenon. On the base of the argument, the variable solicitations, especially, produce structural effects of cold hardening, ageing, anisotropy of the properties, etc which constitute the bases of the machine parts destruction, in generally, of bearings, in particularly. Knowing the tasks will be taken by the bearings during the exploitation by cold plastic deformation, the optimal structure can be realized anticipative [1].This solution, according to [1], it is defined by the concept of structural preconfiguration. According to the equations 1 and 2, it is very helpful that these discontinuities, which develop the pitting phenomenon, to be as much as homogeneous and regularly disposed within the material composition, the dimension of the crystalline grains as smaller as they can be, as like as the intrinsic proprieties of the component elements. The higher proprieties of this alloys are being given, in essence, by the superstructure’s qualities and less by the basic alloys materials.

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