ADHESION NANOMATERIAL USING FOR MICROROBOT COUPLING DEVICES IN REVERSE MOTION

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Introduction

The structure of nanomaterials for coupling devices is under consideration. The main characteristics of such nanomaterials are analyzed on the base of demands to the interaction between contact surfaces in the process of miniature mobile robot's motion. Most of mobile miniature robots such as microrobots are equipped with coupling devices intended for realization contact forces in the motion process in restricted areas, for example inside of small diameter tubes. Acting forces on the robot coupling device and dependence between motion parameters are delivered. Nanostructural material is suggested to satisfy necessary demands for the robot motion[1].

Application of micro- nanotechnologies for miniature robot design

One of the applications of nanotechnology in miniature robotics is the using synthetic fibrillar dry adhesives in robot's grippers [1]. Such material is a polymer hair-covered flexible tape. Each hair has about 0.5-4 μm diameter and 5-10 μm length. When the material contacts with surface the fibers makes intimate contact with variety of surface profiles due to flexibility of the material. A Wan der Waals force, which influence on one fiber is about 70 nN. For various fibrilar dry adhesives the adhesive force achieves 0.5-10 N/sm^2. One of the possible designs of the gripper consists of the elastic plate on which such material is attached.
The main parameters for that gripper are:

– The preload force is the force, which is necessary for gripper has a good cohesion with the surface.
– The force, which keeps the gripper on the surface. It depends on the preload force.
– The torque is needed to tear the gripper from the surface, just as removing a piece of tape from a surface.

A contact of the fibrillar adhesive, which consist of flexible substrate with micro fibers, staying on it and rough surface is considered in [2, 3]. Dependence of interaction force from distance and roughness is presented on Fig. 1.
If the rough is rise than the adhesion is reduce. For attaching the material is necessary previously press it for increase a number of contacting hairs. The elastic force of the contacting hairs is equal the application force. We may remove the application force after the pressing. On the figure 2 dependence of the adhesion force from application force is presented.

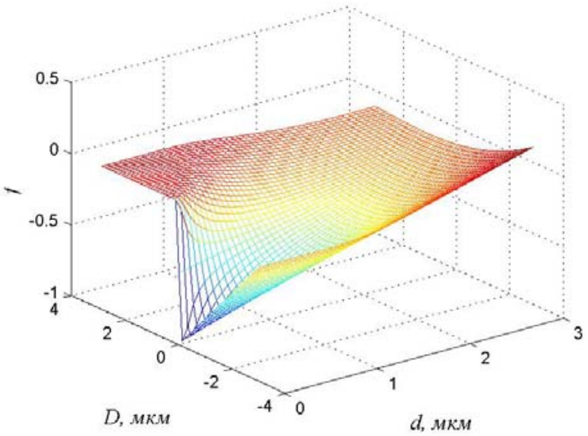

Fig. 1 Dependence of interaction force from distance and roughness.

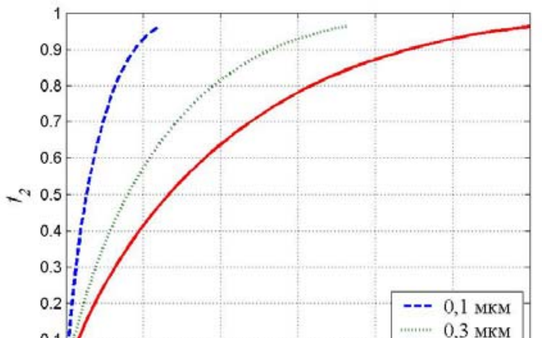

Fig. 2 Dependence the dimensionless adhesion force from the application force.

Increase of anisotropy of friction at use of adhesive materials

At use of a dry adhesive material on contact surfaces of the in-pipe electromagnetic minirobot considered in, it is possible to increase anisotropy of friction of its supports [4] (Fig. 3). The increase in anisotropy of friction is necessary for increase of carrying capacity of the robot. It is possible, for supplied contact surfaces of supports of the robot the overlays made of

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an adhesive material To increase anisotropy of friction (Fig. 3).

Fig. 3. Inpipe miniature robot created in IPM RAS

Overlays should represent nanostructural material pasted on flexible substrate which is pasted in turn on a contact surface of the robot. Flexible substrate is intended for that adhesive nanostructural material densely adjoined to a surface of a pipe in view of it macro unevenness. The dependence between friction forces and inclination angles of hairspring (Fig. 4.) shows that optimum value may be choose.

The angle under which hairsprings are cut off, should be equal $\theta - \alpha$, where α - angle on which hairs deviate at movement back, θ - incline angle of the hairs. Dependence of the angle α on orientation of hairsprings is presented on fig. 5.

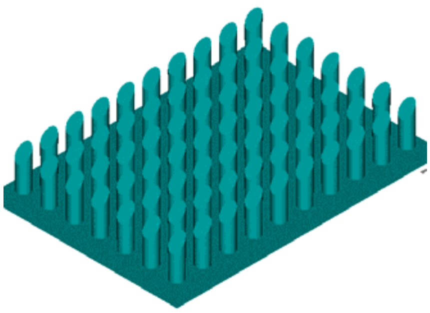

Fig. 3. structure of the adhesion material.

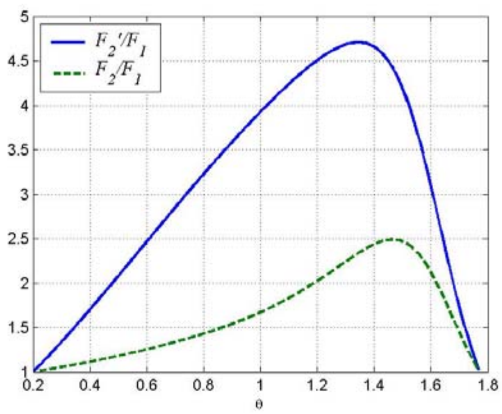

Fig. 4. Dependence of the relation of forces of friction on a angle of an inclination of hairsprings.

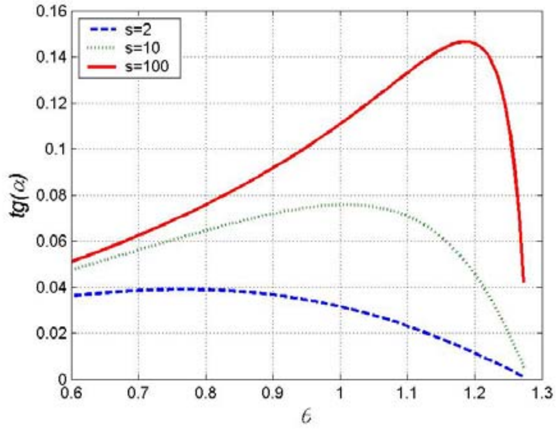

Fig. 5. Dependence of the angle α on orientation of hairsprings (s – ratio of the elastic coefficients of hair in lengthwise direction and across it).

Conclusion

The main characteristics of such nanomaterials are analyzed on the base of demands to the interaction between contact surfaces in the process of miniature mobile robot's motion.

Most of mobile miniature robots such as microrobots are equipped with coupling devices intended for realization contact forces in the motion process in restricted areas, for example inside of small diameter tubes.

Acting forces on the robot coupling device and dependence between motion parameters are delivered.

References

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