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Dependence the Integrated Energy of the Electromagnetic Response from Excitation Pulse Duration for Epoxy Samples With Sand Filler

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Abstract. Results of research of influence of the excitation pulse duration on the parameters of the electromagnetic response of epoxy samples with filler the quartz sand presented in the paper. The electric component of a response was registered by the capacitive sensors using a differential amplifier. Measurements were carried out at two frequencies of the master generator of 65 kHz and 74 kHz. The pulse duration was changing from 10 to 100 microseconds. The stepped sort of dependence of the integrated oscillations energy in the response from duration of the excitation pulse was discovered. The conclusion was made about the determining role of the normal oscillations in formation of such dependence.

1. Introduction

Attraction of the phenomenon of compelled electromagnetic emission for development the non-destructive method of testing defects and the stress-strain state [1-7] determines the necessity of research and optimal conditions definition the excitation of responses of the mechanoelectrical transformations (MET), including as geometry of excitation and measurement and parameters of excitation pulse: frequency, duration.

In work [8] was studied the influence of a pulse duration of acoustic excitation on characteristics of the MET response of composite dielectrics. Shown difference of the compression pulses efficiency and stretching in responses formation of MET and significant contribution of own oscillations in response were suggested.

Below this assumption taking into account amplitude-frequency characteristics of an excitement pulse is considered.

2. Materials and methods

The description of a measurement technique is provided in works [9, 10]. Figure 1 shown block diagram of the measurement procedure.

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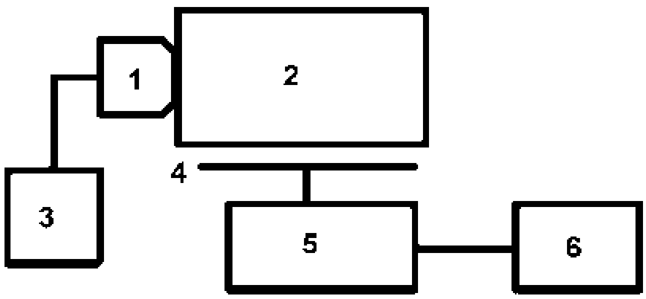

Figure 1. Block diagram of the measurement procedure: 1 – source of ultrasonic vibrations; 2 – sample; 3 – master oscillator; 4 – capacitive sensor; 5 – differential amplifier; 6 – I/O board NI PCI – 6133.

In our experiments the electric component of response was recorded by a capacitive sensor. Experiments were made on the epoxy samples with size 60.5 × 80× 91.5 mm. Quartz sand with a particle size not more than 0.5 mm was used as filler. The filler volume amounted to 0.5 epoxy volume. The piezoelectric transducer on the basis of ceramics of CTS 19 was a source of ultrasonic oscillation. It located on the verge of the sample with size of 60.5 × 80 × 91.5 mm.
The acoustic pulse was initiated by an electric harmonic pulse from the master generator with fixed frequency of 65 kHz and 74 kHz. The pulse duration varied from 10 μs to 100 μs with a step equal 2 μs. The capacitive sensors were installed parallel to the sample verges with size of 91.5 × 80 mm at the distance of 1 mm from a surface. Signals from the capacitive sensor were amplified by the differential amplifier In experiments using the I/O board NI PCI - 6133 was registered the temporal realization of responses from the MET sources at their activation by 140 acoustic pulses with a period of 4096 μs. In the analysis were used the responses averaged by entire temporal realization. The experiments error did not exceed 5%.

3. Results and discussion

Figure 2 illustrates the dependence of integrated energy of the MET responses from duration of the excitation pulses for two values of the master generator frequencies of 65 kHz and 74 kHz.
Dependence for 65 kHz has a step-like sort with duration of steps equal to the period of the generator increasing the duration of the excitation pulse leads to change in amplitude-frequency characteristics of the MET responses both at 65 kHz (Fig. 3) and at 74 kHz (Fig. 4).

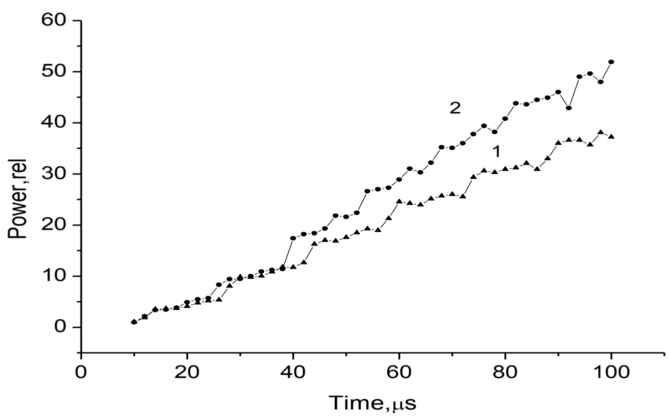

Figure 2. Dependence the integrated energy of the mechanoelectrical transformations response from the excitation pulse duration at 65 kHz (curve 1) and 74 kHz (curve 2).

As seen from the figures a consequence of increasing duration at 65 kHz is a significant decrease of amplitude in the frequency range 69 kHz - 74 kHz. At frequency 74 kHz the pulse duration increase is compliant the amplitude decrease in the frequency range 62 kHz - 67 kHz, and a power increase in the strip of 72.5 kHz.

The calculated amplitude-frequency characteristics of an excitement pulse for two frequencies used in experiment are given in figures 5 and 6.

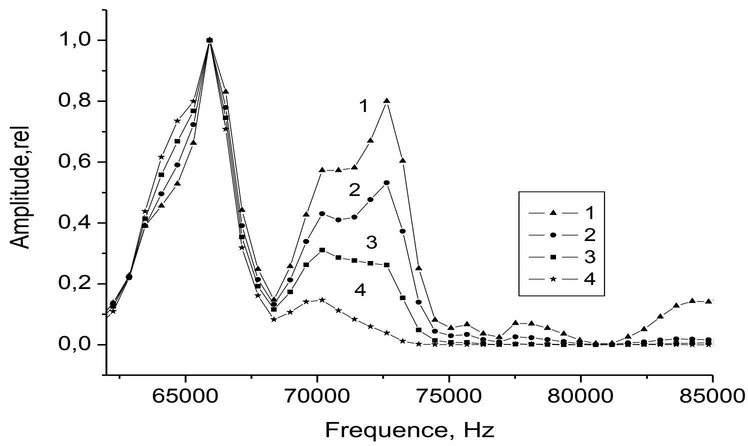

Figure 3. Power spectrum of the electromagnetic response at the excitation pulse frequency of 65 kHz with different pulse duration: 1 – 12 μs, 2 – 33 μs, 3 – 66 μs and 4 – 100 μs.

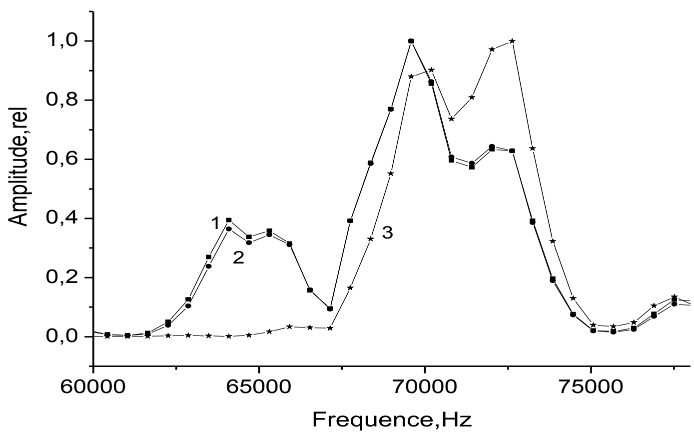

Figure 4. Power spectrum of the electromagnetic response at the excitation pulse frequency of 74 kHz with different pulse duration: 1 – 12 μs, 2 – 33 μs and 3 – 100 μs.

It is seen that with increase a pulse duration the spectrum band excitation is narrowed from 170 kHz to 10 kHz at 100 μs with maxima on the master generator frequencies.
In discussing the experiments results, we adhered to the following logical sequence.

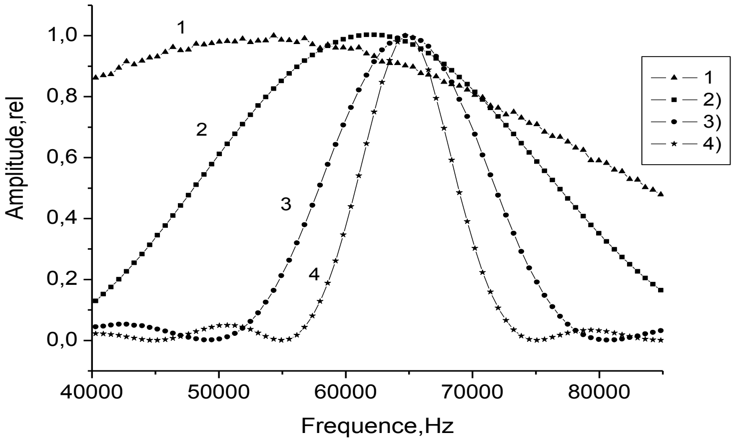

Figure 5. Normalized the power spectrum of excitation pulse for frequency of 65 kHz with different pulse duration: 1 – 12 μs, 2 – 33 μs, 3 – 66 μs and 4 – 100 μs.

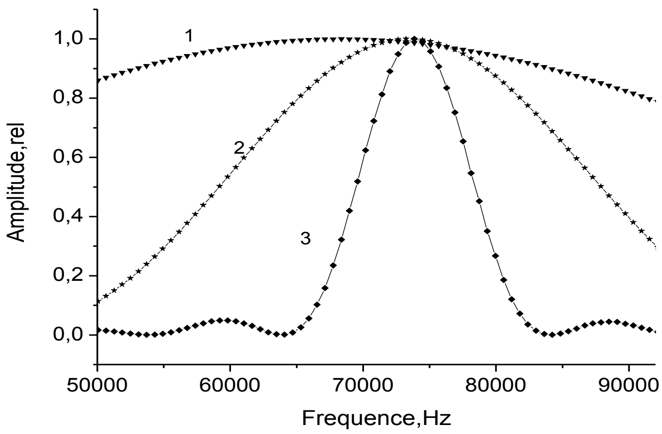

Figure 6. Normalized the power spectrum of excitation pulse for frequency of 74 kHz with different pulse duration: 1 – 12 μs, 2 – 33 μs, 3 – 100 μs.

A voltage pulse from the master generator forces the piezoelectric transducer to radiate ultrasonic oscillations in the certain frequency range. The type of amplitude-frequency characteristics of ultrasound in this range is determined by piezoelectric transducer parameters and emitter design. And as a result, the type of the amplitude-frequency characteristics of a response is determined by frequency range which given by the duration of excitation pulse, the parameters of amplitude-frequency characteristics of the ultrasound, the set of allowed frequencies in sample and the used measurement geometry.

Thus, changes in the amplitude-frequency characteristics of response are determined by decrease the width of an excitation spectral band. In this case at the frequency of 65 kHz (Fig. 3) the excitation spectrum narrowing leads to an apparent bandwidth allocation in response spectrum in the frequency range of 63 kHz - 67 kHz. At the frequency of 74 kHz (Fig. 4) the limitation of the excitation spectrum excludes from spectrum response the frequencies in the range of 63 kHz - 67 kHz. Therefore, appearance of the "steps" on dependence (Fig. 2) naturally connected with acoustic vibrations in the frequency range of 63 kHz - 67 kHz.

For the purpose of identify the oscillations type perpetrated with a frequency of 65 kHz was measured the longitudinal acoustic waves velocity (2585 m/s) and knowing the oscillation frequency was determined the wavelength equal to 1/2 the sample length. This fact, and also results of work [9-12] allowed to assume the main role of normal oscillations in the "steps" formation.

4. Conclusion

The materials of researches given above led to the suggestion that determining share in energy of the MET response and respectively in the formation of uneven dependence of integrated energy of a response are contribute the normal oscillations.

Acknowledgements

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