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Investigation of the regularity of movement of furrow slice at tillage with a plough with ripping moldboard

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ABSTRACT

The theory of the analysis of kinematic behaviour of the movement of furrow slice ripped by plough hulls on the example of ripping mouldboard has been developed. Working out the equation of surface of the mouldboard and using the analytical dependencies of the relative and absolute motion trajectories of the blade movement the mathematical models are received describing the patterns of motion of soil particles, at tillage with hulls with mouldboards of ripping type.

The received equations of absolute trajectory of the movement of the furrow slice allows to make the technological assessment of tillage and the equation of relative trajectory establishes the necessary conditions of the movement of furrow slice along the mouldboard with sliding and gives opportunity to reduce largely the traction resistance of plough frame. The practical significance of the developed theory is that given the substantiated function of the change of angle $\gamma(z)$ and the shape of the directing curve it is possible to create a perfect, from the viewpoint of the least tractive effort, croplands equipment in the design stage.

Introduction

The kinematics of the furrow slice depends on the properties and conditions of the cultivated environment, such as the mouldboard, its geometric shape and parameters [1–3]. This is proved by the results of a number of experimental studies.

However, comprehensive theoretical analysis of the tillage process by different types of mouldboardsurfaces has not been carried out yet. In particular, this refers to the theory of calculating of the functional dependences of the absolute and relative trajectories of the ripping mouldboard on the geometric shape of the surface and the parameters of plough mouldboards.

This problem was considered in general by Academician V.P. Goryachkin [4,5] for plough surfaces and partially by Sh. M. Grigorian for the working surfaces of mouldboard furrow shapers [2].

The particulars versions of this issue are so far solved on the basis of the results of the tests of the experimental hulls. For each type, from cylindrical mouldboards, are set the chart of the directing curve and the regularity of the change of angle γalong the height of the hull, on the basis of which projects and mouldboards are made [6].

In none of the scientific and technical literature known to us, a specific task has been considered to establish the relative and absolute trajectories of the formation under the influence of the mouldboard.

The lack of the design theory in the discussed field has led to the fact that the development of soil-cultivating machines of a new generation is preceded by the forced manufacture of a number of experimental examples of ploughs and their continuous testing.

The existence of mathematical models of the working surfaces of soil-cultivating machines, developed according to the specified technological parameters of ripping and directional movement of the furrow slice, will make it possible to ensure the creation of perfect soil-cultivating machines at the stage of their design [3].

The authors of this work set the goal to fill the gap of this problem to some extent.

Methodology

In this paper, we consider the methodology for solving the problems of technological assessment of the movement of the particles with sliding along the entire surface of the mouldboard using the example of general-purpose ploughs with ripping mouldboards.

Using the methodology by Goryachkin for compiling the equation of the surface of the mouldboard in general [4], we established mathematical models of directing curve and regularities of the change of the angle γ by the height of the hull of the ripping mouldboard.

By profiling the surface of the ripping mouldboard on Goryachkin's

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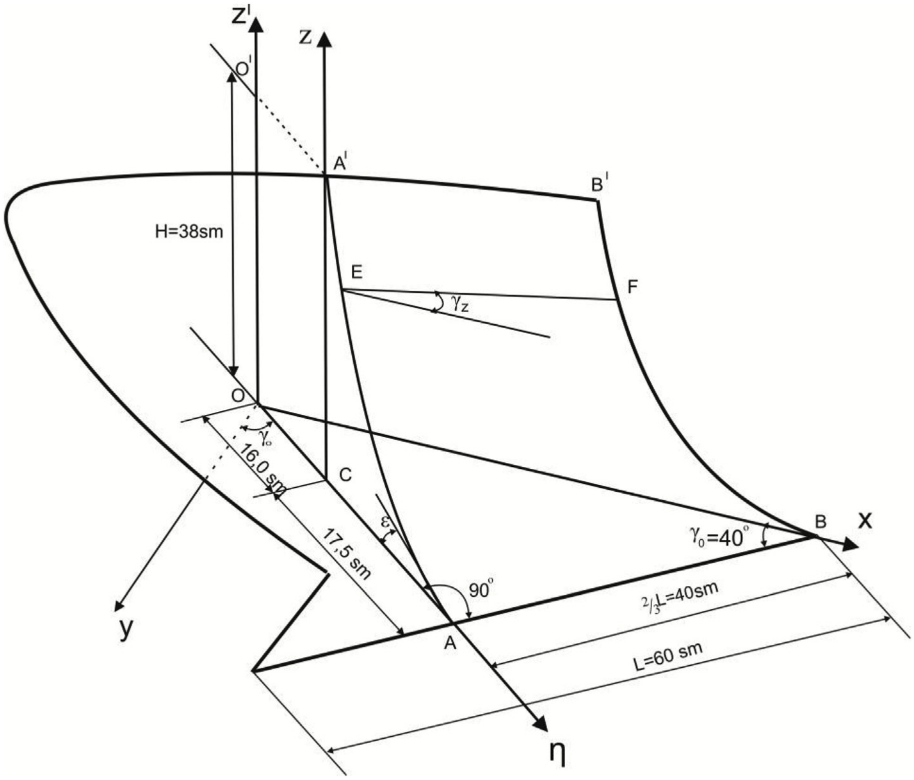

Fig. 1. Common view of the Ripping Moulboard with the Directing Curve AA′.

profilograph, we recorded the true geometric shape of the directing curve (Fig. 2).

After the mathematical development of the profilogram the following equation of directing curve was obtained (Fig. 2):

$$\eta(z) = 0.523\frac{(H - z)^3}{H^2} - 0.073(H - z) + 16.4. \qquad (1)$$

For drawing up the equation of the surface of the ripping mouldboard let's establish the equation of the regularities of the change of angle γ of the constituent line along the height of the mouldboard (EF Fig. 1).

Using the methodology of designing plough surfaces [7] let's define the function $\gamma = \varphi(z)$ for the ripping mouldboard.

According to our records the following parameters of the ripping mouldboard were established: at the height of $z_1 = 5$ cm, minimum value of angle $\gamma_{min} = 39°$, at the height of $z_n = 38$ cm $\gamma_n = 46°$; length of the ploughshare L = 60 cm, the angle of ploughshare installation (cutting angle) $\varepsilon = 30°$; the regularity of change of angle γ within $\gamma_0 - \gamma_{min}$, rectilinear, within $\gamma_n - \gamma_{min} = 7°$, is changed by the equation of parabola:

$$y = \frac{6.2x^2}{100 + x^2}. \qquad (2)$$

Let's go to the definition of intermediate values of angle γ within γ_0 to γ_{min} and from γ_{min} to γ_n.

Dividing the variation limit $\gamma_0 - \gamma_{min}$ into 3 intervals we will obtain:

$$\frac{\gamma_0 - \gamma_{min}}{3} = \frac{40 - 39}{3} = 20',$$

Then we will have:

$$z = 0; \quad 2.5; 5\text{cm},$$

$$\gamma = 39°; \quad 38°30'; \quad 38°.$$

For the branches of parabola we will accept the change interval z by 5 cm. The value γ_n will be defined by the parabola equation for

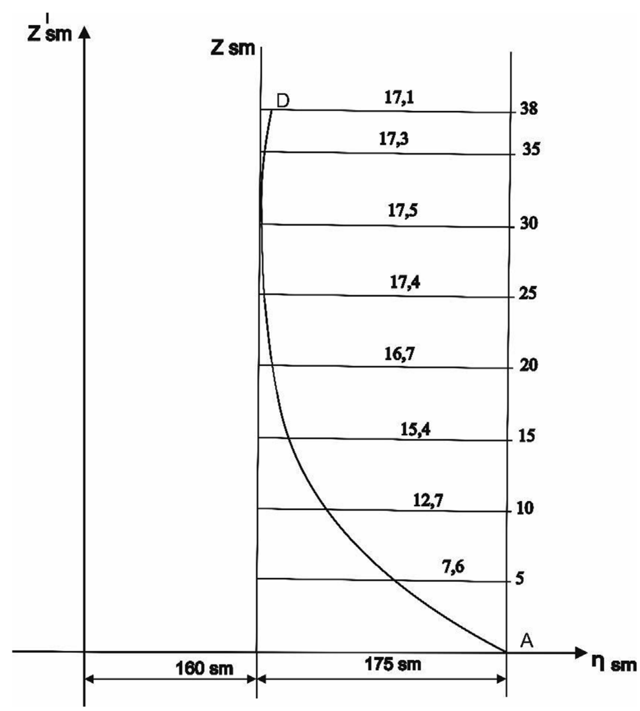

Fig. 2. Graphical view of the AD directing curve of the ripping mouldboard.

$$x_n = z_n - z_1 = 38 - 5 = 33\ cm:$$

$$y_n = \frac{6.2 \cdot 33^2}{100 + 33^2} = 5.68\text{cm}.$$

So, the scale for the value γ_n will be:

$$\lambda = \frac{\gamma_n - \gamma_{min}}{y_n} = \frac{46 - 39}{5.68} = 1.232\ deg/cm.$$