Article ID: 1003－7837(2005)02,03－0156－04

Adhesive contact quality diagnostics in compisite materials with a usage of mechanoelectrical transformatios phenomenon

Fursa T. V., Osipov K. Y., Palyk I. M.

(Tomsk Polytechnic University, Tomsk 634050, Russia)

Abstract: According to the character of gain-frequency characteristic change of electromagnetic response to impact excitation it is possible to trace quality change of components adhesive contact in composite materials and to predict the moment of its destruction.

Keywords: mechanoelectrical transformations; adhesive contact

CLC number: TB33 **Document code**: A

In the Tomsk Polytechnic University during the set of years the development of the composite dielectric meterials structural and mechanical characteristics nondestructing testing is conducted with a usage of mechanoelectrical transformatios phenomenon [1].

In the most of composite materials the weakest part are the adhesive contact zones of the components, composing this composite. Therefore, the quality of this contact will determine the mechanical properties of such material. There is always a double electric layer on the adhesive contact border in composite materials. Its parameters are defined by the electrophysical characteristics of the components composing the given composite and its formation conditions. The experiments carried out earlier is established, that during the composite dielectric materials pulse impact excitation occurs the variable electric fields generation caused by acoustic excitation of double electric layers on borders internal imperfections [2-4]. Therefore there is a basic opportunity to use the mechanoelectrical transformations phenomenon for quality rating of components contact in composite materials, and so their mechanical characteristics.

There is an attempt of adhesive contact quality diagnostics in composite materials by the electromagnetic response parameters appearing during pulse mechanical excitation made in this work.

The decision of a task in view was carried out as follows. Adhesive contact quality changing in composite materials was made by their thermal excitation. Temperature excitation allowed us to create on the contact border of composite system components such mechanical stresses which led to adhesive contact infringement, down to its destruction. Contact zone changing kinetics was traced by optical methods, and electromagnetic response parameters measurement to pulse mechanical excitation was made at various levels of thermal excitation. Such approach has allowed to investigate the influence of stresses increasing under temperature action in the field of adhesive contact to the character of this contact quality changing and to the mechanoelectrical transformations process to composite materials.

Received date: 2005－08－29

Researches were carried out into the two-componental composite materials physical models consisting from materials, differing by the temperature expansion coefficient with the purpose to create the significant mechanical stresses in the field of adhesive contact during the heating.

Mechanoelectrical transformations research of samples during the complex thermomechanical excitation carried out as follows. Samples heated with the heating element usage, located in the field of components adhesive contact. The temperature was measured with the chromel-alumel thermocouple help located in an aperture near by the adhesive contact zone. Pulse mechanical excitation of samples realized by the steel ball 7 g. in weight dropped to a surface of sample. Such mechanical effect allowed us to create a pulse of excitation by energy about 1.2×10^{-2} and speed of a striking body - a ball about 2.2 m/s. As the receiver of an electromagnetic field electric component was used the capacitive gauge placed on 2 mm distance from the bottom surface of sample. Variable electric signal from the capacitive gauge was registered with oscillograph "PSC-500" help, combined with the computer. Electromagnetic response gain-frequency characteristic estimated on the computer with using the standard program "Origin 5.0 Professional" with the help of fast Fourier transformation.

Adhesive contact quality determined with a optical registration technique by standard biological research universal microscope MBI-15. Optical supervision eyepieces used at investigations allowed to receive the resolution by researched object sizes up to 0.5 microns. The image was fixed by the portable videocamera combined with a computer, displayed at the monitor and saved to a database with the help of the special program.

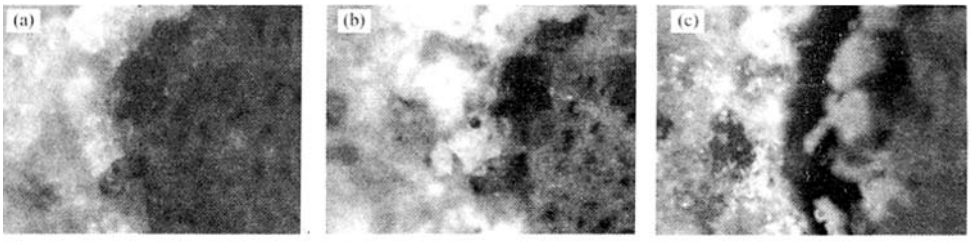
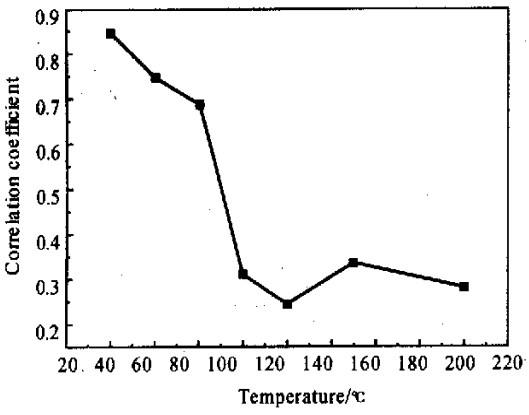


Fig. 1 Composite system adhesive contact changing during the heating
(a)—35°; (b)—80°; (c)—120°

As an example we showed the researching results which have been carried out at a composite, consisting of alabaster and a brass. Microphotos of adhesive contact same part, received at various thermal processing this composite material are presented at Fig 1. It is necessary to notice, that during a sample heating from room temperature up to temperature is lower 80℃ it was not observed any changes in an optical picture. However at the further heating to temperature about 120℃ arising of a pressure on adhesive contact border cause contact serious changes down to its full destruction.

The carried out investigations show the interrelation existence between a thermal stresses level arising on the mediums boundaries in system which components have different factor of linear temperature expansion and the electric response to elastic pulse excitation.

For the received signals quantitative comparison used the correlation analysis method which results are submitted on Fig. 2. Sharp change of the correlation factor serves as a factor of double electric layer destruction at the given temperature as a result of the adhesive contact infringement. The temperature at which the flex point in correlation dependence (Fig. 2) is observed, coincides with adhesive contact optical observable destruction at the same temperature (Fig. 1). Therefore with the help of the electromagnetic re-



Fic. 2 Correlation coefficient from temperature dependance for two-componental system alebaster-brass.

sponse correlation analysis we can estimate temperature and calculate a adhesive contact destruction stresses under the formula:

$$\sigma(\alpha_1-\alpha_2)\Delta T\frac{E_1E_2}{E_1+E_2}$$

Where σ-thermal stresse arising on adhesive contact border; α_1, α_2-factor of linear temperature expansion (FLTE) of components; (T-temperatures difference in the given point of a body from temperature corresponding to originally not intense body, up to temperature after heating; E_1, E_2-composite components modules Junga.

Carrying out the experiments on the composite systems consisting of anidentical filler (alabaster) contact and metals with various factors oftemperature expansion is shown, that the destruction occurs at varioustemperatures, but the level of thermal stresses which concentrator isadhesive contact is always approximately identical - about 6 MPa. These calculations data are resulted below in Table 1. Factor of linear temperature expansion for alebaster, $\alpha=5\times10^{-6}$ deg^{-1}, and alebaster module Junga, $E=6.9\times10^{9}$ N/m^2. Such result is quite coordinated to the theory of adhesion from which it is known, that adhesive contact characteristics basically depends on contacting surfaces structure, and their wettability. Good wetting of a metal surface with filler binding - one of necessary conditions to get a faultless structure composite material, possessing high physicomechanical properties.

Table 1

Composite	$E_1/(10^{-10}$ N·m$^{-2})$, (for metal)	FLTE, $\alpha\cdot10^6$ deg^{-1} (for metal)	Destruction temperature/℃	Contact strength σ/MPa
Alebaster-Lead	1.6	88	40	6.23
Alebaster-Aluminium	7	26	70	6.826
Alebaster-Brass	9	18	90	6.728
Alebaster-Steel	22	12	100	6.111
Alebaster-Cast iron	11	9	120	6.013

Besides, similar researches by definition of adhesive contact durability in some composite systems dielectric- dielectric have been carried out. In particular, contact durability in a composite cement-alabaster appeared about 2 MPa, and in system a cement-wood about 10 MPa.

The carried out investigations show interrelation existence between a thermal stresses level arising on the mediums boundaries in system which components have different factor of linear temperature expansion and electromagnetic response parameters to pulse mechanical excitation. That can be used for adhesive contact quality diagnostics in composite materials.

References

[1] Surzhikov A P, Fursa T V , Osipov K Y. Way of the products from solid matherials durability control// The patent for the invention № 2003118179 with a priority from 16. 06. 2003.

[2] Fursa T V, Horsov N N, Baturin E A. Acoustoelectric transformations sources in concrete // ZTF. 1999. Vol. 69, No. 10. P51-55.

[3] Surzhikov A P, Fursa T V, Horsov N N. Mechanism of Acousto-Electromagnetic Conversion in Concrete // Technical Physics, 2001, Vol 46, No 1, P55-58.

[4] Fursa T V. On One Mechanism of Mechanoelectrical Transformations in Impact-Excited Composites Based on the Cement Binder // Technical Physics, 2001, Vol 46, No 7, P840-843.