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Experimental study of reclining the cultivator's paws on spring racks

Alexey I. Buryanov[1], *Vitaliy I.* Ignatenko[2], *Ivan V.* Ignatenko[2], and *Ivan L.* Vyalikov[2,*]

[1]State Scientific Establishment "Agriculture research center "Donskoy", North Caucasus Institute of Mechanization and Electrification of Agriculture, 347740 Zernograd, Russia
[2]Don State Technical University, 344000 Rostov-on-Don, Russia

Abstract. The article describes the results of experimental determination of the trajectories of the toe of cultivator paws on spring racks of three types: light, medium and heavy. The trajectory was determined by loading on the test bench. It is established that the trajectories are non-linear in nature, and elastic displacements lead to the deepening of the toe of the paw, which violates the established depth of stroke. The loading ranges of the racks are defined, under which the deepening does not exceed the limits of agro-admission. The greatest recession was noted in middle racks, the smallest in heavy racks. It was concluded that it is necessary to monitor the recess of the toe of the feet mounted on the spring post.

1 Introduction

In modern cultivator construction, spring supports are widely used to fasten the legs to the frame. It is believed that the spring struts, due to the elasticity, receive significant vibrations during operation, which have a beneficial effect on the processes of interaction of the paw with the soil: the stickiness decreases. Energy consumption, the quality of soil cultivation is improved [1 - 8].

However, the springs have problems. Under the influence of the load P on the workpiece, the spring post is deformed and the workpiece receives spatial elastic displacements S of the toe of the foot and pivot rotation by an angle θ (Fig. 1). They distort the depth of the paw stroke and the geometry of the cutting, which changes the resistance force P. The distortion of the depth of the stroke can cause the deepening or burial of the toe of the working element. It is limited in agricultural requirements by agrarian A_D. For cultivators, usually A_D = 10 mm.

* Corresponding author: vialikov@mail.ru

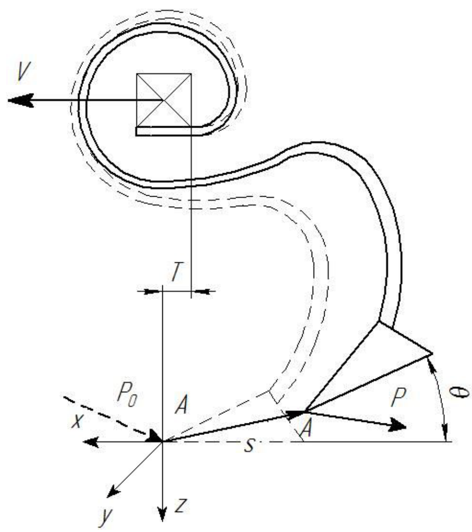


Fig. 1. The scheme of elastic displacements of the cultivator's paw on the spring post: A - the toe of the paw; T - reference of the toe of the paw from the vertical; X, Y, Z - coordinate axes; Po and P are the initial and current loads, respectively; V is the portable speed of the cultivator frame.

Therefore, the magnitude and direction of the elastic displacements of the paws on the spring post are subject to normalization and control.

Purpose of the work: Conducting monitoring of elastic displacements of widespread spring racks of cultivators.

2 Objects of research

In the work, experimental monitoring of the trajectories of the toe of spring struts of three types shown in Table 1.

Table 1. General view and parameters of the springs.

General view of the rack			
Type	light C-shaped spring stand according to GOST 1343-68.	middle S-shaped spring rack OFAS ITALY	powerful S-shaped spring composite stand Vibroflex
Height, mm	425	545	745
Mounting height, mm	225	395	590
upper section bxh, mm	40X10	32x10	150x10
Weight, kg	3,15	3,1	15,9

Table 1:

- light C-shaped spring stand in accordance with GOST 1343-68 [8].
- medium S-shaped spring post OFAS ITALY,
- a powerful S-shaped composite stand "Vibroflex", characterized by increased endurance. The elastic upper part has a wide profile section of 10x150 mm, which increases the strength and lateral rigidity.

3 Methods of experiment

In the theory of terraelasticity [9, 10], the stiffness and angular distortions of the rack at nominal load are taken as indicators of the elastic properties of racks of soil-cultivating machines. However, for practice, such indicators are not clear. The trajectories of the elastic shifts of the toe of the foot under load are more evident, on which the distortions of the depth of travel and the limiting loads of the paw exit beyond the limits of agro-admission are clearly visible.

For the experimental study, we used a stand (Fig. 2) with a static load mechanism in the form of a drum winch [11]. The investigated stand 7 is fixed on the beam 8 of the stand frame. The load is applied to the toe of the foot with cable 5 from the drum winch 3 through the dynamometer 6.

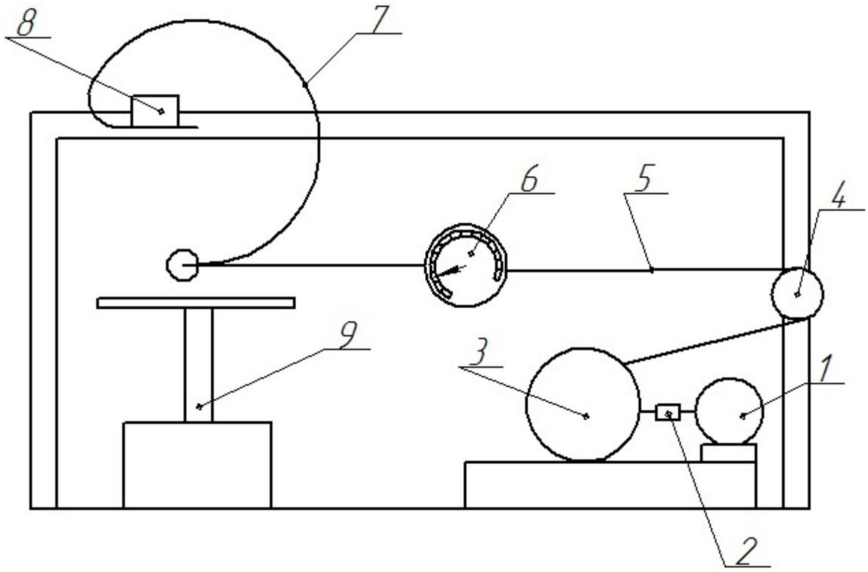


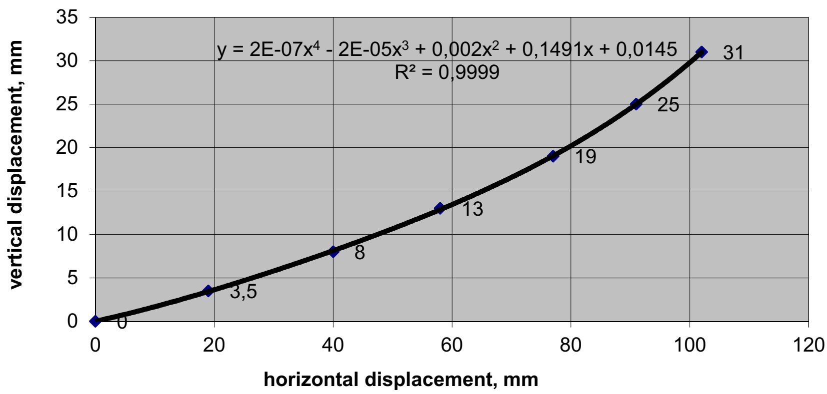
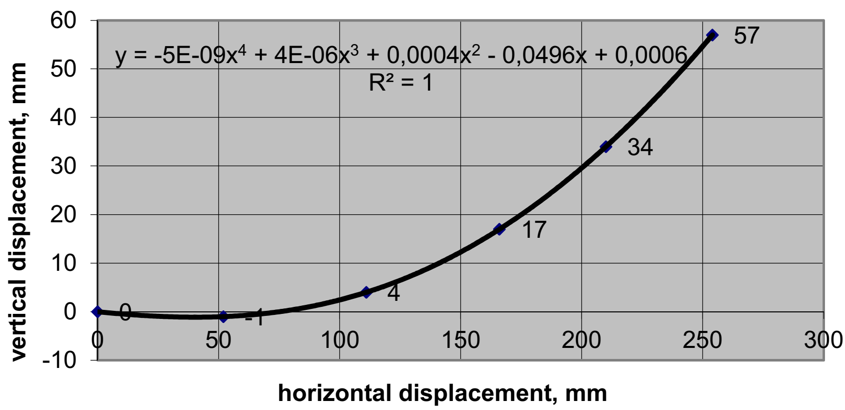
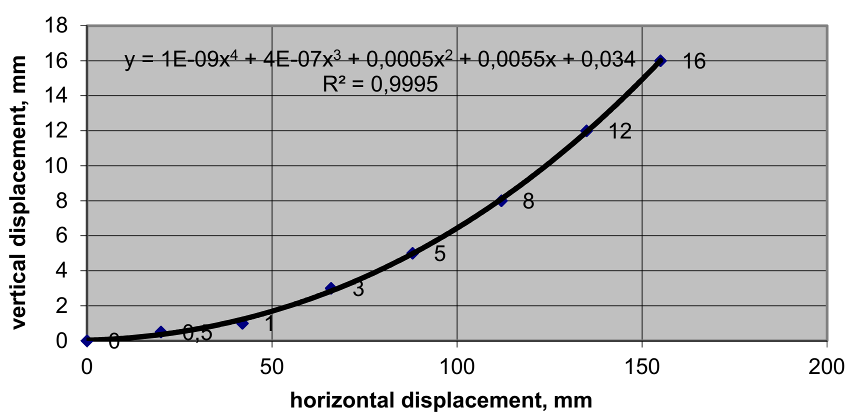
Fig.2. Scheme of the test stand: 1- engine (motor); 2 - coupling; 3 - winch; 4 - a tension pulley; 5 - rope; 6 - dynamometer; 7 - the rack; 8 - a beam for fastening of a rack; 9 - adjustment table.

Displacements of the points were measured in two coordinates: horizontally X and along the vertical Z. Horizontal displacements of the sock are projected by the thicknesser on the table 9 and fixed on paper. The vertical displacements Z are measured by the thicknesser relative to the surface of the table.

As a load, the horizontal force PX was assumed. This makes it easier to compare the results of the experiments. The magnitude of the load was applied in steps such that 8-10 measurements were obtained over the entire loading range. The experiments were carried out in triplicate.

The graphs of the trajectories of the spring racks are given in Table 2.

Table 2. Graphs of foot trajectories of paws on spring racks

Rack	The trajectory of the elastic displacement of the toe of the paw
light	
medium	
heavy Vibroflex	

The obtained graphs clearly demonstrate the nonlinearity of the trajectories. The toe of the paw under the action of the horizontal load shifts not only horizontally, but also vertically, causing the presence of a Z-groove. The graphs show the approximation of the Z = f (X) grooves with fourth-order polynomials with a large value of R2 reliability.

The graphs of the trajectories are obvious, but inconvenient for comparing the degree of recess of the racks, since they are obtained under different loads. More convenient graphs depend on the depth of the load. They are shown in Figure 3, where they can easily be compared.

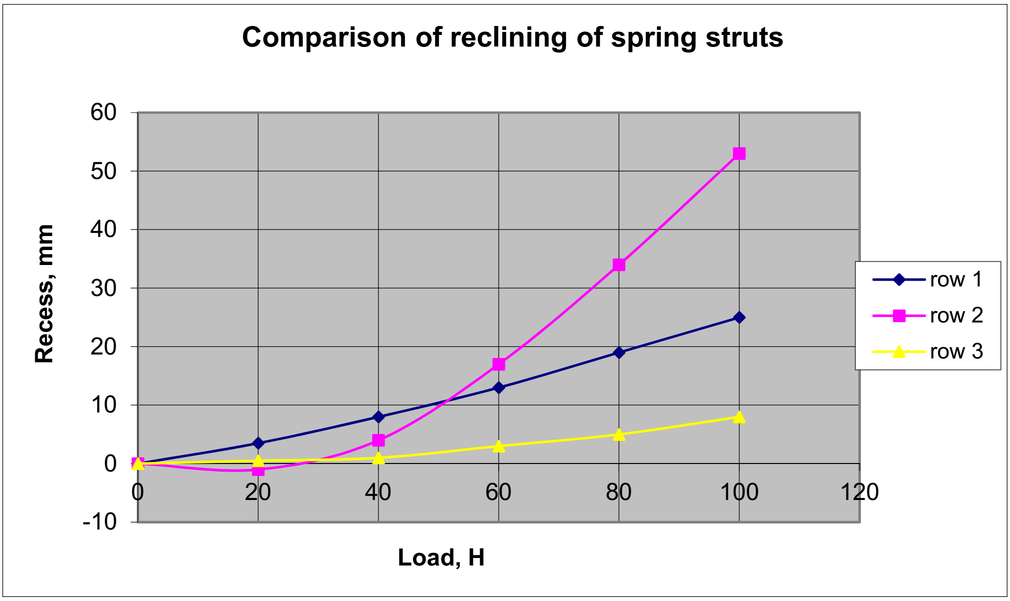


Fig. 3. The path of the toe of the paw under load of different types of S-shaped spring racks: row 1 - light stand in accordance with GOST, row 2 - middle rack OFAS ITALY of Kongskilde type; row 3 - heavy stand Vibroflex. Deepening is limited to agricultural requirements.

4 Results of the study

The analysis of the trajectory shows that all the spring racks operate in a recess mode. Deepening disrupts the depth of the stroke and from this point of view it can be considered a disadvantage. But it also provides some safety effect: when the load increases, the stand picks up the paw, reducing the load. The safety effect increases the reliability of the spring post. The truth is "in the forbidden way" due to the decrease in the uniformity of the course in depth. Here we need a reasonable compromise.

The comparison shows that the average S-shaped spring stand has the greatest safety effect. It "skips" in depth, thus reducing the energy of the process.

The permissible load of the columns is limited to the value when the receding is beyond the agodomass A_D =10 mm. Then it turns out that the light and medium rack can withstand loads of up to 50 kG, and the heavy stand is much larger - 120 kG. The average safety stand has a developed protective effect: if the maximum permissible load for agro-loading is exceeded 2 times, the deepening grows 5.2 times. The heavy stand has the smallest recess: the paw exits for agodomosis at a load of about 120 kG, that is, it has the highest uniformity of stroke in depth, but the smallest safety effect.

5 Conclusion

Thus, the spring pillars, even if they have the same configuration, vary greatly in their depth, which directly determines the uniformity of the depth course and the quality of the cultivation process. Dehiscing the cultivator's paws on different spring stands is an important indicator and when monitoring the quality of the spring racks should be included in the system of mandatory indicators.

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