CRITICAL ANALYSIS OF THE OPERATION OF A TILLER

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Abstract: *The following work focuses on a tiller with maximum power of 6.5hp and aggregated machines. The processes of soil milling, plowing, cultivation and subsoiling were studied. Force and power characteristics were measured. The results show good functionality of the tiller and significant disadvantages of the aggregate. Changes in the construction are required.*
KEYWORDS: *TILLER, AGRICULTURAL AGGREGATE, PLOWING, PLOWING FORCES.*

INTRODUCTION

In the last decades, a variety of small-scale equipment is available on the market, designed for a wide range of soil and agriculture activities. The small variants of these aggregates (for areas up to several acres) are based exclusively on a motor block with aggregate machines.

In the literature, the term "motor block" is known to be part of the wider concept of "one-axle drawbar", which is a self-propelled wheeled machine designed to tow a variety of semi-trailed self-propelled machinery and equipment.

This variation of aggregation brings many advantages associated with a lot of functionality, manageability, simplicity of construction, stability, but there are also disadvantages such as the inability to function without an aggregate machine, such as poor bending stability, complicated aggregation,

The area of application of the motor block varies from the cultivation processes: milling, cultivation, plowing, grooving, harvesting of root crops, mowing with knife- or disc apparatuses; carrying goods with a trailer; snow cleaning with rotor or paddle aggregates to construction of all kinds of devices at home.

EXPOSITION

The subject of the present work is the HSD1G-75 motor block, with a maximum power of 6.5 hp at 3000 rpm, a passport mass of 73 kg and two forward and one rear speeds.

Steel and rubber coupling wheels are attached to the unit. To motor block aggregated: milling drums (up to 1 m in width), plows, row cultivators, grooves, potato mowers and subsoiling.

The aim of the study is to establish the technical capabilities of the motor block and aggregated inventory in terms of stability and functionality and to measure some strength, power and exploitation characteristics.

The conditions, means and method of the study include: not well developed terrain, with a large quantity of waste inert materials; mechanical workshop-laboratory with good measuring and processing capabilities; strain gauge and tension measuring system, etc. The experiments were conducted in natural conditions in autumn 2016 and spring and summer of 2017.

Results and analysis. The first impressions of working with the unit are simplicity in compilation, from one side and difficult manipulations on the other. There is also an inability to precisely adjust working machines, which is available in other models.

In the milling process, the normal operation of the aggregate is established - decomposition up to 25 cm and loosening of the soil layer. Sowing of spring crops in these conditions is questionable.

The mounted traction wheels do not provide sufficient grip on the ground - they are kicking and bending due to the insufficient mass of the motor block. Dragging with milling drums, as some users suggest, if not better, is at least more sustainable as the transverse base is 80 cm. Some authors consider combining milling and cultivation, for example, as a comprehensive prospective soil cultivation (Torikasvili & Koba, 2006).

A furrow paw was used as a chisel when towed from the milling drum. The draw may be considered satisfactory and the penetration depth is below the layer of 25 cm. Insufficient strength of the frog’s material has been established.

When working with a row cultivator, a very good pruning of the vegetation and partial rupture was found. Disadvantage: a very poorly conceived and executed structure of thin-walled profile, with little strength. The welds are just symbolic.

Experiments in the plowing process show better drag resistance with milling drums and insufficient traction force due to the small mass of the aggregate. The installation of ballast weights on the motor block unit housing is difficult and there is a risk of damage to the hexagonal shape of the wheel's shafts. The author's decision is to fill the traction wheels with concrete and steel. Thus the mass of the motor block can be doubled.

The loose soil and the impossibility of precisely adjusting the plow lead to transverse instability and do not allow a qualitative reversal of the plow.

The plow works more like a subsoiled. We also registered adhesion of soil to a part of the share and the moldboard to.

The use of potato mowers in the kit is controversial: the working body is difficult to pull at a depth of 20-22 cm and the clearance between the traction wheels is 25 cm and they can damage the tubers.

Regarding power and fuel consumption, measurements indicate that the average fuel consumption is about 0.5 liters per hour and the available power is unusable.

In order to improve the stability of the unit and to measure some of the power characteristics, a rear support wheel has been added to the structure and tensometric sensors too for measuring the traction force $\mathbf{F_x}$ and the vertical force in the support wheel (Fig. 1.).

Measurements were made during the plowing process at setting depth of 20 cm. The results obtained are shown in Figures 2 and 3. The graphs of the figures show a typical irregularity [Demirev, G. 2012] and the presence of a expressed transition process of penetration at the traction force.

The average traction force is 600 N, which is also confirmed by the deducted empirical dependence on soil reaction (Demirev, G. 2012, Ovsyannikov, S., 2015):

$$R_x = k_0 ab \qquad (1)$$

where $\mathbf{k_0}$ is the specific plow resistance (30 kN/m^2 for light soil), and **a = 0,2** m and **b = 0,1** m are the depth of plow and the width of the plow body.

For vertical soil reaction is valid (Demirev, G. 2012, Ovsyannikov, S. 2015):

$$R_z = mR_x \qquad (2)$$

where ***m*** **= 0,2.**

For the determination of the vertical soil response, it is necessary to construct a torque equation of the vertical forces with respect to the contact point of the traction wheels:

$$R_z = \frac{-G_a x_a - M_r + R_k\, x_k}{x_z} \qquad (3)$$

where: $\mathbf{x_a}$ is the distance along the axis **x** to the mass center of the unit; $\mathbf{G_a}$ is the mass of the aggregate; $\mathbf{M_r}$ reactive torque; $\mathbf{x_k}$

and $\mathbf{R_k}$ are respectively the distance to the support wheel and the force on it.

With an average force measured at the support wheel 210 N, a reactive moment of 60 Nm, the mass of the unit 82 kg and the distances: $\mathbf{x_k = 0{,}82\ m}$, $\mathbf{x_z = 0{,}47\ m}$ and $\mathbf{x_a = 0{,}07\ m}$, for the reaction $\mathbf{R_z}$ we obtain 116,6 N, which is very close to the calculated value of 120 N.

Calculations of useful plowing power, based on the traction force (600 N) and the reported aggregate speed (0.6 m/s), show that only 360 W of available power is realized.

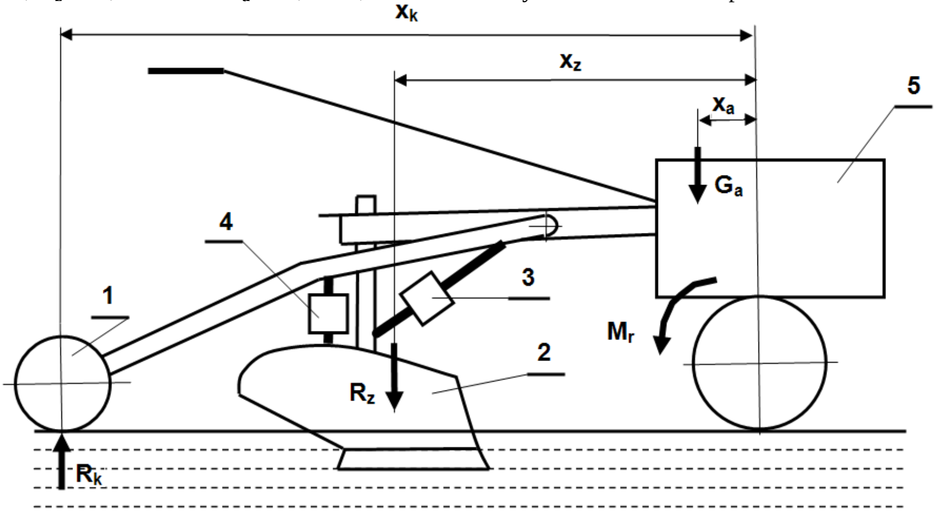

Fig. 1. *The diagram of the aggregate: 1 - support wheel, 2 - plow body, 3 and 4 - tenzometric sensors, 5- moto block.*

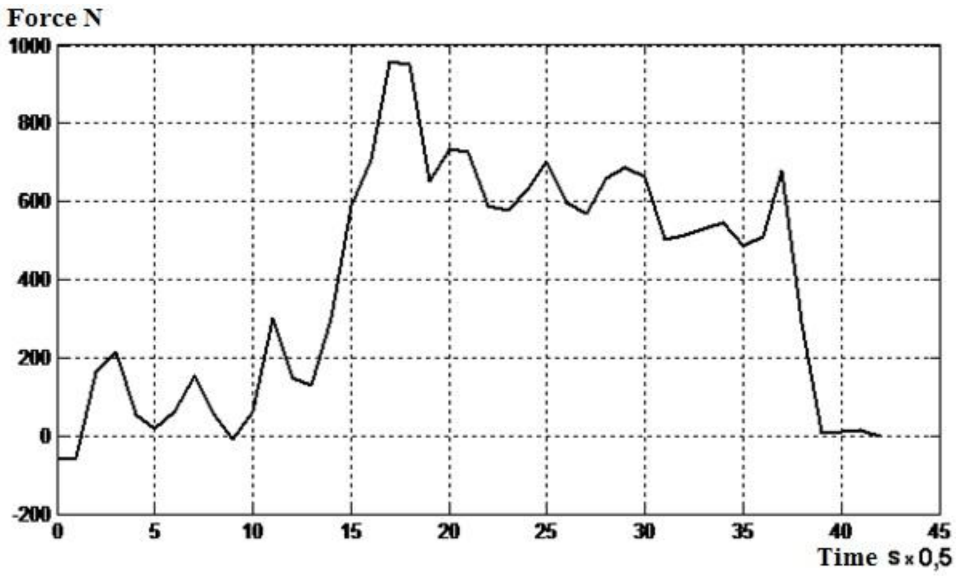

Fig. 2. *The graph of the traction force*

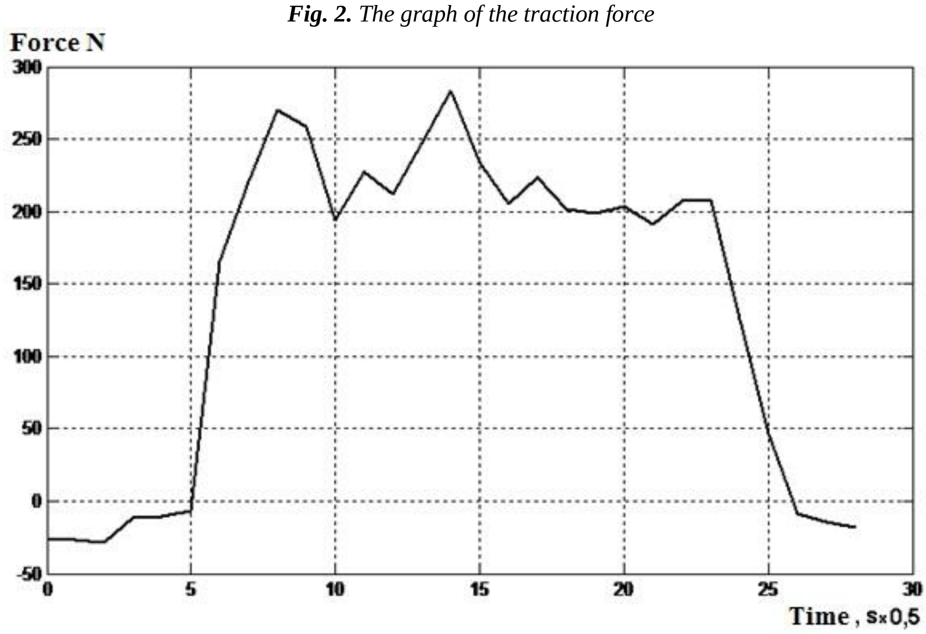

Fig. 3. *The graph of the force* $\boldsymbol{R_k}$ *in the support wheel*

CONCLUSION

- First of all, it should be noted that, in general, the motor block is functional;
- Simultaneously with the above, serious remarks or inability to work the whole unit are also reported;
- Changes in design and workmanship are required to make full use of the unit's capabilities.

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