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DETERMINATION OF THE PARAMETERS OF THE GRAPPLE GRIPPING DEVICE ELASTIC CONTAINERS WITH COTTON

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ABSTRACT: The proposed technology of harvesting cotton in elastic cylindrical containers and their transportation to processing enterprises, bypassing cotton harvesting points, allows to significantly increase the productivity of harvesting and transport operations, as well as to preserve the quality of harvested raw cotton. A significant role in this is given to technical means, we carry out loading and transportation of elastic containers with cotton.

KEYWORDS: Cotton, pressing, elastic container, cotton harvester, unloading, turn lane, tractor, loading device, gripping device, loading.

INTRODUCTION

The technology of harvesting, loading and unloading and transportation of raw cotton by container method has been developed at the Research Institute of Agricultural Mechanization and the Karshi Engineering and Economic Institute. The proposed technology includes the following technological operations [1-2]:

- collecting cotton in elastic cylindrical containers with a seal;
- unloading of filled containers on the turn lane of the cotton field;
- tractor with container loading device in the vehicle body;
- transportation of containers by tractor train from the field to processing plants.

To carry out the technological process of loading and unloading cotton containers, a maneuverable and high-performance loader is required, capable of working in cramped places, in open areas, on the turn lane of cotton fields [2-3]. A tractor with a loading device must load a container into the bodies of tractor trailers, transport a tractor train from the field to the storage and processing points of raw materials.

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The container is loaded in the following order: a tractor train pulls into the turn lane of the map, where the containers are located at a certain distance from each other; a tractor drives up to the container and loads it, maneuvering an extension cord with a gripping device [4-5].

Based on the above features, it is possible to establish the following requirements for loading cotton containers:

1. The loader must be maneuverable and able to work in cramped places, on platforms and on the turning lanes of fields;
2. The gripping device of the device must not damage the surface of the container;
3. The loading capacity of the loader must be at least 500 kg and the loading height must be at least 4.5 m;
4. The loader must work without support legs when performing the technological process;
5. The gripping device of the device must be controllable and capable of gripping containers stacked end-to-end on the turn lane of the cotton field.

In order to carry out loading and unloading operations on the turn lane of the cotton field and harvesting points where maneuvering is limited, the tractor must have the ability to drive up to any lying container with a loading device [6-7]. This requirement is fulfilled provided that the adaptation mechanism provides the necessary degree of freedom.

The length of the frame and the extension of the device are determined taking into account the location of the containers and tractor trailer unloaded by the cotton harvester, the width (8-10 m.) of the turn lane of the cotton card, as well as the conditions of minimum lowering (0.3 m.) and maximum lifting (4.5 m.) of the container during the technological process [8-9]. Based on this, the length of the frame and extension are chosen to be 2.5 m.

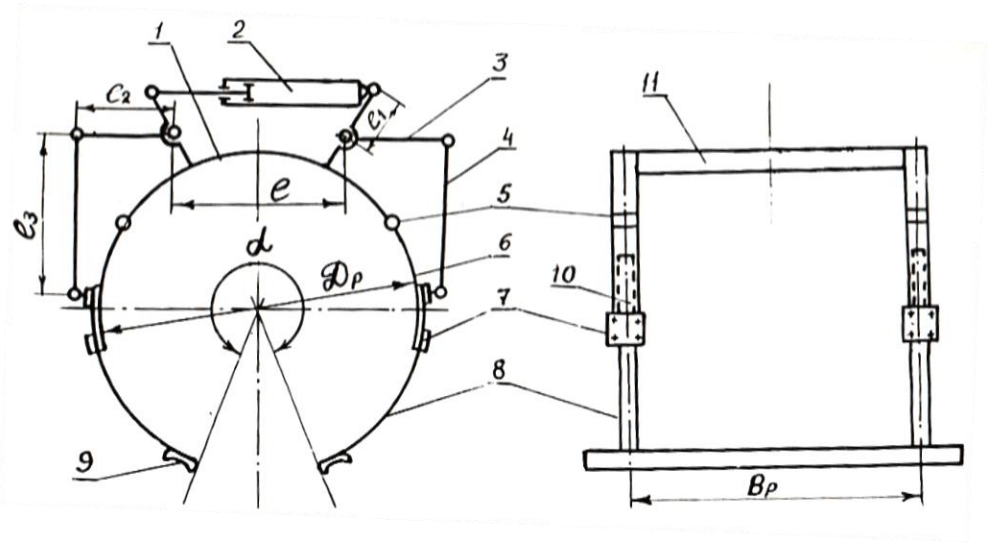

Fig.1. Kinematic diagram of the gripping device:

1-fixed teeth; 2- hydraulic cylinder; 3- double-arm lever; 4- rod; 5- hinge; 6- movable (telescopic) curved tube; 7- stop; 8- arched retractable teeth with grooves; 9- transverse bar; 10- eyelet; 11- transverse frame.

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The following designations are used in the figure [10-11]: l - the distance between the supports; l1, l2 - the lengths of the double-arm lever; α - the angle of girth; Bp - the distance between the arched teeth.

When developing the kinematic scheme of the gripping device, its versatility is taken into account, i.e. the ability to capture round elastic loads of various diameters and densities [12-13]. Based on this, the gripping device includes two sections of teeth, each of which is made of three parts with the extreme movable and two fixed.

The difficulty in developing a general theory of capturing mechanisms is that a large number of factors affect the process of capturing material [14-15]. It is noted that the gripping process, which means filling the teeth of the gripping device with a submerged material, with this nature of the interconnected movements of the teeth elements, depends more on the physical and mechanical properties of the materials to be gripped [16-17].

In order to substantiate the kinematic scheme. the main parameters and modes of operation of the mechanism for capturing and loading cotton containers, the following issues are investigated in this paper [18-19]:

a) Determination of the diameter of the gripping device;

b) Determination of the girth angle and the distance between the transverse bars of the gripping device after additional pressing of the container;

c) Determination of the diameter of the gripping device;

d) Determination of the girth angle and the distance between the transverse bars of the gripping device after additional pressing of the container;

The diameter of the gripping device is determined from the conditions for ensuring that it captures the container having the largest width [20-21]. The study of the dimensional characteristics of a container with different cotton densities in it showed that in order to ensure the free penetration of the gripping device on the container, its diameter should be at least 1.6 m [22-23].

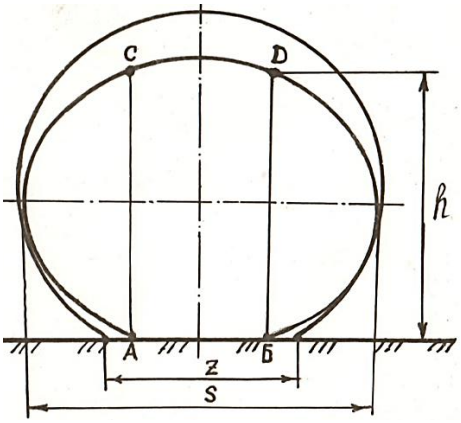

Fig.2. Diagram of the cross-section of the container unloaded on the turn lane of the field.

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From the diagram (Fig. 2), the diameter of the gripping device should exceed the width in magnitude. The section of the container is an ellipse in which the AB section is a straight section. To simplify the calculation, we take CD = AB, and the arcs AC and DB are two semicircles with a diameter equal to the height of the section h of the container [24-25].

To securely hold the container when lifting it from the soil surface, transporting it to the trailer and laying it in the trailer body, the angle of the container's girth with the gripping device should be as large as possible, and the distance between its lower transverse bars should be as small as possible [26-27].

Based on the scheme (Fig.2) we get:

$$\alpha = 2\left(\pi - arccos\frac{h}{d}\right) \qquad (1)$$

and

$$Z = \sqrt{d^2 - h^2}\,, \qquad (2)$$

or

$$\alpha = 2\left(\pi - arccos\frac{2h}{2h+\pi(D_k-h)}\right) \approx 2\left(\pi - arccos\frac{h}{1{,}57D_k-0{,}57h}\right), \quad (3)$$

$$Z = d\sin\frac{\alpha}{2} = h\,\mathrm{tg}\frac{\alpha}{2}, \qquad (4)$$

where, *h* - is the cross-section height of the container lying on the soil surface.

It follows from formulas (3) and (4) that α and *Z* depend on *d* and *h*.

As the diameter of the gripping device increases, it decreases, and the distance between its transverse bars increases, therefore, the probability of the container sliding out of the gripping device during operation increases [28-29].

Calculations carried out according to formulas (3) and (4) showed that the angle of the container's circumference by the gripping device is 270° - 290°, and the distance between the transverse bars is 0.5 – 0.7 m.

In order to increase the angle of circumference of the container by the gripping device and reduce the distance between its transverse bars, the retractable teeth between the fixed arc-shaped frame and the extreme movable teeth of the gripping device are connected pivotally (Fig. 3).

In this case, after the device reaches the soil surface, the gripping begins with movable sections 1 and 2 together with the retractable teeth, which provides additional pressing of the container.

From Fig. 3 it follows that:

$$Z' = A - 2r\sin(\gamma + \gamma'), \qquad (5)$$

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where: r is the distance from the hinge 4 to the end point A; sin γ is the angle of rotation of the end point of the gripping device (the extreme movable sections) relative to the hinge 4 with additional pressing;

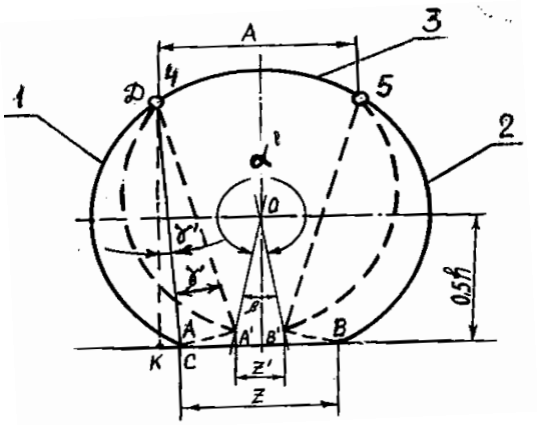

Fig. 3. Diagram for determining the angle α of the girth and the distance between the transverse bars Z' of the gripping device after additional pressing of the container.

$Z' = \text{arc sin}\frac{0{,}5\,(A\,Z)}{r}$, - the angle of deviation of the straight line connecting the hinge 4 to the end point A of the gripping device from the vertical.

Выражая расстояние *r* через известные *A*, *Z*, *d*, *h* из треугольника значения *КЧ* и *АК* в (5) получим *r*.

Expressing the distance *r* in terms of the known *A*, *Z*, *d*, *h* from the triangle values of *K4* and *AK* in (5) we get *r*.

$$Z' = A - 2r\sin(\gamma + \gamma') \quad , \qquad (6)$$

$$Z' = A - 2\sqrt{0.25\left(h + \sqrt{d^2 - A^2}\right)^2 \cdot [0.5(A - z)]^2 \sin(\gamma + \gamma')}$$

Taking into account that $Z = \sqrt{2}\ d^2 - h^2$, we get:

$$Z^1 = A - \sqrt{0.25\left(h + \sqrt{d^2 - A^2}\right)^2 \cdot \left[0.5\left(A - \sqrt{d^2 - h^2}\right)\right]^2 \sin(\gamma + \gamma')}, \qquad (7)$$

The angle of the container's circumference by the gripping device (Fig.3) taking into account expressions (6) and (7) is determined by the following dependency:

$$z' = A - \left(h + \sqrt{d^2 - A^2}\right)^2 \cdot \sin(\gamma + \gamma'), \qquad (8)$$

$$\alpha' = 2\left\{\pi - arctng\frac{[A - (h + \sqrt{d^2 - A^2})]\sin\gamma}{h - (h + \sqrt{d^2 - A^2})(1 - \cos\gamma)}\right\}, \qquad (9)$$

From the analysis of formulas (6) and (8), it follows that the appropriate choice of the distance *A* and the angle γ of the movement of the movable section of the gripping device can provide the required angle of girth of the container and the distance between the transverse bars,

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eliminating the loss of the captured container during the technological process of capturing and loading elastic cotton containers.

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