ABRASIVE WEAR BEHAVIOR OF 65MN10 STEEL

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Abstract: *Fatigue and wear are the main mechanisms determining out operating of machine parts. Abrasive wear involves progressive destruction of the superficial layer of material displacement under the action of particles with higher hardness. In this paper, the authors analyze the collective behavior of abrasive wear of steel structural 65Mn10 in different states.*

Keywords: *wear, hardness, friction.*

1. Introduction

Responsible for approx. 70% of disabling the machine parts, wear was studied by scientific means and methods only in the nineteenth century. Contrary to appearances, the abrasion wear is a complex mechanical process that causes degradation of the surface layer by micro-cutting, fracture, fatigue and material displacement under the action of hard particles from mating or outside.[1] The necessary condition of initiation and development of abrasive wear is the difference in hardness, generally lower hardness are on deteriorating body. In the literature, first formulated wear dependence of material properties was Tonn (1937), completed by Hruşciov and Babicev, which, in their research, developed and completed modeling abrasion wear. This form of destruction is characteristic of mechanical constructions that appear dry friction couplings such as mining equipment and agricultural machinery.

Research on the wear of the abrasive wear phenomena and mechanisms have been initiated in the Faculty of Mechanical Engineering, Mechatronics and Management, "Stefan cel Mare" University of Suceava by Phd Professor M. Gramaticu since 1980 [].

In the laboratory of study materials were studied the influence of chemical composition, metallographic structure and working conditions on the wear resistance of various materials; such material is steel 65Mn10.

65Mn10 steel comes in bars and flat products, laminated, and are used for cutting and wear parts for agricultural machines, general purpose springs to media requests at room temperature and for parts requests contact insufficient lubrication conditions. Chemical composition and mechanical characteristics are presented in tables 1 and 2 and heat treatment recommendations in table 3, according to SR EN ISO 683-17:2002, STAS 11513-88, and STAS 11506-80.

2. Work methodology. Experimental results

For a given steel composition, hardness and metallographic structure is given by the state of tension resulting from the application of heat treatment. The chemical composition of 65Mn10 steel allows, by applying heat treatment variations, hardness can be obtained in a very large range of values from 250 to 800 HV. In the research were considered as variants of heat treatment: anneling, normalizing, hardening with low, medium and high back. For determinations have used samples with size 20x5x50mm. The samples were processed in the same batch of material to eliminate errors due to heredity material. Heating of samples was done in an electric furnace with resistors.

Tabel 1 *The chemical composition of 65Mn10 steel [%]*

C	**Mn**	**Si**	**S** max.	**P** max.	**Cr** max.	**Ni** max.	**Cu** max.
0,60…0,70	0,90…1,20	0,17…0,37	0,035	0,035	0,3	0,3	0,3

Tabel 2 *Mechanical characteristics of 65Mn10 steel*

Diameter sample [mm]	Heat treatment **N**-normalizing **R** - annealed	Minimum flow R_{p02}[MPa]	Minimum tensile strength [MPa]	Break elongation (minimum) [%]	Resilience KCU/5 Minimum [J/cm^2]	Brinell hardness in annealed state Maximum[HB]
25	N	390	735	8	35	229
	R	800	1000	8	35	241

Tabel 3 *Recommendations for heat treatments for 65Mn10 steel*

Annealing		Normalizing		Hardening		Tempering	
T [^{0}C]	Cooling medium	T [^{0}C]	Cooling medium	T [^{0}C]	Cooling medium	T [^{0}C]	Cooling medium
680 - 720	furnace	810 - 840	air	820 - 860	water, oil	540 - 680	water, oil

To eliminate the risk of oxidation or carburizing samples were protected by coating with refractory paint. After heat treatment the hardness of each specimen was measured. HV hardness measurement was made on a universal hardness tester CV - 700.

Abrasive wear tests were performed on a abrasive band machine shown in figure 1, performed in the laboratory.

Abrasive band was replaced after each test. During the test sample was moved in the transverse direction to not go over the same trace. Each sample was tested to wear 10, 20 and 40 minutes, which corresponds to a friction path of 424.1m, 848.2m and 1696.4m. Nominal loading force on the samples was 5 N, performed using a sample weight mount. Grain abrasive band remained throughout the tests A120. They used endless bands 100x1200 mm and aluminum oxide. Gravimetric wear measurement was made using an analytical balance with accuracy of 0.01mg. Before weighing the samples were cleaned by washing with solvent. Test results are presented in table 4.

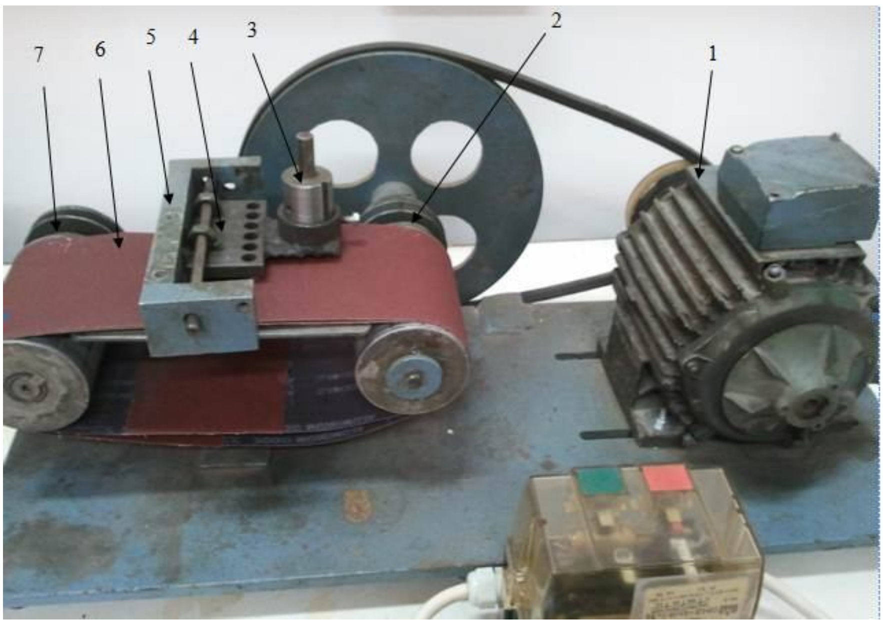

Figure 1 – *Abrasive band machine: 1- electric motor, 2 – drum drive, 3- sample holder, 4 – loading system, 5 – frame support 6 – abrasive band, 7 – drum driven*.

Tabel 4. *Rezultatele încercărilor la uzare abrazivă a oţelului 65Mn10*

Hardness HV	During the test [min]	The path friction[cm]	Wear [g]	Wear volume V_u [cm^3]	Wear coefficient K_u	Resistance to wear $\varepsilon*10^{-6}$ [cm^{-2}]
327	10	42410	0,1354	0,01735897	0,002678	2,443117
362	10	42410	0,1029	0,01319231	0,002253	3,214752
394	10	42410	0,0965	0,01237179	0,002299	3,427960
395	10	42410	0,1173	0,01503846	0,002802	2,820103
420	10	42410	0,0643	0,00824359	0,001633	5,144603
440	10	42410	0,0948	0,01215385	0,002522	3,489429
457	10	42410	0,0922	0,01182051	0,002548	3,587832
460	10	42410	0,0817	0,01047436	0,002273	4,048935
480	10	42410	0,0800	0,01025641	0,002322	4,134975
483	10	42410	0,0639	0,00819231	0,001866	5,176806
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484	10	42410	0,0639	0,00819231	0,00187	5,176806
506	10	42410	0,0780	0,01	0,002387	4,241000
507	10	42410	0,0780	0,01	0,002392	4,241000
537	10	42410	0,0639	0,00819231	0,002075	5,176806
560	10	42410	0,0515	0,00660256	0,001744	6,423266
561	10	42410	0,0515	0,00660256	0,001747	6,423266
561	10	42410	0,0515	0,00660256	0,001747	6,423266
621	10	42410	0,0506	0,00648718	0,0019	6,537509
831	10	42410	0,0513	0,00657692	0,002578	6,448307
327	20	84820	0,1734	0,022230769	0,001714	3,815433
362	20	84820	0,2243	0,02875641	0,002455	2,949603
394	20	84820	0,1139	0,01460256	0,001357	5,808571
395	20	84820	0,1502	0,01925641	0,001794	4,404767
420	20	84820	0,1123	0,01439744	0,001426	5,891325
440	20	84820	0,1487	0,0190641	0,001978	4,449200
457	20	84820	0,163	0,02089744	0,002252	4,058870
460	20	84820	0,0964	0,01235897	0,001341	6,863031
480	20	84820	0,1354	0,01735897	0,001965	4,886235
483	20	84820	0,121	0,01551282	0,001767	5,467736
483	20	84820	0,1124	0,01441026	0,001641	5,886084
484	20	84820	0,105	0,01346154	0,001536	6,300914
506	20	84820	0,1233	0,01580769	0,001886	5,365743
507	20	84820	0,1113	0,01426923	0,001706	5,944259
537	20	84820	0,1394	0,01787179	0,002263	4,746027
560	20	84820	0,067	0,00858974	0,001134	9,874571
561	20	84820	0,0798	0,01023077	0,001353	8,290676
561	20	84820	0,0608	0,00779487	0,001031	10,881516
621	20	84820	0,0598	0,00766667	0,001123	11,063473
831	20	84820	0,0729	0,00934615	0,001831	9,075395
327	40	169640	0,3142	0,04028205	0,001553	4,211305
362	40	169640	0,2593	0,03324359	0,001419	5,102939
394	40	169640	0,3090	0,03961538	0,00184	4,282175
395	40	169640	0,3755	0,04814103	0,002242	3,523813
420	40	169640	0,2060	0,02641026	0,001308	6,423261
440	40	169640	0,3034	0,03889744	0,002018	4,361212
457	40	169640	0,2952	0,03784615	0,002039	4,482358
460	40	169640	0,2615	0,03352564	0,001818	5,060008
480	40	169640	0,2561	0,03283333	0,001858	5,166701
483	40	169640	0,2047	0,02624359	0,001494	6,464055
483	40	169640	0,2047	0,02624359	0,001494	6,464055
484	40	169640	0,2047	0,02624359	0,001498	6,464055
506	40	169640	0,2497	0,03201282	0,00191	5,299127
507	40	169640	0,2497	0,03201282	0,001914	5,299127
537	40	169640	0,2046	0,02623077	0,001661	6,467214
560	40	169640	0,1649	0,02114103	0,001396	8,024207
561	40	169640	0,1649	0,02114103	0,001398	8,024207
561	40	169640	0,1649	0,02114103	0,001398	8,024207
621	40	169640	0,1622	0,02079487	0,001522	8,157781
831	40	169640	0,1644	0,02107692	0,002065	8,048614

Wear resistance was calculated as the ratio between length path friction and material volume.

$$\varepsilon = \frac{L_f}{V_u} \quad [\mathrm{cm}^{-2}] \qquad (1)$$

and the wear coefficient was calculated with the equation:

$$K_u = \frac{V_u \cdot HV}{F_n \cdot L_f} \qquad [2]$$

where:

V_u - the volume of used material
HV - Vickers hardness of the sample
F_n - normal force pressure on the sample in N
LF - length of path friction

Variation of wear, the wear resistance and wear coefficient with hardness and friction path length, expressed during the test are shown in figures 2 - 5.

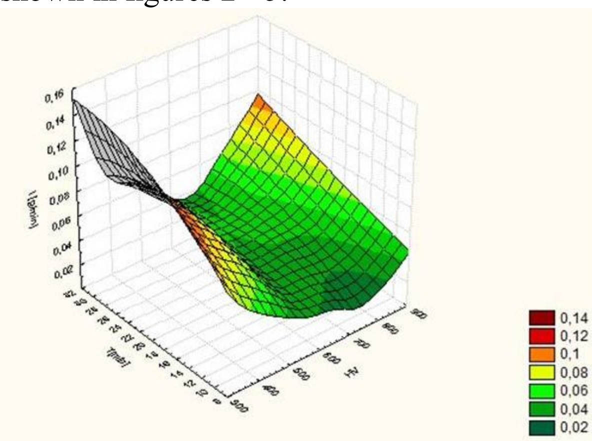

Figure 2. - *Wear intensity depending by hardness and time tests*

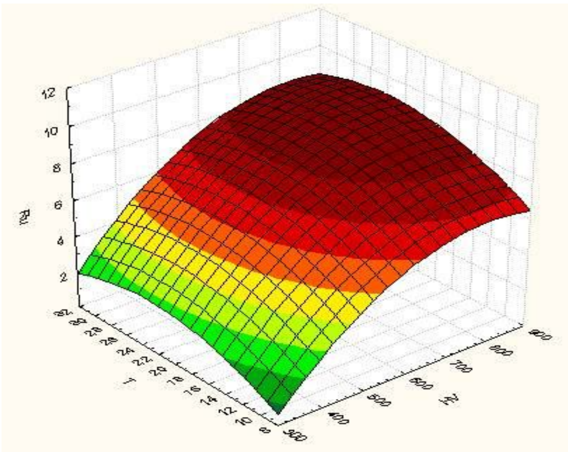

Figure 3. - *Wear resistance depending by hardness and time tests*

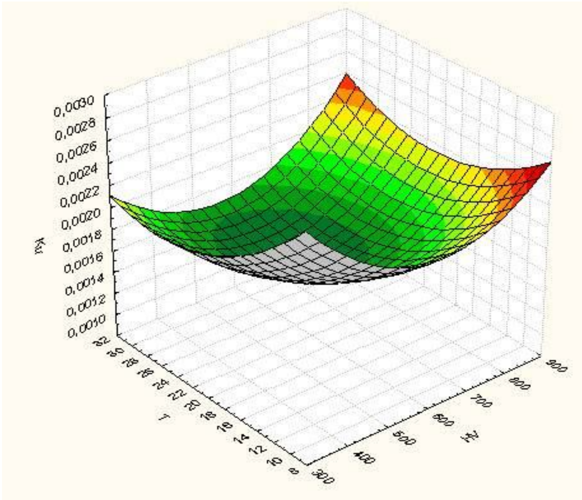

Figure 4 - *The influence of hardness and duration of the wear coefficient*

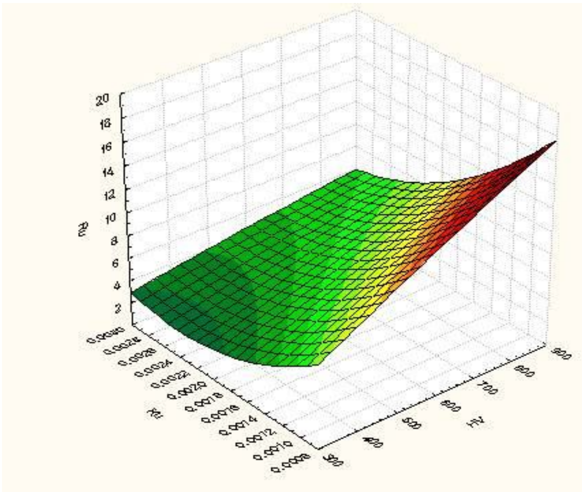

Figure 5. - *The influence of hardness and wear coefficient on wear resistance of 65Mn10 steel.*

3. Conclusions

1. 65Mn10 steel is mild steel construction which, by chemical composition, structure and technology features are positioned in a particular position as a field of use. By modifying regimens can be obtained between 230 HV hardness, corresponding to 650 HV annealing structures corresponding hardening martensite structures. This feature is recommended for various uses such as active organs for soil tillage, mining, and for making springs, torsion bars, gears, etc..

2. The abrasive wear conditions, the intensity of wear depends on the hardness of steel and friction path lengths (Fig. 2 and 6). Tests performed in the laboratory have shown that this feature is superior to alloy test in similar conditions [2,3].

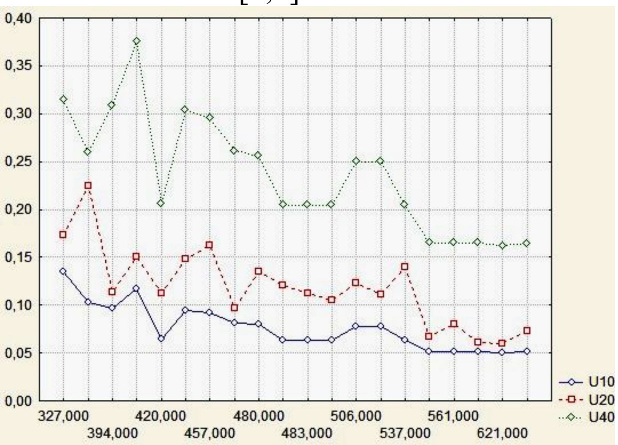

Figure 6. *Intensity wear depending on the hardness for different values of path friction:*
U10 - Lf = 424.1 m;
U20 - Lf = 828.2 m;
U40 - Lf = 1696.4 m

An interesting feature is that, regardless of the length of path friction, wear intensity recorded a minimum hardness of 420 HV, corresponding to sorbite structure type, appropriate treatment to improve, variation of heat treatment that ensures maximum strength characteristics.

3. Wear resistance, expressed by the ratio between the length of path friction and volume wear of material displaced by increases in hardness (Fig. 3 and 7).

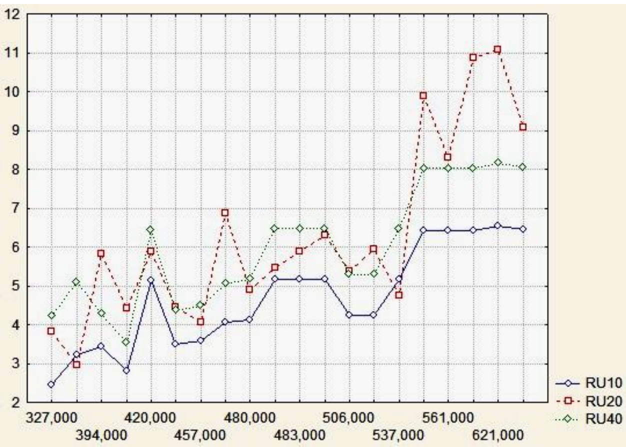

Figure 7. *Wear resistance depending on the hardness for different values of path friction:*
Ru10 - Lf = 424.1 m;
Ru20 - Lf = 828.2 m;
Ru40 - Lf = 1696.4 m

At the higher hardness of 550 HV this feature records a maximum that are store approximately constant, independent of the length of path friction. And for this feature, the hardness of 420 HV has a feature as the intensity of wear.

4. Wear coefficient value is less influenced by hardness and friction path length (Fig. 4 and 8). A significant influence of this factor exerts normal force loading. [2]

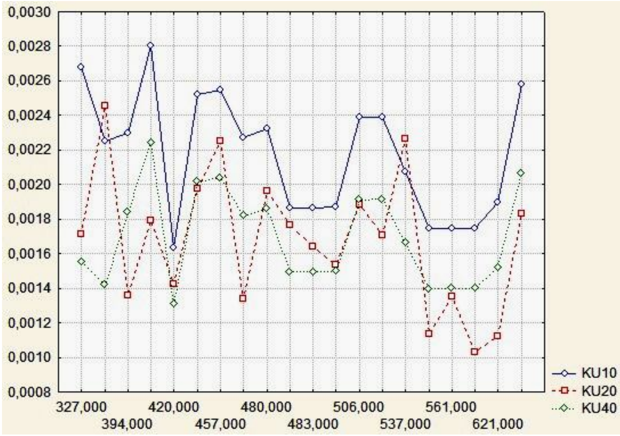

Figure 8. *Variation of wear coefficient with hardness for different values of path friction:*
Ku10 - Lf = 424.1 m;
Ku20 - Lf = 828.2 m;
Ku40 - Lf = 1696.4 m

Analyzing the experimental results and taking into account the requirements of machine required to abrasive wear and shock, results that their maximum durability for 65Mn10 steel is provided for hardness between 400 and 450 HV.

4 References

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