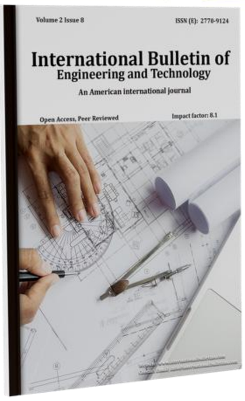

ANALYSIS OF WAYS OF INFLUENCE ON RIGID PARAMETERS OF PACKAGE WORKING BODIES OF VARIOUS FACTORS

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Abstract: The article examines the peculiarities of the influence on the rigidity parameters of package structures, which are a package formed from hard drives having small thicknesses compared to its length and transverse dimensions in various ways. The problem was solved by qualitative analysis of the work of a package structure for bending, torsion and compression-tension. A qualitative analysis of the features of the influence of design and operational factors on the rigidity parameters of the FPR was carried out. The main ways in which structural and operational factors influence the rigidity parameters of package structures are changes in the magnitudes of volumetric contact elastic and plastic deformations of the disk elements of the package, changes in the magnitudes of friction forces on the surfaces of mutual contact of flat elements, and changes in the values of elastic and plastic longitudinal deformations of the tension elements of the package. A qualitative analysis of the features of the influence of design and operational factors on the rigidity parameters of the FPR was carried out.

Keywords: flexible packet rod; bending stiffness; longitudinal stiffness; torsional stiffness; the influence of design factors; the impact of operational factors.

For modern mechanical engineering, one of the characteristic trends remains the desire to increase machine productivity by increasing speed, which leads to an increase in workloads and increased requirements for accuracy, reliability and efficiency.

Simultaneously satisfying these conflicting requirements is a very complex task, the successful solution of which requires the use of non-traditional approaches to its solution. One such approach is optimal design. A feature of optimal design is finding the optimal or extreme value of some parameter, for example, mass or cost, given several given initial parameters or limiting factors. An increase in the number of factors to be taken into account while simultaneously increasing the requirements for design accuracy, characteristic of optimal design, has led to the need for a sharp increase in the accuracy of determining these factors, which have a different physical nature. In conditions of intensification of work processes and increasing complexity of design, especially characteristic of the development of machines in the textile, light and cotton industries in recent years, problems of dynamics and strength, in particular vibration calculations, have come to the fore. These problems become particularly relevant when designing composite working bodies that have packages formed from flat working and spacer elements. These include the main working parts of a number of technological machines in the textile and light industry - fabric-forming bodies of multi-shed weaving machines of the TMM-360 type, separating cylinders of carding machines, condensers of carding-knitting units ChN-180, stacking shafts of finishing machines, saw cylinders in various cotton machines, knife drums of scattering machines, etc. This means that the composite structures under consideration operate as a monolithic body. We will conduct a study of the ways in which the rigidity parameters of such working bodies are influenced by various design and operational factors using the method of qualitative analysis. Research was carried out on the theoretical basis for determining the flexural stiffness of package structures, the issues of determining the flexural rigidity of package structures and the issues of analytical and phenomenological determination of the parameters of bending, torsional and longitudinal stiffness of package structures, as a result of which it was revealed, in particular, that the bending stiffness C of flexible package rods (FPR)) in the form of flat elements pulled into a package by a longitudinal compression force N can, in a first approximation, be defined as twice the product of the compression force and the square of the distance from the extreme point on the contact surface of the flat elements on the concave side of the bending FPR to the geometric axis of the flexible thread compressing it R. Such hydraulic structures are an integral part of the main working parts of a number of technological machines and building structures and help ensure their required rigidity. We study the peculiarities of the influence of design and operational factors on the rigidity parameters of the FPR[1,2,3].

We accept the following conventions and assumptions that we will follow within the framework of this work.

A. A package rod is a composite structure consisting of flat elements of arbitrary configuration, possibly from various materials, connected into a package in any way. The main requirement that a stacked rod must meet is its ability to maintain the integrity of the structure under external force.

b. A packaged rod of the described type and performing a certain structural or technological function will be called a packaged working body. The most typical representatives of batch working bodies of this type are the saw cylinders of various cotton gin machines.

V. A packet rod in which the formation of a packet is produced by a flexible thread that does not have bending and torsional rigidity will be called a flexible packet rod (FPR).

d. A stacked rod, which is formed not due to the compression force of the stack, but due to the fact that the flat elements along the contact surfaces are fastened to each other so that the stack can work in tension, bending and torsion, we will call it a monolithic stacked rod (MSR)[4,5].

On the ways in which design and operational factors influence the rigidity parameters of the hydraulic system. The influence of various factors on the rigidity parameters of packaged working bodies is determined mainly by their influence on the rigidity parameters of the FPR, which are a structural part of the packaged working bodies. The thickness of the flat elements of the FPR package is 2-3 orders of magnitude less than its transverse dimensions. In this regard, under the action of longitudinal compressive forces on the package, almost its entire volume is in a volumetric stress state and experiences contact volumetric deformations. The role of volumetric deformations in FPR packages consisting of flat elements with discontinuous contact surfaces between them is especially great. The theoretical analysis carried out shows that design and operational factors have an indirect effect on the values of the rigidity parameters of all types of hydraulic structures, primarily due to changes in the volumetric contact elastic and plastic deformations of the disk elements of the package under the influence of changes in the compression force of the package and external force factors, changes in shape, geometric the dimensions of the package elements, the number of package elements and the sizes of the contact surfaces between them, the thickness of the elements and the material of the elements, time and other factors. Another important way of indirect influence of design and

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operational factors on the values of the rigidity parameters of the hydraulic structure is the change in the magnitude of the friction forces on the mutual contact surfaces of the flat elements of the package under the action of the compressive force of the package, changes in the shape, geometric dimensions and distribution of the contact surfaces of the flat elements, the number of contact surfaces of the flat elements, frictional properties of the material of flat elements, the state of contact surfaces and the presence of substances with frictional or antifriction properties on them. And, finally, design and operational factors can influence the values of the rigidity parameters of the FPR also due to the appearance and change in the values of elastic and plastic longitudinal deformations of the tightening elements of the package under the influence of changes in their tensile force, the geometric dimensions of their cross sections and length, and the mechanical properties of the thread material in time, its wear, relaxation phenomena, etc[6].

Features of the influence of elastic and plastic contact deformations of flat elements arising during operation are mainly as follows:

Contact deformations lead to a decrease in the numerical values of all rigidity parameters of the FPR. Moreover, if elastic deformations cause a slight decrease in stiffness, then plastic deformations lead to a significant decrease in the bending, longitudinal and torsional stiffness of the FPR. With an increase in the values of primary elastic and plastic contact deformations caused by the mounting compression force, the sensitivity to the action of contact deformations subsequently caused by working loads decreases [7].

The features of the influence of friction forces between flat elements are defined as follows:

Frictional forces between flat elements develop forces and moments of friction forces, complementary to the forces and moments generated by the tensile force of flexible threads, and help to increase the bending and torsional rigidity of the FPR [8,9].

Friction forces to a certain extent prevent the development of elastic and plastic contact deformations of flat elements, and thus contribute to a slight increase in the bending longitudinal and torsional rigidity of the FPR. Features of the influence of elastic and plastic deformations of the tension elements of a package of flat elements are as follows:

Additional elastic deformations of the tension elements of the package under operating loading contribute to the appearance of additional compression forces in them, and thus an increase in the magnitude of bending, longitudinal and torsional stiffness.

Plastic deformations of the tightening elements of the package help to reduce the compressive forces of the package and, thus, reduce the values of rigidity parameters of all types. Qualitative analysis of the influence of design and operational factors on the rigidity parameters of the FPR. Influence of the magnitude of the package compression force. The magnitude of the compression force of the package determines the magnitude of contact deformations in the absence of an external working load. Due to the characteristic features noted above, the influence of contact deformations on the rigidity parameters during compression of the FPR with an increase in the compression force of the package, the degree of its relative influence decreases. In this case, the rigidity parameters during compression of the GPS monotonically increase and asymptotically approach the calculated values determined for a monolithic stacked rod. The influence of the number of flat elements of the package. The number of flat elements of the FPR package determines the number of contact surfaces, therefore, the greater the number of flat elements, the greater the influence of all other factors

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acting due to contact deformations, for example, the magnitude of the compression force on the rigidity parameters of the FPR during compression [10,11,12].

With other design factors remaining unchanged, an increase in the number of flat elements leads to a steady decrease in the values of the rigidity parameters of the FPR.

Influence of physical and mechanical properties of the material of flat elements. The magnitude of contact deformations, other things being equal, depends on the mechanical properties of the material of the flat elements, and the friction force depends on the friction coefficient of the materials. Therefore, with an increase in the elasticity modulus, hardness, and the coefficient of mutual friction of materials, the rigidity parameters of the FPR invariably increase. Conversely, a decrease in the listed parameters, as well as an increase in the plasticity of materials of flat elements, will lead to a decrease in the rigidity parameters of the FPR. The influence of geometric parameters of flat elements of the package. In cases where the contact surfaces are not continuous planes, but discontinuous ones, the intensity of contact deformations increases. Therefore, with a decrease in the values of one or two sizes of contact areas in mutually perpendicular directions as a result of an increase in contact deformations of flat elements under operating loading, the FPR and its rigidity parameters decrease. The nature of the distribution of individual contact surfaces over the cross section also has a certain influence. With an increase in the degree of dispersion of individual contact surfaces and an increase in the distances between them, there will also be an intensification of contact deformations and a decrease in the rigidity parameters of the FPR. The magnitude of the angles of repose of the non-working surfaces adjacent to the contact surfaces and the nature of the transition of some non-working surfaces to others also have a certain significance. A decrease in slope angles to zero, and even more so their negative values, as well as a decrease in their radii of transition of one surface to another also lead to an intensification of contact deformations, which will ultimately lead to a decrease in the rigidity parameters of the FPR. Influence of the state of contact surfaces of flat elements of the package. In the development of compression deformations, as well as contact deformations, the presence and magnitude of friction forces in the contact surfaces of interacting elements plays a certain role. In this regard, the state of the contact surfaces of flat elements will also have a certain influence on the value of the rigidity parameters of the FPR. Thus, a decrease in the roughness of contact surfaces and the presence of foreign substances in the contact zone that have a lubricating effect will ultimately lead to a decrease in rigidity parameters, especially torsional, FPR. Conversely, an increase in roughness and the presence of substances with frictional properties in the contact zone will have the opposite effect [13]. The influence of the accuracy of geometric shapes and sizes.

As experiments show, at low values of compression force, the parameters of the stiffness of the FPR have significantly lower values and have a steady tendency to increase with its increase. One of the main reasons for this phenomenon is the fact that there are deviations from the flatness and parallelism of the contact surfaces of flat elements, for example, their warping due to manufacturing errors, as well as the presence of residual plastic deformations and internal stresses. Therefore, at low values of the compression force, the numerical indicators of the rigidity of the FPR have reduced values. However, with an increase in the compression force, the flat elements, experiencing elastic and small plastic deformations, begin to come into contact with most of the contact surfaces and, accordingly, the rigidity parameters of the FPR gradually increase. Obviously, this tendency will occur up to a certain value of the compression

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force, at which tight contact of all elements is ensured over the entire contact surface. It follows that with an increase in the accuracy of the geometric shapes and dimensions of flat elements in the direction of the longitudinal axis of the rod, it will contribute to an increase in rigidity indicators at compression force values less than a certain value. Some authors consider this value to be the smallest permissible value of the axial compression force in package working bodies [14].

The influence of the time factor, as our observations show, appears regardless of whether the package working body is in operation or in storage. The influence of the time factor is due to the phenomena of creep and relaxation and the rheological properties of the objects under study. In this regard, this influence is more pronounced in package structures in which non-ferrous metals and a number of non-metallic materials are used. The use of only ferrous metals in real structures definitely excludes time as a factor influencing the rigidity parameters. If with moderate compression forces, as in the working rollers of gins with flat elements, the influence of the time factor is most clearly manifested, then with very large preliminary and nominal forces, as in the stacking shafts of finishing machines, this influence is practically absent. Our analysis shows that the influence of the time factor on the rigidity parameters of the FPR can be qualitatively presented as follows. Over time, the magnitude of contact deformations of flat elements made of non-ferrous metals, for example, aluminum, due to the phenomena of creep and relaxation, increases, and contact stresses decrease and, as a result, the compression forces of the packages decrease. The end result of this process is a slight decrease in the values of the rigidity parameters of the FPR with small external compression forces of the package rod [15].

The main factors influencing the rigidity parameters of the FPR design factors are the number, shape, geometric dimensions of the elements of the package, the size of the contact surfaces between them, the thickness of the elements, the material of the elements, the frictional properties of the material of the flat elements, the condition of the contact surfaces and the presence of substances with frictional or antifriction properties on them.

A qualitative analysis of the features of the influence of design and operational factors on the rigidity parameters of the FPR was carried out.

The main ways in which structural and operational factors influence the rigidity parameters of package structures are changes in the magnitudes of volumetric contact elastic and plastic deformations of the disk elements of the package, changes in the magnitudes of friction forces on the surfaces of mutual contact of flat elements, and changes in the values of elastic and plastic longitudinal deformations of the tension elements of the package. A qualitative analysis of the features of the influence of design and operational factors on the rigidity parameters of the FPR was carried out.

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