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THE INFLUENTS OF ANTIFRICTIN ALLOYS OVER FRICTION COEFFICIENT AND MICROHARDNESS IN CASE OF SURFACES OBTAINED BY FINPLAST

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***Abstract**: This paper presents the effect of **finplast** technology over friction coefficient and hardness, by experimental determinations. FINPLAST it's the name of the new experimental finishing technology of antifriction surfaces of sledding bearings (propose by author for upgrading performance of the sliding bearings) by cold plastic deformations. Its studying antifriction alloys AlSn10 and CuPb5 (obtained using warm sintering). The most important of **finplast** parameters: cold plastic deformation force, the number of passes, the dry or with lubrication during cold plastic deformations.*
***Keyworks:** sliding bearings, technology, microhardness, friction coefficient.*

1. GENERALITIES

The author proposes for finishing the surfaces of antifriction layer the cold plastic deformation technology. For this new technology, the author proposed the name **finplast** [1]. The surfaces for experimental determinations are obtained using a wheel which acts with a controlled force over the plain surface with different parameters for study its effects. The most important parameters are *cold plastic deformation force F;*

- *the number of passes n;*
- *the existence or not existence of lubricating oil during cold plastic deformations*
- *antifriction alloys.*

For study, was accomplished on the plane surfaces a small experimental surface. For an easy identification this surfaces are marked with an identification code. The plane surfaces for first alloys, AlSn10, are obtained by convert by plastic deformations on plane surface from OL37. The identification code contains letter A and different numbers for every experimental surfaces. 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. First, all experimental surfaces were manufactured by frontal turnery with the same parameters, and after, obtain the small surfaces finished by FINPLAST technology, with different parameters and conditions, like in table 1. To obtain these small surfaces, the author designs a special device. Table 1 shows every surface, using cold plastic deformation parameters.

2. STUDY OF THE INFLUENCE OF FINPLAST TECHNOLOGY 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", Brasov, 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.

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 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. Analyzing the diagram can be observed 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 comparing the values of friction coefficient μ for the tests *A.1.* with A*.7.,* in the case of finishing without lubrication, the lower value corresponds to the same value of 328.5daN of the finishing force.

In order to study the effect of number of passes on the friction coefficient μ*.,* from Table 1 we select the values corresponding to tests *A.3; A.4;* and *A.5.* For these tests we kept the same *cold plastic deformation force* (248,5daN). In order to compare the results, these values were shown in *Figure 2*.

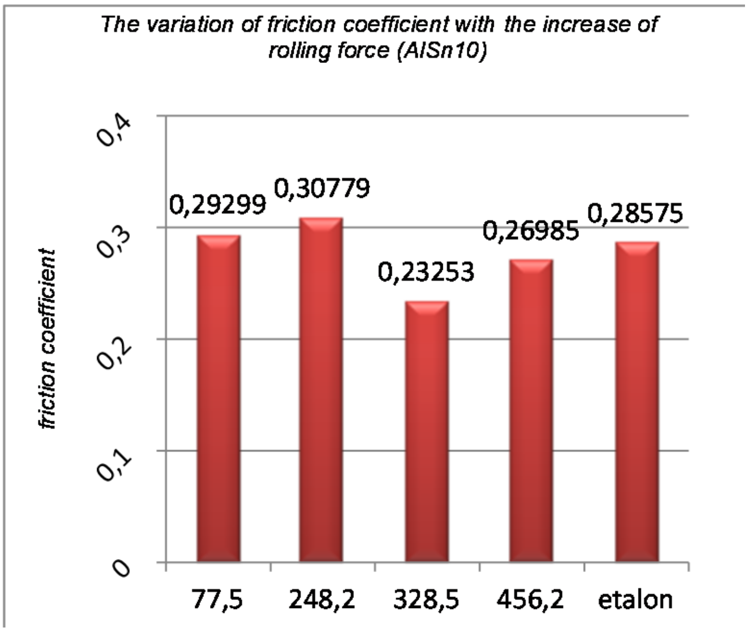
In *Figure 2,* can notice that the optimum value is obtained for *n=2* (*A.4*). Also, from the value point of view, Can be noticed that the influence of number of passes *n* is higher than the one corresponding to the increasing of the values of the *cold plastic deformation force.*

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.

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

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

Identification code	*Cold plastic deformation 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*



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 *cold plastic deformation force*. Modifying the *cold plastic deformation 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 *cold plastic deformation 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 *cold plastic deformation 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 *cold plastic deformation force* of 328.5 and the same number of passes *n=1, the* friction coefficient is significantly decreased by the presence of the lubricant.

If compare the tests *A.9.* and *A.10.*, for a higher number of passes *(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.

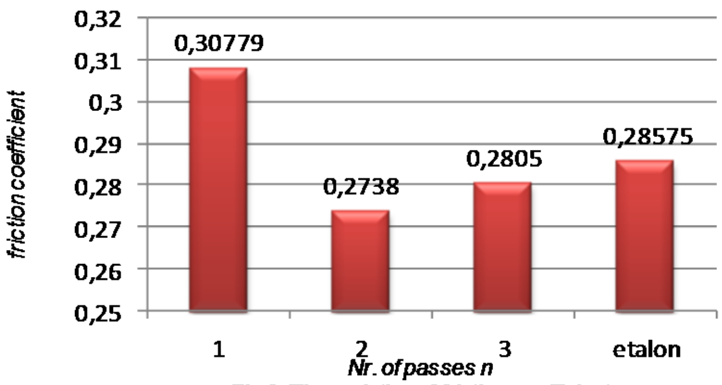


Fig.2. The variation of friction coefficient

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. CONCLUSIONS

- In order to decrease μ, for *AlSn10* alloy 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=328,5 and with lubrication).*
- The maximum value of the friction coefficient is obtained for test *A.9.* (*n=5, F=143 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 $\mu=\mu_{(F)}$. 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. Regardless the value of the force, the friction coefficient increases, which is not desirable. For low forces, to see, that the effect of increase is insignificant. Instead, when passing from a force of 77.5daN to 248.5daN the increase is accentuated.

Table 3 The experimental values of friction coefficient for alloy CuPb5

Identification 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

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.

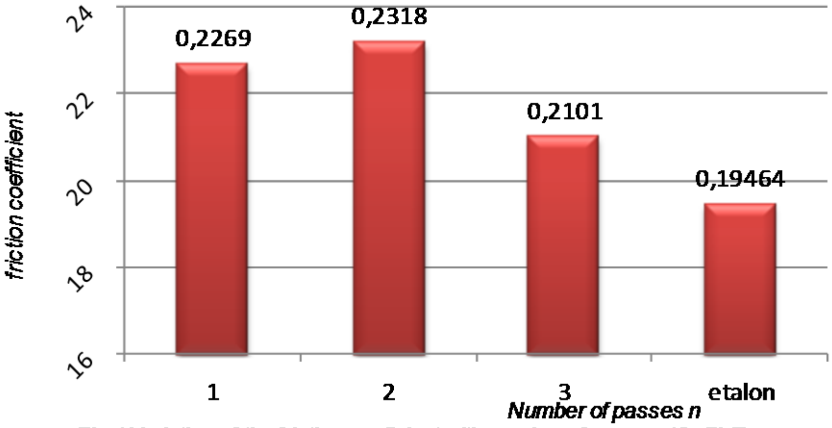


Fig.4 Variation of the friction coeficient with number of passes (CuPb5)

To evaluate the effect of number of passes $\mu=\mu_{(n)}$ 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 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. 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 OVER MICROHARDNESS OF ANTIFRICTION ALLOYS

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.

3.1. The study of the effect of finishing by finplast technology on the hardness of antifriction layer for AlSn10

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.

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 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 hardness of antifriction layer decreases, although the differences are not high. In addition, if we compare these values with the similar ones

Table 4. The medium values of Vichers hardness for AlSn10 alloy

Test code AlSn10	*Finishing Force [daN]*	*Numb er of passes*	*With/withou t 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*

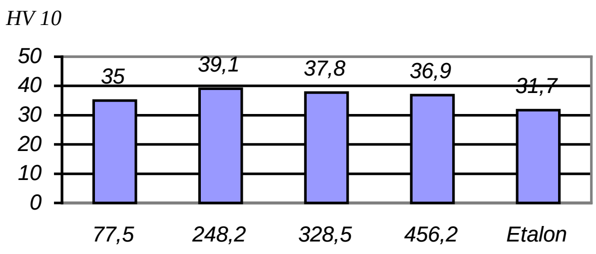


Fig.5. The variation of microhardness HV 10 of AlSn10 alloy depending of the increase of finishing force, with lubricant.

A.1 and *A.2* obtained without lubricating oil, we will observe that in both cases the presence of lubricating oil decreases the hardness of antifriction alloy layer. According to Table 4, comparing tests *A.6* with *A7,* and *A.9 with A.10,* when finishing force increases, the influence of lubricating oil is insignificant.

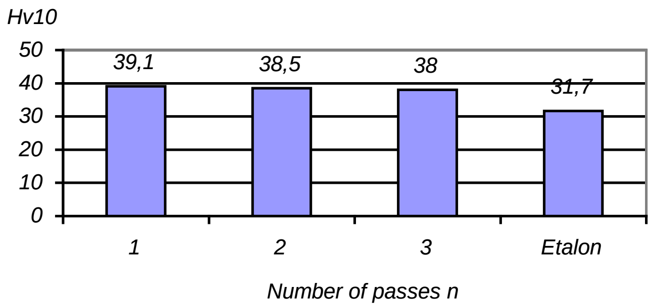


Fig.6. The variation of microhardness HV10 for AlSn10 alloy, depending of increase of number of passes n

3.2. 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. The study of the effect of finplast technology on the hardness of antifriction layer for CuPb5 alloy

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.

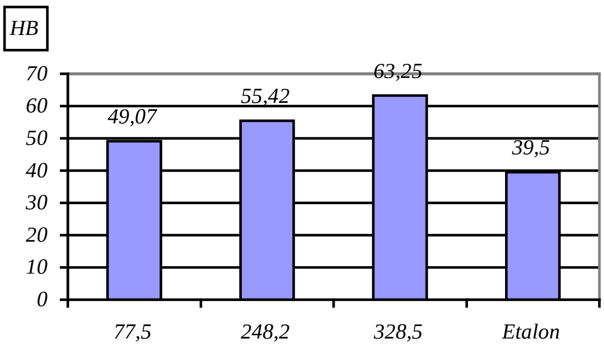
The experimental values of Brinell hardness (HB/2,5/31,5) are shown in Table 5.

Table 5. The medium experimental values of Brinell hardness for CuPb5 alloy

Test Code CuPb5	*Finishing Force [daN]*	*Number of passes*	*With/Without 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*

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.* to getter 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.

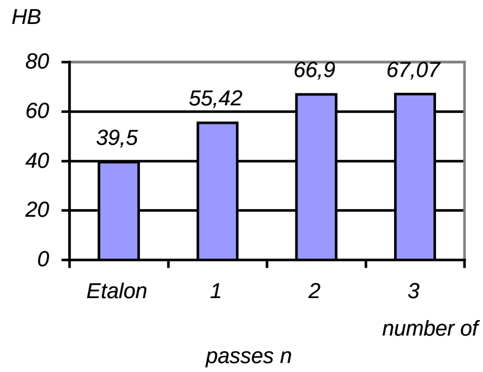


Fig. 8 The variation of microhardness HBS

An important observation, the value of the hardness obtained behind finplast, shows a significant increase beginning 24,5 %. For test *B.6.(*2 passes, applied force of 328.5daN, with lubricant), the increase is 80%. 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. 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 AlSn10 alloy, finishing by cold plastic deformation reduces the friction coefficient;
- For the CuPb5 alloy, the friction coefficient rises, which is a negative effect;
- For the AlSn10 alloy, the increase of number of passes is not advantageous neither for friction coefficient nor for the hardness of superficial layer;
- For the CuPb5 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 CuPb5 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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