ANALYSIS OF TRIBOLOGICAL PROCESSES OF CONSTRUCTION MATERIALS IN THE SOIL MASS ABRASIVE WEAR PROCESS.

Associate Prof. M.Eng.Napiórkowski J. PhD., M.Eng.Drożyner P. PhD., M.Eng. Kołakowski K., M.Eng.Mikołajczak P PhD.,
University of Warmia and Mazury in Olsztyn, Poland

Abstract: *Rational selection of construction materials for working elements requires knowledge not only in the macroscopic friction processes, but also elementary processes occurring in the contact layer of element with the soil mass. Studies have shown the importance of the impact of stationary and dynamic properties of soil mass and speed of the wear process on wear intensity of martensitic steel. Studies are supplemented by measurements of the coefficient of friction force in different types and conditions of soil mass and the assessment of the elementary wear processes.*

Keywords: ABRASIVE SOIL MASS, WEAR PROCESS, INTENSITY OF WEAR

1. Introduction

Selecting of constructional and technological properties of elements used in abrasive soil mass and planning the exploitation process is possible when the course of the depletion of utility resource of material is known. Description of the wear process of this elements is reduces to the structural, functional and evolutional identification of the system of processes. [4]. Specification of system is determined by interpenetration of constructional and technological characteristics of working element, randomness of biological factor which is abrasive soil mass, and impact of constraints of wear process. [5,6,7,8]. Presented in the literature results of surface layers wear process researches mostly concern the estimation for the model abrasive grains. [3,9]. The wear process of working element is a dynamic change of energy stuff and an information, which are proceed in the time and can be regarded as a process. Every process in turn can be describe in the system approach and present in the simplest way in the black box aspect (fig.1).

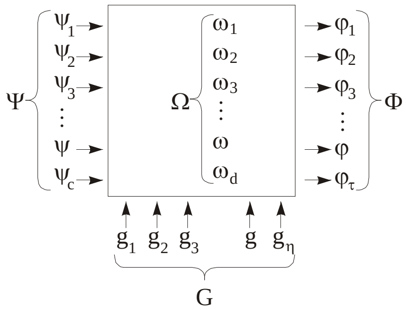

Fig.1. *Conceptual model of wear process of working elements in abrasive wear mass:* $\psi\{\psi_1, \psi_2, \psi_3, ..., \psi_c\}$ *– set of process parameters,* $\Omega\{\omega_1, \omega_2, \omega_3,...\omega_d\}$ *– set of characteristics of working element,* $G\{g_1, g_2, g_3, ..., g_\eta\}$ *– set of properties of abrasive wear mass,* $\Phi\{\varphi_1, \varphi_2, \varphi_3, ..., \varphi_\tau\}$ *– set of answers which describes the wear process.*

Aim of this study is to analyze the tribology processes of the construction materials in different abrasive wear mass properties.

2. The Research Methodology

The laboratory researches have been conducted on a wear machine "spinning mass" type. The sample was a rectangular prism with dimensions 30x25x10 mm, cut from the test material. The abrasive surface was mounted at 2-3° to the work surface. During the test the linear velocity was controlled from 1,39 to 2,00 m/s. Maximum load of the sample - 50kN (67 kPa). The summary distance of wear of the sample was from 10 to 20 km. After the each wear distance of 2 km the weight of the sample was measured and the soil was changed for the new one. To the tests the steal 38GSA with chemical composition: C – 0,38%, Mn – 1,07%, Si – 1,17%, P – 0,028%, S – 0,02%, Cr – 0,18%, Cu – 0,16%, Al. – 0,022% was used. The average value of the measure hardness of the steel was 414HV10. The granulometric composition, characteristic of the percentage of friction dimensions in the soil mass, was determined by aerometric Casagrande method (tab 1.). The acidity was determined by electromotive method with device EpH-117/118.

Table 1. *The granulometric composition of the soil abrasive mass.*

Name of the soil	% fraction of the diameter in mm			
	Gravel > 1,0	Sand 0,1-1,0	Silt 0,02-0,1	Clay <0,02
Gravel	56,6	25,4	9,4	8,6
Medium Clay	1,2	56,5	18,5	25,0
Silt	0,0	9,0	23,6	67,4

Estimation of the wear surface of samples was made under the photographs from JOEL JEM5200 scanning electron microscope.

2. The Results

To the basic mechanical characteristic of static abrasive wear mass granulometric composition is taken which describes the contents of soil fractions [7]. Presented in Figure 1 results showed that with increasing in the abrasive wear mass particle size of diameter <0. 1mm the wear value decreases. In dry soil conditions in the gravel the wear rate was 1.9 x higher than in the medium clay , and 2.4 x higher than in the silt.

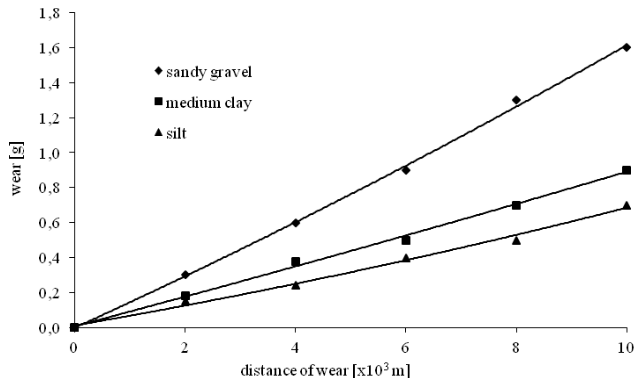

Fig.2. *The process of the wear of 38GSA steel depending on the composition of the wear mass.*

The basic dynamic characteristics of the abrasive wear mass is density (hardness), acidity and moisture [1,4,5]. The course of wear described as exponential functions (fig. 3-5):

$$Z_j = a \cdot e^{b\,x}$$

where: a and b are coefficients dependent on the characteristics of the condition and the type of mass.

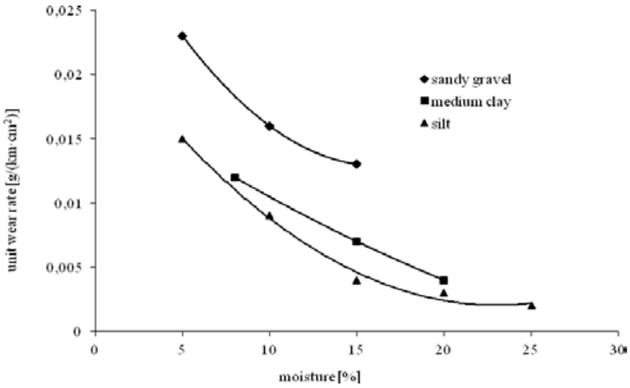

Fig. 3. *The course of wear of steel in different states of moisture.*

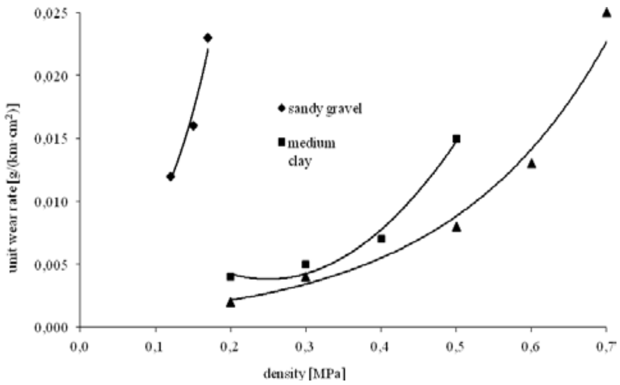

Fig.4. *Relation between consumption of steel and abrasive wear mass density.*

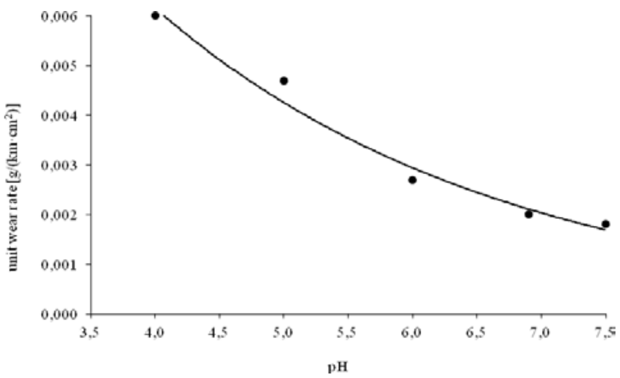

Fig. 5. *Dependence of the unit wear rate of steel on abrasive soil mass acidity.*

The basic characteristics of the working process is the speed of its implementation. Figure 6 shows the effect of friction speed on the course of wear, which is usually identified with the work of friction [2].

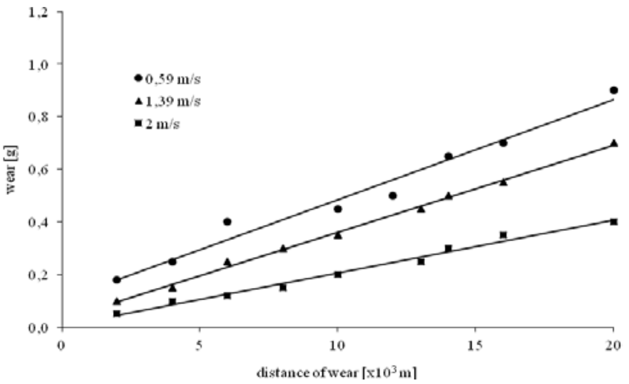

Fig.6. *The course of wear of the steel depending on the speed in medium clay abrasive mass*

These results of experimental researches point to the importance of the speed of working process and the static and dynamic characteristics of soil mass on the abrasive wear process. Searching for the qualitative or quantitative relation between the forces of friction, and wear intensity made the evaluate of the friction coefficient necessary. The friction coefficient was determined using the indirect method of appointment of friction forces, which measured the U98-type force sensor with a recorder Hottinger GMBH SPIDER 8 (Table 2.).

Table 2. *Summary of friction coefficient*

Type of the soil / Moisture	Gravel	
	$\bar{\mu}$	Coefficient of variation [%]
Dry	0,2001	6,25
Humid	0,2892	8,19
Wet	0,5595	3,52
Saturated	0,4073	20,50
Type of the soil / Moisture	**Medium Clay**	
	$\bar{\mu}$	Coefficient of variation [%]
Dry	0,5830	32,72
Humid	0,5357	33,93
Wet	0,2029	21,41
Saturated	0,2829	33,64
Type of the soil / Moisture	**Silt**	
	$\bar{\mu}$	Coefficient of variation [%]
Dry	0,6824	20,07
Humid	0,6268	35,80
Wet	0,4342	40,58
Saturated	0,0952	20,07

Picture of the phenomena occurring on the surface of the work sample during soil treatment is the condition of the soil surface area. You can see clear traces of scalloping and scratching (fig. 7), local craters (Fig. 8) and multi-cycle fatigue wear(Fig.8-9).

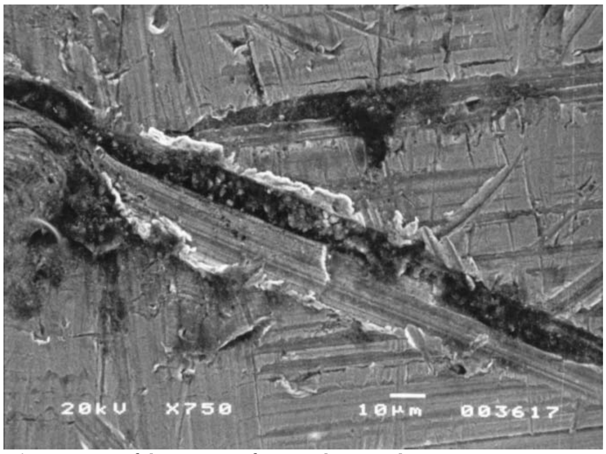

Fig.7. *Image of the wear surface in the gravel.*

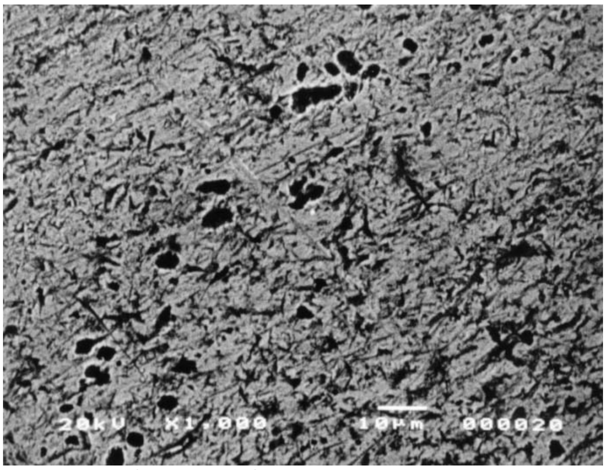

Fig.8. *Image of the wear surface in medium loam.*

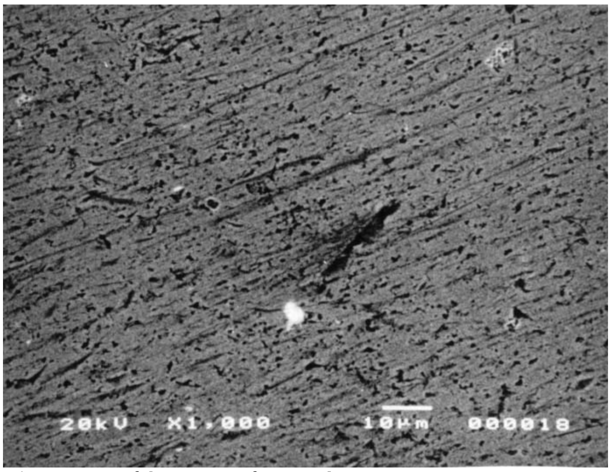

Fig.9. *Image of the wear surface in silt.*

4. Summary

The demands on the formation of the surface layer from the dependence obtained and the analysis of elementary phenomena of wear process indicate a need a of different, depending on abrasive soil mass type and state, construction and fabrication of work elements. In selecting the properties of construction of the materials should be considered first granulometric composition of abrasive wear mass, because it is the sum of determined characteristics of the physical and chemical properties of soils and is a fundamental quantity describing the effect of abrasive soil wear. With the soil mass with water saturation is a reduction in the intensity of wear in all types of soil masses. However, the extent of these changes depends on the type. All the soil masses change their properties with the change of water content. Apparently they are visible in the clay soil. Soil density significantly affect the intensity of wear especially in cohesive masses, commonly regarded as concise. Significant differences were found between the intensity of wear of abrasive acidic soil masses and neutral and alkaline. There were no differences in the intensity of wear in neutral and alkaline soils. These results of experimental investigations point to the importance of speed on wear intensity. With the decrease of speed is an increase in intensity. When significant differences were obtained depending on the nature of the formation of the friction coefficient for the mass of abrasive soils, depending on the grain size composition. The greatest value of the coefficient of friction obtained for the heavy abrasive masses, with a high fraction of clay and silt. The average value of the coefficient for this type of dry soil was three times higher than for gravel.

Bibliography

1. Balla J. 1996. Modelovanie povrchovych interakcji nastrojom a podou. VI th. International Symposium, Intertibo 96, str. 133-136.

2. König U., Grewe H. 1981. Untresuchungen über Herstellung und Eigenschaften von Hartstoffschichten die durch reaktives Aufdampfen abgescheiden werden. Tribologie, Bd 1, Berlin, Springer 1981, str. 197 –250.

3. Gierek A., 2005, Zużycie tribologiczne, Wydawnictwo Politechniki Śląskiej Gliwice 2005(in polisch).

4. Napiórkowski J. Zużyciowe oddziaływanie gleby na elementy robocze narzędzi rolniczych. Inżynieria Rolnicza 2005, Nr 12 (in polisch).

5. Napiórkowski J. Analiza właściwości glebowej masy ściernej w aspekcie oddziaływania zużyciowego. Tribologia 2010, 5: 53-62 (in polisch).

6. Napiórkowski J., Pękalska L., Pękalski G. 1998. Structure of material and its wear resistance in the soil. Tribologia 1998; 6 : 871-879.

7. Natsis A, Petropoulos G, Piandazaras C. Influence of local soil conditions on mouldboard ploughshare abarsive wear. Tribology Int 2008; 41 :151 – 157.

8. Owsiak Z. Wear of symmetrical wedge-shaped tillage tools. Soil Tillage Res 1997; 43 (3,4) 295-308.

9. Stachowiak G W, . Betchelor A W. Engeineering tribology. Elselvier BH 20