Universal non-destructive testing method in the microwave range

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Abstract. Considered in this paper, a new method of nondestructive control based on the spectra of radio wave radiation of the microwave range wideband scanning receiver. It is experimentally shown that this method has a high accuracy in the determination of the frequency spectrum. This allows the method considered to reach a sensitivity of 5-6 Hz/nm.

We propose a method of non-destructive monitoring parameters (chemical, physical and mechanical) in the process of obtaining and using structural composite materials and products based on complex structured materials. A number of new tasks can be solved with the proposed method of non-destructive testing, which allows to determine the control sensitivity 5-6 Hz/nm.

This non-destructive testing method is based on recording spectra of radio-wave radiation from the test object broadband scanning receiver and subsequent analysis of the resulting spectra on PC. The stated technical problem is achieved in that the test object excite the electromagnetic field of the external electromagnetic radiation, as a result, arise macro-currents and characteristic of the capacitive element, the bias currents.

The proposed method of non-destructive testing is based [1] to the following effect. Induced electromagnetic field (Fig. 1) is excited in control object *1* by external electromagnetic radiation source *3*. This gives rise to free currents and displacement currents, which are characteristic of a capacitive element. Irradiation is performed by two flexible conductive plates through two dielectric plates *2* (acting as a sort of a capacitor), between which control object *1* is placed. The dielectric plates are laid along the outline of the control object. Because of this, the field (emitted by the object) and the spectral characteristics being determined become object oriented, the object itself becomes an electromagnetic field radiator. To position details of objects under investigation, the dielectric plates are made as a set of individual parts. To scan in homogeneities and select signals of individual elements, scanning receiver *4* is used, which is controlled by PC *5*.

The presence of two dielectric plates (through which external electromagnetic radiation source *3* excites an electromagnetic field in the control object) minimizes reflections from their external surfaces and, hence, excitation of surface waves. This improves the resolving power of the equipment in case of detecting deviations from the characteristics of a reference sample.

The main difference of this method is that the object of control acts as an antenna radiator.

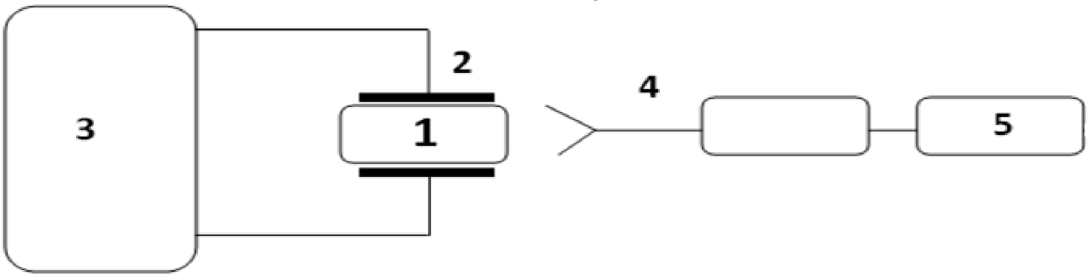

Fig. 1. Schematic of a setup: (*1*) control object, (*2*) plates of capacitive operation sensor, (*3*) high frequency voltage generator, (*4*) scanning receiver, and (*5*) PC

Let us briefly consider the physics of processes in the control object. When the generator is switched on, a high frequency current enters a central coaxial cable and passes to a lead wire connected to the object and the plates of sensor *2*. This results in the formation of standing waves.

In the dielectric media (the dielectric layer of the sensor), displacement currents appear, which rotate dipoles in the dielectric until they are aligned with the current direction. Further, the displacement current takes place in the object of control here, involving mobile electrons induced electric charge. In the center of the object, there is a charge of the same sign, and the edges of the bias current has the opposite sign. Thus, at the edges and the center of the liquid, charges of the opposite signs accumulate, because of which a T-type wave forms. The T-type waves travelling from the center to the edges and the standing waves produced at the lead wires generate a varying electromagnetic field around the object. The spectrum of this field characterizes the control object. By comparing the spectrum of the control object with the spectrum of the reference sample, the changed parameters can be estimated.

As a result of experiments were obtained spectra of defective composite panels . Such defects can be: starved spot, additional inclusion, local destruction and etc. On the spectra one can observe clear differences in the spectral pattern and to detect the presence of defects, which were not included in the design.

As a result the processing of the envelopes of the spectra were obtained (Fig. 2) graphics for defects of various sizes.

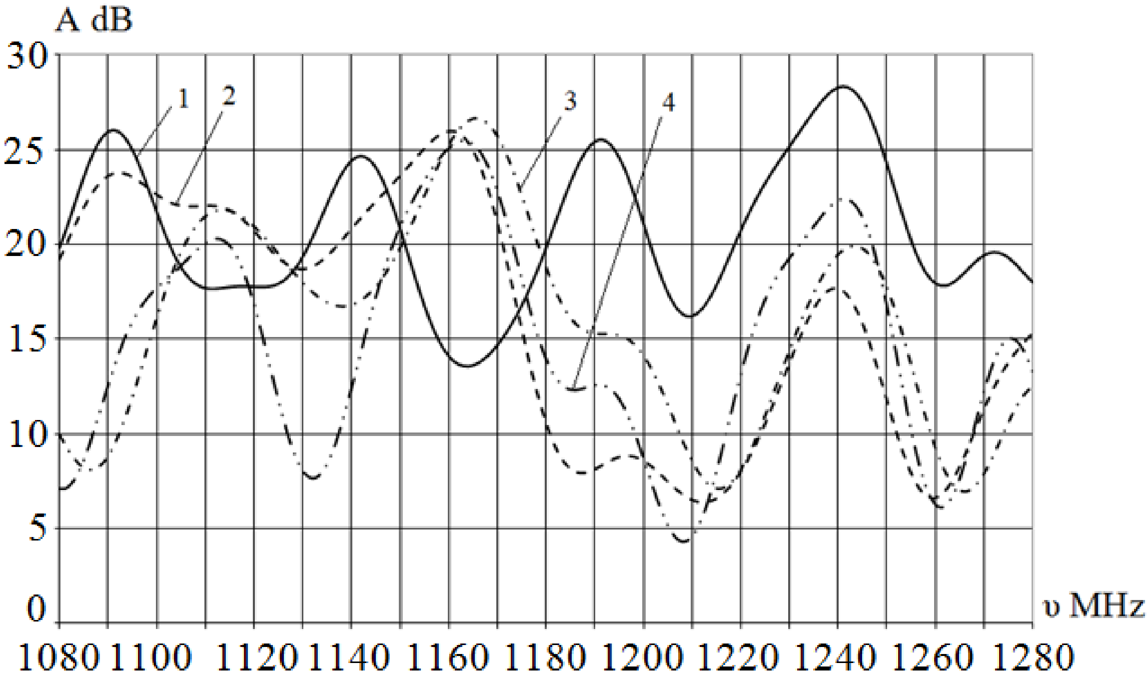

Fig. 2. Graphics data for defect different sizes 1- non-defective sample; 2- defect of 6 mm;3- defect is 8 mm; 4- defect of 10 mm

As a result of comparison you can determine the size and location of the defect. You can see that the spectrum reflecting the highs offset the defects on the period in relation to the chart reflecting the non-defective sample. Charts differ in amplitude, which also allows to distinguish the size and position relative to the capacitive sensors of the defect.

For the determine the accuracy of the method of non-destructive testing were conducted experiments on the powders [2,3]. During the experiments were obtained the spectra of powders of boron carbide, titanium dioxide, silicon carbide. The size of the particles ranged from 3 to 63 μm. On Fig. 3 shown the spectra of electromagnetic radiation at continuous irradiation of samples of micro-powders of silicon carbide with different predominant particle size from 3-5 up to 50-63 microns when excited in the capacitive resonator at the frequency ν=2.4 GHz.

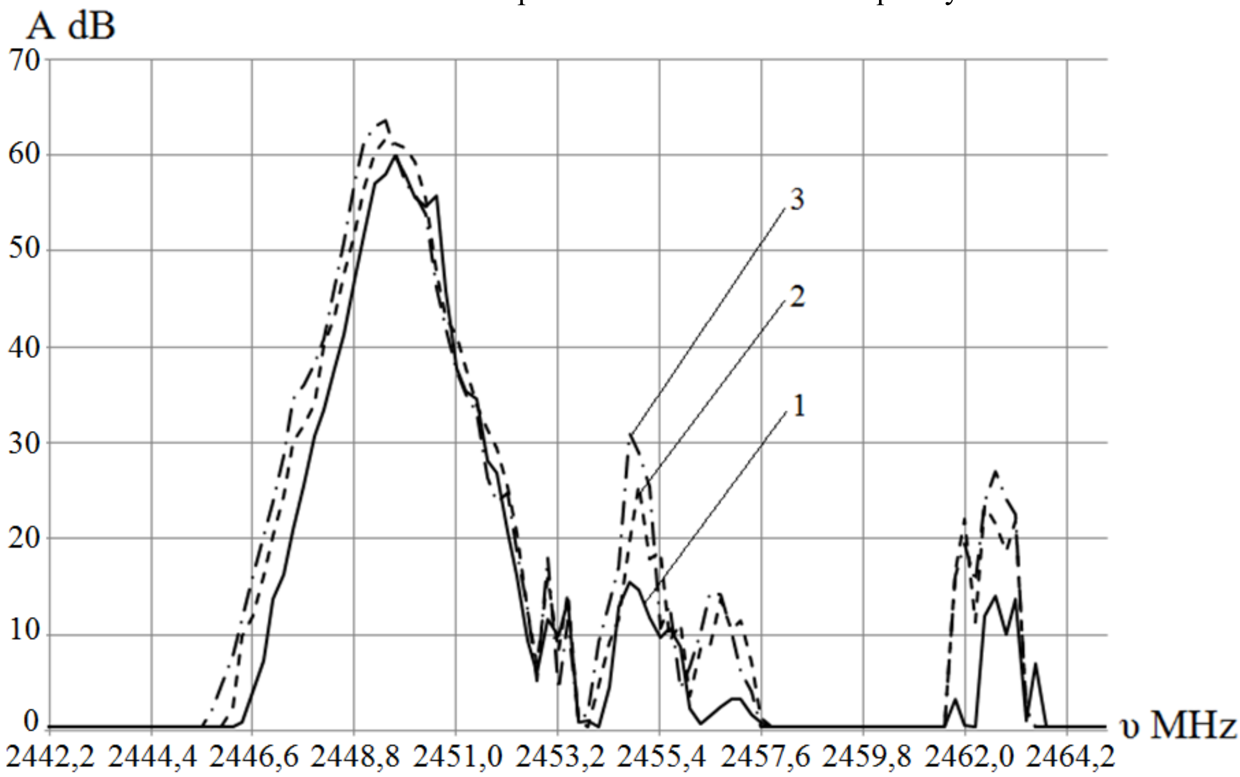

Fig. 3. The spectral characteristics of silicon carbide powders having a particle size of 3-5 μm (1), 20-28 μm (2), 50-63 μm(3)

In all cases, when entering into the resonator of the sample powders were modified forms of the spectra. The General trend is: as you increase the size of powder particles was the reduction of the peak frequency and increasing amplitude, which was reflected in the band offsets of the spectrum. On the graphs of the spectra and the sizes of powder particles has turned out to determine the sensitivity equal to (5-6).109Гц/m = 5-6 Hz/nm at the resolution of the receiver by a frequency of Δν=0,01-0,10 Hz.

References

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