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RESEARCH ON THE CONNECTION OF HETEROGENEOUS NON-METALLIC MATERIALS IN THE MANUFACTURE OF ROCKET AND SPACE TECHNOLOGY STRUCTURES

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In order to choose a method of joining dissimilar non-metallic materials in the manufacture of compartments of rocket and space technology, it is of particular interest to study the adhesion strength using a whole range of materials. These are glues, binders and fabrics that would guarantee high adhesive strength in the structure.

Strong bonding of dissimilar materials is one of the important tasks during construction construction, therefore special attention is paid to the selection and research of the adhesive layer. Consider an example of joining composite materials with rubber.

There are a number of studies that consider the adhesive strength at the interface between an elastic body (rubber) and a composite. The following model of the strength of connections of a cylindrical sample of elastomer with an inflexible material is proposed:

$$\sigma = \sqrt{\frac{8WE^*}{\pi \cdot a}}$$

where σ is the strength of the connection; W – work of adhesion; a – cylinder radius; E* is a composite module calculated as follows:

$$\frac{1}{E^*} = \frac{(1-k_1^2)}{E_1} + \frac{(1-k_2^2)}{E_2}$$

where E_1 and E_2 are the modulus of elasticity of the materials in contact, k_1 and k_2 are the Poisson coefficients of the materials in contact.

It is also possible to give a slightly modified equation, the fundamental difference of which is the introduction of the length of the separation zone instead of the cylinder diameter.

$$\sigma = \sqrt{\frac{2WE^*}{\pi \cdot c}}$$

where c is the length of the separation zone.

The general appearance of the adhesion separation equations in different models remains constant, but depending on the nature of the formation of the separation plane, modifications are introduced to the description of the geometric part of the equation, which affects the coefficient in the numerator.

Analysis of the equations considered above allows us to conclude:

When the modulus of elasticity of one or both materials in contact decreases, the strength of the connection decreases.

When Poisson's ratio increases, the strength of the connection increases.

As the work of adhesion increases, the strength of the connection will also increase.

A comparison of the values of the modulus of elasticity of the materials and their Poisson ratios allows us to conclude that the contact of a high-modulus material - a high-modulus material will be stronger in almost all cases than a high-modulus - low-modulus contact.

However, the presented models consider an almost uniform separation, which allows for a slight decrease in the area of contact between elastic and hard materials. Such models are applicable for those cases where there is a high-modulus interlayer between the components.

Detachment of elastic low-modulus films from rigid material will also be considered. The author notes that during such separation, the contact area between the components decreases with the formation of a cavern-type separation surface pattern. At the same time, the local separation voltage increases significantly due to the reduction of the contact area.

The equation for this separation case

$$\sigma = \frac{F}{\pi a^2} = 1{,}64\sqrt{\frac{WE}{h}}$$

where F is the force required to destroy the contact over the area πa^2: h is the thickness of the film, E is the modulus of elasticity of the composite, W is the work of adhesion.

During a sharp decrease in the contact area, a rapid increase in tension is possible in its part that has not peeled off, which will be compensated with the passage of time due to the stretching of the part of the adhesive that has lost adhesive contact with the composite. Part of the applied energy will be dissipated.

In this case, three main gap schemes are possible:

– in the event that the tension of the adhesive break of a thin film of elastomer with a composite is higher than the cohesive strength of the latter, surface destruction is observed.

– in the event that the tension of the adhesive rupture of a thin film of elastomer with a composite is higher than the cohesive strength of the elastomer, the adhesive layer ruptures.

– in the event that the tension of the adhesive rupture of a thin film of elastomer with a composite is less than the cohesive strength of the adhesive and the composite, the adhesive layer is detached without breaking the integrity of the surfaces.

So, the work of adhesion is a significant factor that determines the nature of contact destruction between materials.

The value of the work of adhesion can be determined by a number of factors, which are described in the relevant theories:

– diffusion (formation of contact due to the penetration of the adhesive layer into the pores and unevenness of the material).

– electronic and electrical (due to charge transfer during the formation of interphase contact).

– adsorption (due to van der Waals adsorption or due to the formation of chemical bonds) and others.

It should be noted that the use of each of the theories should be considered for a specific individual case of adhesive contact formation. For example, in the case of gluing materials with a developed rough surface, mechanical penetration of materials into the composite really occurs, and in the case of contact of polished highly polar surfaces, it will be more valid to consider the system in the application of adsorption, electronic and electrical theories.

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