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The Doppler Detection Fault

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Authors' contributions

This work was carried out in collaboration between both authors. Author KB was intended for studying the problem and made controlled literature. Author SV wrote the first version of the manuscript and managed the analyses of the study. Both authors read and approved the final version of the manuscript

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Original Research Article

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ABSTRACT

In the study of the interaction of ultrasound with metals discovered an unusual phenomenon. Microwave sensor indicates fluctuations of electric surface conductivity when exposed to elastic ultrasonic vibrations in metal objects. The defective area is characterized by a content of microdefects of the type "the mouth of the cracks". They are known as the field of "acoustic activity" the method of Acoustic Emission (AE). The high coefficient of phase modulation of the reflected field allows you to indicate the Doppler signal is useful for 6-30 dB over the noise from a distance of 70-180 mm. The phenomenon is called "of Gorbunov effect". It has been successfully used as remote non-destructive testing method is ultrasonic methods of flaw detection, acoustic emission. It has been successfully used as remote non-destructive testing method that replaces the ultrasonic methods of flaw detection, acoustic emission.

Keywords: Active defects; radar doppler microwave sensor.

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1. INTRODUCTION

A known method of detecting defects in metal, based on the phenomenon of Acoustic Emission (AE) under mechanical loading [1]. Until recently it was believed that AE manifested only in the form of short series of short acoustic signals, born of the violation of the electrical connections. Violations result in elastic waves propagating in the metal from center all directions at the speed of sound. Recording these mechanical vibrations with an amplitude of 0.1-25 nanometers, the piezoelectric sensors of the contact type, the researchers can determine the place of occurrence of vibrations, the degree of danger appearing defect.

Numerous experimental studies of the authors [2,3] argue that with the advent of acoustic signals, an additional previously unknown effect. The essence of the effect lies in the fact that the appearance of the acoustic emission sources belonging to the class of "active" (the counting speed of the acoustic pulse increases in proportion to the first degree the efforts of the destruction), there is a change in the electrical properties area of the metal around the AE sources. Even after cessation of mechanical loading, this area retains its unusual electrical qualities. These properties indicate the authors of the microwave sensor.

Finding defects in metals, the microwave field is dedicated to the many works of domestic specialists and foreign authors [2,3-7,8]. Described experiments for the study of local surface heterogeneities, which are microwave sensors. Open waveguides are placed close to a metal surface (a quarter wavelength) to radiate the incident and reflected waves take. Semiconductor detector responds to the amount of incident and reflected waves, registering the change in reflection coefficient. When injected into the area of the surface that differ in conductivity from the previous one can identify cracks the size of a quarter wavelength. Scan method fails to find these unusual areas. Upon further research it turned out that it is possible to determine the degree of risk of unusual areas, surface cracks, scale, bundles.

2. EXPERIMENTS

A new effect, called "effect of Gorbunov, was first discovered in the spring of 1995. It is in contradiction with known theories of the process of destruction of metal [9], theory of ionization of metal, is possible only in the x-ray sources. The essence of the phenomenon is that if you act on a defective area of the elastic oscillations (waves of ultrasound of low power, up to 5-10 W/cm^2) one can observe simultaneous change in the surface electrical conductivity of the virtual amplitude of 200-400 nanometers. Vazomotoriani lateral component of the spectrum of a signal reflected from the surface being studied exceeds the spectral power of noise 6 to 20 dB. In the absence of zones of "active" lateral component of the spectrum photomodeling signal does not exceed the noise level. Operating frequency of the microwave sensor significantly affects the level of the useful signal. For a frequency of 33 GHz, the effect of the interaction (level of the lateral component) exceeds the same value for the frequency of 10 GHz by 10-12 dB. A distinctive feature of the "Gorbunov effect" is it the time of registration. So, if the duration of the "active" sources of the AE lasts fractions of a millisecond, always coincides with the time of mechanical loading, "the of Gorbunov effect " is characterized by the detection time from several minutes to tens of hours after removing the load. Check the "Gorbunov effect" microwave sensor possible for significant (70-180 mm) distance from object surface. The irradiation zone not tied to zone "activity" takes up the entire surface of the metal. There is no reason to scan, which is necessary for previous methods of microwave diagnostics.

The possibility of a new diagnostic method is not yet fully investigated. No rigorous theory of the observed phenomena [8,10]. However, the authors developed an instrument that uses Doppler radar as a microwave sensor [2], now significantly improved, allows the study of dangerous defects in metals instead piezoelectric sensors. Some of the results of the authors published [3,4]. This work continues the results of these studies. A new version of the device, which we call "microwave detector" uses a microwave frequency generator 33 GHz (pulse mode operation to reduce power consumption) ultrasonic generator at frequency of 50 KHz, an output power of 15-20 W, a piezoelectric emitter type MA40E9-1. The area of the emitter 1 sm2. The working distance of the microwave sensor to the sample is increased to 90-180 mm. the Exact distance is now adjusted with the help of the indicator current of the mixer.

In the present work, a new device demonstrates its capabilities compared with conventional ultrasonic flaw detectors. We studied the samples already tested by ultrasonic flaw detector. Two samples were further investigated by x-ray installation of Fig. 1a and b. Photographs of the samples shown in Fig. 2a-d of useful signals are now obtained using the Fast Fourier Transform (FFT) without using spectrum analyzer type SK4-59. The chart shown in Fig. 3a-d. Two samples were further investigated by x-ray installation of Fig. 1a and b.

X-rays show the presence of welding defects (natural Fig. 1a) and artificial (Fig. 1b - the four drilled holes with a diameter of 4 mm, subsequently brewed). The signal level from natural defects (seam Fig. 2a) was 14 dB (Fig. 3b), two dB greater than that of artificial (seam Fig. 2b) Fig. 3a.

Experiment on samples with surface defects (Fig. 2c) showed that the small size of the defect (transverse fracture of alloyed layer on the steel plate to a depth of 2 microns, the sample No. 11, experiment 1) results in low signal level on the output of the microwave sensor (6-7 dB above the noise level). While the significant size of the defect (transverse crack-doped layer with a depth of 9.5 microns, the sample No. 15 experiment No. 2) shows a significant level of the wanted signal (12 dB, Fig. 3d). An experiment on serial steel sample (Fig. 2d) showed a low level signal (1-2 dB Fig. 3c) close to the noise level. This proves that the new device can not detect the defects having the degree of danger. This quality of different methods for diagnosis of AE. This is a qualitative difference between the AE method from ultrasonic methods. But their use is mandatory in the preliminary mechanical loading. It is absent in the new method of diagnostics of the microwave sensor.

But their use requires prior mechanical loading. It is absent in the new method of diagnostics together with the microwave sensor.

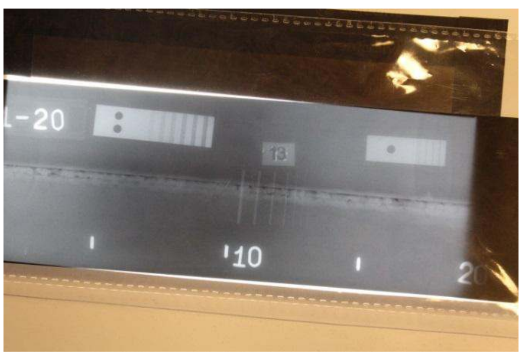

Fig. 1a. x-ray of the weld of experiment No. 6, the wanted signal is 14 dB. In the picture under the welding cracks

Fig. 1b. x-ray the weld in the experiment No. 3, the desired signal 12 dB the picture shows 4 empty holes

Fig. 2a. Welded plate experiment No. 6 the wanted signal is 14 dB

Fig. 2b. The weld bead of experiment No. 3, the desired signal 12 dB

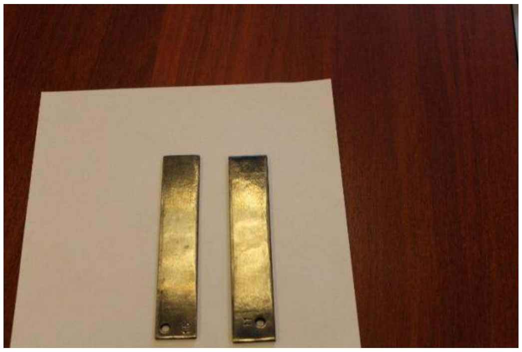

Fig. 2c. Steel samples Experiment No. 1 (sample 11, right) the wanted signal is 6 dB, the transverse fissure of the doped layer, the depth of the 2 micron. The steel sample. Experiment No. 2 (15 a sample left) transverse fracture of alloyed layer, the useful signal is 12 dB depth of 9.5 microns

Fig. 2d. Steel bar (standard sample) experiment No. 4 size 210x59x30 mm Steel 20 delay 20 MS at a length of 59 mm. the Useful signal 2-4 dB

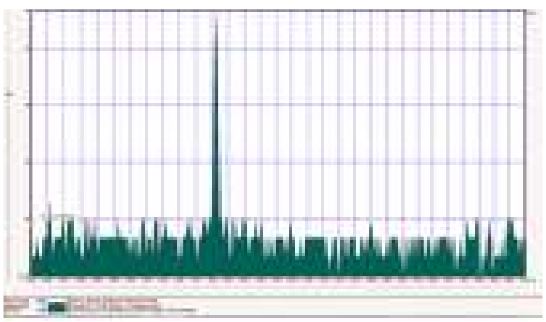

Fig. 3a. The desired signal 12 dB. Experiment No. 2

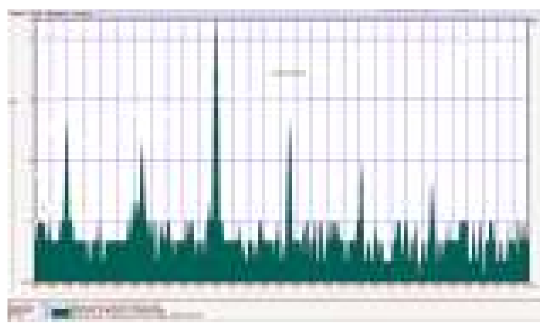

Fig. 3b. The desired signal 14 dB Experiment No. 6

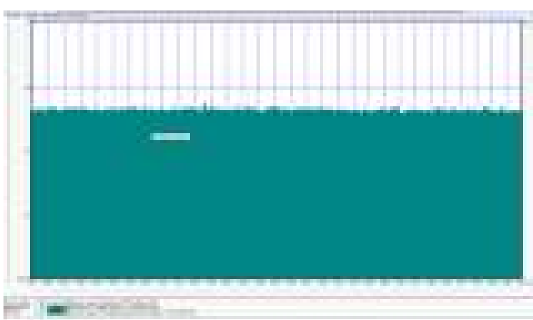

Fig. 3c. Useful signal 1-2 dB. Experiment No. 4

Fig. 3d. the desired signal 12 dB. Experiment No. 2

3. CONCLUSION

The described method of remote detection of active defects increases the scope for non-destructive control methods. Previously published in the journal work Dopler Radar in Crack Testing [2] contain a short theoretical basis of the "of Gorbunov effect". A new variant of the developed device has improved performance. Able in most cases to replace a known ultrasonic flaw detectors, which has many separate contact sensors of different frequencies. Dramatically reduces the cost of research by means of AE due to the lack of phase is indispensable mechanical loading. Allows you to perform a re-inspection after the end of the studies the AE. Given the high cost of modern contact sensors used in the AE method. Presents the results along with a high speed of propagation of the conductivity can be used for minor modifications of the device to determine the location of the dangerous defect. Measuring the phase delay between the start of the ultrasonic oscillations and the beginning of the registration of the wave conductivity it is possible to determine the locus of the lines which is a defect. Perform this operation several times for different positions of the source of ultrasound, the researcher will be able to determine the intersection of these lines (surfaces). To find a point (area) of the dangerous defect. A good prospect for the method of contactless diagnostics. We should not forget that the excitation of ultrasonic frequencies up to 100 KHz is possible with a laser beam power up to 10 W [11].

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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