EXPERIMENTAL RESEARCHES ON DETERMINING THE WEAR OF CHISEL KNIFE MADE OF THREE TYPES OF MATERIALS
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CERCETĂRI EXPERIMENTALE PRIVIND DETERMINAREA UZURII CUTITELOR TIP DALTA REALIZATE DIN TREI TIPURI DE MATERIALE DIFERITE

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ABSTRACT
The paper presents the interaction system within soil working mechanical process, consisting of two elements, namely the soil and the tool metal, between which there is a relative movement at the level of the interface between the two elements. Research has shown that there are at least two main forces acting on the active parts: friction and impact, the action of these forces causing wear.
In order to test the soil working knives under laboratory conditions, a test stand was used to test different types of soil working knives by modifying their functional parameters, respectively the working depth, knife angle relative to the soil, lateral angle relative to the forward direction, working speed and, if necessary, granulation and moisture of the test medium respectively.

REZUMAT
Lucrarea prezintă sistemul de interacţiune din cadrul procesului mecanic de prelucrare a solului, constituit din două mari elemente, solul şi metalul sculei, între care există o mișcare relativă la nivelul interfeței dintre cele două elemente. Cercetările au arătat că există cel puțin două forțe principale care acționează asupra părților active: frecarea și impactul, acțiunea acestor forțe determinând uzura.
În vederea încercării în condiţii de laborator a cutitelor de lucrat solul, s-a folosit un stand ce permite încercarea în condiţii de laborator a diferitelor tipuri de cutite de lucrat solul, prin modificarea parametrilor funcţionali ai acestora, respectiv a adâncimii de lucru, unghiului de aşezare, unghiului lateral faţă de direcţia de înaintare, a vitezei de lucru şi respectiv, după necesităţi, a granulaţiei şi umidităţii mediului de încercare.

INTRODUCTION
Within the main soil works, the active parts, such as: body, ploughshare, disc, chisel, etc., are quickly subjected to abrasive wear because of the contact with the soil. The active parts must be checked for wear resistance under different working conditions, so that, over an average service life, wear resistance should be determined (*Mehrang et al., 2019*), in order to ensure the exchange of parts in a timely manner. The article presents the experimental research carried out to find out the wear resistance of chisel knives, at a certain depth, working speed and the interaction of chisel knives with a certain type of material (sand) so that between these parameters is determined a correlation, to improve the life of chisel knives (*Cardei et al., 2018*).

Research carried out by some authors (*Matache et al., 2008*) has shown that there are two main forces acting on the active parts: friction and impact. The action of these forces causes wear, which manifests in two distinct aspects, namely: impact wear and friction wear.

Deep soil working, without turning the furrow, is one of the works that influence the condition of crops when climatic conditions are not favourable. A special problem is the one that appears in the areas with drier climate, where the intensive soil working and the removal of vegetal residues contribute to the loss of water from the soil, accentuating the processes of drought and desertification.

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Chisel soil loosening equipment is designed to loosen the soil without overturning the furrow, in order to increase the thickness of the loosened layer and increase the water penetration capacity.

Chisel soil tillage is recommended prior to the establishment of straw crops (*Epure, 2011, Kuht et a.l, 2012*). Studies show that the positive effects are observed after the first year of activity and consist in increasing the porosity of the soil, as well as increasing the biological activity in the soil (*Odey and Manuwa, 2018*).

Changing the geometry of chisel knives, because of premature wear generated by the interaction with the soil, leads to large increases in working resistance and fuel consumption (*Canarach A., 1990; Iznaga et al., 2018; Pirowski et al, 2012; Ucgul et al., 2015*).

It has been shown that the hardness of the material the active parts are made of is not always the decisive factor that influences wear the most. There is an inverse relationship between the hardness of the material and its ability to withstand abrasive wear, thus carbon steels have a higher abrasion resistance than cast iron with globular graphite, but the choice of cast iron is due to low production costs (*Voicu et al., 2019 ; Bednar et al., 2013*).

As the chisel knife advances into the soil, there is a relative movement at the level of the interface between the two elements. These chisel knives are subject to variable stresses, with higher values, compared to the stress other parts of the equipment are subject to (*Matache et al., 2008; Tomescu et al., 1981; Tomescu et al., 1987; Tudor et al., 2000*).

Various studies have shown that the intensity of wear increases in proportion to the increase in stress and the size of the abrasive particle dimensions. Speed does not have a decisive influence on the intensity of wear. Also, the intensity of chisel knives' wear is influenced by the wear resistance of the materials they are made of.

In the present research, the phenomenon of wear that occurs as a result of the interaction between the chisel knife and the sandy material in the sample stand was analysed.

Mechanical soil working is a complex process that requires high energy and material consumption because of soil resistance to breakage and intense abrasive wear of chisel knives.

In order to optimize the process of soil mechanical working, the following parameters are taken into account:

- geometric parameters of the chisel knife;
- soil specific parameters;
- functional parameters of the process.

MATERIALS AND METHODS

In order to test the chisel knives, a test stand (Fig. 1) made by the National Institute of Research - Development for Machines and Installations Designed for Agriculture and Food Industry - INMA Bucharest was used. With the help of this stand, different types of soil working knives can be tested under laboratory conditions, by modifying their functional parameters: working depth, angle of soil working knives, working speed (indirectly established as the tangential speed in the circular movement of the support arms), granulation and humidity of the test medium.

The stand for testing chisel knives consists of the following main subassemblies:

- Sand basin;
- Worm gear motor for driving;
- Assembly of working part support arms;

The stand allows the modification of the following functional parameters of chisel knives:

- working depth;
- lateral angle relative to the forward direction;
- working speed (by varying the speed of the drive motor).

Due to the overall dimensions and functional dimensions established, the stand allows the testing of chisel knives on a circular trajectory with a diameter of 1600 mm, at a maximum depth of 300 mm.

The main technical characteristics of the stand are:

- gear motor type:	worm gear motor MRV 100 U02A;
- electric motor:	HB2 132M B5;
- power, kW:	7.5;
- frequency, Hz:	50;
- electric tension, V:	400;

- International Protection Marking: IP55;
- speed, rpm: 1460;
- mounting position: V5;
- gear ratio: 10;
- output speed, rpm: 146;
- maximum adjustment depth: 300;
- overall dimensions, mm
    - basin outer diameter: 2000;
    - basin height: 1000.

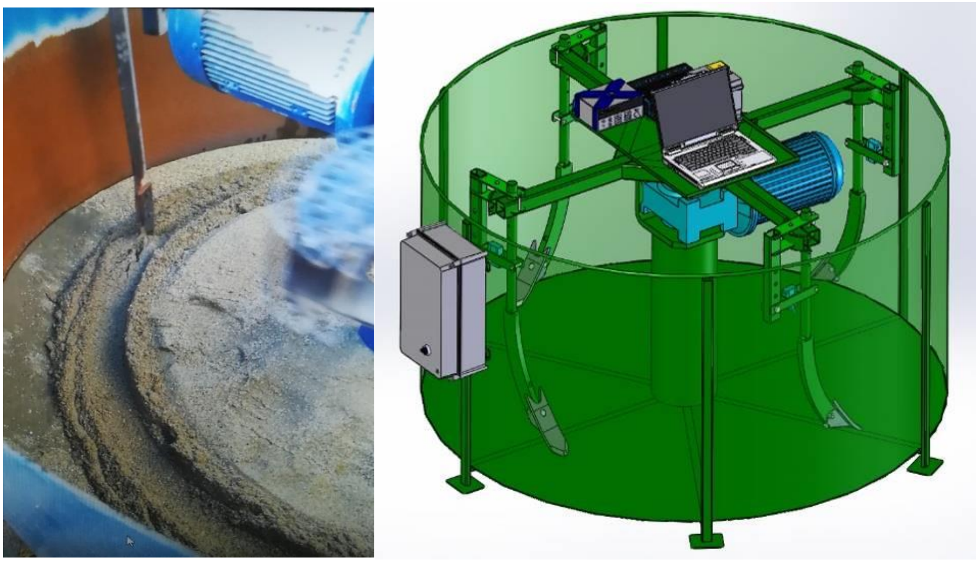

Fig. 1 – Experimental stand for testing chisel knives

Using the stand, the following types of chisel knives were tested under laboratory conditions:

For tests, 3 types of chisel knives (Figure 2) were made of different materials: C45 (sample 1), C45 heat-treated (sample 2), E295 (sample 3).

Sample 1	Sample 2	Sample 3

Fig. 2 - Types of chisel knives made of different materials:
1 - C 45; 2 - C 45 heat-treated by hardening; 3 – E295

In order to reduce the influence of various physical parameters that characterize agricultural soil and to maximize its effect on the wear of chisel knives, it was decided to conduct experiments in a medium that favours basic observations on the chisel knife-soil interaction.

Thus, we chose as test medium fine quartz sand for dry adhesive mortars, as commercial application, obtained by washing and mechanical grading which falls within the particle size class coarse sand and fine sand (according to the Attenberg limits) with a particle diameter between 0 and 0.3 mm.

By using this test medium, it is desired to determine the data in purely fictional test mediums.

The test medium used is a fictional medium, without cohesion and without structure with maximum wear effect (wear is maximum when the percentage of abrasive particles with a size of 0.25 mm has maximum value).

A KERN EG precision balance with the following characteristics was also used:

- Division: 0.01 g;
- Maximum capacity: 4200 g;
- Minimum capacity: 500 mg;
- Minimum weight of the piece to be counted: 10 mg;
- Weighing plate size (WxD): 180x160 mm;
- Reproducibility: 0,01 g;
- Linearity: +/-0.02 g;

Penetration resistance F was calculated with the formula:

$$F = \rho \cdot S \quad [\text{N}] \tag{1}$$

where: p is the pressure, [MPa];

S - the surface of the penetrating cone, [mm^2].

The gravimetric method was used to determine the overall wear, which consisted in determining the difference between the initial mass and the mass measured after a certain period of chisel knife operating.

RESULTS

The chisel knives were mounted one by one in the test stand (Figure 3), where they worked at an angle of attack of 27° (Figure 4) and at a depth of 22 cm in the sand of the test stand, so that their wear could be determined after a number of operating hours.

Fig. 3 - Chisel knife mounted on the experimental stand

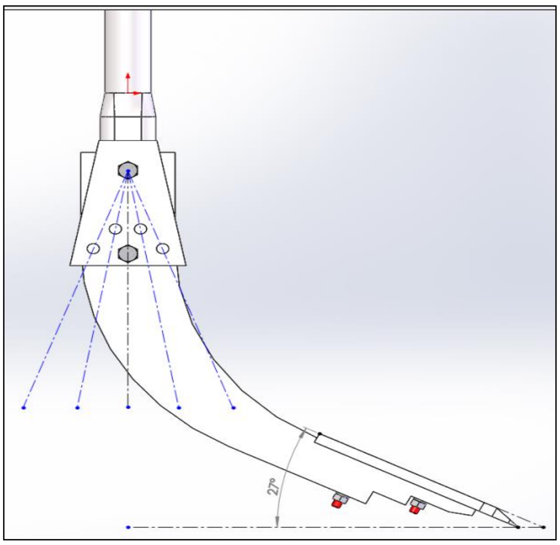

Fig. 4 - Adjusting the angle of attack on the tool holder

The chisel-type knives were weighed (Figure 5) before being mounted on the test stand and let operate for one hour, after which they were weighed and mounted back on the stand for another hour of testing, process repeated 8 times for each knife, thus tracking material losses through wear.

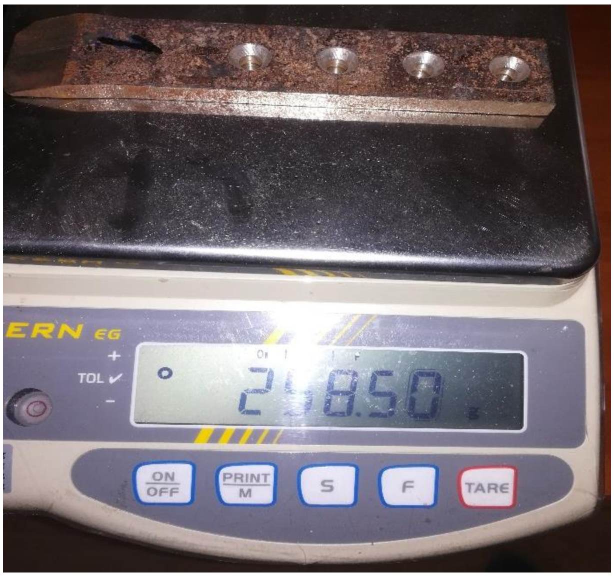

Fig. 5 - Chisel knives weighing

Tables 1 and 2 show the actual wear for each hour of operation. During the 8 hours of operation, the chisel knife made of E295 registered 1.07 grams wear, the one made of C45 heat treated by hardening, 1.47 grams wear and the chisel knife made of C45, 2.12 grams wear.

Table 1

Evolution of weight loss of the 3 chisel knives after 8 hours of testing

Knife type	Weight of chisel knife, after weighing, at a test time interval on the experimental stand (grams)									
	Initial	After 1 hour	After 2 hours	After 3 hours	After 4 hours	After 5 hours	After 6 hours	After 7 hours	After 8 hours	Total wear
C 45	259.51	259.15	258.96	258.82	258.57	258.14	257.85	257.59	257.39	2.12
C 45 heat treated by hardening	254.74	254.37	254.16	253.95	253.82	253.66	253.53	253.38	253.27	1.47
E295	236.75	236.63	236.55	236.38	236.24	236.05	235.91	235.8	235.68	1.07

Table 2

Mass differences (actual wear) after each test hour:

Knife type	Wear at a time interval in dry sand (grams)								
	Initial	After 1 hour	After 2 hours	After 3 hours	After 4 hours	After 5 hours	After 6 hours	After 7 hours	After 8 hours
OLC 45	0.36	0.19	0.14	0.25	0.43	0.29	0.26	0.2	2.12
OLC 45 heat-treated	0.37	0.21	0.21	0.13	0.16	0.13	0.15	0.11	1.47
OL 50	0.12	0.08	0.17	0.14	0.19	0.14	0.11	0.12	1.07

Figure 6 shows the evolution of the wear of the 3 chisel knives before and after the 8 hours of testing.

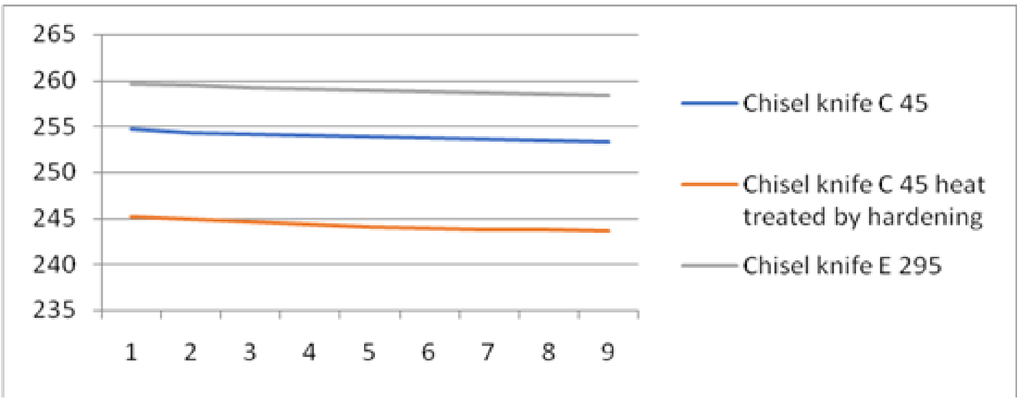

Fig. 6 - Evolution of the wear of the 3 chisel knives

Plotting the regression line of the experimental data can be seen in Figure 7, for our data choosing a polynomial distribution. It is also represented the evolution of the increase in wear degree of the 3 chisel knives, in the 8 hours of operation. Thus, it can be seen that the chisel knife made of E295 suffered less wear during the entire period of operation, followed by the chisel knife made of C 45 heat treated by hardening, while the chisel knife made of C 45 suffered the biggest wear.

It can also be seen that the chisel knives suffered the highest degree of wear in the first hours of operation, after which the degree of wear decreases.

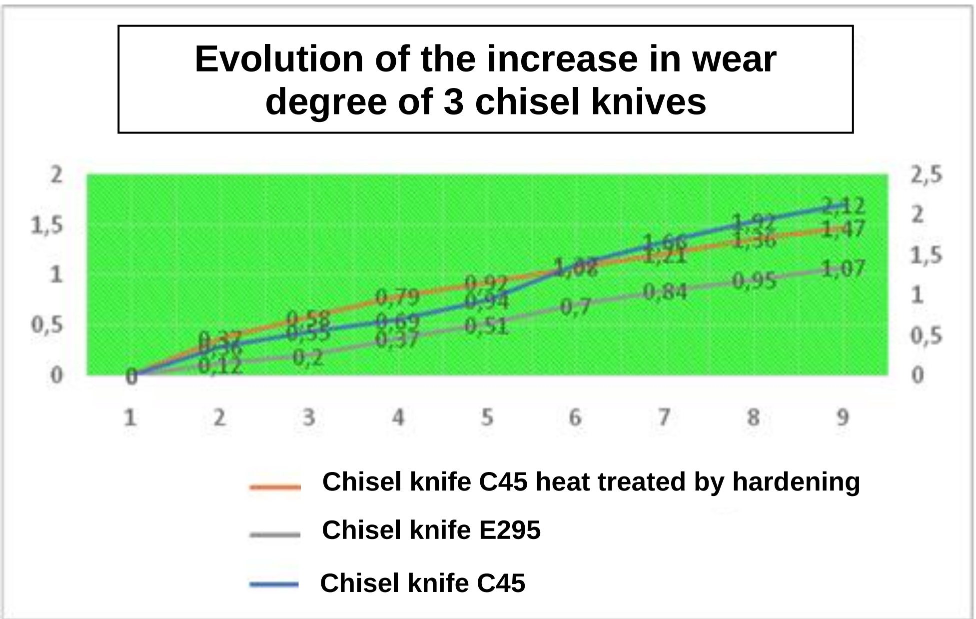

Fig. 7 - Evolution of the increase of the wear degree of the 3 chisel knives

CONCLUSIONS

Mechanical soil working is a complex process that requires high energy and material consumption because of soil resistance to breakage and intense abrasive wear of chisel knives.

Following the tests of these chisel knives, for 8 hours each, it resulted that the E295 chisel knife suffered less wear, followed by the chisel knife made of C 45 heat treated by hardening. The chisel knife made of C 45 suffered the biggest wear.

It is important to continue the research to estimate the average operating time of the chisel knives for working the soil and to establish the appropriate maintenance intervals.

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