ON THE ANALYTICAL DETERMINATION OF THE LONGITUDINAL RIGIDITY OF COTTON GIN MACHINES

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Abstract: *The article investigates the issue of determining the rigidity parameters of the saw drum of cotton ginning machines, formed by stacking on the shaft a package of disks having the same thickness at different diameters and compressed by a longitudinal compression force. The problem is solved on the basis of the rules of theoretical mechanics and phenomenological analysis*

Key words: *cleaning drum; stiffness parameters; longitudinal forces; compression; a set of drums; thickness; diameter; theoretical mechanics; phenomenological analysis.*

INTRODUCTION

Cotton gins use composite structures in in the form of a package of flat elements compressed by a longitudinal force imparted by a special tension cable. Flat elements can have the same shape characteristics or change according to a certain pattern, as well as be made of the same or different material. The main purpose of using such structures is to increase the rigidity parameters of the bearing elements and working bodies of machines in the form of flexible package structures. In technological machines of the modern textile industry, composite working bodies are often used in the form of a package of flat disk elements assembled on a shaft and compressed by a longitudinal force imparted by the shaft. The results of a number of studies indicate the promise of using the drum method of cleaning cotton in the apparatus system of the cleaner, in which the most characteristic equipment is the cotton gin drum.

One of the most important working parts of cotton-cleaning machines is the cotton-cleaning drum (Fig. 1), which is assembled from drums of two different diameters [1]. A set of discs forms alternating protrusions and grooves, the widths of which are equal to each other. A set of disks is compressed by a longitudinal force with clamping nuts and forms a package capable of working not only in compression, but also in bending and torsion. Important mechanical parameters of dividing cylinders are longitudinal, bending and torsional stiffness. Obviously, these parameters of the dividing cylinder will be equal to the sum of the stiffnesses of the shaft and the package in the form of a drum set. Since the stiffness parameters of the shaft are determined in a known way [2], it is enough for us to determine the parameters of the package of disk elements.

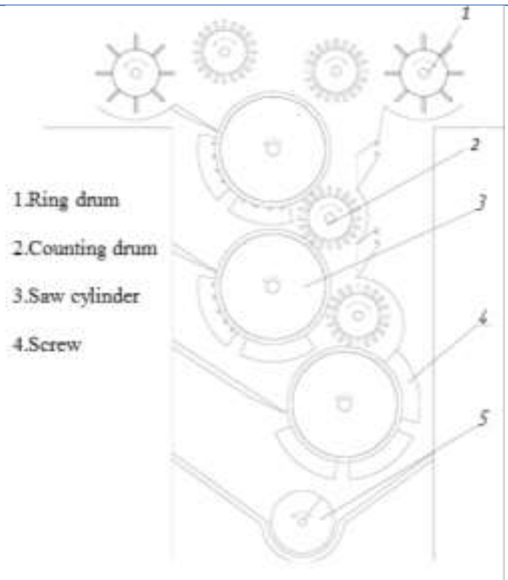

Fig.1. Scheme of cotton gins.

The problems of the mechanics of such package structures have been developed very poorly, which is due to the lack of a scientifically substantiated and reliable method for the theoretical determination of their rigidity parameters and the features of the flow of dynamic processes in them.

The study of the work of package structures in bending, tension, compression and torsion, and analytical methods for determining their stiffness parameters, the mechanisms of influence of structural and operational factors and the features of this influence showed that the issues under study are rather complex in physical and mechanical terms. Under these conditions, the use of too simplified models will give results with low accuracy. The complication of models is impractical not only because of the large number of factors to be taken into account, but also due to the large range of variation in the manifestation of their influence in stacked rods of different designs.

In the study of complex objects, methods of diacoptics and finite elements, as well as phenomenology, have recently been more effective. Based on the division of the object of study into separate parts, the methods of diacoptics and finite elements require the individualization of tasks to a large extent or the use of powerful computers.

Analytical determination of the longitudinal stiffness of package structures. We will assume that, under tension, the deformations do not exceed in absolute value the preliminary assembly deformations of the package compression. Otherwise, the package should be considered destroyed. For the time being, we will neglect the influence of contact deformations and other factors.

When working in tension of flexible stacked rods formed by longitudinal compression, only the tightening elements carry the load. Therefore, in this case, its stiffness will be equal to the sum of the stiffnesses of the tightening elements:

$$B_{bc} = \sum_{i=1}^{n} E_{ib} F_{ib} \qquad (1.1)$$

Here:

B_{bc} is the total stiffness of the tightening elements;

E_{ib} are the elastic moduli of the materials of the tightening elements;

F_{ib} are the cross-sectional areas of the tightening elements;

n is the number of tightening elements.

Now we should determine the stiffness and tensile and compression of monolithic stacked rods and on compression of flexible package rods in the absence of screeds working on compression. Obviously, the reciprocal of the relative stiffness of monolithic stacked rods in tension and compression and flexible stacked rods in compression will be equal to the sum of the reciprocals of the relative stiffnesses of flat elements.

$$\frac{L}{B_{nc}} = \sum_{i=1}^{n} \frac{l_i}{E_{in}F_{in}} \qquad (1.2)$$

Here:

E_{in} – moduli of elasticity of materials of flat elements;

F_{in} are the areas of the surfaces of flat elements subjected to compression;

L – packet length;

n is the number of flat elements;

l_i are the thicknesses of flat elements.

It follows that the rigidity of monolithic stacked rods in tension and compression , and flexible stacked rods in compression will be equal to

$$B_{nc} = \frac{L}{\sum_{i=1}^{n} \frac{l_i}{E_{in}F_{in}}} \qquad (1.3)$$

Based on the obtained solution, we write an expression for the longitudinal rigidity of a monolithic stacked rod consisting of alternating working and spacer disks:

$$B_{pn} = \frac{(l_p + l_n)E_pF_pE_nF_n}{l_nE_pF_p + l_pE_nF_n} \qquad (1.4)$$

Here:

l_p, l_n – thickness of working and intermediate disks;

E_p, E_n – moduli of elasticity of materials of working and intermediate disks;

F_p, F_n – cross-sectional areas of working and intermediate disks.

Let us assume that both the package and the tightening elements work in compression in a package design . In this case, the stiffness of monolithic stacked rods in tension and compression , and of flexible package rods for compression will be equal to the sum of the compressive rigidities of the tightening elements and the package:

$$B_{cc} = \sum_{i=1}^{n} E_{ib} F_{ib} + \frac{L}{\sum_{i=1}^{n} \frac{l_t}{E_{in} F_{in}}} \qquad (1.5)$$

In this case, the flexible package rod will be a statically indeterminate system.

Conclusion. The obtained solutions of the problem describe in qualitative and quantitative terms the change in the values of the longitudinal stiffness of the components of the working bodies such as separating cylinders of cotton gin drums in the form of packs of disk elements.

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