Research on the Use of Plastics in order to Increase the Life of the Product

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The research highlights the main trends and guidance in the design of products using plastics in conditions of sustainable development of society. Plastics have an important role in the configuration of the new products still in the phase of conception. Having in view the main advantages of the utilization of plastics the expectation is to see an increase of the weighting of these ones in the products development. The present work spotlights the positive influence of the covering of the alloys with polyester. Especially it aims to increase the wearing resistance and resistance to fragility that has a direct effect on the increase of the functioning time in the total life cycle of the product.

Keywords: polyester graphite, wear resistance

The purpose of the improvement of the products development is to concentrate the human imagination such that the result of the designing processes represents a connections system acceptable from the point of view of utilization and efficiency [8].

On a global scale, the accent is put on the digital development in order to shorten the project loops and attentive forming of the subordinated organizational culture and structure.

Coverage of the alloys based on copper with thin polyester layers impregnated with graphite aims to increase the functional performances and the durability of the metallic parts for auto vehicles. The polyester impregnated with graphite ensures not only the lubrication but also the increase of the resistance to oxidation [1, 5]. The alloys based on copper treated by salt hardening + ageing possesses a high hardness, the polyester layer permitting a reduced friction and wearing concomitantly with the increase of the durability in service.

Trends in the use of plastics in order to improve product characteristics

Light constructions are a distinct purpose for the achievement of the innovative products in all industrial fields. Decrease of the vehicles weight and aerodynamic and power improvement represented a permanent target for the vehicles manufacturers. The upward trend of using plastics is supported by the following:

-thermoplastics reinforced with glass fibers permit the replacement of the metals and is used in the places strongly stressed. They are used to manufacture vehicles bodies, having the possibility to provide a geometric perfection, homogeneity, big rigidity, low thermal dilatation and different coloring. Weight savings can reach 60% and the price reduction, 30% [2,3];

-composite materials based on plastics are less energy-intensive than the steel, aluminum and copper;

-resistance practically unlimited to the action of the processes determined by the atmosphere and environment agents (oxidation, corrosion, micro-organisms) [6];

-high capacity of vibrations amortization, the vibrations, three times bigger than that of the aluminum;

-low dilatation coefficient in comparison with metals;

-chemical stability at high temperatures;

-high endurance in service [7].

An important trend is the increase uptime by using plastic parts. They contribute to the amelioration of vibration, dispersion and ease tensions. The covering of the alloys based on copper (minimum 90% Cu, 4-5% Ni, 2-3% Al, 0.5-1.5% Si) 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 putting out of function and decreasing of maintenance and service expenses, having as final purpose the increase of the competitiveness [4].

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 initial diameter d_1 = 50.02 mm and a thickness B=10 mm. Before being covered, the surfaces have been polished and submitted to the operation of cleaning-degreasing. The rollers of copper alloy have been covered with polyester resin in which carbon graphite has been incorporated in a proportion of 10%. The reactions of polymerization took place during the treatment of the covered surfaces: $T_{heating}$ =200°C, $t_{maintaining}$ =20 min.

The rollers of copper alloy covered with polyester impregnated with 10% graphite before the wearing test have been rectified, the average thickness of the polyester layer being 100μm.

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. 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. At equal diameters of the rollers a sliding of

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Table 1
TESTS AT DRY WEARING ON ROLLING PAIRS

Types of couplers roller -roller			*Roller nr.1: copper alloy covered with polyester*							
			Roller nr.2: copper alloy treated by salt hardening + ageing							
Friction time (h)	d_1 (mm)	d_2 (mm)	S (%)	Q (N)	ΔT (s)	L_f ($x10^6$) (mm)	G_f (mm)	Im ($x10^{-9}$)	I_{mc} ($x10^{-9}$)	Um (%)	Umc (%)
0	50.02	52.64	-	-	-	-	-	-	-	-	-
1	50	52.63	5.26	60	3600	1.8840	0.01	5.3078	5.3078	0.04	0.04
2	49.96	52.59	5.26	60	3600	1.8824	0.02	10.6247	15.9325	0.08	0.12
3	49.94	52.51	5.14	60	3600	1.8817	0.01	5.3142	21.2467	0.04	0.16
4	49.92	52.47	5.10	60	3600	1.8809	0.01	5.3163	26.5630	0.04	0.20
5	49.90	52.43	5.07	60	3600	1.8802	0.01	5.3184	31.8814	0.04	0.24
6	49.88	52.39	5.03	60	3600	1.8794	0.01	5.3206	37.2020	0.04	0.28
7	49.86	52.35	4.99	60	3600	1.8787	0.01	5.3227	42.5247	0.04	0.32
8	49.84	52.31	4.95	60	3600	1.8779	0.01	5.3248	47.8495	0.04	0.36
Types of couplers roller -roller			*Roller nr.1: copper alloy treated by salt hardening + ageing*								
			Roller nr.2: copper alloy treated by salt hardening + ageing								
Friction time (h)	d_1 (mm)	d_2 (mm)	S (%)	Q (N)	ΔT (s)	L_f ($x10^6$) (mm)	G_f (mm)	Im ($x10^{-9}$)	I_{mc} ($x10^{-9}$)	Um (%)	Umc (%)
0	50.02	52.64	-	-	-	-	-	-	-	-	-
1	50	52.63	5.26	60	3600	1.8840	0.01	5.3078	5.3078	0.04	0.04
2	49.96	52.60	5.28	60	3600	1.8824	0.02	10.6247	15.9325	0.08	0.12
3	49.94	52.56	5.24	60	3600	1.8817	0.02	10.6285	26.5550	0.08	0.20
4	49.90	52.52	5.25	60	3600	1.8802	0.02	10.6369	37.1919	0.08	0.28
5	49.86	52.48	5.25	60	3600	1.8787	0.02	10.6455	47.8374	0.08	0.36
6	49.82	52.44	5.25	60	3600	1.8772	0.02	10.6541	58.4915	0.08	0.44
7	49.78	52.40	5.26	60	3600	1.8757	0.02	10.6626	69.1541	0.08	0.52
8	49.74	52.36	5.26	60	3600	1.8742	0.01	5.3356	74.4897	0.04	0.56

d_1 = roller diameter 1; d_2 = roller diameter 2;
B= 10 mm – width of contact between rollers;
n_1 = 200 rev./min - speed of rotation of the roller 1; n_2 = 200 rev./min - speed of rotation of the roller 2;
$S = \frac{n_2 \cdot d_2 - n_1 \cdot d_1}{n_1 \cdot d_1} \cdot 100$ - sliding; Q = 60 N – normal load on the rollers;
T – friction time; ΔT = 3600 s – time between two measurements;
$L_f = \frac{\pi d_1 n_1 \Delta T}{60}$ - friction length;
$G_f = \frac{d_{1,i} - d_{1,i+1}}{2}$ – thickness of worn out layer;
$Im = \frac{Gf}{Lf}$ – wearing intensity;
$I_{mc} = \sum_1^n I_m$ - wearing intensity cumulative.
$U_m = \frac{2G_{f,i}}{d_{1,i}} \cdot 100$ – current wear;
$U_{mc} = \sum_1^n U_m$ – current cumulative wear.

approx. 10% is obtained. In order to point out the improvement of the wearing resistance by covering with polyester the alloys based on copper, tests on the following types of pairs roller-roller have been performed: alloy –alloy and alloy covered with polyester –alloy.

In the table 1 the results of the tests at dry wearing on rolling pairs of experimental alloys are shown.

The results of the experiments are shown in the graphics of the figure 1, spotlighting the intensity values of the actual wearing and cumulated wearing.

The percentage values of the actual wear and the cumulated actual wear after the trial 8 h of dry friction without gliding are presented in figure 2.

The presence of the polyester layer is contributing to the diminishing of the actual wear cumulated with 35.72% as to the wear of the treated rolls. The polyester layer impregnated with 10% graphite is decreasing the wear value through its cumulated effects: lubrication agent; insulating thermal barrier; attenuation layer and even distribution of the loads; dissipation environment and reciprocal extinction of the tensions.

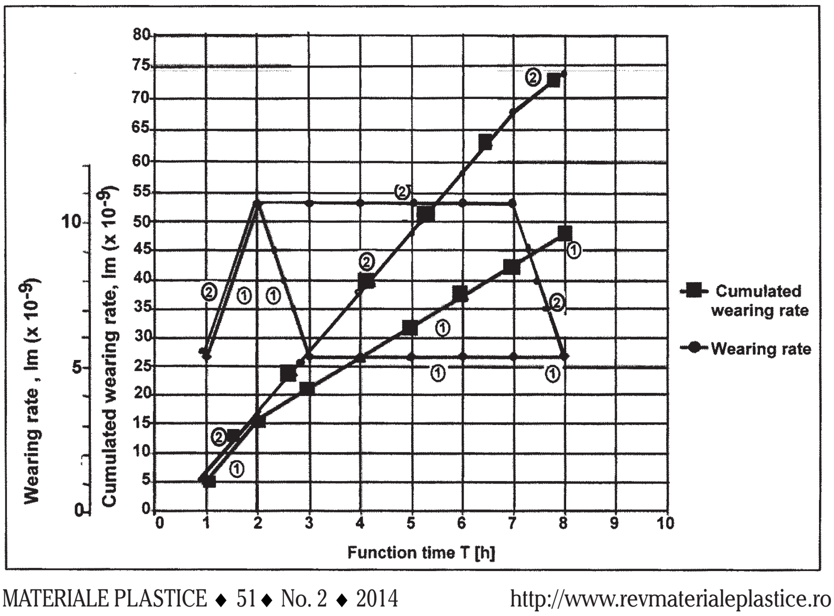


Fig. 1. Wearing intensity and cumulated wearing intensity (dry friction without relative sliding) 1 - roller nr. 1 (copper alloy covered with polyester). 2 - roller nr. 1 (cooper alloy treated by salt hardening + ageing)

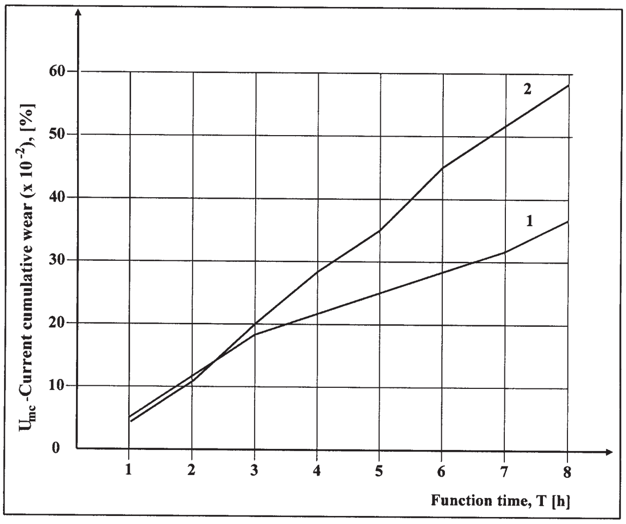


Fig. 2. Percentage values of the actual wear and the cumulated actual wear 1 - roller no. l (copper alloy covered with polyester). 2 - roller no. l (cooper alloy treated by salt hardening + ageing)

Results and discussions

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

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 to the alloy an elastic deformation, the polyester layer following this deformation and not permitting the contact alloy-alloy. By comparison the positive influence of the thin polyester layer has been remarked.

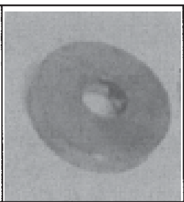
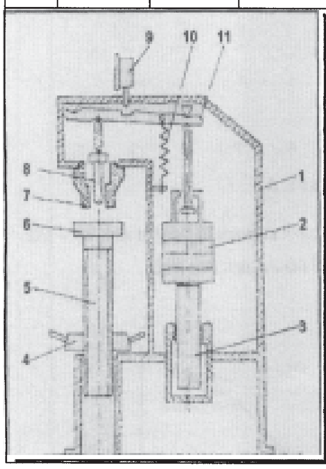
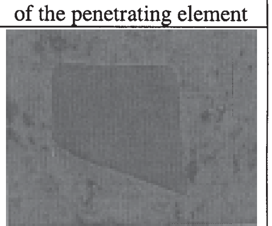
The experimental results make evident the fact that the samples of alloy based on copper covered with polyester impregnated with 10% graphite have a bigger wearing resistance comparing with the samples of treated alloys. Thus the wearing cumulated intensity registered after 8 h of tests on the Amsler apparatus in the case of the samples of alloys covered with polyester is 35% lower than the samples of alloy treated by salt hardening + ageing. 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 alloy.

Practically the polyester layer is contributing to the decrease of the cumulated actual wear from 0.56% to 0.36%. After an 8 h trial period the polyester layer is contributing to the diminishing with 35.72% of the actual cumulated wear of the rolls.

Fragility analysis layers

After the wear tests, there were performed different researches regarding the fragility. The plane surfaces of the rolls covered in polyester were tested to increasing pressing forces by means of a penetrator with a diamante pyramid cap (the penetrator is an integrated part of the equipment for the determination of fragility). The trapezoidal marks at the surface of the assays were studied at the optical microscope with enhancement 1000:1. The results of the researches upon fragility are presented in table 2.

Table 2
STUDY FRAGILITY LAYERS

Nr. crt.			***Roller nr. 1: copper alloy covered with polyester***		
0	T (s)	g_i (µm)	g_f (µm)	F_f (daN)	Analysis
1	28800	100	10	14,8	Cracks or ruptures don't appear visually on the outline of the imprinted marks
2	28800	100	10	28,2	Cracks or ruptures don't appear visually on the outline of the imprinted marks
3	28800	100	10	44,7	Cracks don't appear, of which start from the outline of the mark
4	28800	100	10	67,9	A fine net of cracks is remarked, of which some start from the outline of the mark of the penetrating element
				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	 Fine net of cracks on the ends of the trapezoidal penetrating element; copper alloy covered with polyester impregnated with 10% graphite; F_f = 67,9 daN; (1000:1)

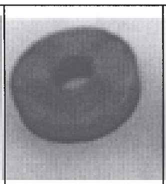
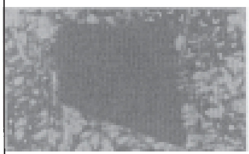
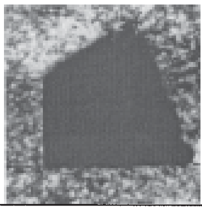
Nr. crt.			*Roller nr. 1: copper alloy treated by salt hardening + ageing*		
0	T (s)	g_i (μm)	g_f (μm)	F_f (daN)	Analysis
1	28800	0	0	14,8	Cracks or ruptures don't appear visually on the outline of the imprinted marks
2	28800	0	0	28,2	Cracks or ruptures don't appear visually on the outline of the imprinted marks
3	28800	0	0	44,7	Cracks is remarked, of which some start from the outline of the mark of the penetrating element
4	28800	0	0	67,9	Net of cracks is remarked, of which some start from the outline of the mark of the penetrating element
 Cracks on the ends of the trapezoidal penetrating element; copper alloy treated by salt hardening + ageing; F_f = 44,7 daN; (1000:1)					 Fine net of cracks on the ends of the trapezoidal penetrating element; copper alloy treated by salt hardening + ageing; F_f = 67,9 daN; (1000:1)

Table 2
STUDY FRAGILITY LAYERS

T – friction time (length of time to tests at dry wearing on rolling pairs);
g_i – the initial average thickness of the polyester layer impregnated with graphite 10%;
g_f - final average thickness of the layer of polyester (after trying to wear dry);
F_f – pressing force trying fragility.

Due to its cumulative effects, the polyester layer has a special influence also upon the resistance to fragility:

-a good adherence of the surfaces will lead to an insignificant fragility;

-in the case of polyester covered rolls, the crack network is visible at values of 1000:1, and pressing forces of 67,9 daN (this is a very high value for the copper alloys);

-in the case of treated rolls the cracks are noticed starting from the contour of the track from the pressing force of 44,7 daN.

The cumulated effects of the polyester layer upon the rolls are contributing to the decrease of the pressing force which determines the appearance of fragility, with 34.17%. We can notice the following correlation: the percentage with which the wear is reduced is almost equal with the percentage of enriched resistance to fragility. The effect of the polyester layer is beneficial and it represents a method with good chances to be promoted on industrial scale.

Conclusions

As a result of experimental research have emerged following:

-any improvement of the development of the product will be most salutary if a better exploitation and solving of the changes of the systems in the initial project definition stages are permitted, having in view the fact that the time and the cost of correction or of elimination of the defects increase exponentially with each step of the cycle of product development;

-the layer of polyester deposited by polymerization treatment has a positive influence on the copper alloys as it leads to the reduction of wear with 35.72% and to an the increase in resistance to fragility with 34.17%;

-it was noticed that the percentage with which the wear is reduced is almost equal with the percentage of enriched resistance to fragility;

-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 copper alloys, contributing directly to the improvement of the wearing resistance and reduction of the friction by ensuring an adequate lubrication;

-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 auto gears and parts.

The polyester layer is improving the wear resistance and the resistance to fragility due to the cumulated effect of this layer: as lubrication agent; insulating thermal barrier; attenuation layer and even distribution of the loads. The qualitative effect induced by the use of the polyester layer is imposing the control of the method in the case of industrial scale production.

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Manuscript received: 18.03.2014