Device For Determining Multi-Cycle Tensile Strain Of Knitted Fabrics (Pulsator)

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ABSTRACT

The article discusses the need to create equipment for determining the multi-cycle tensile deformation of knitted fabrics and the possibility of a more complete analysis of the dimensional stability of knitted fabrics by determining it, as well as the creation of a special pulsation device for this purpose. The composition of the main parts of the pulsator device and its use, as well as a schematic and external drawing of the device, are given.

Keywords: single-cycle stretching deformation, longitudinal, transverse, dispersion, plastic deformation, elastic deformation, recommended device, pulsator

Introduction

The strength and elasticity of knitwear are determined by the fabric structure (i.e., weave type), knitting density, and finishing method and technique. The ability of knitwear to regain its shape after being subjected to a force less than the breaking strength depends on the weave type, weave density, and fiber composition of the fabric. This property of knitwear is especially important for outerwear, as changes in shape and size during wear lead to wear and tear. Knitted fabrics have high volumetric elasticity, meaning they can conform to the body without creasing or wrinkling, and maintain a defined shape.

Knitted fabrics, thanks to their high elasticity, easily assume spatial shapes; they exhibit relative elongation of up to 35%, and for more elastic fabrics of elongation groups II and III, up to 55%. The ability of knitted fabrics to recover their shape under the influence of a force less than the breaking force depends on the type of weave, knit density, and fiber composition of the fabric.

Plastic deformation in knitted fabrics primarily depends on the interfiber bonding of the material and the density of the weave. The structure and knitting technology of knitted fabrics influence the degree of plastic deformation. Analyzing the relationship between elastic and plastic deformation of knitted fabrics is important when assessing the durability of the fabric during long-term use.

High-cycle elongation deformation characterizes the fatigue properties of textile fabrics, that is, the magnitude of residual deformation, necessitating an analysis of the shape-retention properties of knitted fabrics.

METHODS

To study the deformation properties of textile fabrics, specialized pulsator devices are used. Their design and operating principles vary, as do the analysis of the obtained results. The recommended device (pulsator) for determining the tensile deformation of knitted fabrics is important in terms of the reliability of the mechanical components, the accuracy of the measuring systems, and ease of use.

The core of the device is a massive St45 steel plate measuring 500 x 300 x 20 mm. The plate is equipped with stiffening ribs, ensuring high stability of the entire structure and reducing vibration during operation. The plate provides mounting points for the device components using a tongue-and-groove system. This mounting system ensures the accuracy of the relative positioning of the components and ensures ease of installation. The device is driven by a 0.25 kW DC motor, which transmits rotational motion via a belt drive. This transmission consists of a control pulley, a belt, and a driven pulley. The belt drive ensures smooth movement and effective damping of dynamic forces, which is essential when applying periodic loads to specimens. To adjust the position of the crank, which is part of the crank mechanism, rotational motion is transmitted from the pulley to the disk. This mechanism periodically stretches the specimen mounted on a reciprocating clamp, with rotational motion. The precision of the moving parts, made of hardened steel and mounted on supports, is ensured by a guide system. P5 precision linear bearings are used to minimize friction and ensure smooth operation. When moving the moving parts in a straight line, a movement accuracy of no more than 0.02 mm per 100 mm is guaranteed, a critical parameter for obtaining reliable test results. During the design of the device, special attention was paid to the specimen clamping system. It is made of a special material with an optimal coefficient of friction. The clamps are mounted on sliding and rigidly fixed clamps, allowing for precise specimen positioning. The clamp design ensures secure holding of specimens of varying thicknesses (from 0.5 to 5 mm) without damage. Initial tension is applied to the specimen using adjusting nuts and a force sensor through a threaded screw, which controls the force with an accuracy of ±0.1 N. This system allows for smooth adjustment of the initial force in the range from 0 to 50 N. Experimental parameters are monitored using a set of measuring instruments, including a Hall sensor for cyclic force, a strain gauge for calibration, and displacement sensors based on linear encoders. All data is recorded by a data acquisition and processing system integrated into the automated control system. This system, built on an AT mega 2560 microprocessor, ensures cyclic force frequency stabilization with an accuracy of ±0.1%, motion amplitude control, and real-time recording of test parameters.

The device's technical specifications confirm its high performance and reliability. The maximum load is 100 N, and the motion amplitude ranges from 0 to 50 mm. The frequency of the periodic force application can vary from 0.1 to 5 Hz, allowing the device to be adapted to various testing modes. The force measurement accuracy is ±0.1 N, and the elongation measurement accuracy is ±0.01 mm. The device is capable of performing 107 cycles, making it suitable for long-term studies.

A key feature of the device is its automatic test parameter recording system. Signals from all sensors are transmitted to a microprocessor control unit, where they are first processed and stored in permanent memory. This allows not only for real-time monitoring of the testing process but also for detailed analysis of the obtained results. The testing process begins with the sample being placed in clamps, the clamp design of which ensures a strictly vertical position of the sample and uniform force distribution across its width.

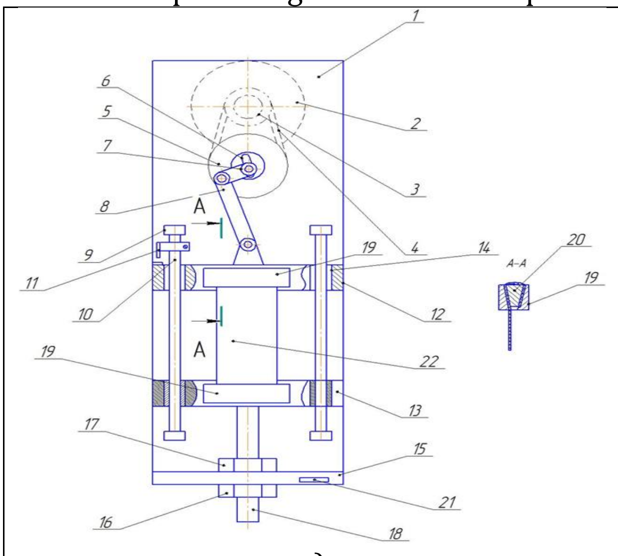
After the initial force is generated, its value is selected based on the type of fabric being tested, the drive is activated, and the initial force is applied to the sample. The frequency and amplitude of the force are precisely controlled by the control system, ensuring repeatable test results. Tests can be conducted over a wide range of parameters: the frequency of force application ranges from 0.1 to 5 Hz, the deformation amplitude ranges from 1 to 50 mm, and the initial force ranges from 0 to 50 N. This wide range of parameters allows for the study of various types of knitted fabrics and the development of their applications in real time. The control system ensures smooth changes in test parameters during testing, which is important for studying the fatigue properties (residual deformation) of fabrics.

The main part consists of plate 1, on which electric motor 2 is mounted, transmitting rotational motion to a V-belt drive comprising pulleys 3 and 5, as well as V-belt 4. Pulley 5 transmits rotational motion to the cross-shaped adjusting disk 6, which converts the rotational motion into reciprocating motion of clamp 12. The clamps (movable 12 and fixed 13) are mounted on guides 10 using linear bearings 14 and 9, ensuring high movement accuracy and reducing friction.

To secure fabric sample 22, wedge clamps 19 with fasteners 20 are used, ensuring a secure hold of the material and preventing its slippage during testing. The initial force on the sample is generated using screws 18 with nuts 16 and 17. The magnitude of the initial force is monitored by sensor 21, allowing for precise determination of the initial test conditions.

The number of loading cycles is monitored by Hall sensor 11, equipped with a slider whose position can be adjusted depending on the required frequency amplitude. This sensor design allows it to be adapted to various testing modes, a significant advantage of the developed device.

The developed experimental device has been used to determine the high-cycle tensile strain of knitted fabrics. The device design ensures control of all necessary testing modes and parameters.



a)

b)

Figure 1. a) Schematic diagram of the device, b) appearance of the device

The instrument's design allows for maintenance of all adjustable components and the quick replacement of worn parts. Routine maintenance includes checking and adjusting belt tension, lubrication of guides and bearings, calibration of measuring systems, and positioning accuracy testing. To ensure the reliability of test results, an accuracy monitoring system has been developed. It includes checking geometric parameters (straightness of movement, parallelism of guides, interconnection of nodes), monitoring force parameters (calibration of the load cell, checking of load uniformity), and analysis of dynamic characteristics (load frequency, vibration, smoothness of movement). All these instructions guarantee the stability of the tool's properties during operation.

Conclusion

The advanced pulsator for determining the multi-cycle tensile strain of textiles is a state-of-the-art device that delivers high measurement accuracy (force measurement error of ±0.1 N, displacement of ±0.01 mm), ease of use, and reliable results. Its design allows for the implementation of all necessary testing modes with high accuracy (power frequency stability of ±3%). The device's compact dimensions (800 x 400 x 350 mm) and weight of 45 kg allow it to fit on a standard laboratory bench, and its 220 V power supply allows for its use in a variety of environments. The modular architecture of the control and data acquisition system allows for adaptation to various material mechanical properties studies and expands its functionality by connecting additional sensors and measuring instruments.

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