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EXPERIMENTAL TESTS PERFORMED USING THREE BALLS TRIBOMETER FOR POLYMER-METAL CONTACTS

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Abstract: *In this paper are presented in terms of experimental tests, the determination of friction coefficient, using three balls tribometer, for polymer-metal contacts, at tribology macro scale, under dry friction.*
Key words: *friction coefficient, tribometer, dry friction, polymer*

1. INTRODUCTION

Productivity and reliability of manufacturing processes are largely determined by the friction that occurs in the contact area of the friction couplings, and the intensity of wear of the tribo components.

Knowledge of the friction couplings materials in contact, the methods of treatment and special surface treatment and mechanical properties of materials helps to decrease friction, reduce energy consumption and costs from reduced maintenance and replacement of worn parts constituting equipment used in industrial production.

The aim of this study is to determine the friction coefficient using three balls tribometer, for polymer-metal contacts, for six different material couplings: high density polyethylene (HDPE)/OLC45, polypropylene /OLC45, polystyrene /OLC45, polytetrafluoro-ethylene (PTFE)/OLC45, torlon/OLC45 and nylon/OLC45.

2. USED EQUIPMENT

For the experimental tests, was used the three balls tribometer [1], [4], existent equipment Group of disciplines Machine Elements and Tribology, Department of Mechanical Engineering Systems.

3. MATERIALS

A polymer is a substance composed of molecules with high molecular weight consisting of a large number of identical small molecules, called monomers, connected by covalent bonds. The word comes from the Greek, πολυ, polu, "more", and μέρος, meros, "part" [7].

For experimental measurements performed were used six types of polymers: high density polyethylene (HDPE), polypropylene, polystyrene, polytetrafluoroethylene (PTFE), torlon and nylon.

High Density Polyethylene (HDPE) arises through polymerization of ethylene. It is characterized by a density greater or equal to 0.941 g/cm3. Has a low degree of branching, strong intermolecular forces and good tensile strength. Properties: Flexible, transparent/wax, weatherproof, good low temperature resistance (-60 ° C), easily processed by several methods, low cost and good chemical resistance.

Polypropylene (PP) is a thermoplastic polymer, known as the polipropan and is one of the most versatile existing polymers. Is

semi-rigid, transparent, good chemical resistance, tough, good resistance to fatigue and heat.

Polystyrene is an aromatic polymer made from the monomer styrene, a liquid hydrocarbon, made from petroleum in the chemical industry. May be thermoplastic or heat resistant. The thermoplastic polystyrene is solid (glassy) at room temperature, if heat flows over the transition temperature above 100 ° C, but it returns to solid on cooling. Pure material is a hard plastic, transparent, with limited flexibility and can be used to create shapes with fine detail.

Polytetrafluoroethylene (PTFE) is an artificial polymer, thermoplastic white, solid at room temperature, composed of carbon and fluorine. It is also known as Teflon. It has high molecular weight, low friction coefficient, thermo plasticity, good dielectric properties, high electronegativity and low chemical reactivity. PTFE is hydrophobic, and due to high electronegativity of fluorine atoms, will not adhere and will not absorb/adsorb on surface water, alcohols, and other compounds containing oxygen or hydroxyl oxygen. It is a good insulator and the liaison structures are very stable.

Nylon is a generic name for a family of synthetic polymers known generically as polyamides. It is a thermoplastic silky, used in various areas: textiles, sports and leisure applications, the development of personal care, products of the engineering domanin: the manufacture of bolts and nuts, gears, cables, electrical connectors, liquid tanks, gas tanks, devices, cam bearings. It is very elastic and easy to maintain, has a good resistance to abrasion, high elongation, does not burn, melt, and has good strength, is durable, flexible and low friction coefficient. It is used for the manufacture of the seat belts and tire cords.

Torlon is a high-strength plastic among the most expensive on the market. The torlon can be injected into the mold, mold pressed and extruded. Can be used to the maximum allowable temperature, so it is an ideal material for severe environments. It is used in various applications such as pump parts, seats of valves, bearings, rollers, bushings for high temperature molding and extrusion. Can be used to the maximum allowable temperature, so it is an ideal material for severe environments. It is used in various applications such as pump parts, seats of valves, bearings, rollers, high temperature insulators, electronic equipment, compressors parts and bearing cages.

4. RESULTS

The determinations of the friction coefficient were made by load (12,8N , 16N, 18,2N and 19,65N), with three different sliding speeds: 1,555 m/s, 1,900 m/s and 2,246 m/s.

Using the mathematic formula from the paper [4], were obtained the friction forces and the friction coefficients reproduced in the table 1, for material couplings high density polyethylene (HDPE)/OLC45 and polystyrene/OLC45.

Table 1

Resulted friction forces and friction coefficients

Nr. crt.	Div. nr.	F_n [N]	v [m/s]	F_f [N]	μ_i
Friction coupling 1: High density polyethylene (HDPE)/OLC45					
1	6.25	12,8	1,555	9,222	0,720
2	8	16	1,555	11,804	0,737
3	9,5	18,2	1,555	14,017	0,770
4	10,5	19,65	1,555	15,493	0,780
5	7,5	12,8	1,900	9,05	0,707
6	9,75	16	1,900	11,770	0,735
7	11,5	18,2	1,900	13,883	0,762
8	13,25	19,65	1,900	15,996	0,805
9	9,5	12,8	2,246	9,704	0,758
10	12	16	2,246	12,258	0,766
11	14,25	18,2	2,246	14,556	0,799
12	16,5	19,65	2,246	16,855	0,849
Friction coupling 2: Polystyrene/OLC45					
13	6	12,8	1,555	8,853	0,691
14	7,75	16	1,555	11,435	0,714
15	9	18,2	1,555	13,28	0,729
16	10,5	19,65	1,555	15,493	0,780
17	7,5	12,8	1,900	9,054	0,707
18	9,75	16	1,900	11,770	0,735
19	11,5	18,2	1,900	13,883	0,762
20	13,25	19,65	1,900	15,963	0,804
21	9,5	12,8	2,246	9,704	0,758
22	12,25	16	2,246	12,523	0,782
23	14,25	18,2	2,246	14,556	0,799
24	16,5	19,65	2,246	16,855	0,849

For the friction coupling high density polyethylene (HDPE)/OLC45, the friction

coefficient values varied in the range 0,720-0,849 with a medium value of 0,765667.

For the friction coupling polystyrene/ OLC45, the friction coefficient values varied in the range 0,691-0,849, with a medium value of 0,759167.

Table 2

Resulted friction forces and friction coefficients

Nr. crt.	Div. nr.	F_n [N]	v [m/s]	F_f [N]	μ_i
Friction coupling 3: Polypropylene (PP)/OLC45					
25	4,5	12,8	1,555	6,64	0,518
26	6	16	1,555	8,853	0,553
27	7,5	18,2	1,555	11,066	0,608
28	8,5	19,65	1,555	12,542	0,631
29	6,5	12,8	1,900	7,847	0,613
30	8,5	16	1,900	10,261	0,641
31	9,75	18,2	1,900	11,770	0,646
32	11,5	19,65	1,900	13,883	0,699
33	8,25	12,8	2,246	8,427	0,658
34	10,5	16	2,246	10,726	0,670
35	12,25	18,2	2,246	12,513	0,687
36	14,5	19,65	2,246	14,8	0,745
Friction coupling 4: Polytetrafluoroethylene (PTFE) /OLC45					
37	5	12,8	1,555	7,377	0,576
38	6,5	16	1,555	9,591	0,599
39	7,5	18,2	1,555	11,066	0,608
40	8,25	19,65	1,555	12,173	0,613
41	6,25	12,8	1,900	7,545	0,589
42	8	16	1,900	9,658	0,603
43	9,5	18,2	1,900	11,469	0,630
44	10,5	19,65	1,900	12,676	0,638
45	7,5	12,8	2,246	7,661	0,598
46	9,75	16	2,246	9,96	0,622
47	11	18,2	2,246	11,798	0,648
48	13,25	19,65	2,246	13,535	0,681
Friction coupling 5: Torlon/ OLC45					
49	7,5	12,8	1,555	11,066	0,864
50	9,5	16	1,555	14,017	0,876
51	11,5	18,2	1,555	16,968	0,932
52	13	19,65	1,555	19,182	0,966
53	9	12,8	1,900	10,865	0,848
54	11,75	16	1,900	14,185	0,886
55	13,25	18,2	1,900	15,996	0,878
56	14,25	19,65	1,900	17,203	0,866
57	11,75	12,8	2,246	12,003	0,937
58	15	16	2,246	15,323	0,957
59	17	18,2	2,246	17,115	0,940
60	18,75	19,65	2,246	19,153	0,964
Friction coupling 6: Nylon/OLC45					
61	7,75	12,8	1,555	11,435	0,893
62	9,75	16	1,555	14,386	0,899
63	10,75	18,2	1,555	15,862	0,871
64	12	19,65	1,555	17,706	0,892
65	10	12,8	1,900	12,072	0,943
66	12,25	16	1,900	15,006	0,937
67	14,25	18,2	1,900	17,203	0,945
68	15,5	19,65	1,900	18,712	0,942
69	10,75	12,8	2,246	10,981	0,857
70	13,25	16	2,246	13,535	0,845
71	15,75	18,2	2,246	16,089	0,884
72	17	19,65	2,246	15,892	0,808

Table 2 reproduce the friction coefficient values for the friction couplings: polypropylene/OLC45,polytetrafluoroethylene (PTFE)/OLC45, torlon/OLC45 and nylon/ OLC45, using the loads and sliding speeds mentioned before.

For the friction coupling polypropylene (PP)/OLC45, the friction coefficient values varied in the range 0,518-0,745 with a medium value of 0,639083.

For the friction coupling polytetrafluoro-ethylene (PTFE)/OLC45, the friction coefficient values varied in the range 0,576-0,681, with a medium value of 0,617083.

For the friction coupling torlon/OLC45, the friction coefficient values varied in the range 0,864-0,966, with a medium value of 0,9095.

For the friction coupling nylon/OLC45, the friction coefficient values varied in the range 0,8579-0,9452 with a medium value of 0,893442.

The results of the testing experiments, for the friction forces values and for the friction coefficient values obtained in table 1 and table 2 are presented graphic, using the Microsoft Excel software, in figure 1.1 (friction forces), and figure 1.2 (friction coefficients).

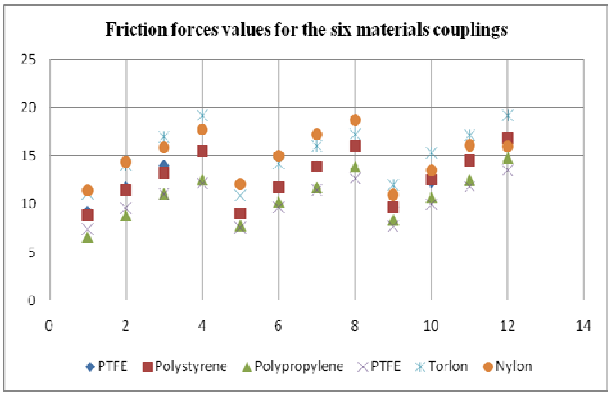

Fig. 1.1. Friction forces values for the six materials couplings.

The biggest friction forces resulted for the friction couplings Torlon/OLC45 and for Nylon/OLC45.

The smallest friction forces resulted fot the friction couplings polypropylene/OLC45 and for polytetrafluoroethylene/OLC45.

The biggest friction coefficient resulted for the friction couplings Torlon/OLC45 and for Nylon/OLC45.

The smallest friction forces resulted fot the friction couplings polypropylene/OLC45.

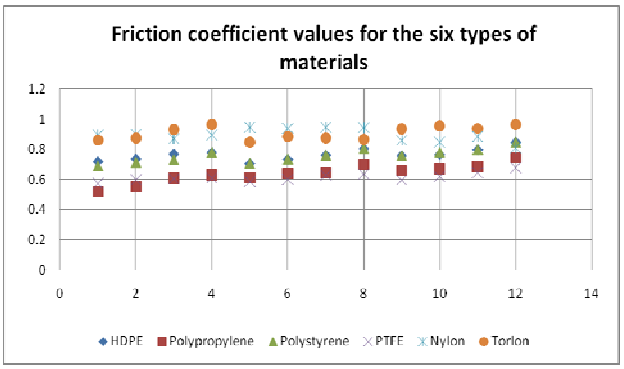

Fig. 1.2. Friction coefficient values for the six types of materials couplings.

Experimental test results for friction coupling pure PTFE/steel showed a simultaneous increase in friction coefficient with increasing load, reaching values of the friction coefficient of 0.23. For friction coupling PTFE+ 5%diamond/steel were obtained lower values of friction coefficient of up to 0.18 by the addition of diamond, and the coefficient of friction decreases with increasing load [3].

5. CONCLUSION

Comparing experimental results with those from the literature on PTFE [3], were obtained similar values for the friction coefficient.

6. REFERENCES

[1] Bîrleanu C., Herculea L., *"Experimental study of dry friction to different materials couplings"*, Acta Tehnica Napocensis, seria Matem. Aplicate şi Mecanică, nr.52, vol 3. 2009 ISSN 1221- 5872

[3] Lai S.H., Yue L., ş.a. *The friction and wear properties of polytetrafluoroethylene filled with ultrafine diamond*", Wear 260, pag. 426-468, 2006

[4] Popa I., "*Încercări experimentale realizate cu ajutorul tribometrului cu trei bile*", Acta Tehnica Napocensis, seria Matem. Aplicate şi Mecanică,

[5] Sucală, F., Belcin, O., ş.a *"Organe de maşini, mecanisme şi tribologie. Studii de caz"*, Ed. Todesco, Cluj-Napoca, 2008

[6] http://ro.wikipedia.org/wiki/Polimer

[7]http://www.matbase.com/material/polymers/thermosets/

[8]http://www.efunda.com/materials/polymers/general_info/polymer_index.cfm

Încercări experimentale realizate cu ajutorul tribometrului cu trei bile pentru contactele metal-polimer

Rezumat : *În această lucrare sunt redate încercările experimentale în ceea ce priveşte determinarea coeficientului de frecare, cu ajutorul tribometrului cu trei ştifturi, pentru contactele metal-polimer, la macro scară tribologică, în regim de frecare uscată*

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