NEW METHOD AND DEVICE FOR MEASURING SLIDING FRICTION

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Abstract: *In the article the new solution of friction measurements for the sliding friction coefficient innerducts housing fibre optic micro-cables, catheters, cannulas are presented. The measurements and studies will significantly contribute to broaden the scope of studies in tribology for elements of various designs and materials undergoing sliding interactions. Moreover, the device enables analyses of diverse cross sections and dimensions to be carried out, all at one testing station and retooling time of 10 minutes. The invention allows scientific research to be carried out, novel materials to be designed and new materials for sliding layers to be effectively selected. The application of the invention reduces costs of analyses of innovative products by 55%-70% in relation to those used at present.*

Keywords: TRIBOLOGY, POLYMER TOP LAYER, SLIDING FRICTION, INNOVATIVE MEASUREMENT

1. Introduction

Friction is a very common phenomenon in daily life and industry, which is governed by the processes occurring in the thin surfaces layers of bodies in moving contact (Fig. 1). The simple and fruitful idea used in studies of friction is that there are two main non-interacting components of friction, namely, adhesion and deformation. Measurement of the molecular forces acting between solids is one of the most difficult experimental tasks. Since the forces are small and distances at which they act are short the measuring instruments should meet the specific requirements. One of the main problems arising when measuring the molecular forces is that the latter increase rapidly with decreasing the distance between the specimens under testing. Hence, the measurements should be carried out at a very small speed that cannot be done using the design of the common balance. The frictional force is attributed to deformation taking place when the asperities of two sliding surfaces come into contact with each other. The surface asperities experience elastic, plastic or viscoelastic deformation depending on material behavior. At initial application of load to polymer, the deformation will be mainly plastic if polymer is in glassy state or mainly viscoelastic (or even viscoplastic) if polymer is in highly elastic state. Therefore mechanical properties of contact materials should be taken into account at any scale level but depending on this level such parameters as Young's modulus and hardness can differ not only in magnitude but also in their physical interpretation. This deformation is accompanied by dissipation of mechanical energy depending on deformation mode, sliding conditions, rubbing materials, scale level of mechanical properties, environment, and other factors.

Fig. 1. *Example of elements in sliding interaction: a) the duct for telecommunication cable, b) catheters in to the human body*

2. The sliding layers manufacturing

During the technological process of extrusion or co-extrusion the duct or catheter we can received the high sliding top layers. Manufacture of this kind of coatings can be obtained from different polymers materials conducted with use of a modernized process during the technological line. New constructions of cables or ducts with modified coatings can significantly change the existing assumptions of cable installation, significantly increasing lengths installed. However, there is no methodology for examining friction-less layers for systems that work slidingly over longer distances, with relatively low pressure forces, such as for cable-duct pairs [1,2].

3. Measure method of the friction factors

The method and the device for testing elements, particularly the polymers, with one-sided sliding contact which moves in a plane motion. Therefore the method for testing elements with their sliding interactions have been known and described in a several publication [3]. Their characteristics is that the motion of structural element made in a sliding system by a tested sample is reciprocating with an external contact with another structural element, i.e. the tested counter-sample. The contacting elements, i.e. the sample and counter-sample, especially made for the tribological tests, frequently in compliance with the standards, are rigid and little-deformable and have various shapes and relatively small sizes [4].

The essence of testing the elements (fig. 2), particularly the polymers with sliding interactions, whose tested elements having various shapes of small sizes, while the sample and counter-sample are pressed onto each other with various forces of different values and move in relation to each other in different directions, consists in that the tested polymer element, i.e. a sample and being the fragment of a finished product, like a tube or section, with elements of geometric macrostructure or a sliding layer on the tested area, is fixed in the handle of the device [5,6]. Next the sample is contacted with another structural polymer element with an counter-sample, possibly of a cylinder or non-cylinder external surface, such as a section, a tube of small diameter, rod, cable, conductor or a line. The counter-sample is fixed into the driving-measuring unit which ensures a uniform plane motion and facilitates the measurement of a resisting force that develops during the contact with the tested sample. The counter-sample is moved with a uniform plane motion in vertical direction up with a constant linear speed. The sample and counter-sample are contacted on one side with each other, with a constant pressure.

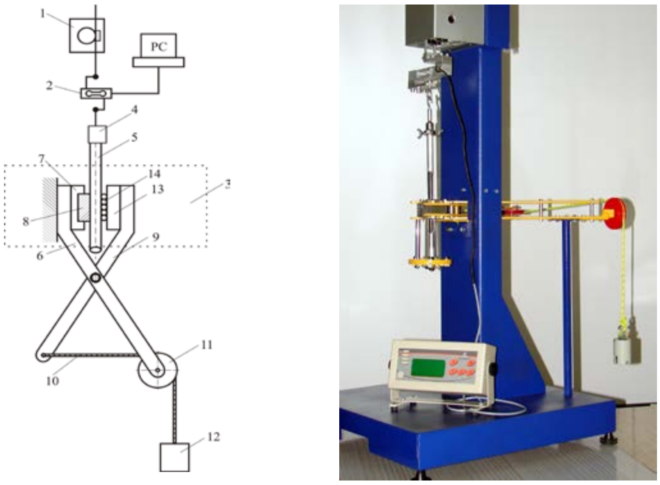

Fig. 2. *The scheme and the laboratory test machine to measure coefficient of friction on specifically length with one-sided sliding*

The next innovative machines which is constructed in our Department of Technical University (fig. 3) make it possible to measure precisely and reproductively the friction resistance force between the outer surface of the fiber optic cable and inner surface of the duct [7,8].

During the tests it's possible to conduct simulation of the installation process in laboratory conditions. We can change some input factors such as: lenth of contact, duct curve angle, speed of fiber optic cable movement, load during the measure ect. Measurements of maximum friction resistance force (F) enable to make it easy to analyse on the base of received diagrams (fig. 4.) the contact of cooperation bodies cable and dut.

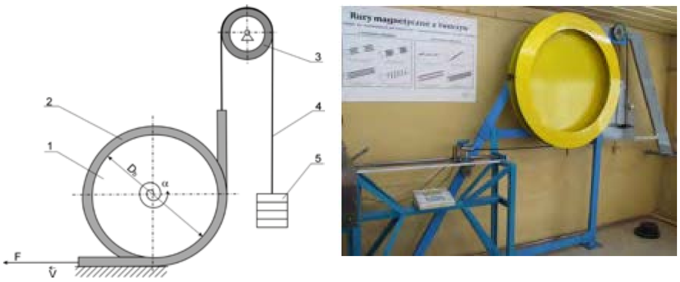

Fig. 3. The scheme and the laboratory test machine to measure coefficient of friction:1 – measuring drum, 2 – duct, 3 – roller, 4 – fiber optic cable, 5 – load; Db – diameter of the measure drum, α - wrapping angle of pipe around the drum, V – speed of the cable movement

The value of sliding coefficient of friction was calculated according to the Eytelwein's formula, relates the hold-force to the load-force if a flexible cable is wound around a cylinder with requirement wrapped angle with an equivalent mathematical relation:

$$\mu = \frac{\ln \frac{F}{G}}{\alpha}$$

where: μ- sliding coefficient of friction, F- maximum friction resistance force, G - load on the free end of cable, α - the total wrapped angle of duct around the drum.

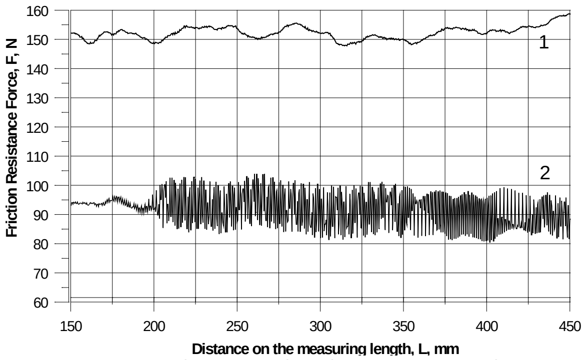

Fig. 4. The sample of diagram of the friction resistance force as the function of distance L; 1-duct without slip layer on the inner surface, 2-duct with thin silicone slip layer on the inner surface. duct outside diameter 40 mm with triangular macro deviations, optotelecommunication cable (XOTKtd) outside layer made of PE-HD

The new modified test method [9] can be applied to products with very small dimensions cooperating with each other in the slide system. The invention enables friction measurements to be carried out and sliding friction coefficients to be determined for elements such as tubes and inner ducts housing fibre optic micro-cables, catheters, cannulas or stents.

The essence of the invention is the fact that the section of interest is introduced into the innerduct, etc. with a constant linear velocity. The jacket is fixed to grips and wrapped around a cylinder with the radius R. In measurement mode, the fixtures move away from each other with a constant velocity V2. Consequently, the actual radius of belting changes. The fixture of the measured elements allows for their independent movement against each other and controlled modification of the radius of their belting on the cylinder.

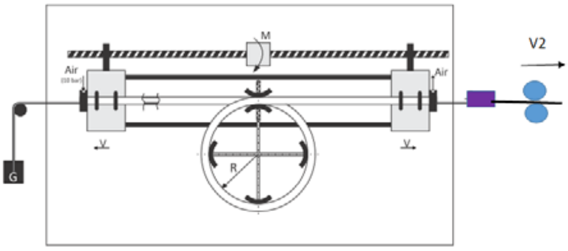

***Fig. 5.** An example of test stsndt to measurements sliding friction in medical devices catheter and guide*

4. Conclusion

Interaction of duct and cable (or guide in medical application) during installation process is a very complicated research problem. The reason is that, there are many different measurements methods of tribological properties [9]. The test machines which are constructed in different research laboratories, have different value of characteristic factors and technical conditions of measure depends of geometrical dimensions and specific function.

The [resented inventions allows scientific research to be carried out, novel materials to be designed and new materials for sliding layers to be effectively selected. The application of the invention reduces costs of analyses of innovative products by 55%-70% in relation to those used at present.

Owing to the measurement of particular values, obtaining lower friction coefficients between working elements will be possible. In addition, the invention will enable more effective and less invasive diagnostic procedures to be carried out, energy consumption for scientific work to be reduced, interactions improved and tooling time shortened.

The universal character of the invention is manifested in its ability to be applied in opto-telecommunication (FTTH broadband internet), medicine (vascular surgery), microbiology and agriculture, among others.

In addition, the device expands the scope and means of standardization regarding analyses of sliding friction carried out independently in various R&D institutions in the EU, USA, Canada, China and Japan.

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