Tillage implement with vibrating working body

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Abstract. A tillage implement with a vibrating working body based on a chisel cultivator allows to reduce the implement traction resistance by creating resonance to 35%. The use of an eccentric vibration generator contributes to a significant reduction in tillage operation energy costs, due to the decrease in the strength characteristics of the soil itself, without leaving the agrotechnological requirements framework.

1. Introduction

The agricultural productivity improving is possible through the improvement in various directions. The human factor as a personnel potential is an indirect and organizational link [1]. The directly assessed increase in efficiency is the improvement of existing technological processes, mainly due to the computer modeling, microelectronics, and automation [2]. However, this development has a limitation, complicates the process and its costs. Also, developments to improve the existing equipment design can increase the efficiency of its work, but are limited by the equipment design [3]. The agricultural implements working bodies improving is the most effective, since it allows to affect the work quality and effectiveness directly [4], however, like all previous methods, it is limited in development and effectiveness. The best in this direction is the creation of new working tools according to a different principle [5]. Most tillage machines in their design have an elastic element in the working body fastening, capable to reduce the traction resistance of the working body and the tillage machine as a whole [6]. Reducing the operation energy costs for soil tillage by reducing traction [7] is possible during generating vibration acceleration of the working body due to the soil formation destruction process dynamic features.

To reduce energy costs, it is advisable to use the method of working body forced vibration from an external source of vibration, which will improve the productivity of the tillage implement.

2. Materials and methods

A chisel cultivator with a spring-loaded working body was selected for research, it was equipped with an inertial, adjustable, deformer (vibrator) of directional action, which makes possible to change the amplitude and frequency of oscillations in various ranges [8].

The design of the tillage implement working body equipped with a vibration generator is shown in figure 1 and consists of the stand mounting (1) mounted on the cultivator frame, on one side of which an elastic element (2) is attached, on the other a cultivating stand (3) on which eccentric vibration generator (4) is mounted in figure 2. Eccentric weights are mounted on the shaft; the shaft rotates on two bearings. The device is attached to the working body elastic by the upper and lower covers by
means of a bolted connection. The eccentric vibration generator is driven by a hydraulic motor through a flexible shaft.

When the hydraulic motor is turned on, the vibrator loads begin to rotate, creating a perturbing force. The vibrator reciprocates along with the cultivator blade. Mechanical vibrations occur when the eccentrics rotate under the action of centrifugal forces. In the design, by changing the values of the rotation speed and mass of the loads, it seems possible to adjust the frequency and amplitude of the vibrations necessary to optimize the unit operation. The vibration generator inertial force, created by the centrifugal force of rotating loads, creates forced vibrations of parts and mechanisms.

Figure 1. Working body with an eccentric vibration generator.

Considering the system of an elastically fixed working body equipped with an eccentric vibration generator, it is necessary to optimize its design parameters to minimize energy costs by providing specified values of the perturbing force generated by the vibrator. It was assumed that the smallest value of the perturbing force, providing the maximum value of the working body oscillations amplitude, would occur under the condition of resonance, that is, under the condition of the elastically fixed working body natural frequencies equality, the working body was equipped with a vibration generator with a frequency of perturbing force from the soil background.

3. Results
An eccentric vibration generator was designed to create suitable conditions for forced vibrations from an external source. This design allows to work on different types of soils, if the settings for adjusting the frequency of oscillations from the eccentrics rotation speed are provided. The tests were carried out mainly on light chestnut soils. The prepared chisel cultivator with an improved design of the working body in figure 3 was aggregated with a wheeled tractor equipped for recording and processing field test data. To illustrate the experiment, tests were carried out both with the working vibration generator and without its use [9, 10].

During the experiments, the parameters were continuously recorded in the form of oscillograms (figure 4). A computational-measuring complex was used to ensure continuous recording of parameters recorded during the experiment. The main indicators in this case were the horizontal component of the working body traction resistance and the rotational speed of the hydraulic motor shaft connected to the system to create the cultivator working body forced vibrations.
Figure 3. An experimental sample of a working body with the eccentric vibration generator.

Figure 4. Oscillogram of experimental parameters continuous fixation.

The analysis of the working body traction resistance horizontal component graphical dependence on the rotational speed of the hydraulic motor shaft in figure 5 showed that, on the stubble soil background, the horizontal component of the traction resistance decreased with a gradual increase in the hydraulic motor shaft rotation frequency to the optimal values of the vibration generator operating mode. The total decrease in the traction resistance horizontal component reaches 35%.

Figure 5. The tool R traction resistance horizontal component dependence on the rotational vibrator hydraulic motor shaft ω speed.

According to the analysis of the influence on the working body stability in the vertical axis it was noted that: with the increase in the hydraulic motor shaft revolution the increase in the deviations of the soil cultivation depth towards approaching the prohibited operating modes is recorded, but it still remains within acceptable limits without violating the agrotechnological requirements (figure 6).
4. Conclusion

After analyzing the graphic data, it can be observed that the use of a forced vibration generator in the design of the cultivator's working body oriented to optimal work characteristics has a positive effect on power costs during the tillage operations, by reducing the strength characteristics of the soil, without leaving the scope of agrotechnological requirements.

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