



## THE ANTIFRICTION LAYER OBTAINED THROUGH FINPLAST TEHNOLOGY - THE COMPOSITE MATERIAL CHARACTERISTIC PROPERTY

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*Abstract: The paper presents a new type of composite obtained in the superficial layer of antifriction alloy of the sliding bearings, finished through FINPLAST technology. The paper shows several theoretical and experimental results of the authors, obtained after theoretical and experimental studying of this proceeding. The FINPLAST technology for finishing by cold plastic deformation of antifriction alloy of sliding bearings is an original proposal of the authors.*

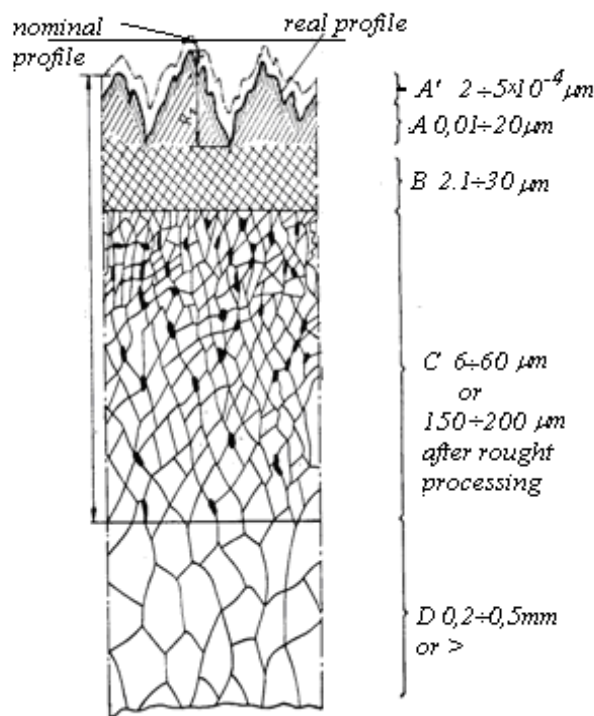
*Key words: antifriction materials, composites, FINPLAST, design.*

### 1. IN-DEPTH MODIFICATION OF CRYSTALLINE STRUCTURE IN THE SUPERFICIAL LAYER AFTER CHIP REMOVING PROCESS

The first aspect is being shown in fig.1, where the modifications of the materials after the chip removing process can be seen [1], [2], [6]. It becomes obvious in the diagram, the fact that after the chip removing process the superficial layer of the processed material has a certain depth of modified structure. According to the experimental tests which are shown in fig.1, the real profile obtained after the chip removing process is being covered by a superficial layer made of crystals pieces that are attached to the basic material with reduced bonds. There are two possibilities to obtain this type of layer, called "absorption layer" marked "A" in the diagram. The first is obtaining it from polar molecules, which are connected to the basic material by Van der Waals connection, and the second possibility is by chemical bonds made between the structure of the profile and the pieces of crystals as a result of the chip removing process.

Immediately under the real profile, an oxide layer can be seen, called reaction layer and marked "A" in the diagram. Next, another layer called "BEILBY LAYER" noted marked "B" can be noticed. This is an amorphous layer (without regular crystalline structure) formed on the surfaces of the metal via mechanical working, wearing or mechanical polishing. A BEILBY'S layer is a disorganized molecular surface layer (science Dictionary). Next under the BEILBY layer, a layer marked "C" which has a deformed crystalline structure can be noticed.

The last modified layer is marked "D", and has normal crystalline structure. The specific characteristic of "D" layer is the fact that the tension in "C" layer determines a strain in it. This tension makes it possible for some structure modifications in case of a big loading force of contact to the surface to appear. There is a possibility that the C layer will increase and will penetrate the D layer. The dimensional limits of these layers are shown in fig. 1. All these layers determine a specific superficial structure of the antifriction layer. This structure is characterized by a "memory" of generation mode that is obligating us to use the same way of turning of sliding bearings. The Beilby layer presenting a special crystalline structure has been known since 1903, but it was experimentally confirmed after three decades. This is characterized by a very fine structure that contains a high density of dislocations. This is similar to the amorphous structure. By the experimental determinations [1], [4], [6], this layer is very important for a good tribological function of bearings. In conclusion, it's very important for this layer to be obtained and maintained after the finishing process [6]. The ensemble of all these layers (A', A, B, C, D) represents an area in the depth of the material, with specific proprieties for each antifriction alloy. Next, this ensemble of layers is called LCRP (Layer-Chip Removing Process). [1], [2], [6].



**Legend:**

*A' – Absorption layer;*

*A – Amorphous structure;*

*B – Beilby layer (particularly amorphous structure);*

*C – Deformed crystalline structure layer*

*D - Intact crystalline structure but tensed, which makes it possible for some changes to occur;*

**Figure1.** The superficial layer modifications of crystalline materials, after the chip removing process

LCRP and the experimental values which can be determined are shown in table 1, in the end of the paper. By analyzing the data from table 1, the influence of the technological process of fabrication and also the final finishing quality of the LCRP thickness can be seen. Due to the specific tenacity and plasticity of the antifriction materials, finishing by chip removing process brings multiple challenges. In order to solve the problem, special technologies like cathode deposit, thermo-chemical treatment, ionic plating, structural modifications with laser, etc. are used. The author has experienced and studied an original technical solution, which consist of finishing the antifriction layer by cold plastic deformation method, called finplast. The procedure is in accordance with the conclusion [5], which shows that tribologically speaking, actually the surface layers are the ones that influence the durability and reliability of a bearing and not the rest of the material.

Table1. The values of LCRP depending of processing method

Processing method for finishing	Roughness $R_a, R_z, [\mu m]$	Beilby layer $[\mu m]$	Deformation Layer $[\mu m]$	LCRP $[\mu m]$
Rough turning, cold stamping, hot rolling, deepening	25-50 100-200	0.1	50-100	130-150
Lathe turning, milling, shaping, drilling, deepening	6.3-12.5 25.-50	0.05	25	50-70 (80)
Finishing turning, finishing milling, shaping, boring, broaching	1.6-3.2 8-12.5	0.01-0.02	5	15-20
Exact milling, rectifying, lapping, boring, fine turning	0.6-1.2 3-6	0.003- 0.008	2-4	4-8

Abrasive fine polishing, shaping, boring	0.4—0.6 2-3	0.003- 0.005	2-4	4-7
Finishing rectifying, diamond fine turning, polishing, honing, lapping	0.2-0.4 1-2	0.003- 0.005	2-3	3-5
Lapping, exact rectifying	0.1-0.2 0.5-1	0.003	1.5	2-2.5
Mechanical super finishing, polishing, lapping	0.025-0.05 0.125-0.25	0.001-0.0015	1.5	1.7
Electrolytic super finishing, polishing	0.012-0.025 0.063-0.125	0.0003	0.0034	0.01-0.2

## 2. FINPLAST TECHNOLOGY. GENERAL ASPECTS

The originality of the procedure is given by the use of the cold plastic deformation when finishing the contact surface of antifriction material of the sliding tribological couplings.

Keeping in mind the fact that the possibilities of finishing the antifriction alloys through cutting are reduced, the improvement of the performances both on the surface plane and in depth plane is solved by the help of other procedures. Besides other procedures known in the literature of specialty, the author considers the proposed procedure very useful. As we can see in figure 1 the procedure is very simple.

This one deals with the sag of the semi-finished material transformed through cutting, under the action of the lay-on roller. Previously, these surfaces were obtained through a cutting procedure. The main technological parameters of the procedure are:

- $F$  – rolling force;
- $N$  – number of passing;
- If the contact is or is not lubricated during the processing.

Besides these parameters, the processing results could be influenced by other measurements too, such as: rotary speed, which is equal to the displacement of the device mass, the asperity of the lay-on roller and its roughness, the hardness of the device and the precision of the relative position between the roller axis and the mobile mass plan, the steadiness of the rotary load and speed, the thickness of the antifriction material, etc.

The roller diameter is necessary to be correlated to the thickness of the antifriction alloy layer first. In order to avoid the adherence of the antifriction material on the roller surface, liquid and solid lubricants can be used.

## 3. THE DESCRIPTION OF THE DEVICE USED TO OBTAIN STUDY SAMPLES

For the study of the proposed procedure, two rectangular steel (OL 37) plates, one coated through plastic deformation with alloy AlSn10 and the other with alloy CuPb5, deposited through warm sintering were used. Both materials are used in the series production to get sliding bearings.

To obtain the study surfaces and the thickness of the antifriction layer, the frontal facing of the semi-finished materials on a normal lathe has been used. In order to do this, the study plates have been fixed on a rigid plane support, fixed in the lathe universe. The facing of the alloy AlSn10 has been obtained with the following technological parameters: rotation  $n=60$  rot/min, radial advance  $s=0.14$  mm/rot, and the cutting depth  $t=0,57$ mm. For the alloy CuPb5 have been used:  $n=460$  rot/min,  $s=0.18$  mm/rot,  $t=0.5$  mm.

In order to get study samples, a very simple device has been conceived in conformity with the pictures in figure 1.

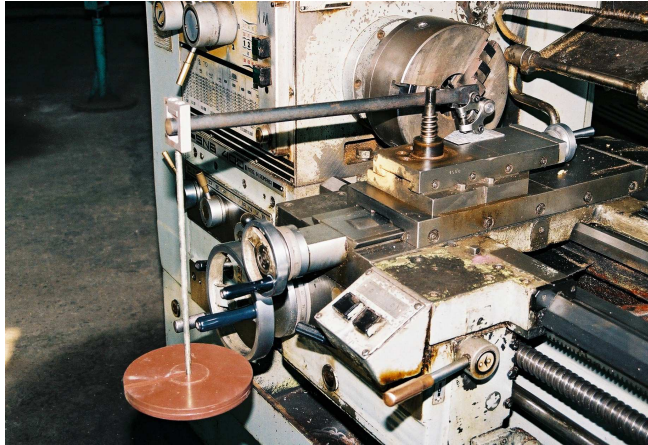


Figure2. General view of device for finishing test surfaces

#### 4. EXPERIMENTAL RESULTS AND OBSERVATIONS

For observing and analyzing the effect of finishing by FINPLAST technology, the scanned image of the sample study was used. In figure 3, the scanned images of samples for AlSn10, and a few details are represented. By comparison, in the fig. 4 there are represented the scanned images of CuPb5 alloys and also a few details. In order to observe the modifications after the contact with rolled surfaces after finishing by FINPLAST technology, in the detail there are presented and references the standard surfaces. These surfaces result after chip removing process.

As we can see in the picture, the device allows a wide range of modifications of the technological parameters described above.

From the details that are shown, one can observe that the studied surfaces present visible modifications. In the same time, one can also observe differences between details depending on the technological parameters used. This aspect is presented in scanned images.

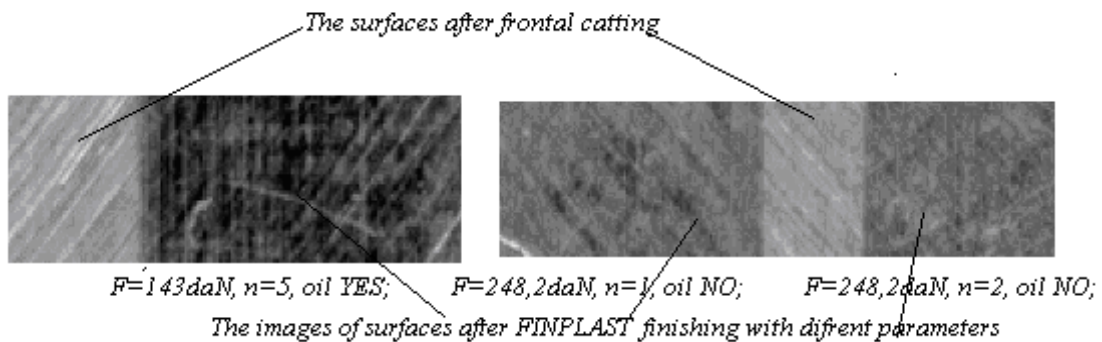


Figure.3 The most representative scanned image of the sample study from AlSn10

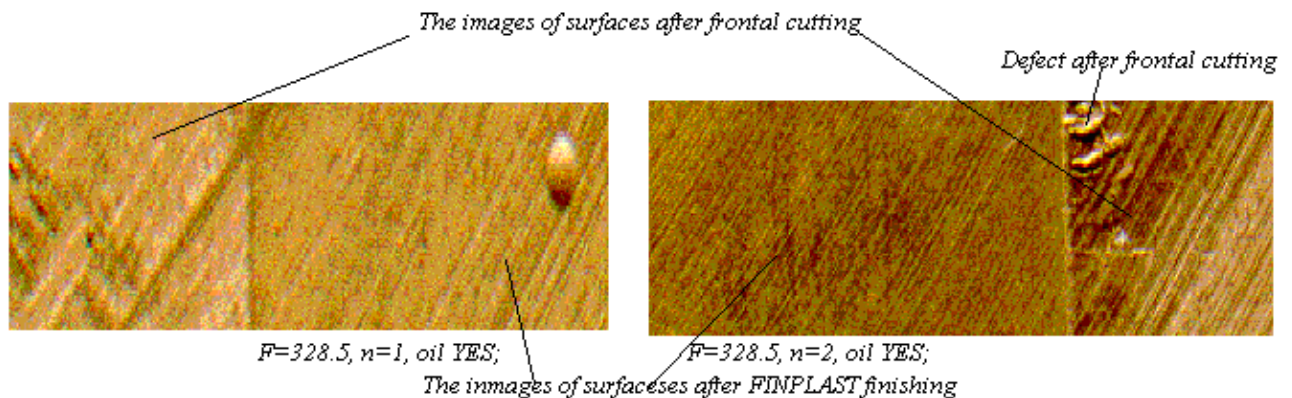


Figure 4. The most representative scanned image of the sample study from CuPb5,

By comparing figure 4 with figure 3, one can observe the different effect of Finplast finishing depending on the antifriction alloy. In the same time, one can also observe the better homogeneity of the finished surfaces in comparison with those obtained through sintering. It can be remarked how the sintering defects shown in fig. 4, detail of defect which is modified after finishing, and surfaces are corrected. The result is a surface which is no different from the surface with no defects.

As we can see in the picture, the device allows a wide range of modifications of the technological parameters described above. With the help of this device more study samples have been obtained under the form of plane bands.

This aspect expresses with no doubt the utility of the proposed procedure and the influence of the technological parameters.

## 5. CONCLUSION

### 5.1 General aspects

During chip removing process, we also find the two components of the force: radial and axial forces. After the chip removing process, the material suffers complex transformations in the superficial layer (figure 1 and table 1);

This shows that the obtained material layer will suffer in-depth, a preferential deformation of structure, described in paragraph 1. By creating a plastic deformation to these layers, like the ones presented until now, we have to consider sense of movement of the splinting tool.

Another important aspect of the problem is the LCRP layer. Due to plastic deformations suffered, the couplings between the crystals and the crystal fragments of these layers are becoming stronger. Inside of the layer, the crystals that suffered structural transformations by movements and/or deformations create a tensioned structure with a high number of dislocations. This will give the material's superficial layer superior tribological properties compared to the ones of the material before the plastic deformation.

### 5.2. The composite characteristic property of the antifriction layer obtained through FINPLAST technology

- After chip removing process in the superficial layer, a plastic layer (under D layer) is obtained. These represent the plastic matrix of composites material.
- In layer A, A', and B, there are a lot of particles like: oxides of components of antifriction materials, crystals, or crystal fragments and specific amorphous layer BEILBY;

- After finishing through FINPLAST technology, the layers A' and A will penetrate the Beilby layer, which will penetrate into the layers found beneath it (matrix of composites). All these will result in the enlargement of their dimensions.
- After this process, a metal (plastic) matrix which incorporates in its masse the hard particles is obtained;
- After incorporating in the masse the hard particles, a new superficial layer is obtained. This layer is more tensioned, and has better elastic properties;
- According to the theories of reinforcing (Orowan) of these materials, this irreversibility of structural transformation is very advantageous for antifriction layer of sliding bearings. In the normal case of using a sliding bearing, the material is stressed with variable forces. According the Orowan theory, these variable forces cause in the plastic material the aging and precipitation phenomenon.
- This solution of composites is also utilized in construction/ architecture, where the special composites with soft matrixes (different mortars) and different hard materials for special ornamental, mechanical characteristic or friction surfaces are obtained. Usually, in the soft matrix (mortar) it's loading of stock. Very seldom the hard and special components are pushing in soft matrices.
- In construction, this method gives the possibility to obtain special quality composites.

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