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COMPUTER SIMULATION TO VISUALIZE THE RESULTS OF SOIL TILLAGE WITH DISC HARROW

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Abstract

The disc harrow is the basic machine for shredding soil. It loosens, smooths and mixes the top layer of soil during shredding. It also chops and incorporates weeds and stalk residues into the soil. In this paper, we will explore the factors that influence the operation process of the disc harrow and apply them to the Bomet BTP 4×6 disc harrow. A body model of the Bomet BTP 4×6 disc harrow is prepared and the results of its operation process are simulated in three different operating situations.

Keywords: *disc harrow, computer simulation, operation process.*

1. Introduction: Overview of the Disc Harrow

The disc harrow is a widely used implement in soil shredding and tillage operations. In addition to shredding the soil, it also loosens, levels, and partially mixes the upper soil layer, making it a viable alternative to traditional ploughing in certain cases **[1]**.

The main working elements of the disc harrow (**Figure 1**) are the disc blades, which can feature either smooth or cutout edges. These disc blades are mounted on a common axle, separated by spacer sleeves to maintain consistent spacing. A set of disc blades mounted on the same axle forms a disc battery, which is attached to the frame of the implement.

Fig. 1. *Construction of the Bomet BTP 4×6 Disc Harrow.*

Based on the configuration of these disc batteries, disc harrows can be categorized into V-shaped or X-shaped configurations.

The disc harrow is considered a semi-active tillage implement: during operation, the disc blades rotate relative to the frame during the work machine is towed. The axis of the disc battery is typically set at an angle of attack γ relative to the direction of travel **Figure 2.a**. As the machine is towed, the disc blades mounted on the axle rotate and continuously cut into the soil **Figure 2.b**. The soil clods are lifted along the inner surface of the disc blades and subsequently fall back to the ground. This process results in the fragmentation, loosening, mixing, and slight turning of the soil. The worked soil is also displaced laterally.

As a consequence of the disc harrow's operation, the bottom of the tilled soil is not uniform; a ridge forms between the disc blades, which may even be detectable at the surface (**Figures 2.b, 2.c**).

Requirements for the disc harrow's working process:

- The worked soil surface should be even, with no untilled strips remaining **[2]**;
- The furrow bottom should be as smooth as possible, and the height of the formed ridge should be minimized **[2, 3]**;
- The disc blades should effectively chop and incorporate crop residues and stubble into the soil **[4]**.

To meet these requirements, the second disc battery is offset relative to the first, so the rear disc blades work between the areas already cultivated by the front battery, **Figure 2.**

The disc blades mounted on the second battery return the soil displaced to the sides.

Effective fragmentation is achieved by cut-out-edge disc blades, typically mounted on the front battery.

The working process of the machine is rapid, making field observation and evaluation challenging.

To better understand the disc harrow's operation, we aim to visualize the process through computer simulation in this paper.

2. Computer Simulation of the Operation Process of the Disc Harrow

Methodology:

- A solid model of the Bomet BTP 4x6 disc harrow, located at the machine yard of Sapientia Hungarian University of Transylvania, Faculty of Târgu Mureș, is created.
- The key factors that characterize the working process of the disc harrow are identified.
- The working process is simulated using real operational data.
- The relationships between the key characteristics and the working process are analyzed.

2.1. Solid Model of the Bomet BTP 4×6 Disc Harrow

The Bomet BTP 4×6 2,2m disc harrow is equipped with four batteries **Figure 1.** These batteries are arranged in an X-configuration, with each battery consisting of six disc blades.

The diameter of the disc blades is Φ 460 mm, and the spacing between the blades is 172 mm. The working width of the machine is 2200 mm, and its total mass is 615 kg **[5]**.

Figure 3 shows the solid model of two consecutive disc batteries, both depicted with smooth-edged disc blades.

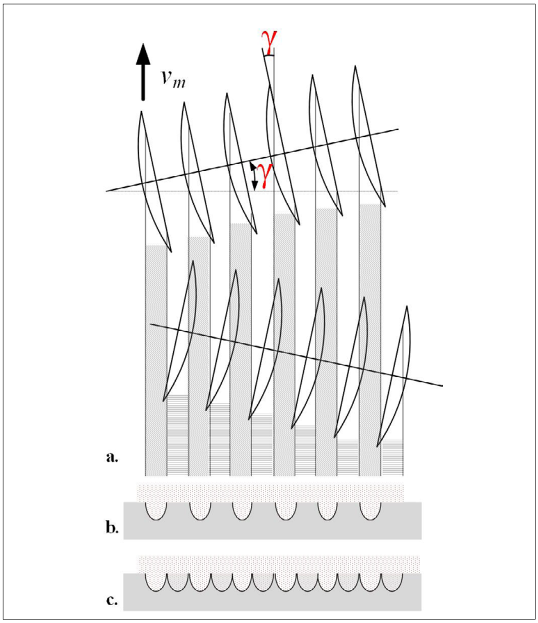

Fig. 2. *Operation process of disc harrows: a – on the soil surface; b – at the furrow bottom after the first disc battery; c – along the furrow bottom after the disc blades operating in staggered alignment.*

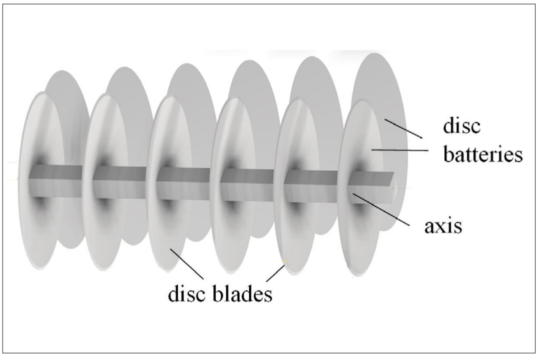

Fig. 3. *Solid Model of the Disc Harrow Batteries.*

2.2. Factors Characterizing the Operation Process of the Disc Harrow

Figure 4 illustrates the cross-sectional profile of the soil worked by two adjacent disc blades, along with the corresponding geometrical parameters of the blades.

The working process requirements of the disc harrow, such as the absence of untilled strips, uniformity of the furrow bottom, the cross- section of the cultivated soil and the ridge height, can be assessed based on these factors.

The relationship for the cultivated soil cross-section S_d is described in [3]:

$$S_d = 2(a-c)\sin\gamma\sqrt{c(D-c)} + \frac{1}{8}D^2(\varphi_c - \sin\varphi_c)\sin\gamma \;[mm^2], \quad (1)$$

where: a is the working depth [mm]; c is the height of the unworked soil ridge [mm]; γ is the attack angle of the disc battery [°]; φ_c is the theoretical central angle corresponding to the disc blade ridge height [°].

The relationship for the theoretical central angle corresponding to the ridge height on the disc blade is given in [3]:

$$\varphi_c = 2\,acos\left(1-\frac{2c}{D}\right). \quad (2)$$

The relationship between the ridge height and the geometrical characteristics of the disc harrow is given in [4]:

$$b = 2\tan\gamma\sqrt{c(D-c)}, \quad (3)$$

where: b is the distance between adjacent disc blades working side by side [mm].

Based on the (1), (2), and (3) relationships, the working process of the disc harrow is influenced by:

– the working depth;
– the attack angle γ of the disc blades.

2.3. Simulation of the Operation Process of the Disc Batteries

The four batteries of the Bomet BTP 4×6 2,2m disc harrow are symmetrically arranged, so the simulation is performed only for two consecutive disc batteries.

The disc batteries of the Bomet BTP 4×6 2,2 m disc harrow can be set to attack angles of γ = 12°/15°/17° [5].

The working depth of the disc blades depends on the weight force applied to the blades, which can be adjusted by adding supplementary weight. The simulations are carried out for working depths of a=60 mm, a=90 mm, and a=120 mm.

Three simulations were performed, based on the data in Table 1. Nine isometric views were prepared for illustration, six of which are shown in the paper.

Table 1. *Operational Parameters of the Simulations*

Simulation	γ [°]	a [mm]
First	12	60
Second	15	90
Third	17	120

The computer simulations were performed using the continuous remeshing extraction method [6]. The removed soil is not returned to the surface, allowing for the observation of the unworked ridge peaks and the furrow bottom. The simulation can also be recorded as a moving image.

During the simulations, the effects of the disc battery 's attack angle and working depth on the cross-section of the cultivated soil and the uniformity of the furrow bottom are observed.

The first simulation is shown in Figure 5.

In Figure 5 it is clearly visible that there are unworked areas and strips on the soil surface.

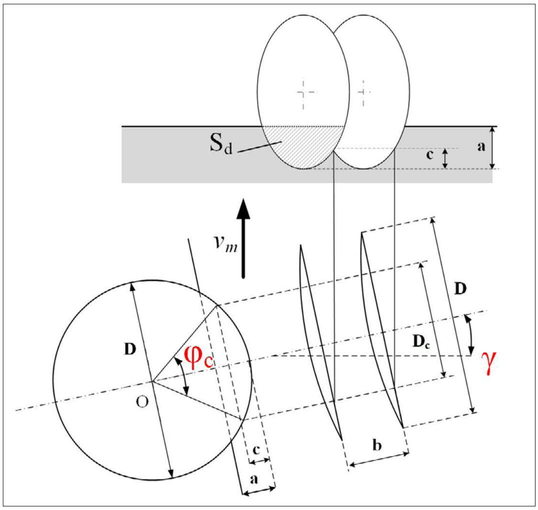

Fig. 4. *Geometry and Kinematics of the Disc Blades.*

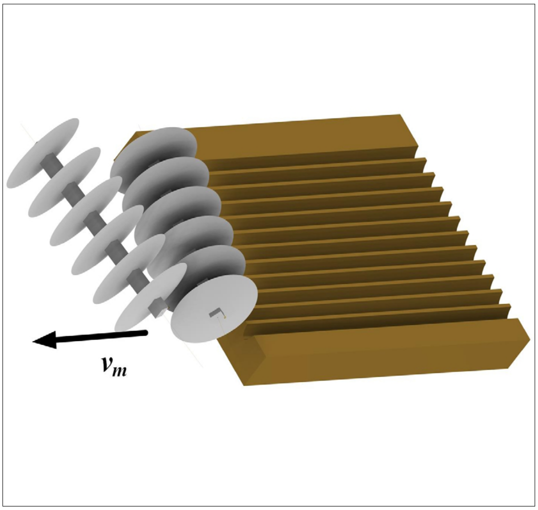

Fig. 5. *The First simulation, γ = 12°, a = 60 mm.*

The second simulation is shown in **Figure 6**. This simulation was performed with a larger attack angle and working depth, improving the soil processing. There are no unworked strips on the surface, but the furrow bottom is still quite uneven.

The third simulation is shown in **Figure 7.**

The third simulation was performed with the largest attack angle and working depth. The ridge height is smaller than the working depth, meaning the formed ridge peaks are not visible on the surface.

The results of the working process with the three different angle settings and working depths are illustrated in **Figure 8.**

The computer simulations clearly show that increasing the attack angle of the disc battery and the working depth results in a larger cultivated soil cross-section, as expected from the (1) relationship.

A larger attack angle leads to a more uniform formation of the furrow bottom.

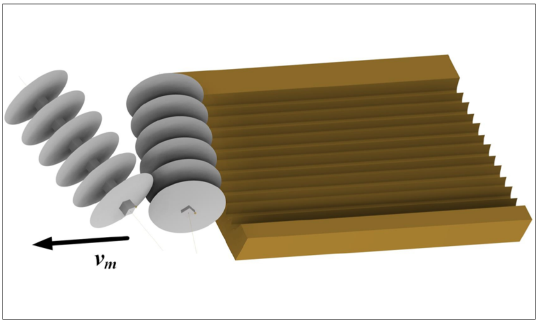

Fig. 6. *The Second simulation, γ = 15°, a = 90 mm.*

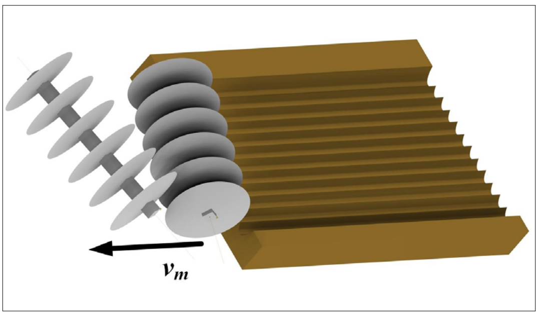

Fig. 7. *The Third simulation, γ = 17°, a = 120 mm.*

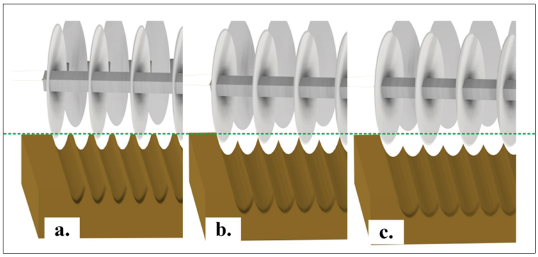

Fig. 8. *Illustration of the Cross-Section of the Worked Soil and the Ridge Peak Height: a) γ = 12°, a = 60 mm; b) γ = 15°, a = 90 mm; c) γ = 17°, a = 120 mm*

3. Conclusion

The simulation of the disc harrow's working process, implemented with real operational data, clearly illustrates the phenomenon and confirms that adding counterweights to the disc harrow or increasing the attack angle of the disc batteries is necessary to achieve a uniformly cultivated seedbed.

References

[1] Vlăduț N.-V., Atanasov A., Ungureanu N., Ivașcu L.V., Cioca L.-I., Popa L.-D., Matei Gh., Boruz S., Cerempei V., Țîței V., Nenciu F., Milea O.-E., Dumitru Ș., Caba I.: *Trends in the Development of Conservation. Ecological Agriculture in the Context of Current Climate Change – A Review*. INMATEH - Agricultural Engineering, 74/3. (2024) 980–1032. https://doi.org/10.35633/inmateh-74-86

[2] Qiu Y., Chen Z., Hou Z., Liu H., Gu F., Dai N.: *Investigation on Data Collection and Fractal Characteristics of Soil Surface Roughness.* INMATEH - Agricultural Engineering, 61/2. (2020) 135–142. https://doi.org/10.35633/inmateh-61-15

[3] Căproiu Ș., Scripnic V., Ros V., Babiciu P., Ciubotaru C.: *Mașini agricole de lucrat solul, semănat și întreținere a culturilor*. Ed. Didactică și Pedagogică, București, 1982, 202–209.

[4] Naghiu A., Baraldi G., Naghiu L.: *Mașini și instalații agricole.* Risoprint Kiadó, Kolozsvár, 2004, 150,168.

[5] https://www.dianatrans.ro/utilaje-agricole-noi/discuri-trase--65/disc-btp--724.htm (letöltve 2025.02.28.)

[6] Tolvaly-Roșca F., Pásztor J.: *Work Process Analysis of the Machines with Working Parts Entrained in Seedbed Preparation Works.* INMATEH-Agricultural Engineering, 58/2. (2019) 2068–2239. https://doi.org/10.35633/INMATEH-58-01