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Optimization of the parameters of the spring rack of the cultivator

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Abstract. An important generally recognized factor in improving the quality of cultivation in recent years is the elastic fastening of working organs. It is believed that the working bodies fixed with elastic struts make intense vibrations, which leads to an improvement in the quality of soil crumbling and a decrease in traction resistance similar to the vibrations of a vibrator. However, the paws on the elastic rack when working receive a deviation from the set processing depth by 10-15% more than with a rigid suspension and do not maintain the optimal cutting geometry. It is established that elastic displacements depend on the configuration of spring struts.

1 Introduction

A competent choice of the optimal ratio of stiffness and angular distortions of the cultivator rack implies the inclusion in the quality monitoring program of the rack an assessment of the magnitude of the distortion of geometry and the constancy of the depth of the course of the pointed paws.

2 Materials and methods

Foreign spring racks of leading companies with different stiffness and bearing pointed legs were selected for monitoring (Fig. 1). The stiffness of the racks was estimated by the cross-sectional area, it varies from a minimum of 45x12 (Hatzenbichler) to a maximum of 150x10 (VibroFlex).

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Hatzenbichler Bellota 2488-C2A VibroFlex

Fig.1 Spring struts

The geometric parameters of the racks are presented in Table 1.

Table 1. Geometric parameters of spring racks

№ Rack	Title	Height H, mm	Length L, mm	Diameter of the coil	Mounting height, *H*, мм	Takeaway Sock *T*, mm	Elastic element cross section, mm × mm	Paw grip width, cm	Weight, kg	Specific
1	Hatzenbichler	670	320	260	510	-145	45×12	15	5,0	0,33
2	Bellota	670	320	250	510	-175	65×12	23	8,7	0,37
3	VibroFlex	760	370	270	580	-120	150×10	32	14,8	0,45

The determination of elastic displacements was experimentally carried out on a specialized stand Figure 2, designed for the purpose of monitoring spring racks.

Fig. 2 Loading stand

At each stage, the vertical coordinate of points A, B and C relative to the table is measured. The results are entered in tables.

The results of measurements of elastic displacements of cultivators' paws for three types of foreign spring racks are given in Tables 2, 3, 4.

Table 2 - Elastic displacement of the paw on the Hatzenbichler rack

P_X	XA	YA	ZA	ZB	ZC
0	0	0	124	106	119
20	40	0	123	113	122
40	77	0	125	120	131
60	114	0	129	130	141
80	145	0	134	140	153
100	180	0	140	152	164

Table 3 - Elastic displacement of the paw on the Bellota 2488-C2A rack

P_X	XA	YA	ZA	ZB	ZC
0	0	0	103,5	102	105
20	25	0	102,5	106	109
40	56	0	102	113	115
60	86	0	102	119	121
80	115	0	103	128	128
100	144	0	105	137	140
120	178	0	109	147	152

Table 4 - Elastic displacement of the paw on the VibroFlex rack

Px	XA	YA	ZA	ZB	ZC
0	0	0	50	34	62
20	25	0	46	38	65
40	68	0	43	57	82
60	85	0	42	65	88
80	105	0	42,5	71	97
100	123	0	44	79	105
120	146	0	47	88	118

The data in Tables 2, 3, 4 were transformed as follows.

Determination of vertical displacements of the toe of the paw are defined as increments of the ZA coordinate:

$$dZA = ZA - ZA(0), \quad (1)$$

Determination of the coordinates of the midpoint of the cut-off paw E:

$$ZE = \frac{(ZB+ZC)}{2}, \quad (2)$$

Increment of coordinates of point E:

$$dZE = ZE - ZE(0), \quad (3)$$

Exceeding the point E over A:

$$dZEA = ZE - ZA, \quad (4)$$

The sine of the angle of the axis of the paws AE:

$$sin\,\alpha = \frac{dZEA}{L}, \quad (5)$$

where L - is the length of the paw.

The angle of the paw axis:

$$\alpha = arcsin\cdot\left(\frac{dZEFA}{L}\right), \quad (6)$$

Pitch - the angle of rotation of the paw around the Y axis:

$$\theta_Y = d\cdot\alpha = \alpha - \alpha(0), \quad (7)$$

Pitch is most important for assessing the distortion of the cutting geometry; it is clearly discernible under longitudinal loading, when the load is greatest.

Yaw angles:

$$\theta_Z = arcsin\frac{Y}{L}, \quad (8)$$

Angle Roll:

$$\theta_x = arcsin\frac{Z}{L}, \quad (9)$$

The roll of the angles when loaded in the plane of the rack is much less than the pitch, they have little effect on the distortion of the geometry. Therefore, they are not given.

As a result of processing these tables, graphs of the distortion of the depth of the working organ of the cultivator are constructed.

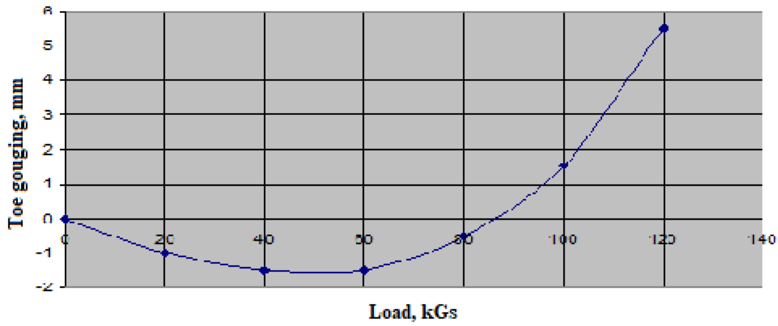

Fig. 3 Spring strut VibroFleX

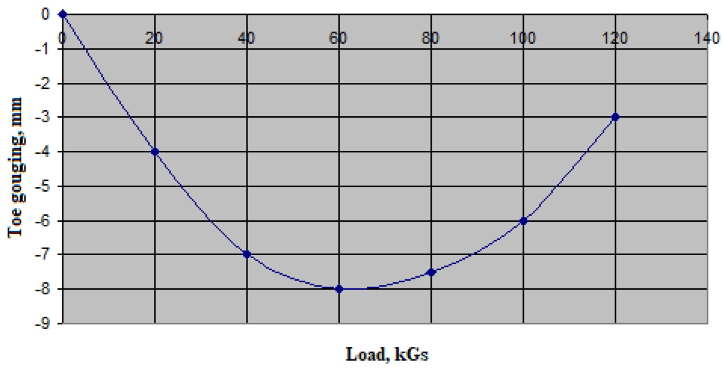

Fig. 4 Spring strut Bellota 2488-C2

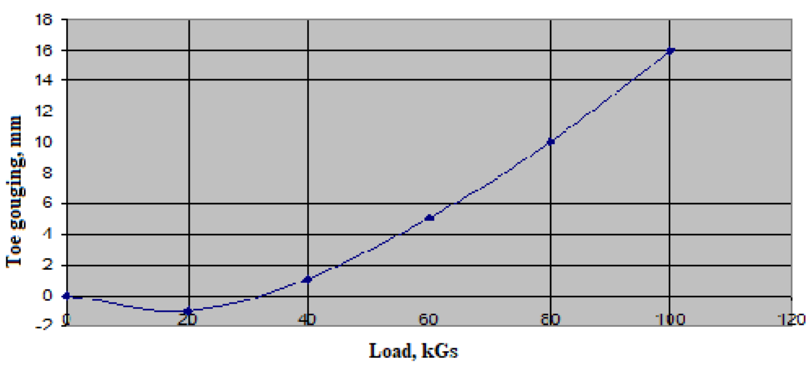

Fig. 5 Hatzenbichler spring stru

3 Results and discussion

The Hatzenbichler rack is too malleable. The weight is the smallest, but the paw width is only 150 mm and there will be more such racks on the cultivator. A 4.2 m wide cultivator will require 30 paws with a total weight of 150 kg. Going beyond the tolerance to the depth of the stroke is achieved at a load of P = 25 kGf, which is not enough to work even on medium-sized agrophones. It is suitable only for old-arable fields. It is not possible to take the Hatzenbichler rack as a sample for optimization due to low rigidity and large deformations.

The VibroFlex rack is much stiffer, carries a wide paw, geometry distortions limit the workload at the level of 80 kGf, which allows you to work with wide paws up to 330 mm even on heavy agrophones. However, the rack is composite, assembled by a bolted connection, unreliable with vibrations. A 4.2 m wide cultivator requires 14 paws with a total weight of 207 kg. High metal consumption makes this option economically unprofitable.

4 Conclusion

Elastic kinematics at the Bellota rack turns out to be more rational. It carries a fairly wide paw of 230 mm, the working load at the border of the agricultural pass of 60 kGf allows you to work on dense agrophones. The weight of 8.7 kg is 40% lighter than rack 1. A 4.2 m wide cultivator will require approximately 18 paws with a total weight of 156 kg.

The analysis shows that from the point of view of endurance and small capacity, the Bellota 2488-C2A spring strut with a cross section of 65x12 is preferred as a prototype.

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