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THE INFLUENTS OF ANTYFRICTON COMPOSITE LAYER OBTAIND BY FINPLAST OVER FRICTION COEFFICIENT AND MICROHARDNESS

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***Abstract**: FINPLAST it's the name of new experimental technology, propose by author for upgrading performance of the sliding bearings. As a result of finishing the antifriction layer [4] by FINPLAST, result a very small superficial composite layer. This top composite layer it's obtained by pressing and impregnated in antifriction layer of a strong particles results after cutting. For obtained this small superficial composite layer us a new processing ,,FINPLAST''. This paper presents the influents of FINPLAST parameters (cold plastic deformation force, the number of passes, the existence or not existence of lubrication during cold plastic deformations, and antifriction materials) based on experimental determinations over hardness and friction coefficient. It's presenting the value of the most important trybological parameters.*
***Keyworks:** sliding bearings, small superficial composite layer, finplast technology, micro hardness, friction coefficient.*

1. GENERALITIES

This solution was proposed by similarity with the large number of application in finishing layers in construction and architecture. In these case the last finishing layers change the property and quality and performances of final obtain surfeits. The authors propose for finishing the surfaces of antifriction layer the cold plastic deformation technology [1], [4].

The name proposed for this new technology **FINPLAST** [1]. For study, we accomplished on the plane surfaces a small experimental surface. For an easy identification this surfaces are marked with an identification code. The surfaces test for experimental determinations is obtained using a wheel which rolling with a controlled force over the plain surface with different parameters for study its effects. The most important parameters are:

- *rolling plastic deformation force F;*
- *the number of passes n;*
- *the existence or not existence of lubricating oil during rolling;*
- *type and particularity of antifriction alloys.*

The plane surfaces tests for first alloy, AlSn10, are obtained by convert by plastic deformations on plane surface from OL37 with antifriction alloy. The identification code contains letter A and different numbers for every experimental surfaces (A.1, A.2,…, etc). The plane surfaces for second alloy, CuPb5, is obtained by worm sintering alloys on plane surface from OL37, an adders material with large importance in construction of sliding bearings. The identification code for this alloy contains letter B and different numbers for every experimental surface (B.1, B.2,…, etc). First, all experimental surfaces were manufactured by frontal turnery with the same parameters. The value of these parameters is presented in table 1, and table 3. In the next place, generated the small surfaces finished by FINPLAST technology, with different parameters and conditions, describe hereinafter in deferent table. To obtain these small surfaces, the authors design a special device [1], [2].

2. THE INFLUENCE OF FINPLAST TECHNOLOGY PARAMETERS, US FOR OBTAIN SMALL SUPERFICIAL COMPOSITE LAYER, OVER FRICTION COEFFICIENT

In order to experimental determine the friction coefficient, we used the very determinately tribometer, in the ***laboratory Technique of invention and tribology***, of ,,TRANSILVANIA" UNIVERSITY of Braşov, Romania. This friction coefficient was determinate out of dry lubrication.

2.1. STUDY OF DRY FRICTION COEFFICIENT FOR **AlSn10**

The experimental values of friction coefficient for AlSn10 are shown in the last column of Table 1. To compare the effect of finplast technology, in the last rows of table 1 is shown the value of friction coefficient for surfaces obtained after turnery for AlSn10. All these values are presented in table 1. For every surface were experimental determinate ten values of friction coefficient and with ***Chuvenet*** and ***Charlier*** method, select average value.

Tabel1. Experimental value of friction coefficient μ after FINPLAST for AlSn10

Test identification code	*Rolling force F [daN]*	*Nr. of passes n*	*Existence or not existence of oil*	*Friction coefficient μ*
A.1.	*248.2*	*1*	*No*	*0.28940*
A.2.	*248.2*	*2*	*No*	*0.318497*
A.3.	*248.2*	*1*	*Yes*	*0.30779*
A.4.	*248.2*	*2*	*Yes*	*0.2738*
A.5.	*248.2*	*3*	*Yes*	*0.2805*
A.6.	*328.5*	*1*	*Yes*	*0.23253*
A.7.	*328.5*	*1*	*No*	*0.25097*
A.8.	*456.2*	*1*	*Yes*	*0.26985*
A.9.	*143*	*5*	*No*	*0.34644*
A.10.	*143*	*5*	*Yes*	*0.33723*
A.11.	*77.5*	*1*	*Yes*	*0.29299*
standard				*0.28575*

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For beginning we will study, for this alloy, the effect of variation of friction force for a single passing. To accentuate the effect of increasing of finishing force, we will analyze the

The variation of friction coefficient with the increase of rolling force (AlSn10)

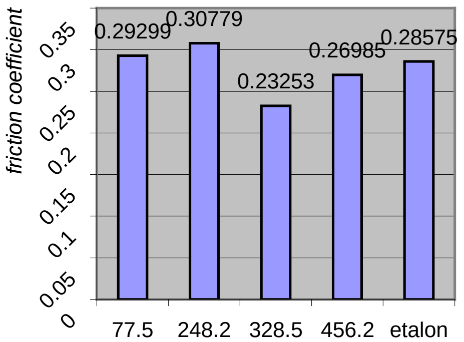


Fig.1

values from Table 1, for a single passing case (*n*=1), in the presence of lubricating oil. From Table 1 we selected these values and for an easier explanation in fig. 1 we graphically present the respective values of the friction coefficient μ. Can be observed in diagram an interesting thing, the minimum value of the friction coefficient corresponds to a cold finishing force of 328,5daN. Comparing with the value of friction coefficient μ of the standard surface obtained by turning in the lathe machine, can be noticed that, the increase of F will increase μ. For higher values of finishing force, the friction coefficient will decrease bellow the standard surface values.

If the finishing is without lubrication, the values of friction coefficient μ, for the tests *A.1* if comparing with A*.7.,* the lower value corresponds to the same value of 328,5daN.

In order, well be study the tests *A.3, A.4,* and *A.5.* Ken observe the effect of number of passes on the friction coefficient μ.. For these tests we kept the same *rolling force* (248,5daN). In order to compare the results, these values were shown in *Figure 2*.

In *Figure 2* we can notice that the optimum value is obtained for *n=2* (*A.4*). Also, from the value point of view can be noticed that the influence of number of passes *n* is higher than the one corresponding to the increasing of the values of the rolling force*.*

Both for *n=2* and for *n=3,* the friction coefficient is lower than the value for a high number of passes *n=5,* but acting with a lower finishing force *F*, can be noticed a high increase of friction coefficient corresponding to the standard (etalon) value.

If comparing the pair of tests *A.9* and *A.10*, for a high number of passes *n=5,* and applying one finishing force *F*, can be noticed a high increase of value of friction coefficient.

In order to evaluate the effect of lubricating oil on the contact surface in both cases, with, and respectively without lubrication, during finishing of surface by cold plastic deformation technology, we carried out a smaller number of tests but for a higher number of values of *rolling force*.

Modifying the *rolling force F* and the number of passes *n,* four pairs of tests have been carried out. According to the values from Table 1, for the same *rolling force, F* and number of passes *n=1*, for tests *A.1 and A.3*, μ presents an increase when lubrication is present. If we keep the same *rolling force* but we carry out 2 passes (*A.2* with *A.4.*), μ has a significant decrease in this situation with lubrication. An interesting situation is if we compare the effect of increasing the number of passes without lubrication (*A.1* with *A.2*) and with lubrication (*A.3* with *A.4*), we can notice that the effects are opposite. In first case can be noticed an increase of μ with the increase of *n*, and in second case a decrease. From the value point of view, this decrease of friction coefficient μ, is approximately equal with the increase from the first case.

Another pair of values is for tests *A.7* and *A.6.*, when the friction coefficient is minim. For the same *rolling force* of 328.5 and the same number of passes *n=1, the* friction coefficient is significantly decreased by the presence of the lubricant.

For a higher number of passes (tests *A.9.* and *A.10*, *n=5)*, for a lower force *F*, the influence of lubrication on the value of friction coefficient is lower. The author considered useful to observe the effect of finishing when we determine the wet friction coefficient. For comparison, in *Table 2* are shown the values of dry and respectively wet friction coefficient, for tests *A.9.* and *A.10.* In conclusion, the wet friction coefficient shows a significant reduction when getting close to the standard (etalon) value.

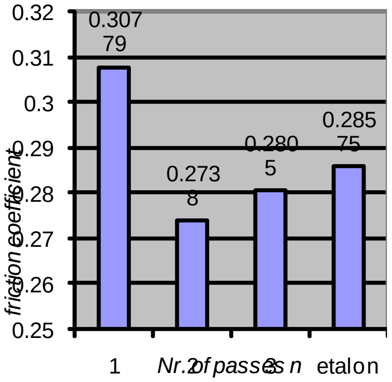


fig.2. The variation of friction…

Table 2. The values of dry, respective wet friction coefficient

Test code	μ *(dry)*	μ *(with lubrication)*
1.9.	*0.34644*	*0.2846*
1.10.	*0.33723*	*0.2929*

2.2. PARTIAL CONCLUSIONS

- For *AlSn10* alloy, in order to decrease μ, the lubrication during finishing has positive effects regardless of the other parameters.
- Generally speaking, if the finishing forces increases, for μ, the effect is positive. Observation: μ has a minimum value for an intermediate value of the finishing force.
- The increase of *n* is not useful. The influence of the number of passes on the friction coefficient has to be correlative with the value of finishing force. For *n=5,* friction coefficient is much higher than the etalon value.
- The minimum value of friction coefficient is obtained for test *A.6.* (*n=1, F=328,5daN, and with lubrication).*
- The maximum value of the friction coefficient is obtained for test *A.9.* (*n=5, F=143daN, and without lubrication*).
- Wet friction coefficient shows a significant decrease when is getting close to the etalon value.

2.3. STUDY OF FRICTION COEFFICIENT FOR CuPb5

For the second studied material (B), *CuPb5* sintered alloy, the results of the experiments are shown in table 3, in order to study the influence of material on friction coefficient after finplast finishing, the same values of finishing force *F* have been used. For comparison, as for the first material A, a few tests have been carried out for the surface obtained by lathe turning, without being finished by finplast technology. In order to evaluate the influence of finishing force *F,* tests *B.1, B.2, B.5.*have been carried out. In all these cases only one pass was done (*n=1).* In Figure 3 is shown the variation diagram of $\mu_{(F)}$. For comparison, near these values, also the value of the friction coefficient for the surface considered as etalon (standard) obtain by turning is shown. According to the diagram, an interesting thing is noticed.

Table3. The experimental values of friction coefficient for alloy CuPb5

Test code	*Finishing Force [daN]*	*Number of passes n*	*With / without lubrication*	*Friction coefficient μ*
B.1	*77.5*	*1*	*No*	*0.1976*
B.2.	*248.2*	*1*	*No*	*0.2269*
B.3.	*248.2*	*2*	*No*	*0.2318*
B.4.	*248.2*	*3*	*No*	*0.2101*
B.5.	*328.5*	*1*	*Yes*	*0.2152*
B.6.	*328.5*	*2*	*Yes*	*0.2101*
Etalon				*0.19464*

Regardless the value of the force, the friction coefficient increases, which is not desirable. Can see, for low forces, the effect of increase is insignificant. Instead, when passing from a force of 77.5daN to 248.5daN the increase is accentuated. By comparing *B.2 and B.5.*can be noticed that, although the finishing force has risen due to the existence of lubricant during finishing, the friction coefficient will decrease.

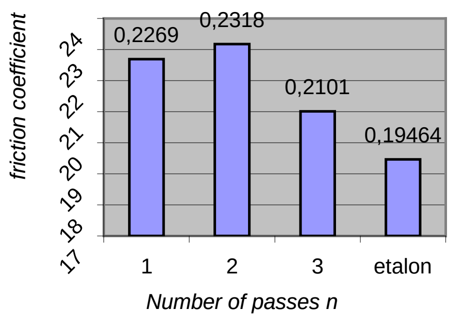


Fig.4 Variation of the friction coeficient with number of passes (CuPb5)

To evaluate the effect of number of passes $\mu_{(n)}$ tests *B.2, B.3, B.4,* were carried out. In this case the same force of 248.2daN had been applied, resulting in increasing the number of passes when lack of lubricant.

Comparing the value of μ corresponding to the etalon surface with the ones for the surfaces finished by cold plastic deformation technology, this will be the minimum as well. Again is confirmed that for this material the friction coefficient increases, therefore the technology is not advantageous.

According to the diagram from Figure 4, can be noticed a tendency of decrease of μ when the number of passes *n* increases. The value obtained for *n=3* is getting close to the etalon value. If analyze tests *B.5 and B.6,* we observe that for the same force and when finishing with lubricant the number of passes doesn't have any influence.

2.4. Partial conclusions

- For *CuPb5* alloy, finplast technology increases the value of friction coefficient with relatively low values. According to this criterion the method is not advantageous.
- According to table 3, for *CuPb5* alloy, the presence or the lack of lubricant, the increase of finishing force and of number of passes have small influence on the friction coefficient.
- Regardless the parameters of finplast technology used, the friction coefficient has an increase of its value.
- Also have to be evaluated other trybological aspects.

3. THE INFLUENTS OF FINPLAST TECHNOLOGY PARAMETERS, US FOR OBTAIN SMALL SUPERFICIAL COMPOSITE LAYER OF ANTIFRICTION ALLOYS, OVER MICROHARDNES.

It is known the fact that the hardness of the antifriction layer of the multilayer bush bearings is hard to be presented. Due to the fact that in both cases the antifriction alloy is on the same base manufactured from OL37, the errors are comparable for all the tests done.

For alloy A (AlSn10) we carried out the Vichers hardness (HV10). For the second alloy B (CuPb5) laid-down by warm sintering, considering it's proprieties we determined Brinell hardness (HB/2,5/31,5). Same as for determination of friction coefficient, in order to be able to evaluate the way the material influences the hardness of antifriction layer obtained by finplast technology proposed by the author, for both materials have been used same values of force as for the first material A.

Table4. The medium values of Vickers hardness for AlSn10 alloy

Test code AlSn10	*Finishing Force [daN]*	*Number of passes*	*With/without lubrication*	*Vichers hardness HV10*
A.1.	*248.2*	*1*	*no*	*44.8*
A.2.	*248.2*	*2*	*no*	*40.*
A.3.	*248.2*	*1*	*yes*	*39.1*
A.4.	*248.2*	*2*	*yes*	*38.5*
A.5.	*248.2*	*3*	*yes*	*38*
A.6.	*328.5*	*1*	*yes*	*37.8*
A.7.	*328.5*	*1*	*no*	*37.3*
A.8.	*456.2*	*1*	*yes*	*36.9*
A.9.	*143*	*5*	*no*	*35.4*
A.10.	*143*	*5*	*yes*	*35.6*
A.11.	*77.5*	*1*	*yes*	*35*
standard				*31.7*

3.1. STUDY OF THE INFLUENTS OF FINPLAST TECHNOLOGY PARAMETERS, US FOR OBTAIN SMALL SUPERFICIAL COMPOSITE LAYER OF ANTIFRICTION ALLOY AlSn10, OVER MICROHARDNES

The values of HV10 hardness experimentally obtained are shown in *Table 4*. To study the influence of finishing force when lubricant is present, tests *A.11, A.3, A.6,* and *A.8* have been done. In order to be easier to compare, in *Figure 5* are shown the trends of these determinations and the value of the etalon layer, obtained only by turnery.

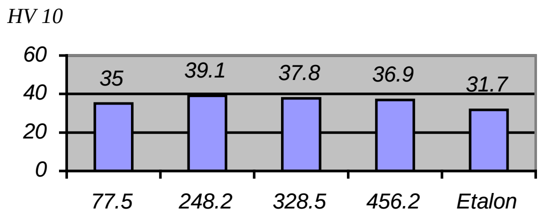


Fig.5. The variation of microhardness HV 10 of AlSn10 alloy depending of the increase of

According to the trends, can be noticed a significant increase of hardness compared with the value of etalon surface. Same as for friction coefficient, the optimum value of finishing force, is 328,5daN. For 456.2daN the micro hardness starts to decrease. To study the effect of number of passes of antifriction layer finished by finplast technology, in fig. 6 are shown together with the values of % of etalon surface, the values of tests *A.3, A.4,* and *A.5.*, obtained by applying the same force, with lubricant. From the trend is observed that when the number of passes increases, the micro hardness of antifriction layer decreases, although the differences are not high.

In addition, if we compare these values with the similar ones, *A.1* and *A.2* obtained without lubricating oil, we will observe that in both cases the presence of lubricating oil decreases the micro hardness of antifriction alloy layer. According to table 4, when finishing force increases, can be notified that, comparing tests *A.6* with *A7,* and *A.9* with *A.10,* the influence of lubricating oil is insignificant.

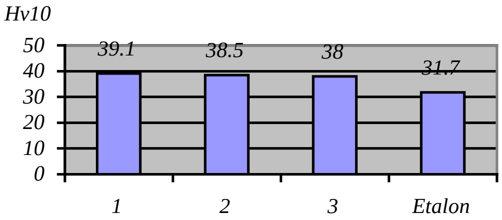


Fig.6. The variation of microhardness HV10 for AlSn10 alloy, depending of increase of

3.2. PARTIAL CONCLUSIONS:
For AlSn10 alloy, can be observed the following:

- The hardness of antifriction alloy layer shows an optimum value depending of the finishing force between maximum and minimum values used.
- The increase of number of passes *n* decreases the hardness of antifriction alloy layer
- The presence of lubrication during finishing by finplast technology decreases the hardness of layer.

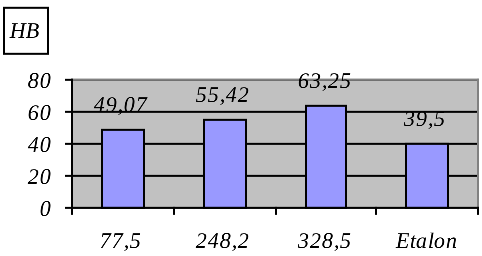
3.3. STUDY OF THE INFLUENTS OF FINPLAST TECHNOLOGY PARAMETERS, US FOR OBTAIN SMALL SUPERFICIAL COMPOSITE LAYER OF ANTIFRICTION ALLOY CuPb5, OVER MICROHARDNES

We will analyze the effect of finishing by finplast technology proposed by the author on the hardness of antifriction layer obtained from the second antifriction alloy CuPb5 (B), obtained using warm sintering.

Table5. The medium experimental values of brinell hardness for CuPb5 alloy

Test code CuPb5	*Finishing Force [daN]*	*Number of passes n*	*With/With out lubrication*	*Brinell Hardness HB 2.5/31.5*
B.1	*77,5*	*1*	*No*	*49,07*
B.2.	*248,2*	*1*	*No*	*55,42*
B.3.	*248,2*	*2*	*No*	*66,90*
B.4.	*248,2*	*3*	*No*	*67,07*
B.5.	*328,5*	*1*	*Yes*	*63,25*
B.6.	*328,5*	*2*	*Yes*	*71,15*
Etalon				*39,5*

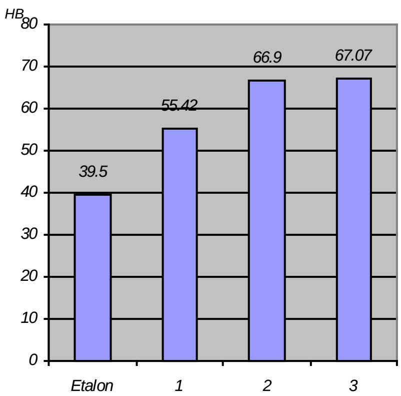
The experimental values of Brinell hardness (HB/2,5/31,5) are shown in Table 5. For a better evaluation of the effect of finishing by finplast technology on the hardness of antifriction layer, same as for the first alloy A, in the last row of Table 5 is shown for comparison the value of the hardness of etalon layer, obtained only by turnery. In order to evaluate the influence of increasing of finishing force *F*, tests *B.1, B.2, B.5* have been done. In all these situations only one pass was done (*n=1)*. In Figure 7 is shown the trend of hardness of antifriction layer compared with the value of etalon layer.



Finishing force F [daN]
Fig.7. Variation of microhardness HB 2,5/31.5 depending of the increase of force for CuPb5 alloy.

According to the graph, the hardness increases significantly compared with the etalon one and proportional with the increase of finishing force.

To study the effect of number of passes *n* have been shown in fig. 8 the values determined for tests *B.2, B.3, B.4,* together with the hardness of etalon test. The tests have been obtained without lubrication, applying the same finishing force. From the trend results that, the hardness significantly increases compared with the etalon one and proportional increases with the number of passes. Observation, the maximum value of the hardness obtained shows a significant increase of over 50%. Can be noticed, that, for test *B.6,* (n=2 passes, applied force of 328.5daN, with lubricant) the increase is over 70%.



number of passes n
Fig. 8 The variation of microhardness HBS 2.5/31.5, with the increase of number of

This result is more than good, due to the fact that from trybological point of view, a higher hardness allows a reduction of bearings size and a superior reliability.

3.4. PARTIAL CONCLUSIONS

For CuPb5 alloy subjected to finishing by finplast technology, we can conclude the following:

- Regardless the values of the finishing parameters, the hardness of antifriction layer increases. From the value point of view, the increases can exceed over 50% of the values of the hardness of etalon surface.
- Along with the increase of value of finishing force, the hardness shows a continuous increase;
- By increasing the number of passes, can be noticed significant increases of the hardness of the antifriction layer.

4. FINAL CONCLUSIONS

In virtue of the experimental results and also of the analyses shown so far, we can conclude the following general conclusions:

- The both two materials are acting quite different after finishing by finplast technology.
- For the A alloy, finishing by cold plastic deformation reduces the friction coefficient;
- For the B alloy, the friction coefficient rises, which is a negative effect;
- For the A alloy, the increase of number of passes is not advantageous neither for friction coefficient nor for the hardness of superficial layer;
- For the B alloy, the increase of number of passes results in insignificant effects on the friction coefficient, but produces significant high increases of the hardness of antifriction layer.;
- The presence of the lubricant during finishing of surfaces by finplast technology has a positive effect on the friction coefficient, reducing it's value, but also decreases the hardness of obtained layer;
- For B alloy, the presence of lubricant doesn't have significant effects either on the friction coefficient or on the hardness of antifriction layer.
- For each particular case of bearing is necessary a full investigation starting from the maximum values of stresses of the designed bearing.
- The possibility to use a new concept for designing the bearings, developed by the author under the name of structural pre-configuration.

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