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STUDY ON THE INTERACTION BETWEEN A CHISEL WORK ORGAN AND SOIL

Ion Măruнțelu [1], **Florean Rus**[1]
[1] Transilvania University of Brasov, ROMANIA, ion.maruntelu@unitbv.ro

Abstract: *Soil cultivation plays an essential role and the development of the plants depends on its quality. Soil treatment processes have evolved over time and the beneficial effect of soil treatment has been recognized since ancient times due to its influence on the physical-chemical and biological properties of the soil, resulting an increase in the percentage of pores in the soil, allowing for a better penetration of the roots plants.*
Keywords: *interaction, soil processing, work organ, load, friction force*

1.INTRODUCTION

This study presents an analysis of the interaction between the soil and the work organs of some types of soil-working machines.
Soil is one of most crucial factors for life on Earth. For the farmers, the soil in considered the medium and environment for plant roots. The soil nutrients, water and air have to be suitable form and amount as well as all other properties (soil temperature, soil mechanical properties).
Soil also presents the important building material and the foundation for various structures in civil engineering.
Through the soil processing process, the dynamic exchange of gas in the soil is promoted, oxidation processes are favored, a better absorption of nutrients takes place, humus formation throughout the soil structure and are conducted to depths of the soil surface substances harmful to plants.
At different types of soil, the effect of soil processing is influenced by a multitude of factors. Even at the same soil type, the working process is significantly influenced by soil condition (water content, subsequent processing, etc.)
Through the soil works there have to be realized a layer of plants, in which the plants can find optimal conditions for growth and development. In such a soil, the roots develop more and penetrate more easily into the soil, especially in the first phase of vegetation. As a result, favorable conditions are created for the accumulation and retention of large amounts of water in the soil in the dry regions, and in wetter areas it contributes to deep drainage, so as to avoid excess moisture in the arable layer.
Soil treatment also influences chemical properties by increasing the action of factors that contribute to the processes of mineral alteration and the decomposition of organic matter.
The working process of a chisel work piece is similar to the "sticking" in the ground of a pillar under the action of a static load. As a result, the analysis of forces acting on the work organ is similar to an undetermined static pillar, and the exact analysis is more distant than most of the problems encountered in soil mechanics.
The resistance to ground penetration of the work piece cannot be accurately calculated. Soil structures are different and the physical state constantly changes under the action of climatic elements. Numerous researchers have dealt with soil cutting studies. The empirical or semi-empirical conclusions drawn by them can be used to build tools and to choose their parameters.

2. TASKS THAT WORKON THE WORK ORGAN WHEN IT ENTERS THE GROUND

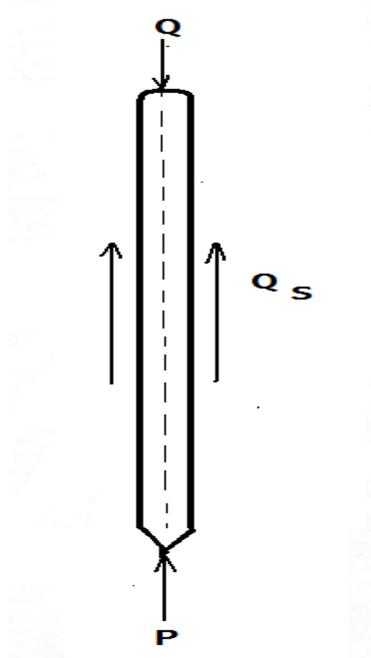

Figure 1: Axial tasks on theworking organ.

The workload applied to the working organ when entering the soil opposes the resistance of the soil under the top of the working organ and the lateral rubbing between the working organ and the soil. Thus, the force of pressing on the working body is determined with the relation:

$$Q = P + Q_S \tag{1}$$

Where , P - resistance to soil

Qs – axial friction

$$P = A_p(\Delta q_s)_u = A_p(cN_c + \frac{\gamma B}{2} N\gamma + \gamma dNq) \tag{2}$$

$$Q_S = \sum(\Delta L)(a_s)(s_s) \tag{3}$$

Where, Ap= area of the working body section

$(\Delta q_s)_u$ = carrying capacity

ΔL = elongation of the working organ

a_s= the area of the elongated surface in contact with the ground

s_s= axial soil resistance

γ = the unit weight of the soil

d=the depth of penetration of the working organ

B = the diameter of the work-piece section

c= medium resistance (cohesion)

Nc,Nγ,Nq= dimensionless factors that depend on the ground friction angle

On sandy soils, because cohesion is zero, relation (2) becomes:

$$P = A_p(\frac{\gamma B}{2} N\gamma + \gamma dN_q) \tag{4}$$

Because the term $\frac{\gamma B}{2} N\gamma$ is small compared to γdN_q , the equation (4) becomes:

$$P = A_p(\gamma dN_q) \tag{5}$$

yd is denoted by σ and the relation (5) becomes:

$$P = A_p \, \sigma \, N_q \tag{6}$$

The axial load will be:

$$Q = A_p\, \sigma\, N_q + \sum(\Delta L)(a_s)(s_s) \tag{7}$$

On soils with high cohesion:

$$P = A_p(cN_C + \sigma N_q) \tag{8}$$

In this case the axial load becomes:

$$Q = A_p(cN_C + \sigma N_q) + \sum(\Delta L)(a_s)(s_s) \tag{9}$$

3. RESISTANCE TO CHISEL KNIFE MOVEMENT IN SOIL

The vertical knife chisel type is a wedge-type work piece. The resistance of the feather according to Gorjatschkin consists of three forces:

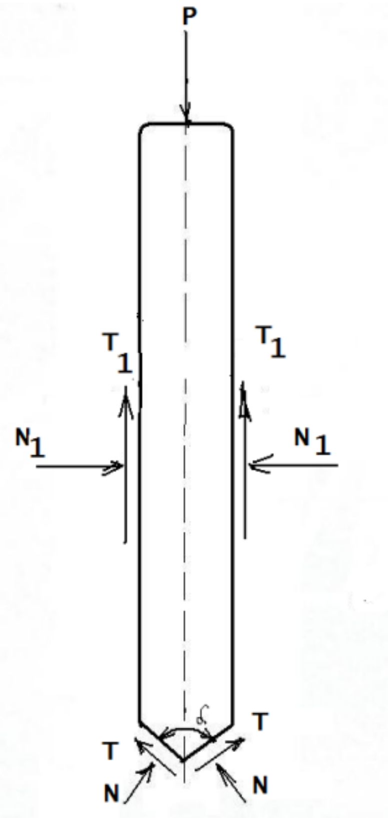

Figure 2: The forces that act on the working body

$$P = P_1 + P_2 + P_3 \tag{10}$$

P1 = the normal force component N in the direction of cutting the soil due to the pressure exerted on the feather surface

P2 = the component in the direction of cutting of the frictional force resulting from the effect of the normal force (T=μN)

P3 = the component due to the friction resulting from the N1 soil pressure on the side of the knife

$$P = 2N\sin\frac{\alpha}{2} + 2\mu N\cos\frac{\alpha}{2} + 2\mu N_1 \tag{11}$$

Forces N and N1 are proportional to the surface of the feather, respectively the side surface of the knife.

$$N = k_1 F_1 \text{ and } N_1 = k_2 F_2 \tag{12}$$

Where, k_1 = specific resistance to soil displacement

F_1 = the surface of the feather

k_2 = specific soil resistance on the lateral area

F_2 = side surface

Entering the expressions (12) in equation (11), the resistance to advancement is determined with the relation:

$$P = 2k_1F_1\sin\frac{\alpha}{2} + 2\mu k_1F_1\cos\frac{\alpha}{2} + 2\mu k_2F_2 \tag{13}$$

The factors k_1 and k_2 do not have fixed values but it changes once with the soil deformation process. The soil deformation values for determining factors k_1 and k_2 are:

$$l_1 = \frac{s}{4\cos(\frac{\alpha}{2}+\varphi)} \tag{14}$$

$$l_2 = \frac{s}{2\cos(\frac{\alpha}{2}+\varphi)} \tag{15}$$

Where, s - body hardness;
φ – arctg μ.

According to equations (14) and (15) the deformation of the soil at the constant width of the working organs depends on the angle a. The behavior of the components P1 and P2 according to the angle a, is shown in figure 3.

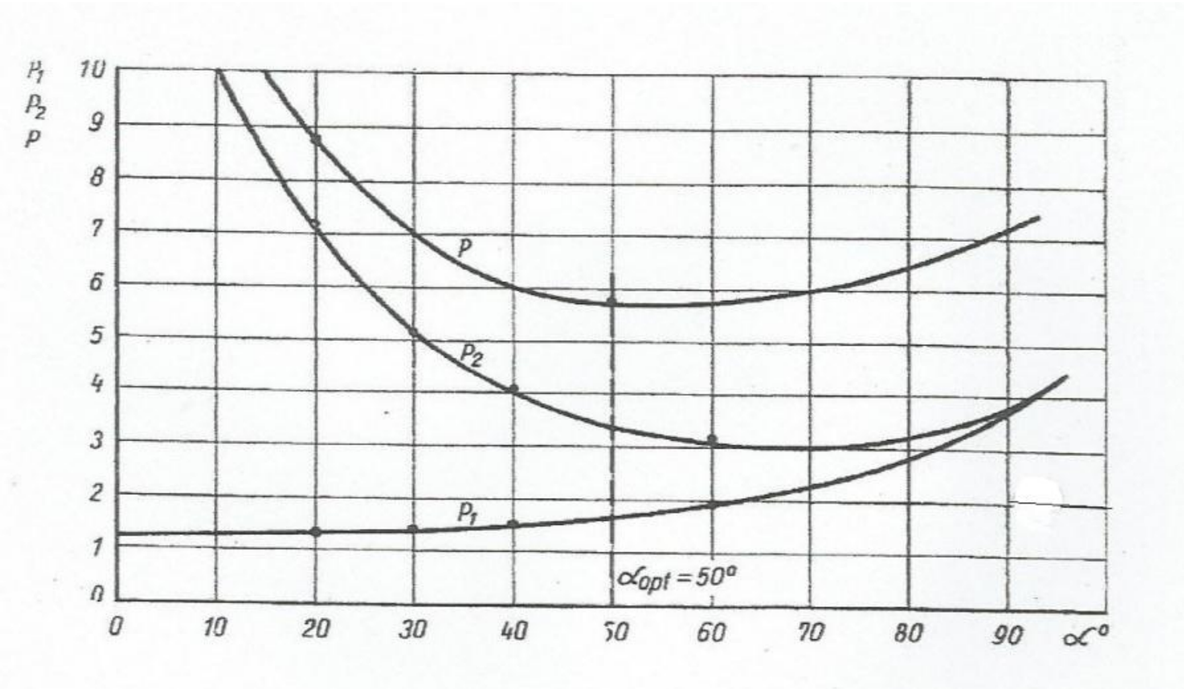

Figure 3: The resistance to soil cutting according to angle α

4. CONCLUSIONS

- The resistance to soil penetration of the work-piece depends on the soil type, its texture, moisture, friction with the soil.
- The optimum value of the angle from the top of the work-piece of 40°-50° determines the minimum resistance to soil penetration.
- The values of the resistance forces can influence the shape of the working organs and their geometric parameters.
- The geometric dimensions of the work organs influence the value of the traction force and implicitly the energy consumption
- A curved form of working organs is more efficient. Following the experiments, the traction force in curved work organs is about 12-15% less than traction force for straight works organs.

REFERENCES

[1]Balaton,J., Untersuchung des Zugkrafbedarps der Untergrundlockerer, Budapest,1971
[2]Lambe,T.W., Whitman,R.V., Soil Mechanics, New Yorg, John Wileg and Sans Ino, 1969
[3]McKeys, E., Soil cutting and tillage, Elseviei, Amsterdam,1985