Research on the Wearing Resistance of Quaternary Alloys Covered with Polyester

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The actual tendencies of the European market of metallic component parts for auto vehicles impose the utilization of materials that lead to the increase of the products reliability and their framing into the matrix cost-quality imposed by the big European producers [4, 9, 11, 14]. The covering of the quaternary alloys based on copper with polyester is inscribed among the technological procedures that aim at the improvement of the performances of the metallic parts of the auto vehicles with a view to reducing the percentage of out of operation and decreasing the maintenance and service expenses, having as final purpose the increase of the competitiveness on an European market being in a strong competition. The present work spotlights the positive influence of the covering of the quaternary alloys CuNiAlSi with polyester impregnated with 10% graphite on the main mechanical characteristics, especially of the wearing resistance that has a direct effect on the increase of the functioning time in the total life cycle of the product.

Keywords: polyester graphite quaternary alloys

The industry of parts for auto vehicles is confronted in the last decade with a pronounced increase of the diversity of the methods and technologies of depositing of thin layers [8, 13]. In general the role of these layers is to increase the resistance to corrosion and wearing of the metallic parts for auto vehicles as well as to reduce the friction [2,7,13]. This way, by covering the quaternary alloys CuNiAlSi with thin polyester layers impregnated with graphite it was intended to increase the functional performances and the durability of the metallic parts for auto vehicles (bushes, drums, pinions, girth gears). The polyester impregnated with graphite ensures not only the lubrication but also the increase of the resistance to oxidation. [3, 5]. The quaternary alloy CuNiAlSi treated by salt hardening + ageing possesses a high hardness, the polyester layer permitting a reduced friction and wearing simultaneous with the increase of the durability in service of the metallic parts for auto vehicles.

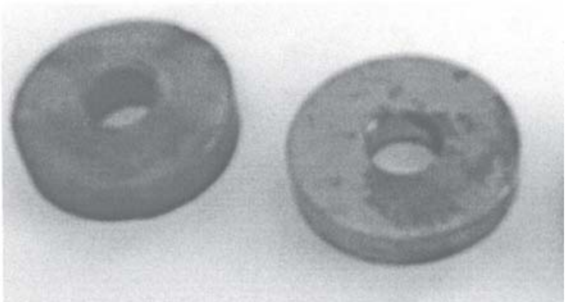

Fig. 1. Specimens type roller of quaternary alloy CuNiAlSi treated by salt hardening + ageing, used for the study of the behaviour to wearing

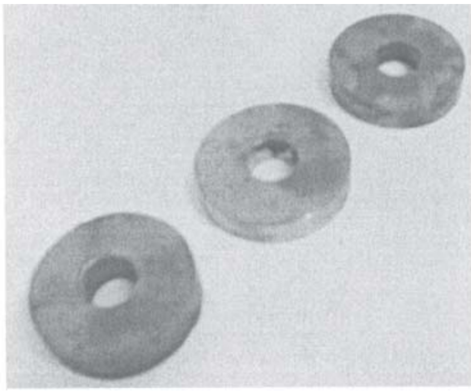

Fig. 2. Specimens type roller of quaternary alloy CuNiAlSi treated and covered with polyester impregnated with 10% graphite

Experimental part

The wearing tests have been performed on the Amsler tests stand of the mechanical tests laboratory on pairs type roller-roller having the diameter of 50,02 mm and a thickness of 10 mm. The rollers of quaternary alloys CuNiAlSi have been covered with polyester resin in which carbon graphite has been incorporated in a proportion of 10%. Before being covered, the surfaces have been polished and submitted to the operation of cleaning-degreasing avoiding the solutions based on silicates [10]. The reactions of polymerisation took place during the treatment of the covered surfaces. The main technological parameters of the polymerisation treatment are: $T_{heating}$ =200ºC, $t_{maintaining}$ =20 min. In the figures 1 and 2 the rollers submitted to the wearing test are shown.

The rollers of quaternary alloys CuNiAlSi covered with polyester impregnated with 10% graphite before the wearing test have been rectified, the average thickness of the polyester layer being 100 µm. In figure 3 the microstructure of the quaternary alloy covered with polyester is shown.

In table 1 are shown the characteristics, symbols and calculation relations used into the framework of the study of wearing resistance [1].

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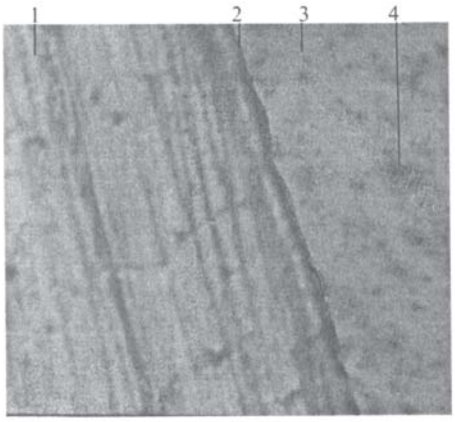

Fig. 3. Microstructure of the quaternary alloy CuNiAlSi covered with polyester (x100)
1 - base material - CuNiAlSi - s.s.α homogeneous; 2 - transition area (oxides are dissolved: concentrations of defects appear); 3 – deposited layer: polyester +10% graphite; 4 – graphite nests

Table 1
SIZES, SYMBOLS AND CALCULATION RELATIONS USED IN THE STUDY OF LINEAR WEARING

Characteristics	Symbol/ m.u.	Values- calculation relations
Rollers diameter	d_1, d_2/mm	d_1=50.02
Contact width	B/mm	B=10
Work revolutions number	n_1, n_2/r/min	n_2=200
Sliding	S/%	$S = \frac{n_2 \cdot d_2 - n_1 \cdot d_1}{n_1 \cdot d_1}$
Normal load on the rollers	Q/N	Q=60
Friction time	T/s	-
Friction length	Lf/mm	$L_f = \frac{\pi d1n1T}{60}$
Thickness of worn out layer	Gf/mm	-
Wearing intensity	Im	$Im = \frac{Gf}{Lf}$

The experimental tests had in view the study of the friction in linear contact pairs and on curved surface using the Amsler machine with specimens type roller, shown in figure 4 [1,6].

The revolution movement of the motor is transmitted by the cinematic chains of girth wheels. The normal load on the rollers, Q, is achieved by a mechanical system with screw and compression arc, varying into the limits 0-2000 N. The value of the load Q is read directly on the graduated scale attached to the compression arc. The diameters of the rollers vary within the limits 30-60 mm and their width is of 10 mm. The motor functions at 1450 r/min. The two specimens type roller rotate in an opposite sense, at their contact existing a pure rolling movement or a sliding rolling movement, depending on specimens diameters.The working number of revolutions for the two specimens is constant, about 200 r/min. At equal diameters of the rollers a sliding of approx. 10% is obtained. By modifying the diameters of the two rollers variable sliding between 0-30% can be obtained. In figure 5 the wearing scheme of specimens type roller is shown.

The nominal load on the contact surface is of 60 N. The wearing tests are of dry friction without relative sliding.

Study of wearing tests

In the tables 2 and 3 the results of the tests at dry wearing on rolling pairs of quaternary alloys CuNiAlSi are shown. The tests at dry wearing on rolling pairs achieved on the Amsler stand took 8 h . The time between two measurements has been of one hour.

The measurements made on the diameters before and after the test spotlight the depth of the worn out layer and the wearing intensity. The contact pressure creates

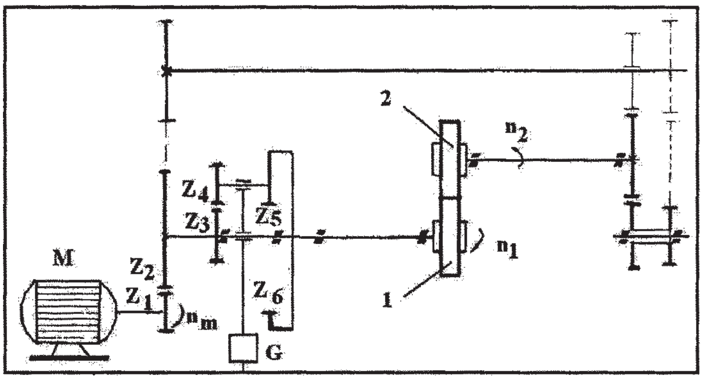

Fig. 4. Principle scheme of the Amsler machine
1- roller nr. l of CuNiAlSi covered with polyester; 2- roller nr. 2 of treated CuNiAlSi

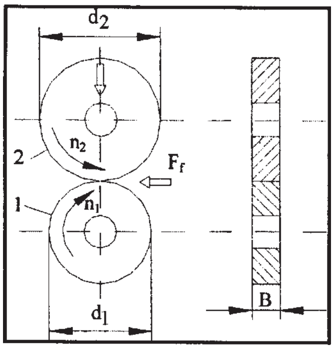

Fig. 5. Wearing scheme of the rollers

Table 2

TESTS AT DRY WEARING ON ROLLING PAIRS

ROLLER NR.1: ALLOY CuAlNiSi COVERED WITH POLYESTER; ROLLER NR.2: ALLOY CuAlNiSi TREATED BY SALT HARDENING + AGEING

Friction time (h)	d_1 (mm)	d_2 (mm)	S (%)	Q (N)	ΔT (s)	L_f (m)	G_f (mm)	Im ($x10^9$)	I_{mc} ($x10^{-9}$)
1	50	52.63	5.26	60	3600	1884.00	0.01	5.3078	5.3078
2	49.98	52.59	5.22	60	3600	1883.24	0.02	10.6199	15.9277
3	49.94	52.51	5.14	60	3600	1881.74	0.01	5.3142	21.2419
4	49.92	52.47	5.10	60	3600	1880.98	0.01	5.3163	26.5582
5	49.90	52.43	5.07	60	3600	1880.23	0.01	5.3184	31.8766
6	49.88	52.39	5.03	60	3600	1879.47	0.01	5.3206	37.1972
7	49.86	52.35	4.99	60	3600	1878.72	0.01	5.3227	42.5199
8	49.84	52.31	4.95	60	3600	1877.97	0.01	5.3248	47.8447

Table 3

TESTS AT DRY WEARING ON ROLLING PAIRS

ROLLER NR.1: ALLOY CuAlNiSi TREATED BY SALT HARDENING + AGEING; ROLLER NR.2: ALLOY CuAlNiSi TREATED BY SALT HARDENING + AGEING

Friction time (h)	d_1 (mm)	d_2 (mm)	S (%)	Q (N)	ΔT (s)	L_f (m)	G_f (mm)	Im ($x10^9$)	I_{mc} ($x10^{-9}$)
1	50	52.63	5.26	60	3600	1884.00	0.01	5.3078	5.3078
2	49.98	52.60	5.24	60	3600	1883.24	0.02	10.6199	15.9277
3	49.94	52.56	5.24	60	3600	1881.73	0.02	10.6285	26.5562
4	49.90	52.52	5.25	60	3600	1880.23	0.02	10.6369	37.1931
5	49.86	52.48	5.25	60	3600	1878.72	0.02	10.6455	47.8386
6	49.82	52.44	5.25	60	3600	1877.21	0.02	10.6541	58.4927
7	49.78	52.40	5.26	60	3600	1875.71	0.02	10.6626	69.1553
8	49.74	52.36	5.26	60	3600	1874.20	0.01	5.3356	74.4909

to the quaternary alloy an elastic deformation, the polyester layer following this deformation and not permitting the contact alloy-alloy. In order to point out the improvement of the wearing resistance by covering with polyester the quaternary alloys based on copper, tests on the following types of pairs roller-roller have been performed: quaternary alloy – quaternary alloy and quaternary alloy covered with polyester – quaternary alloy. By comparison the positive influence of the thin polyester layer has been remarked.

The results of the experiments are shown in the graphics of the figures 6 and 7, spotlighting the values of the actual wearing and cumulated wearing.

The experimental results make evident the fact that the samples of alloy CuNiAlSi covered with polyester impregnated with 10% graphite have a bigger wearing resistance comparing with the samples of treated alloys CuNiAlSi. Thus the wearing cumulated intensity registered after 8 h of tests on the Amsler apparatus in the case of the samples of alloys CuNiAlSi covered with polyester is of the order of 47.8447 . 10^{-9}, relative to 74.4909 . 10^{-9} in the case of the samples of CuNiAlSi alloy treated by salt hardening + ageing, that represents a reduction with approx. 40% of the cumulated wearing intensity. Impregnation of the graphite into the polyester as a dry powder due to the lamellar structure improves the lubrication. A percentage of 10% graphite grants a good lubrication and further a thermal barrier, insulating the quaternary alloy [15].

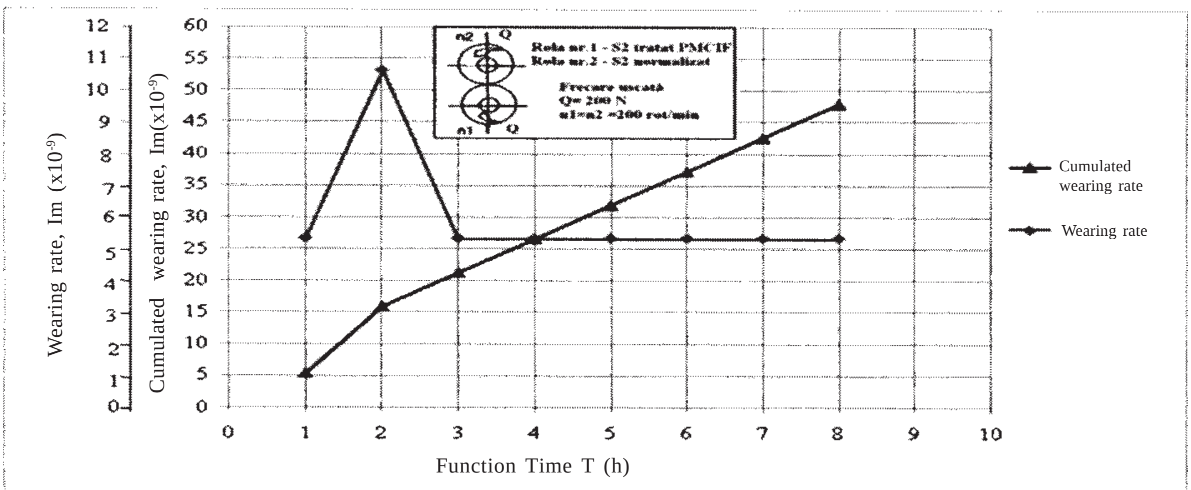

Fig. 6. Wearing rate and cumulated wearing rate for the roller nr.l (alloy CuNiAlSi covered with polyester). Dry friction without relative sliding

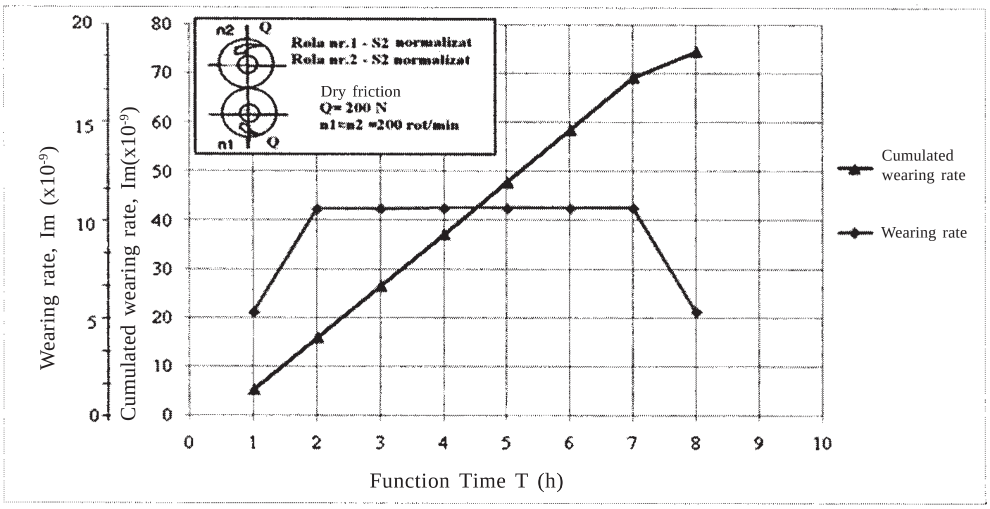

Fig. 7. Wearing rate and cumulated wearing rate for the roller nr.1 (alloy CuNiAlSi treated by salt hardening + ageing). Dry friction without relative sliding

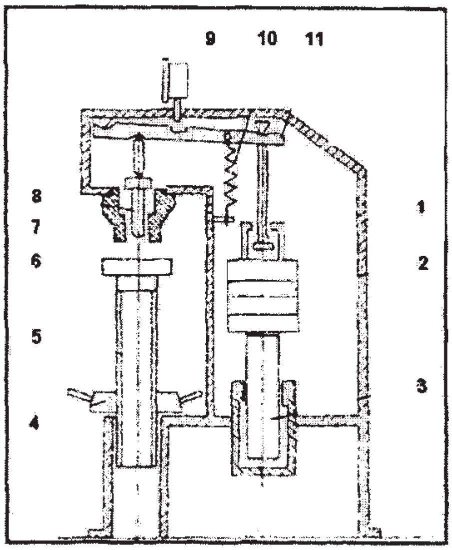

Fig. 8. Scheme of the modified and adapted apparatus for the measurement of the fragility. 1 – external frame; 2 - weights; 3 – hydraulic damper; 4 – hand wheel; 5 – threaded rod; 6 – table for samples; 7 – guiding elements; 8 –penetration element; 9 –comparing clock;10 - arc for ensuring the penetrating load; 11 –loading lever

Researches regarding the measurement of the fragility of superficial layers

Researches have been performed regarding the fragility of the deposited superficial layers of polyester using the method and the modified and adapted apparatus shown in figure 8, with increasing pressing forces F = 14.8 – 28.2 - 44.7 – 67.9 - 98.5 daN.

On the plane rollers surface of Ø 50 . 10 mm covered with polyester a pressure has been exercised with the pyramidal diamond pointed end, for imprinting. The trapezoidal marks left on the samples surface have been studied with the optical microscope at the amplifying power of 500:1 and 1000:1. At pressing forces of 14.8 daN and 28.2 daN visually there are not cracks or ruptures on none of the samples. On the alloys CuNiAlSi covered with polyester, at pressing forces of 44.7 daN cracks or ruptures do not appear visually on the outline of the imprinted marks. In exchange, at the same pressing force of 44.7 daN and at magnifying forces of 1000:1 a fine net of cracks is remarked, of which some start from the outline of the mark of the diamond penetrating element, as per the figure 9.

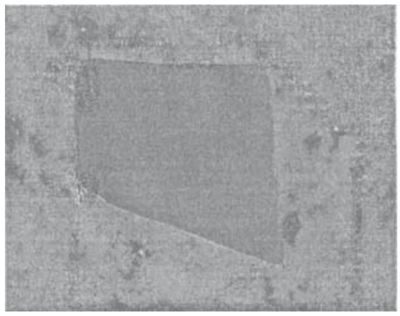

Fig. 9. Fine net of cracks on the ends of the trapezoidal penetrating element, alloy CuNiAlSi covered with polyester impregnated with 10% graphite

Following the researches regarding the fragility of the layers deposited on the quaternary alloy it can be confirmed that the polymerizing treatment grants to the superficial layers a good adherence and a negligible fragility, as the fine net of cracks appears at pressing forces bigger than 28.2 daN that represents a high value for the quaternary alloys based on copper [16].

Conclusions

The layer of polyester deposited by polymerisation treatment has a positive influence on the quaternary alloys CuNiAlSi as it leads to the reduction of the cumulated wearing with approx. 40%. The polyester impregnated with graphite takes over a part of the elastic deformations that appear during the service of the parts for auto vehicles made of quaternary alloys, contributing directly to the improvement of the wearing resistance, reduction of the friction by ensuring an adequate lubrication, the increase of corrosion resistance and of the oxidation resistance.

The deposited layer of polyester ensures a good adherence and a negligible fragility taking over a part of the stresses generated by the impact and contact forces that appear during the service of the metallic gears and parts.

The effects of the covering of the parts for auto vehicles of quaternary alloys with layers of polyester are felt in economical field by: reduction with 5% the average percentage of scraps, respectively with 400 ppm., and the decrease with 10%of the premature out of operation [1].

From an ecological point of view, the covering of the quaternary alloys with polyester does not create special problems regarding the exceeding of the limit value of emission of volatile organic compounds in the working atmosphere, framing into the requirements imposed by the Environmental European Directives.

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Manuscript received: 19.11.2008