The device for manufacturing torsion bars with helical anisotropy UISAT-1

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Abstract

The article describes the device for manufacturing torsion bars with helical anisotropy, performed as a braid made of Kevlar filaments (fibers). It is demonstrated physical and kinematic configurations, operation concept of the device is described. Characteristics produced torsion bars is discussed.

Keywords: The device for manufacturing torsion bars, Kevlar, torsion magnetometer

1. Introduction

There exists a range of devices, in sensitive elements (SE) of which threads, suspension or stretching are used. Among them are torsion devices (for example torsion balance, several magnetometers), string accelerometers, seismographs, etc. Main requirements for a SE are imposed upon: linearity and unambiguity of static characteristic, high sensitivity and resolution capability; repeatable accuracy in time, load tolerance of static characteristics, minimal inertia; minimal external influence (temperature, vibration, etc.); chemoresistance; simplicity and manufacturability of design; interchangeability (repeatability of characteristics); ease of installation and operation activity. The type of selected SE is depends on system accuracy requirement, its destination and operation conditions [1].

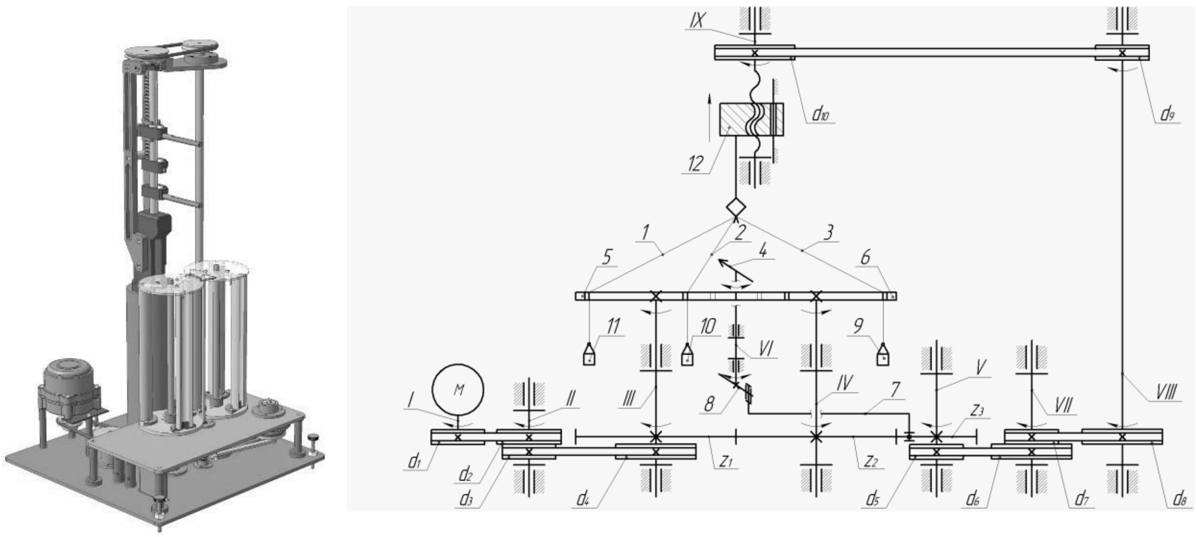
To improve performance of devices of this type, it was suggested of making SE in a form of braid, which comes from the theory of spiral-anisotropic bodies. Filaments of Kevlar threads have been selected as a raw material.

The device for manufacturing of the particularly thin ultrastrong torsion bars has developed. For the time being, they are used as a suspension of the magnetosensitive element (MSE) of torsion magnetometer (TM), which is a part of the geophysical complex GI-MTS-1 (SPbF IZMIRAN). The main advantage of TM with this MSE is a recording of the magnetic fields and their variations in the frequency range of 0…8 Hz, with the meansquare noise level not exceeding 1 [$pT/\sqrt{Hz}$], however device has low climatic factors (temperature, moisture) dependence and have increased resistance to dynamical load.

2. Operation concept of the UISAT-1

The suspension of the MSE is made of three strings with the help of UISAT-1. A single filament is used in string, diameter of each doesn’t exceed 15 microns.

Physical and kinematic configurations of the device are shown in Fig. 1.

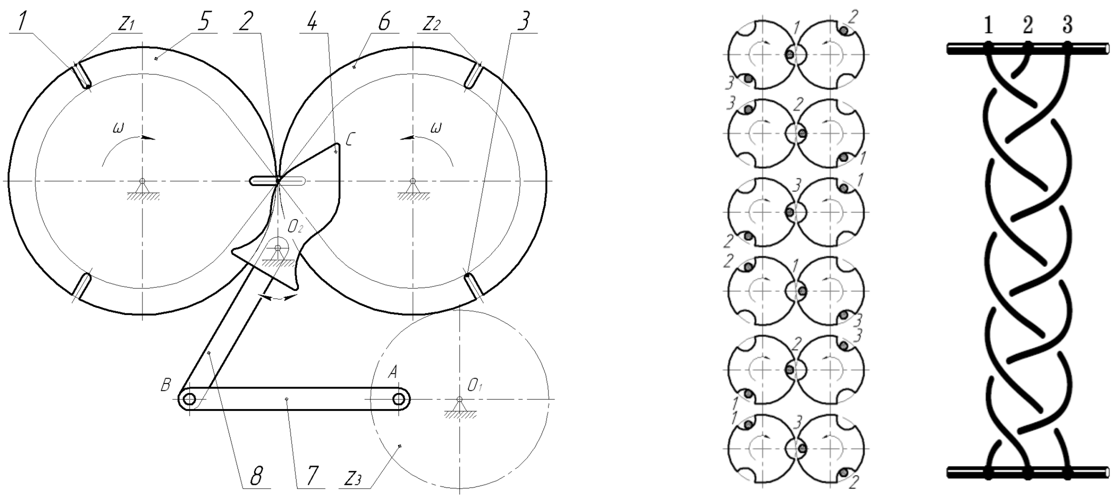


(a) (b)

Fig. 1. Physical (a) and kinematic (b) configurations of the UISAT-1
1..3 – braid strings, 4 – arrow-like cam, 5,6 – disks, 7 – con-rod, 8 – yoke,
9..11 – plummets, 12 – screw-nut, I..IX – axles, $z_1 .. z_3$ – gear wheels, $d_1 .. d_{10}$ – sheaves.

The process of braiding is implemented as follows: using the electric motor M through some intermediate transfer mechanism ($d_1 .. d_4$) revolves two disks 5 and 6, in which slots three strings (1..3) of future braid are passed through. With the help of gear wheels z_1 and z_2 rotation in the mutually-opposite direction of the disks is realized. Synchronically with the rotation of the disks reciprocating rotary motion of arrow-like cam is implemented through the yoke mechanism drive (z_3, 7, 8) of cam 4 . Thus, the arrow-like cam transfers braid string from slots of one disk to free slots of another one. Feed gearing ($d_1 .. d_{10}$, IX, 12) provide a uniform lift of braiding block as strings are being interlaced by braiding mechanism. Constant braid strings (1..3) tension is provided by plummets (9..11).

The sketch of executing mechanism of the device, the diagram of working cycle and the structure of produced torsion bar are accordingly shown in Fig. 2 [2].



(a) (b) (c)

Fig. 2. Executing mechanism of the UISAT-1 (a), diagram of working cycle (b) and product (braid) (c).
1..3 – braid strings, 4 – arrow-like cam, 5,6 – disks, 7 – con-rod, 8 – yoke, $z_1 .. z_3$ – gear wheels.

3. Characteristics of torsion bars

Torsion bars obtained by means of device are made of Kevlar filaments. The synthetic high-modulus yarns designed by the Russian scientists and engineers are rated as para-aramid fiber. Yarns are unique by its properties: high tensile strength, high modulus of elasticity, low elongation to break, high resistance to thermal and thermo-oxidative destruction, resistance to chemical reagents and decent compatibility with binders of different types. Yarns are not toxic or highly explosive, not combustible; they start burning at direct contact with the open fire and stop burning at its dying. Yarns may be stored for a long period without loosing characteristics and are under minor change hereby when being wet. They are stable to a long staying in water and are biologically stable.

Physical and mechanical features of raw material – para-aramid yarn with linear density 100 tex are shown in Table 1 [3].

Table 1. Physical and mechanical features of para-aramid yarn with linear density 100 tex.

No.	Description of Index	Normal Value
1	Specific Breaking Load of Yarn, cN/tex, min	210
2	Maximal Breaking Load Variation Coefficient, %	10
3	Relative Deviation of Actual Linear Density from Nominal Linear Density, %	+5,0 -3,0
4	Elongation of Yarn at Breakup, % min	2,6
5	Number of Twists at 1 meter of Yarn, twists per meter	50+10; 100+10
6	Lubricant Mass, %	1,0 - 2,0
7	Modulus of Elasticity, GPa, min	135
8	Number of Filaments	300 (600)

Produced samples (photographs are shown in Fig. 3) have quasirectangle form in size 41x33 microns in the section and have the following characteristics: length not exceeding 100 mm, the density of braiding – 5…10 knots/mm (subject to strands tension and the braiding angle), specific breaking load thread average $156{,}5 \cdot 10^{-2}$ N. The capacity of the device does not exceed 100 mm/h (taking into account the prior operations).

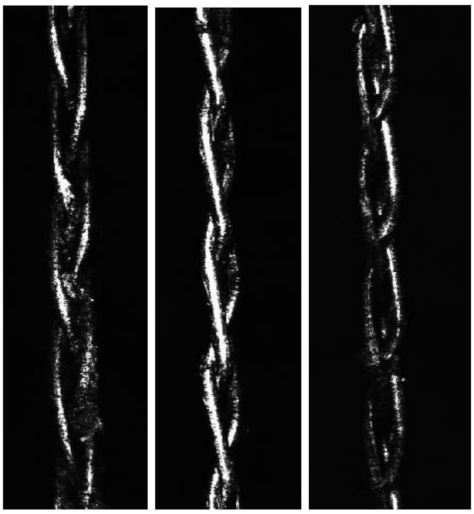


Fig. 3. Photographs of torsion bars.

4. Conclusion

The article describes the device for manufacturing torsion bars with helical anisotropy, performed as a braid made of Kevlar filaments (fibers). It is demonstrated physical and kinematic configurations, operation concept of the UISAT-1 is described. Characteristics produced torsion bars are discussed.

Application of torsion bars with helical anisotropy as a suspension of the MSE considerably improved performance of the TM, which is a part of the geophysical complex GI-MTS-1.

Note: Tex is a unit of measure for the linear mass density of fibers and is defined as the mass in grams per 1000 meters.

5. Acknowledgements

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References

1. G.P Ahromeev. *Robotics and flexible manufacturing systems.* In 9^{th} volumes. Vol. 2. Drivegears of robotics systems. 1986.
2. A.D. Perechesva, P.A. Sergushin. *Motion law of the device for manufacturing torsion bars with helical anisotropy.* Science-Technical gazette of SPbStU ITMO. 1-st Session of Science School ”Mechanical and precisional problems instrument-making”, edited by PhD. V.N. Vasilyev. SPb.: SPbStU ITMO. 2006, vol. 28.
3. Para-aramid fiber and yarns [non-legible resource]: official site JSC “Kamenskvolokno”. Access mode: http://www.aramid.ru, free.