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COMPRESSION TESTING OF SAW GASKETS OF A LINTER MACHINE

ИСПЫТАНИЯ МЕЖДУПИЛЬНЫХ ПРОКЛАДОК ЛИНТЕРНОЙ МАШИНЫ НА СЖАТИЕ

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The article presents the results of testing the saw blades of a linter machine under compression. A universal testing machine was used in compression testing of saw gaskets of a linter machine made from aluminum alloy AK5M2 and steel St3. An analysis of the test results showed that with an increase in the sheet width from 1 mm to 2 mm, the deformation decreases from 0.0126 mm to 0.0004 mm, respectively. Therefore, in the manufacture of the gasket for the linter machine with the provision of resistance to deformation and low cost, it is necessary to use St3 sheet with a width of at least 1.5 mm. For the design of a saw gasket of 1.5 mm wide, the stress is 0.12 MPa and the compression force is 125.4 N; this leads to a 4.7 times increase in the deformation resistance during the assembly of the saw cylinder.

В статье представлены результаты испытаний междупильных прокладок линтерной машины на сжатие. При испытании междупильных прокладок линтерной машины на сжатие как из алюминиевого сплава АК5М2, так и стального Ст3 использована универсальная испытательная машина. Анализ результатов испытаний показал, что с увеличением ширины полосы с 1 мм до 2 мм деформация соответственно снижается с 0,0126 мм до 0,0004 мм. Поэтому при изготовлении прокладки линтерной машины с обеспечением устойчивости к деформациям и сниженной себестоимости необходимо использовать сталь 3 с шириной не менее 1,5 мм. Для этой конструкции междупильной прокладки с шириной 1,5 мм напряжение составляет 0,12 МПа, а сила сжатия 125,4 Н, что приводит к увеличению устойчивости к деформациям в процессе сборки пильного цилиндра в 4,7 раза.

Keywords: linter machine, saw cylinder, saw gasket, aluminum alloy AK5M2, St3, compression, stress, compression force, deformation.

Ключевые слова: линтерная машина, пильный цилиндр, междупильная прокладка, алюминиевый сплав АК5М2, сталь 3, сжатие, напряжение, сила сжатия, деформация.

Introduction

In the existing designs of linter machines, gaskets made of aluminum AK5M2 (fig. 1a) are used; they are mounted on the shaft along the entire length with gaps for saws to enter the working chamber through the ribs [1]. The operating practice of existing linter machines shows that the design of the elements of the saw-rib system does not allow obtaining the specified accuracy of assembly, which leads to a violation of spatial coordination between the conjugated links of the system [2].

The assembly of ribs is extremely time-consuming and requires a lot of highly skilled labor to perform fitting works. The principle of assembling ribs according to the method of individual fitting is applied not because of technical necessity, but because of the unresolved issues of accuracy and the low technology of design of the rib itself and its elements [3].

The main reason for the low operational reliability of the ribs is the premature wear of ribs, which leads to the premature exit of furry seeds from the working chamber of the linter machine.

In order to eliminate these shortcomings, it becomes necessary to identify the reasons for the low reliability of the saw-rib system and develop new designs that can improve the performance of linter machines while maintaining the quality of the linter and reducing its cost.

It is known that most of the ribs in the grate wear out from direct contact with the saws due to their warping and assembly errors of the saw cylinder [2, 3].

During the operation of the linter machine, the wear of ribs leads to an increase in the inter-rib gap in the working area and disruption of the linting process.

When assembling the saw cylinder of a linter machine, the technological gaps between the saw blades fluctuate over a wide range. As a result, saw blades exert additional lateral pressure on the ribs, which leads to damage to seeds and lint, and to intensive wear of the ribs [2].

Materials and methods

There are the following design and technological solutions [4] used to avoid the above disadvantages of the saw cylinder of a linter machine

- reducing the weight of the saw gasket due to the fact that through holes are made in the blade between the outer and inner diameters;
- ensuring balancing between the saw blade due to the fact that two proximate holes on the blade, located on the diametrically opposite side from the welds, are made with a reduced size;
- ensuring the coordination of the saw blades on the saw cylinder due to the fact that a second belt with holes is installed in the inner hole of the blade;
- ensuring the rigidity of the fastening of the saw blades in the saw cylinder due to the fact that in the inner surface of the blade, on the diametrically opposite side from the weld, a protrusion is made in the form of a straight-sided slot with the possibility of the protrusion entering the hole of the second belt and the groove of the saw cylinder shaft (fig. 1b).

The study in [5] presents the results of theoretical calculations of the stability of the saw blade of a 5LP linter machine under compression. An increase in the number of half-waves for steel St3 (n=0.4672) in contrast to aluminum AK5M2 (n=0.3276) by 42.6% and a critical compressive force (for St3 - Tcr=2263.4 MPa and for AK5M2 - Tcr=1642.3 MPa) by 37.8% was stated. According to the results of calculations of the stability of saw gaskets made of St3 and aluminum AK5M2, it is recommended to use a steel saw gasket when assembling the saw cylinders of the 5LP linter machine.

a) b)

Fig. 1

The study in [5] presents the results of theoretical calculations of the stability of the saw blade of a 5LP linter machine under compression. An increase in the number of half-waves for steel St3 (n=0.4672) in contrast to aluminum AK5M2 (n=0.3276) by 42.6% and a critical compressive force (for St3 - Tcr=2263.4 MPa and for AK5M2 - Tcr=1642.3 MPa) by 37.8% was stated. According to the results of calculations of the stability of saw gaskets made of St3 and aluminum AK5M2, it is recommended to use a steel saw gasket when assembling the saw cylinders of the 5LP linter machine.

However, to determine the practical stability of the recommended design of saw gasket, it is necessary to subject them to a compression test.

To determine the compressive stability of the saw blades of the linter machine, made of aluminum alloy AK5M2 and steel St3, the universal testing machine WAW-1000D was used (fig. 2) [6].

Universal testing machine WAW-1000D for tension and compression consists of: 1 – control unit; 2 – Maxtest software; 3 – traverses with a helical column; 4 – grippers (wedge clamps); 5 – 4-column load frame; 6 – test space for tension; 7 – test space for compression; 8 – oil cylinder (fig. 2).

To test samples for compression, it is necessary to mount the upper pressure plate 4 on the lower part of the lower beam 6 and fix the cap with screws 3. The lower saddle of the ball plate is positioned by cap 7 and placed on the desktop. In this case, installation with an inclination is allowed. It fits the flat sample under pressure, and the centerline must match the centerline of the pressure plate 6 to avoid eccentricity (fig. 3: 1 – Traverse; 2 – Tap; 3 – Bolts; 4 – Upper pressure plate; 5 – Sample; 6 – Lower pressure plate; 7 – Tap; 8 – Bench).

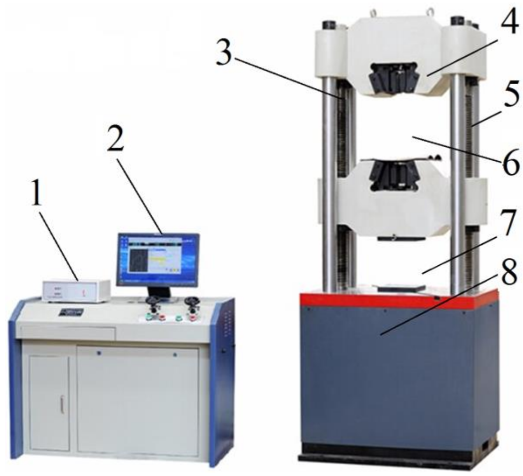

Fig. 2

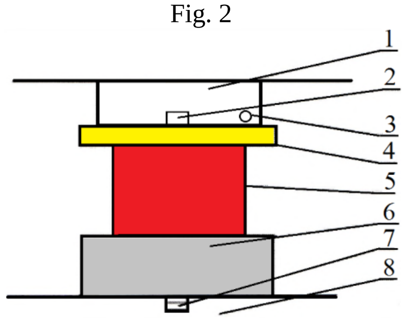

Fig. 3

Basic requirements, methods, and equipment set standards for testing samples to determine the characteristics of mechanical properties and tensile strength of construction and other materials at a certain temperature [7].

The standard establishes a method for testing specimens to determine the mathematical relationship between stress and strain and to evaluate the ultimate strength. The mechanical characteristics defined in the standard can be used in [8]:

- selection of materials and justification of design solutions;
- acceptance inspection sampling of normalization of mechanical characteristics and evaluation of the quality of materials;
- development of technological processes and product design;
- calculations for the strength of structural elements.

Instruments and systems for measuring the deformation of materials must be accurate enough to perform a reliable analysis of the stress-strain state over the entire measurement range.

Results and discussions

The results of experimental tests for compression of the saw blades of a linter machine made of aluminum alloy AK5M2 and steel St3 (with a blade thickness of 1, 1.5, and 2 mm) are shown in fig. 4-7.

According to the requirements of experiment planning, the interval for varying the load on the sample was changed. Mathematical processing of the results of the experiment was performed with a level of reliability (ρ=0.95) [9-11].

Experimental results show that an increase in the area of contact between the gasket and saw blades leads to an increase in stress in the working area. The axial compression force of the saw blades when assembling the saw cylinder should not be less than $20 \cdot 10^3$ N [2]. If we take the area of contact of the gasket of the linter machine as 0.00209 m^2, then the stress is 9.567 MPa. Here, 159 saw gaskets are installed on the saw cylinder, the tightening force on one gasket is 125.786 N, and the stress is 0.06 MPa.

The gaskets of linter machines made from different materials and at the same load values have different strain and stress values. It is known that the influence of forces on materials leads to the deformation of gaskets in linter machines. To study this process, materials for linter machines made of steel 3 and aluminum were chosen (fig. 4-7). The values of strain and stress are determined for the same working areas. Generally, the area of a serial (aluminum) gasket of linter machines is on average $2.09 \cdot 10^{-3}$ m^2, while the proposed steel (Steel 3) gaskets with a thickness of 1.5 mm have an area of $1.04 \cdot 10^{-3}$ m^2, that is, the area is reduced to 2 times.

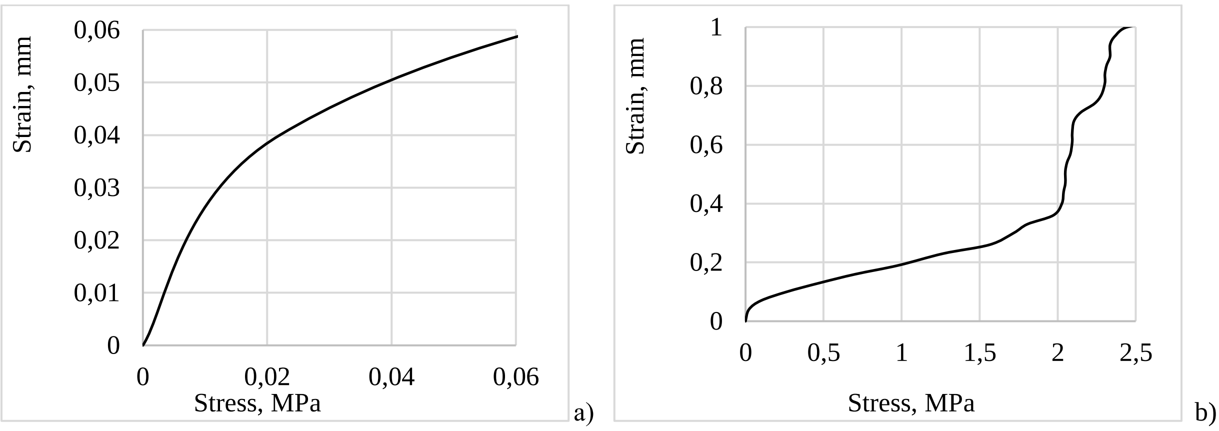

Fig. 4

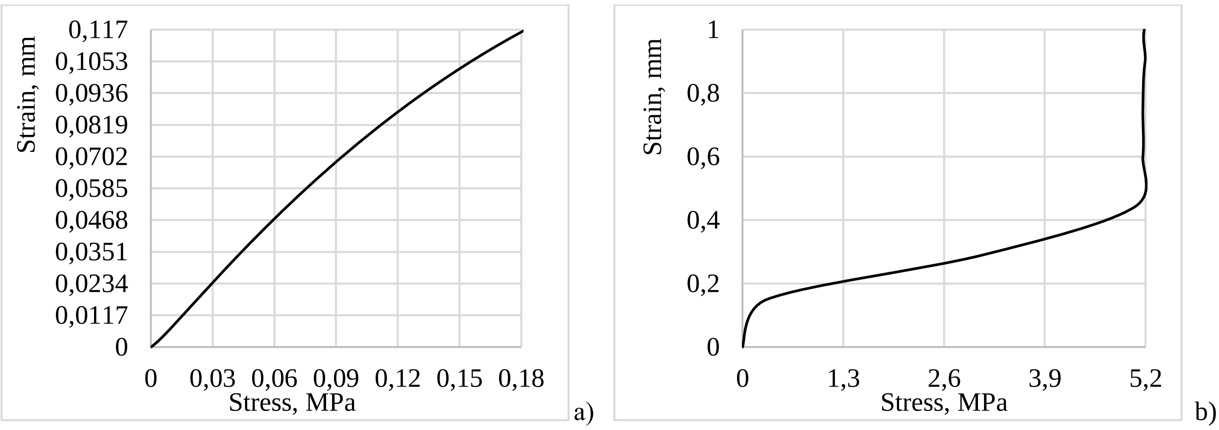

Fig. 5

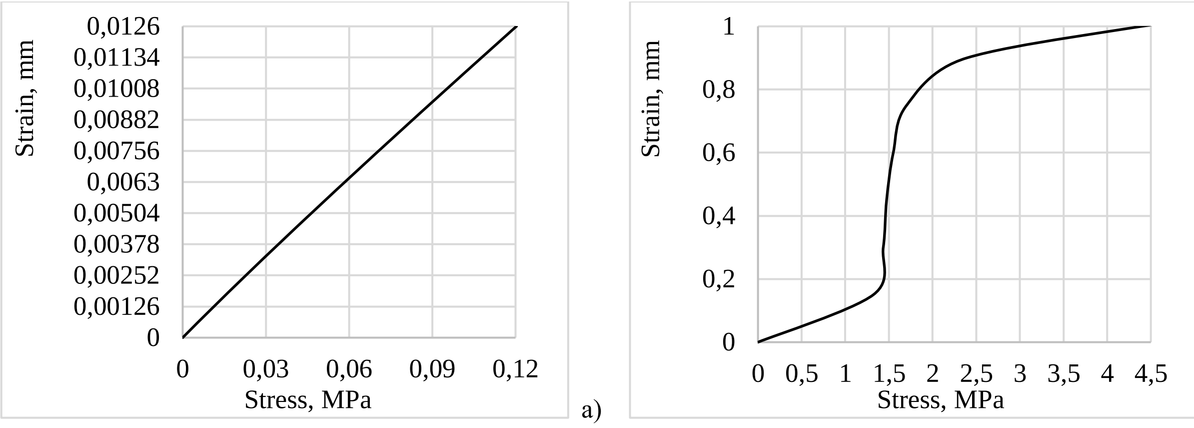

Fig. 6

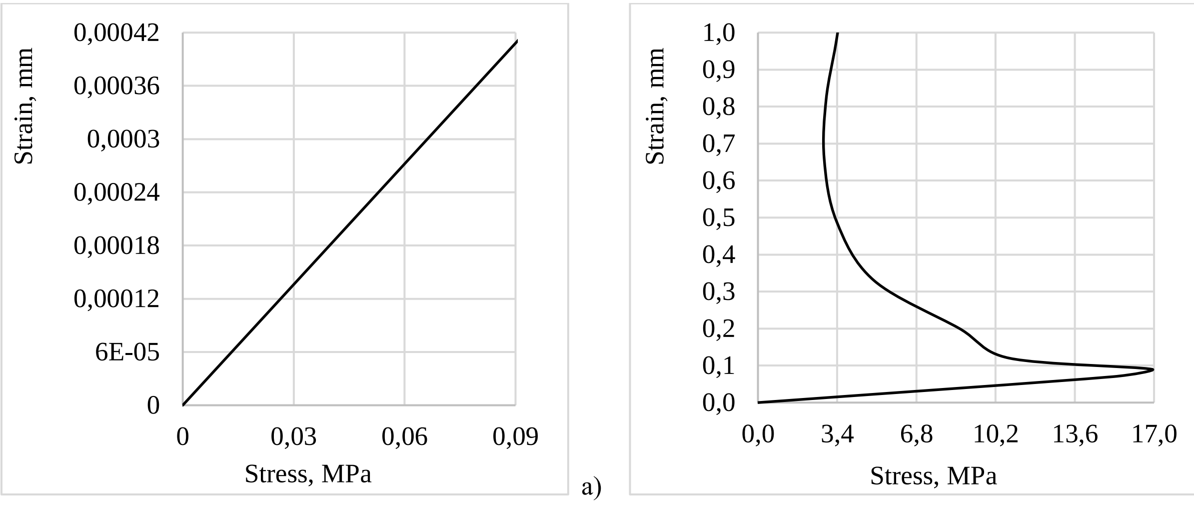

Fig. 7

Table 1

№	Sort and material of gasket	Thickness, mm	Width, mm	Contact area, mm^2	Compression force, N	Stress, MPa	Strain, mm	Difference, %
1	aluminum (AK5M2)	8.75	3	0.00209	125.4	0.06	0.06	100.0
2	St 3	8.75	1	0.00070	125.4	0.18	0.114	52.6
3	St 3	8.75	1.5	0.00104	125.4	0.12	0.0126	476.2
4	St 3	8.75	2	0.00139	125.4	0.09	0.0004	14285.7

According to the results of the research, it was found that the accuracy of fastening increases, and the contact area of the steel gasket decreases, which leads to a decrease in the tightening force of the saw blades.

The results of an experimental study on compression of the gaskets of linter machines (strain and stress) using the WAW-1000D universal testing machine are shown in table 1.

An analysis of the test results showed that, with an increase in the sheet width from 1 mm to 2 mm, the deformation decreases from 0.0126 mm to 0.0004 mm. Therefore, for the manufacture of the gasket of the linter machine, in terms of resistance to deformation and cost, it is necessary to use steel 3 with a width of at least 1.5 mm. For this design, the stress is 0.12 MPa and the compression force is 125.4 N; the resistance to deformation during the assembly of the saw cylinder is increased by 4.7 times.

CONCLUSIONS

According to the results of the research, it was found that the accuracy of fastening increases and the contact area of the steel gasket decreases, which leads to a decrease in the tightening force of the saw blades on the shaft of the saw cylinder of the linter machine. In addition, it was found that, with an increase in the sheet width from 1 mm to 2 mm, the deformation decreases from 0.0126 mm to 0.0004 mm. Therefore, for the manufacture of a gasket for a linter machine, steel 3 with a width of at least 1.5 mm is required. For a gasket with a width of 1.5 mm, the stress is 0.12 MPa, and the pressure force is 125.4 N; so, the resistance to deformation during the assembly of the saw cylinder increases by 4.7 times.

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