Universal Row-Crop Tractor with a Variable Base

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Abstract: This article discusses the development of a universal row-crop tractor with a variable base. The following are general information about a tractor with a variable base, the scope of application, information about previously created tractors with a variable base. Based on the analysis of existing designs of tractors with a variable base, a new design developed and its 3D model presented. The design of the mechanism, the calculation of the strength of the details of the mechanism of the structure and the principle of operation of the mechanism of changing the base of the tractor.

1 INTRODUCTION

Due to the fact that most row-crop tractors are designed for processing crops sown with different row spacings, they provide for changing the track size. All modern wheeled row-crop tractors have this capability, with the exception of some special-purpose tractors. However, all these listed tractors practically do not have the ability to change the length of the tractor base (Akhmetov and Usmanov, 2018, Omonov et al., 2022). It is known that on rainfed land, especially on arable lands located in mountainous and foothill areas, the sown area has an uneven surface. When working on these lands, as already mentioned, in order to ensure the stability of the tractor during transport work, its base should be the largest, and when working on a plain in small contour areas, on the contrary, to ensure a minimum turning radius, the base of the tractor should be the smallest (Akhmetov and Usmanov, 2018). To date, these lands have not been fully developed due to the lack or shortage of equipment capable of performing work operations in areas with mountainous terrain. Difficulties in the mechanization of field work in areas of mountainous and foothill lands lie in the fact that, due to the significant unevenness of the fields, the longitudinal and lateral stability of machines and tractors is reduced, and maneuverability and controllability are deteriorating (Omonov et al., 2022). And so, in order to increase stability and maneuverability, as well as to ensure the possibility of using the same universal row-crop tractor both in transport work and in inter-row cultivation of crops of vegetable and melon crops, it is necessary to have a changeable base of the tractor (Akhmetov and Usmanov, 2017 Omonov et al., 2022). Solving the problem by changing the length of the tractor base would make it possible to use a universal row-crop tractor in mountainous and foothill areas in a wide range of transport and other types of work, both in rain fed agriculture and vegetable growing and melon growing, from pre-sowing tillage and sowing to inter-row cultivation of

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cultivated crops and harvest (Strebko et al., 2016, et al., 2011). Tractor with a variable base are known from literary and patent sources (Strebko et al., 2016, et al., 2011). However, they have a number of disadvantages, the main of which are the high labor intensity of the process of changing the base, the complexity and metal consumption of the structure, the need for special devices (crane or jack) and the presence of an additional mounted and dismantled replaceable module (Omonov et al., 2022).

2 MATERIALS AND METHODS

LLC «Design and technology center of agricultural machines» created a row-crop tractor with a variable base. Based on the research, this tractor was developed. In tractors with a variable base, the main change was the design of the front part. Each development has its own advantages and disadvantages (Akhmetov and Usmanov, 2018, Omonov et al., 2022). We also worked on the creation of a changeable base of the universal row-crop tractor, created sketch drawings, layout diagrams of the changeable base mechanism using computer programs and developed its design. In this, we also made the front axle of the tractor changeable, just like it was developed in LLC «Design and technology center of agricultural machines», but we used a different mechanism. To do this, we used a screw-nut mechanism. The screw-nut transmission is used to convert the rotational motion of one of the links into the translational motion of the other link. Such a transmission consists of two links - a screw and nuts, while one of the links is fixed from axial movement Sultanova et al., 2021). Improving this transmission, bringing it to the appropriate ends and fixing it between the semi-frame of the tractor, and on the link of the nut-front axle Beam, by absorbing the front axle of the tractor, we achieve that the changeable base of the tractor (Omonov et al., 2022). Our proposed design consists of two hydrosilinders 4.11, guides 8.10, a front beam 7, special sliding elements 6 that slide along the guides in the spars. Thus, the principle of operation of the mechanism with a variable base is as follows: the spars are processed on 2 cutters at 8.10, a special slider moves back and forth across 6 cutters. In this case, forward movement is obtained by two hydraulic cylinders in 3.9 seconds, when the hydraulic cylinder rod 5 begins to move forward, the slider attached to the rod, the area of the front jumper is fixed to the sliding part, and the slider moves along with the beam when moving forward, and as a result, the front axle also moves, and the base of the tractor changes from from one base to another, on the contrary, the base of the tractor becomes smaller when the rod returns back. The fact that there are two hydraulic cylinders in the design makes it possible to place a hydraulic cylinder between small spars and, using two, easily change the tractor base, overcoming the load on the front axle with a force exceeding the required (Fig. 1).

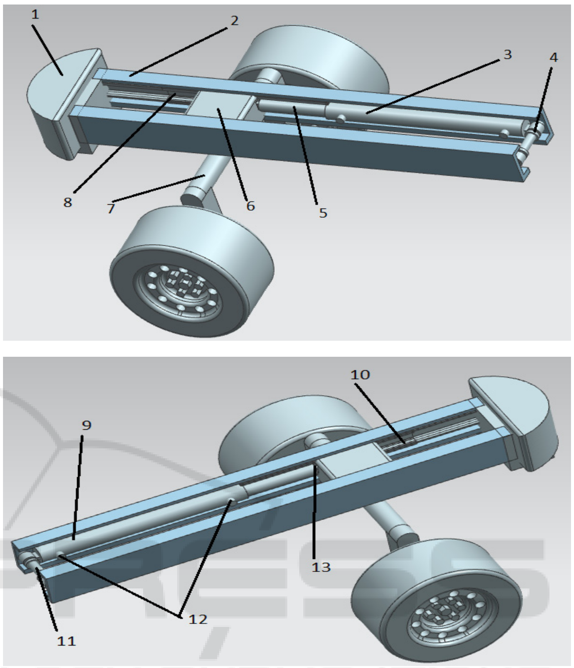

Figure 1: General view of the mechanism (3d model in NX 10 program)

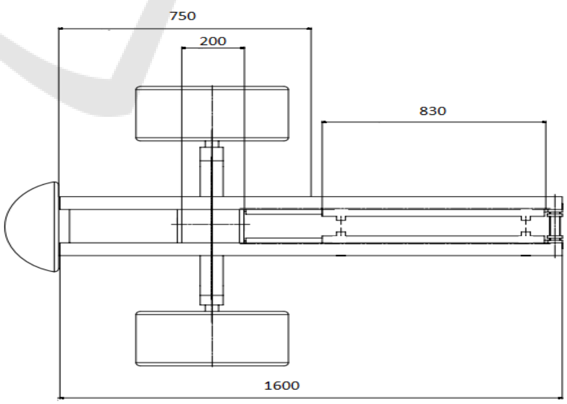

Figure 2: Gabarite dimensions of the variable base mechanism

By giving the servomotor movement at the right moment and in the right place, the tractor base can be made changeable within the dimensions of the mechanism. It differs from other changeable base tractors in that the mechanism installed between the frames and has automatic control, that is, it does not require additional equipment and additional adjustments

3 RESULTS AND DISCUSSION

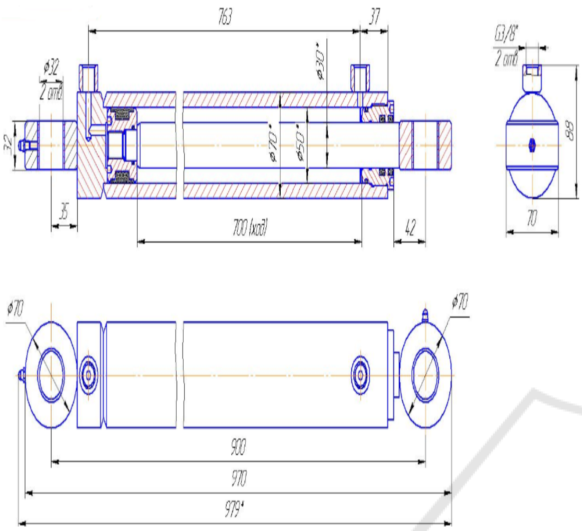

Figure 3: C50 hydraulic cylinders.

Strength calculation of the front bridge balcony

Mк=Pz*li-Pzl*hb

Mg=-Pzp*(B- li)-Pzp* hb

Cross section center of gravity coordinate (Akhmetov, 2018):

$$Y_{ST} = \frac{\sum_{i=1}^{n} F_i y_i}{\sum_{i=1}^{n} F_i},$$

Moment of inertia on x of the joint section:

$$\sum I_{x^i} = (\sum_{i=1}^{n} I_{xi} + (a_i)^2 F_i),$$

Bending resistance moment:

$$W_u = \frac{\sum I_{x^i}}{y_{max}},$$

The center of gravity coordinate of the cross section is (Strebko et al., 2016, et al., 2011):

$$X_{ST} = \frac{\sum_{i=1}^{n} F_i \cdot X_i}{\sum_{i=1}^{n} F_i},$$

Moment of inertia on x of the joint section:

$$\sum I_{y^i} = \left(\sum_{i=1}^{n} I_{yi} + (b_i)^2 F_i\right),$$

Table 1.

Base	B, мм	Pк, N	Gpт, N	Pz, N	Pzp, N	Pzl, N
	I position (minimum base)					
left	1820	0	16775.1	16775.1	14164.3	14537.1
right					1865.2	2237.9
left	1420	0	16775.1	16775.1	15896.6	16269.4
right					132.9	505.7
	II position (maximum base)					
left	1820	0	13832.1	13832.1	11613.9	11986.7
right					1472.6	1845.4
left	1420	0	13832.1	13832.1	13042.3	13415.1
right					44.1	416.9

Table 2: Bending moment.

Base	B = 1820 мм		B = 1420 мм	
	l_i, mm	Mk, N*мм	l_i, mm	Mk, N*мм
	I position (minimum base)			
left	498	2645188	498	2938261
right		3958903		459961
left	910	3190535	710	431816
right		3190535		431777
	II position (maximum base)			
left	498	2213685	498	2455344
right		3177959		318874
left	910	2571269	710	309623
right		2571269		309515

Table 3: Final standings.

Accounting mode	Loading type	B, мм	Cross section	σ, MPa	n_T	$[n_T]$min
I	Side slip	1820	I-I (minimum base)	23.3	> 10	2.12
			I-I (maximum base)	18.8	> 10	
			II-II(minimum base)	9.3	> 10	
			II-II(maximum base)	7.5	> 10	
		1420	I-I(minimum base)	17.3	> 10	
			I-I(maximum base)	14.4	> 10	
			II-II(minimum base)	1.3	> 10	
			II-II(maximum base)	0.9	> 10	
II	In unevenness movement	1820	I-I	88.9	3.15	
			II-II	80.02	3.5	
		1420	II-II	62.5	4.5	
III	In passability in difficult places to pass	1820	I-I	88.9	3.15	
			II-II	70.5	3.9	
		1420	II-II	55.6	5.1	

4 CONCLUSIONS

The theoretical studies and calculations show that if we applied this mechanism, we would be able to change the base of the tractor within ±300 mm. Because we use an automatic control system, there is no need for additional equipment and additional adjustments compared to other changeable base tractors. Our work in this direction is not yet complete; we are working on the creation of a solid, simple in principle, easy to use design.

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