CONSIDERATIONS ON ROLLING RESISTANCE OF MACHINERIES FOR SEEDBED PREPARATION

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ABSTRACT

The paper presents considerations on traction resistance of machineries for seedbed preparation based on several references and making observations on forces that are involved and their interdependencies during the working process.

MATERIAL AND METHOD

Within the paper there are made some considerations on the traction resistance of machineries designated for seedbed preparation and, generally, of all machineries for tillage including ploughs. The alleged idea is an innovative one in relation with the studied bibliography. The exposed point of view starts from two sources. The first one is represented by studied bibliography that approaches the optimization of energetically aspect of machinery aggregate [1], [3], [4], [7], [9] that introduces dependencies of rolling resistance of second degree of forward movement in order to find optimal points in strict sense for machinery designated for tillage. The introduction of these terms is made in friction forces with the soil or the composite material with vegetal material (stubble). The second source is constituted by [2] that largely analyses the rolling resistance force, both theoretical and experimental being among few sources that affirms the presence of second degree terms within the calculus formula of rolling resistance. There are not linear laws for rolling resistance force of machineries that are structured as friction forces and resistance to deformation of soil. These generalizations are common in the physics of movement of things in air, for instance [14].

Our comments and solutions are little linked to the first source where the introduction of second degree terms is not motivated but by the aim of obtaining optimal points in strict sense (by cancellation of derivative of first order of some functions or by calculus of some problems of extremes with links) and they are intimate linked to the profound structure of the proposed rolling resistance in [2] and accepted in majority of specialty literature. The solidity of affirmations in [2] is based on experimental facts that are mentioned by the author. Nevertheless, in [2] there are present a little inadvertence between the analytical structure of the rolling resistance formula (formula 24'') that is re written below in terms of this paper:

$$F_t = (\mu G_m + kab) + \varepsilon\rho abv^2 , \qquad (1)$$

as well as the graphic representation from figure 64 from the same source [2]. The author [2] mentions that „ formula (24'') shows that by varying the speed and maintaining the other factors constant, the needed force of traction increases after a parabolic model. Multiple determinations of the needed traction force made by Goreacikin confirms in principle this situation, too, as shown by data presented in figure 64 where there is shown the variation of P force in function of speed, with the case when there was plowed at the same depth a field with specific resistance (k) that is constant at different speeds. There is true that this increase is low enough, which indicates a low value of the last term of (24'') relation as compared with the values of other terms.

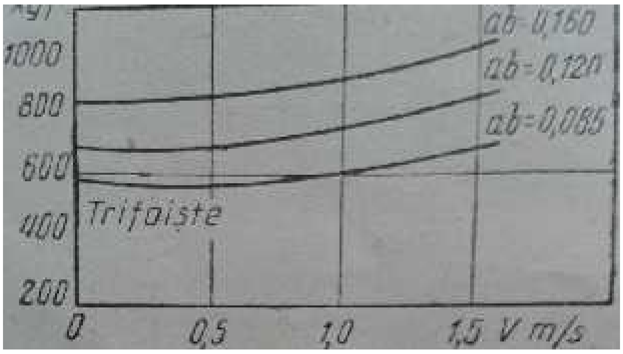

Fig. 1 The diagram of dependency between rolling resistance and the working speed, after [2].

The low inadvertence mentioned above, between formula (6.10), respectively (24'') from [2] and the diagram from figure 64 from the same [2] consists of the fact that some parabolas from graphic representation have the minimal point for a positive speed while the (1) formula has the minimal point exactly for the nil value of the speed. As a result, (1) formula of rolling resistance force is susceptible to improvements if data from figure 1 represents experimental values.

As inspiration source for improving formula [2] it seems, at least an important solution, a suggestion that comes from the domain of study of friction source from source [12].

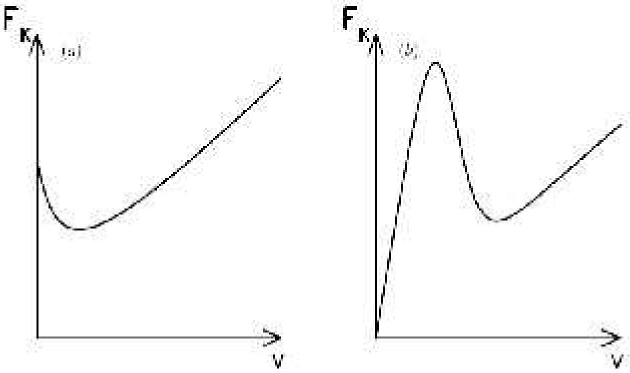

Figure 2 The schematic dependency between friction force and rolling speed, after [12].

The schematic dependency between friction force and the rolling speed appears in [12] and they are made after this paper in figure 2.

The novelty thing that will be made in this paper is the generalization of dependency between the working speed and friction force of wheels (written in [12]) as well as with coeficient of resistance to soil deformation that, in this way, becomes a function of rolling speed of working device in the soil.

As a result, there are proposed the following formulas of dependency between the friction coefficients:

$$f(v) = f_0 + f_1 v + f_2 v^2, \mu(v) = \mu_0 + \mu_1 v + \mu_2 v^2, \quad (2)$$

Respectively, for the coefficint of resistance to soil deformation:

$$k(v) = k_0 + k_1 v + k_2 v^2. \quad (3)$$

The coefficients of square functions (2) and (3) are linked by the points from diagram and they become:

$$f(v) = f_0 + 2\frac{f_1 - f_0}{v_f}v + \frac{f_0 - f_1}{v_f^2}v^2,$$
$$\mu(v) = \mu_0 + 2\frac{\mu_1 - \mu_0}{v_\mu}v + \frac{\mu_0 - \mu_1}{v_\mu^2}v^2, \tag{4}$$
$$k(v) = k_0 + 2\frac{k_1 - k_0}{v_k}v + \frac{k_0 - k_1}{v_k^2}v^2$$

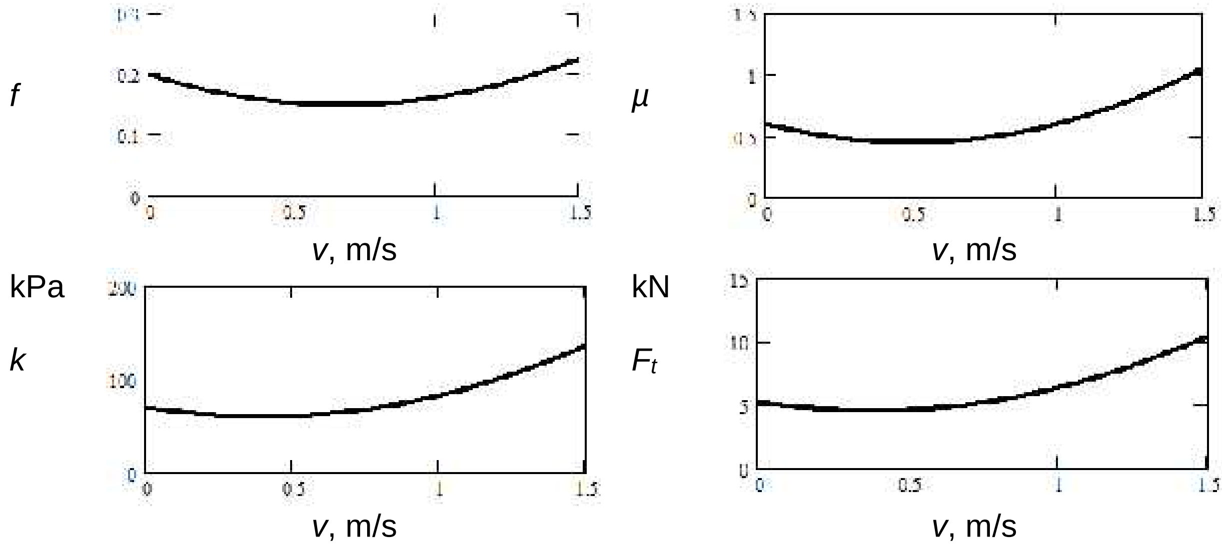

Figure 3 The variations with the speed of friction coefficients, resistance coefficient to deformation and of resistance force to traction.

With relations (4) the general form of the traction resistance (pulling force) of a seedbed preparation or tillage machinery, generally, becomes:

$$F_t(v) = \mu(v)G_m + k(v)ab + \varepsilon\rho abv^2\,. \tag{5}$$

or, unfolding the relations from (4):

$$F_t(v) = \mu_0 G_m + k_0 ab + 2\left(\frac{\mu_1 - \mu_0}{v_\mu}G_m + \frac{k_1 - k_0}{v_k}ab\right)v + \left(\frac{\mu_0 - \mu_1}{v_\mu^2}G_m + \frac{k_0 - k_1}{v_k^2}ab + \varepsilon\rho ab\right)v^2 \tag{6}$$

Similarly, adding to (6) the force needed to tractor self-propulsion, there is obtained the total force consumed by the tractor for pulling the machinery:

$$F_T(v) = f_0 G_t + \mu_0 G_m + k_0 ab + 2\left(\frac{f_1 - f_0}{v_f}G_t + \frac{\mu_1 - \mu_0}{v_\mu}G_m + \frac{k_1 - k_0}{v_k}ab\right)v + \left(\frac{f_0 - f_1}{v_f^2}G_t + \frac{\mu_0 - \mu_1}{v_\mu^2}G_m + \frac{k_0 - k_1}{v_k^2}ab + \varepsilon\rho ab\right)v^2 \,. \tag{7}$$

If the speeds of points of minimum of the three coefficients in function of v variable are very high, even though the equalities mentioned above do not take place yet the respective differences are negligible in relation to the speeds of minimum points, the law (7) is reduced to (1).

CONCLUSION

There can be proposed the hypothesis that all, or a part of involved coefficients in the definition of functions (2) – (4) can depend by other characteristics of the soil: moisture, chemical composition, gravel and sand content, etc.

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