Features of the Amplitude-Frequency Characteristics of Electromagnetic Emission during Uniaxial Compression of Dielectric Composites

V P Surzhikov[1]**and N N Khorsov**[1]

[1] *Tomsk, 634050, Russia,* Tomsk polytechnic university
E-mail: iva1954@ mail.ru

Abstract. We have studied the electromagnetic emission from samples of epoxy resin filled with sand subjected to uniaxial compression . Capacitive sensor measures the electrical component of the response when excited electromagnetic emission of ultrasonic pulse using a differential amplifier. It was shown the influence of the load on the spectral signal characteristics: with increasing pressure, the formation of bands at frequencies corresponding to possibly quasi-Rayleigh waves generation. It is concluded that the use of the experimental geometry studies the main contribution to the response of electromagnetic emissions create born normal vibrations, which are damped standing waves.

1. Introduction

Investigation of the state of the object under load is one of the tasks of non-destructive testing. For this it is developed a variety of methods based on different physical phenomena, such as an acoustic emission [1], which allows to evaluate the concentration of defects on the parameters of acoustic signal, accompanied by their formation and development. Moreover, the character of energy distribution of acoustic emission may serve as a measure of estimate [2].

To study the dynamics of crack it is also used electromagnetic emission (EME), due to the formation of an alternating electromagnetic field in the separation of charges in the mouth developing cracks, at the interfaces of heterogeneous media, the interaction of acoustic waves with inclusions having piezoelectric properties.

For the first time this phenomenon has been used in the Tomsk Polytechnic University in developing methods for forecasting geodynamic phenomena (earthquakes, rock bursts, landslides). In the future, efforts were focused on the phenomenon EME in developing methods for non-destructive testing of defects and strength [3-5].

It was investigated the effect of the stress-strain state of the sample on the parameters of electromagnetic emission during pulsed acoustic excitation, the effect of the volume defects on space-time characteristics of the electromagnetic response due to the mechanoelectrical conversions in dielectric samples, determined the nature of the EME energy distribution of the level of operating loads and possible criteria for monitoring the stress strain state [6-8]. However, it was not carried out analyzing the EME frequency response, depending on the load until the destruction of the samples.

2.Experiment results and discussion

For the experiment the sample was prepared of an epoxy resin with sand filling comprising quartz. Specimen dimensions were $60 \times 80 \times 100$ mm^3.

The edge 60×80mm^2 served as basis. Hammering device on the basis of piezoelectric transducer was pressed by the end edge 100x60mm2. Symmetrically the plates with capacitive sensors were located at the edges 100×80mm^2. The sample was placed in the press and subjected to a stepwise uniaxial compression .
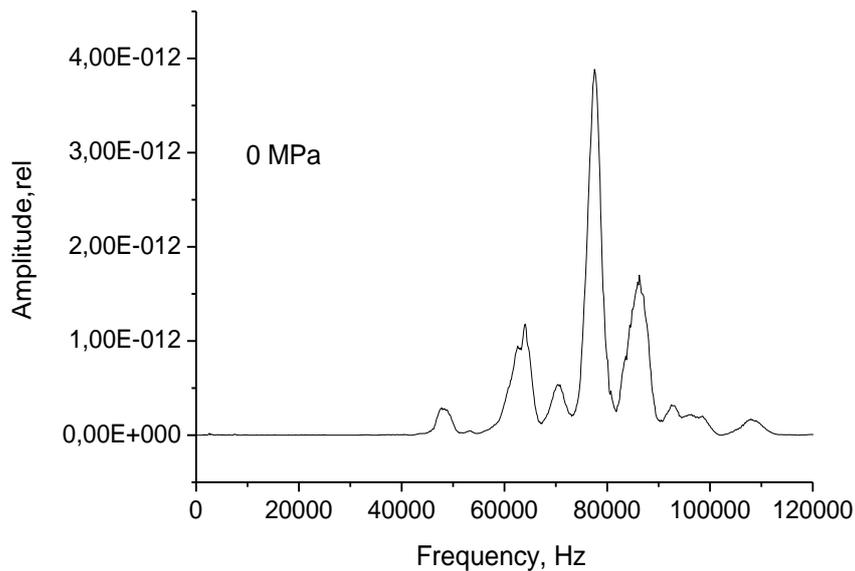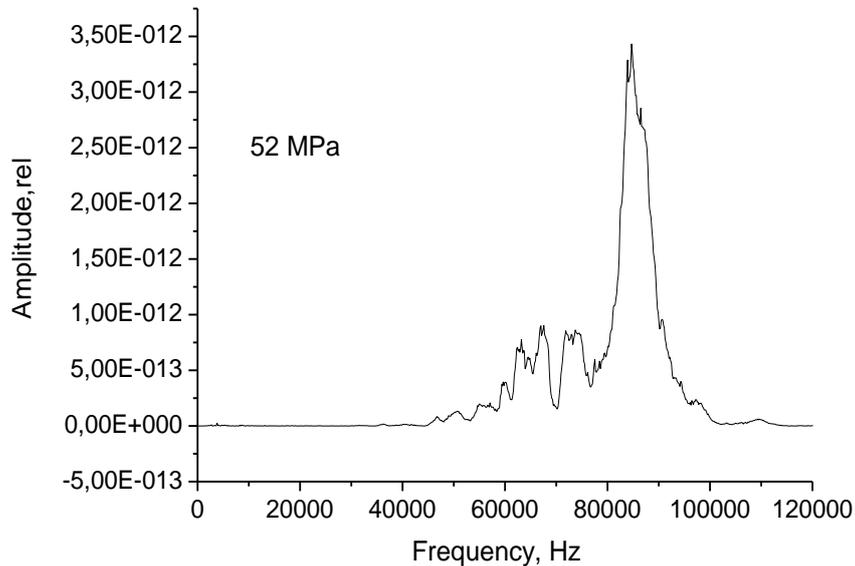

Figure 1. EME frequency response power of the sample without load.
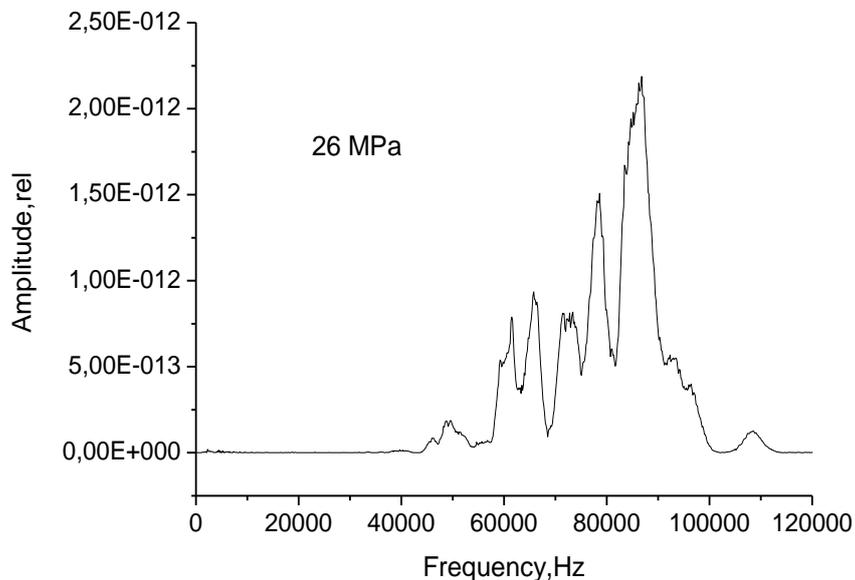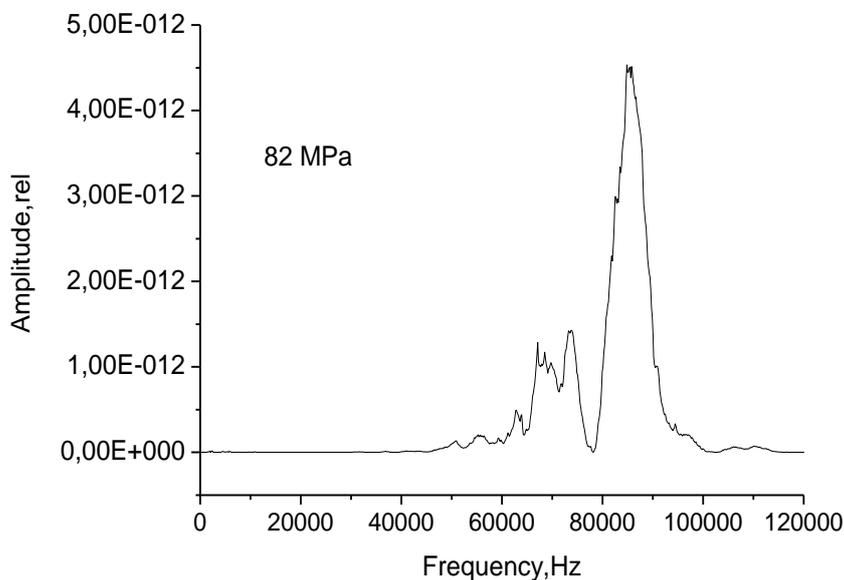

Figure 2. EME frequency response power of the sample under 26 MPa load

The step size was about 4 MPa. At each the step of the pressure the sample was excited by a series of 80 mechanical pulses with the registration responses using the capacitive receiver connected to an input of the differential amplifier.

Figure 3. EME frequency response power of the sample under 52 MPa load.

Figure 4. EME frequency response power of the sample under 82 MPa load.

Amplitude-frequency response characteristics were calculated using the fast Fourier transformation. The EME spectra calculated for different values of the applied pressure are shown in figures 1,2,3,4. The figures show that the increase in load leads to the transformation of the spectrum: decrease in the intensity of the low-frequency peaks and the appearance of a broad intense higher frequency peak with a maximum at a frequency of 88.5 kHz.

Analysis of the amplitude-frequency characteristics was conducted for the cut EME responses in which portions from the beginning of the response to a certain time tn excluded. The presence of a broad spectrum band with maxima at frequencies of 87.85 kHz and 89.74 kHz has been revealed. Peak amplitudes at these frequencies at tn of 48 μs and 64 μs reached the maximum value that is significantly greater peak amplitudes for other frequencies. This ratio of peaks in the spectrum with minor changes remains up to tn is 105 μs. With a further increase tn amplitude of the peaks at the frequencies 87.85 kHz and 89.74 kHz begin to decrease and at tn equal 160 μs almost become indistinguishable. The amplitude of the excitation pulse at the same time was decreased by 46 times. When tn is 1500 μs and the pressure is 82 MPa in the EME spectrum more low-frequency peaks at 1.9 kHz, 3.8 kHz, 7.9 kHz, 11 kHz appear.

Values of tn 48 μs and 64 μs coincide with periods of natural oscillations of the sample excited longitudinal and transverse waves. The sample can be excited vibrations of ultrasonic waves with a frequency of 88,5 kHz with wavelength, propagating at a speed 1325 m/s, equal to 1/4 of the sample thickness d, that corresponds to the speed of the surface wave in the sample.

The analysis used the speed of the longitudinal wave, measured in the experiment, and the velocities of transverse and surface waves obtained from the estimates.

Analysis of the EME spectra indicates the major role in the formation of the eigen oscillations of the sample frequencies given geometrical dimensions of the sample and the rate of propagation in it longitudinal, transverse and surface waves.

The appearance of size d/4 may also indicate the existence of a quasi-Rayleigh waves in the sample [9] of length equal to d, at which the maximum displacements and maximum stresses are created on the surface of the component parallel to the surface and that at a depth approximately equal to ¼ wavelength changes according to the direction and sign [10].

2. Conclusion

 In the experimental geometry studies the main contribution to the response of EME create born normal vibrations, which are damped standing waves.

References
[1]. Dunegan H.L., Harris D.O. 1969 *Ultrasonics*,. **7**.
[2]. Damasinskaja E.E., Kadomzev A.G. 2013 *Technical Physics Letters in Russian.* **39**. p. 29
[3]. Surzhikov V. P. , Khorsov N. N. 2012, *Control. Diagnostics in Russian* **11**(173), p. 69
[4]. Surzhikov V. P. , Khorsov N. N. , Khorsov P. N. 2012   *Russian Journal of Nondestructive Testing* , **48**, p. 85
[5]. Surzhikov V. P. , Khorsov N. N. 2013, *Proceedings of the universities. Physics in Russian* **56**. p. 261
[6]. Surzhikov V. P. , Khorsov N. N. 2015, *Technical Physics*, **60**., p.148.
[7]. Surzhikov V. P. , Khorsov N. N. 2014, *Modern problems of science and education in Russian.* **5**; URL: http://www.science-education.ru/119-15035
[8]. Surzhikov V.P., Khorsov N.N. 2011 *Russian Journal of Nondestructive   Testing*, **47**, p 687.
[9]. Viktorov V.I., Grigorjan R.A. 1959 , *Acoustic journal in Russian* **5**. p. 366
[10].Viktorov V.I. 1966 The physical basis for the use of ultrasonic Rayleigh and Lamb waves in engineering (Moscow :Nauka) 164 p.