Non-destructive Quality Control of Materials and Constructions using the Method of Electron Shearography

L.M. LOBANOV, V.A. PIVTORAK,
E.O. Paton Electric Welding Institute, NASU, Kiev, Ukraine
V.G.TYKHIJ, KB "Yuzhnoje", Dnepropetrovsk, Ukraine

Abstract. Technology and procedures of non-destructive quality control using electron shearography are presented. Examples of application of quality control of materials and elements of structures are given.

The improvement of quality, reliability and serviceability of welded structures is connected indispensably with the development and progress of express methods and equipment of non-destructive quality control and determination of residual stresses.

In modern branches of industry the radiographic, ultrasonic, magnetic, acoustic-emission, eddy-current and many other methods of NDT arc used [1, 2]. The method of a laser interferometry, such as electron shearography, finds the more and more wide application in different branches of industry.

Over the recent years, the electron shearography is the most intensively progressing coherent optical method of tests and measurements, which is realized by using simple optical devices and allows no-contact examination of the object surface without its damage. This method can be used in investigation of different materials and structures. It gives a feasibility to measure the first derivative from displacements along the selected direction of the shear. By this, the non-sensitivity of shearography to the rigid displacements of the object, caused by effect of the surrounding medium, is stipulated that predetermines its universality and effectiveness of application under industrial conditions [3, 4].

The principle of the shearography method is as follows. The object being examined is illuminated partially or completely by a light wave, which after reflection from its surface is falling on a shear element, arranged in front of an objective of CCD-camera and dividing the aperture into two halves. In this case two displaced images of the object being examined are appeared in the plane of CCD-camera image.

When interfering the light waves, the chaotic microinterference speckle-pattern is formed and put into computer using CCD-camera. The obtained microinterference speckle-patterns, recorded for two states of the object (before and after its loading), are compared and processed to obtain the macrointerference fringes (shearograms).

In fulfillment of the non-destructive quality control of elements and assemblies of structures a compact shearographic equipment, composed of a single-mode laser with a wave length λ = 532 nm for the illumination of object surface being examined; a shearographic interferometer forming an object image; a CCD-camera for images recording; and a computer for obtaining and processing of interference fringes, was used (Figure 1).

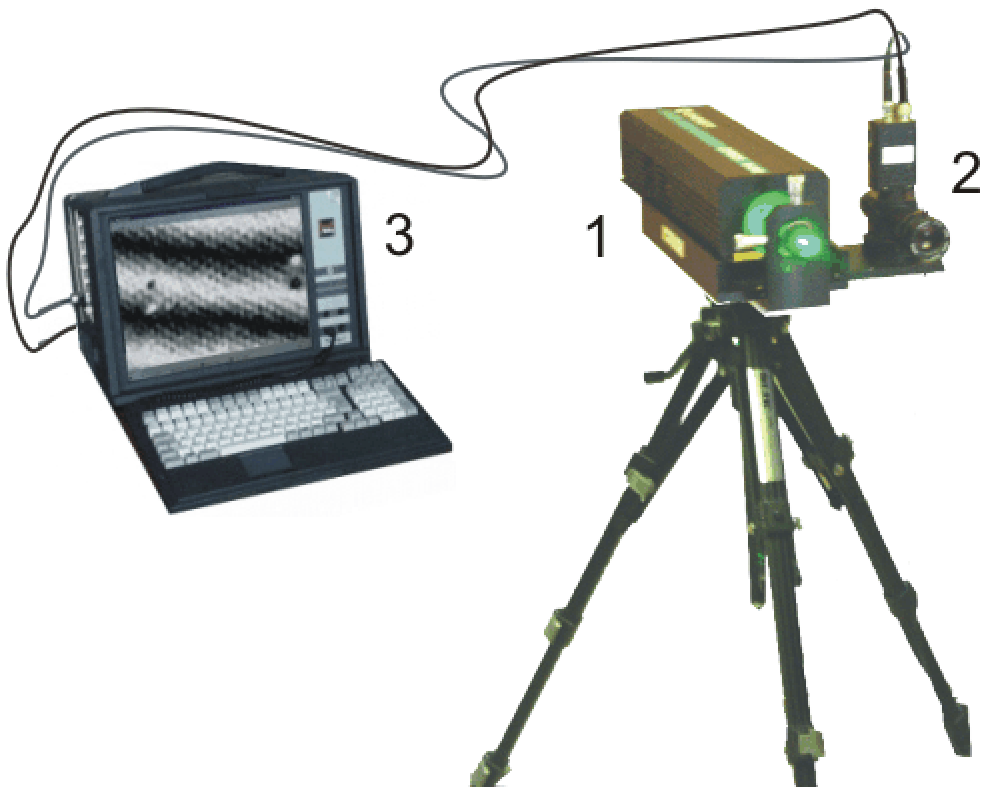

Figure 1. General view of a shearographic unit: 1 – laser, 2 – shearographic module; 3 – computer.

Experiments were made on non-destructive shearographic examination of quality of glass-reinforced plastic tubular elements of 300 mm length, 65 mm diameter and 2 mm wall thickness. The internal pressure of 300 kPa, which was created in a tubular element by a compressor, was used for loading. The general view of the tubular clement examined and defects of about 10 mm, revealed as a result of experiments, are given in Figure 2.

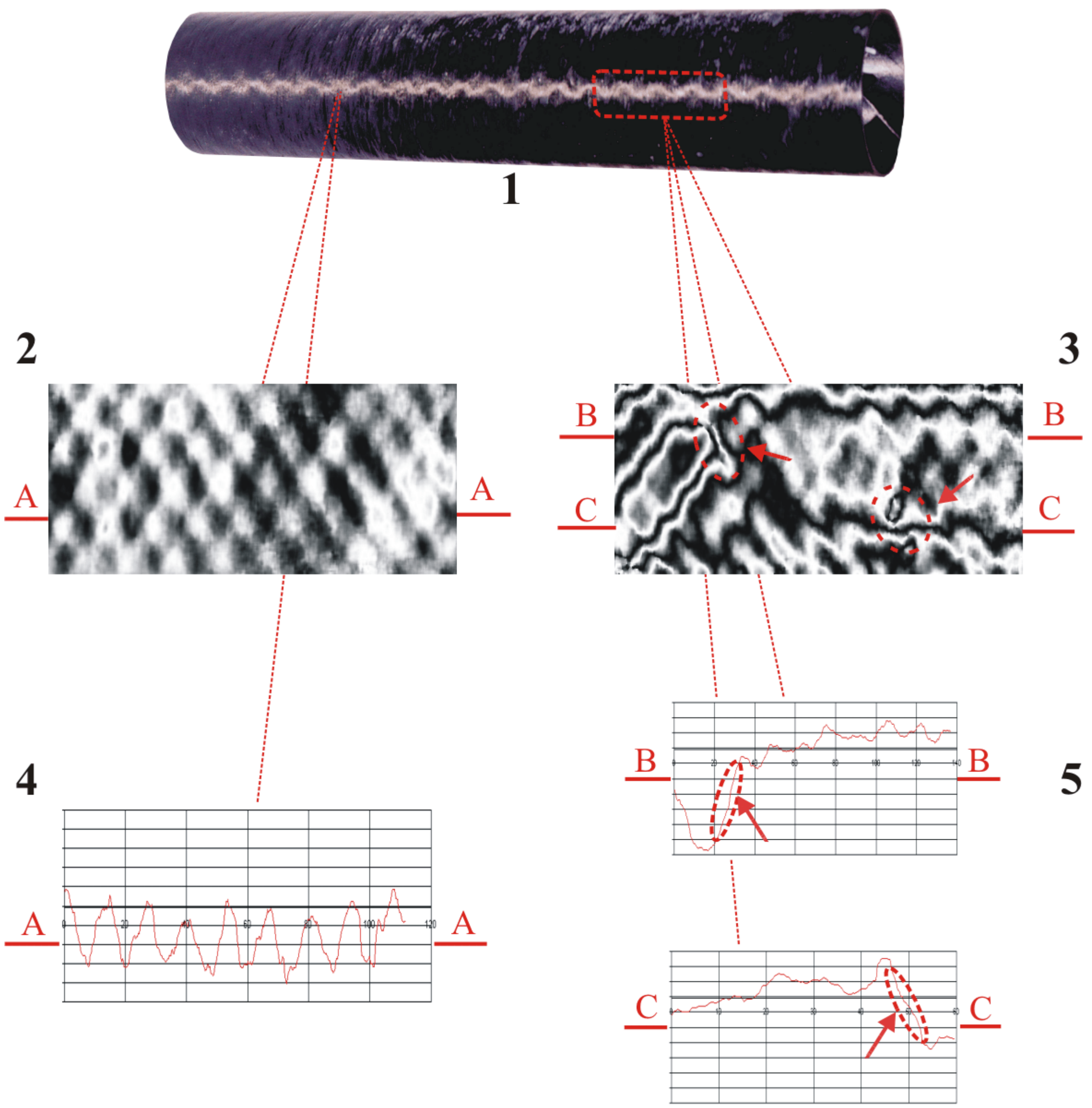

Figure 2. Results of quality control of glass-reinforced plastic tubular element: 1 – general view; 2,3 – typical interference pattern obtained in testing areas, respectively, with and without defects; 4,5 – change in derivative from out-of-plane displacements of structures along the selected sections (zones of defects are distinguishes and shown by arrows)

The high efficiency of the method of electron shearography was confirmed in control of a three-layer 600 x 500 x 29 mm welded panel, made of steel St3. The inner filler was a corrugated 2 mm thick sheet, to which external sheets of the same thickness were welded by a resistance spot welding. To load the element examined, the heating of the area examined by a hot air *(T* = 70 °C) for 10 s was used. The general view of the welded panel and results of assessment of quality are given in Figure 3. The surface profiles of the object examined in section show the sites of visualization of defects of size of about 5 mm, whose occurrence was caused by a non-quality spot welding.

The important advantage of the electron shearography method is the fact that it makes possible to perform quality control of elements of 3D structures having an access only from one side. Figure 4 presents the general view of a thin-walled structure made from aluminium alloy AMg6. The internal side of its lining was strengthened by transverse and longitudinal stiffeners. Size of structure was 1580x 680 x 420 mm, lining thickness was 1 mm.

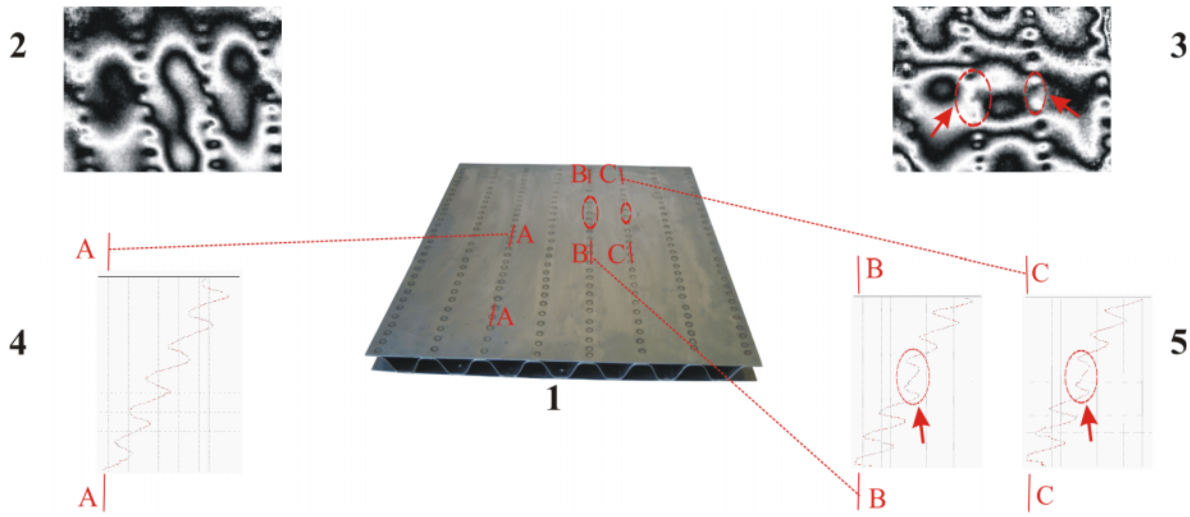

Figure 3. Results of quality control of a three-layer made by a spot resistance welding (for designation see Figure 2)

In service of thin-walled structure a crack of 100 μm width and 5 mm depth was initiated at the area of crossing the transverse and longitudinal stiffeners in their vertical flange. Moreover, the thin-walled lining was not damaged. To load the structure, the heating of the examined area with a hot air (T = 60 °C) for 5 s was used. The results of examination are presented in Figure 4.

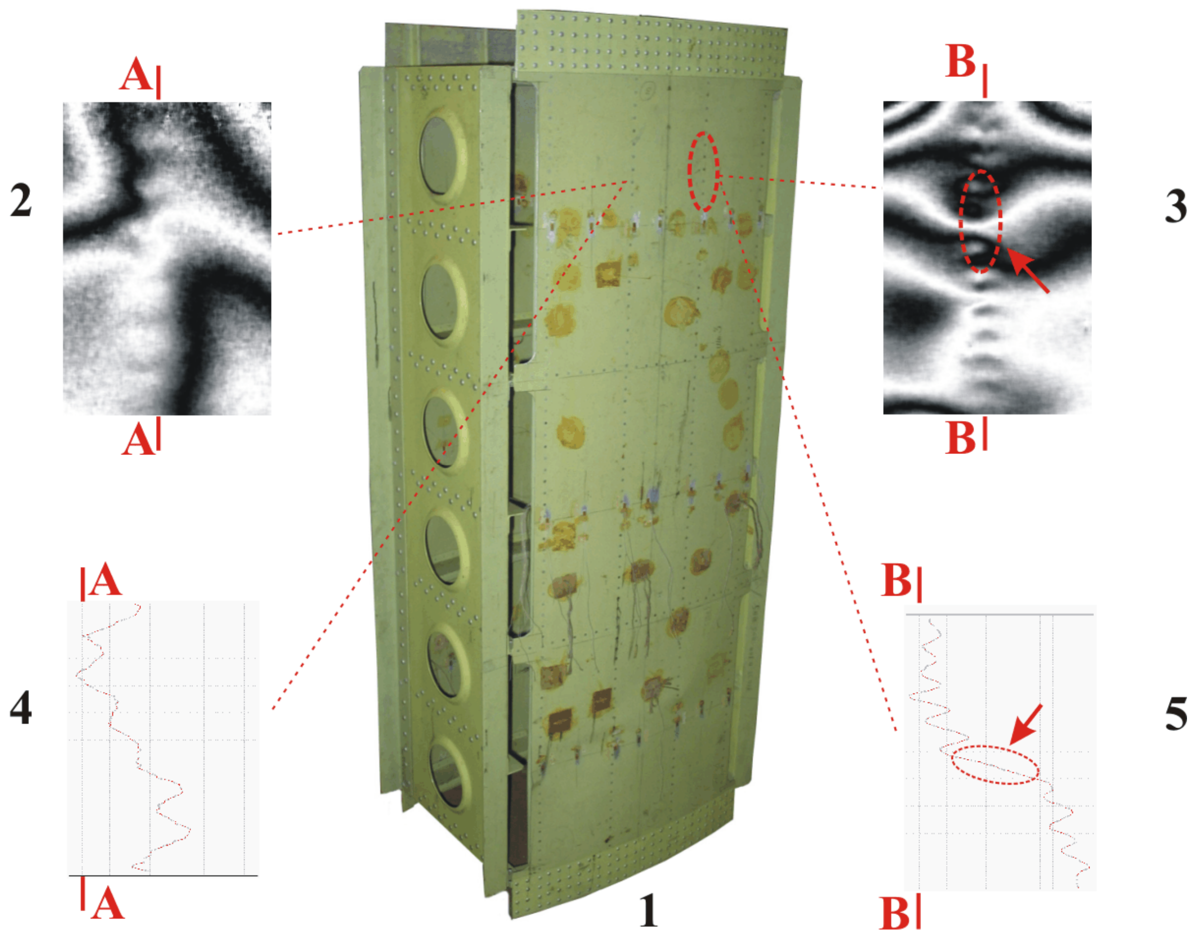

Figure 4. Results of quality control of thin-walled structures (for designations see Figure 2)

The non-destructive quality control of elements and assemblies of structures using the electron shearography method showed that the created technology at a proper selection of the method of loading with account for a geometry of elements and materials examined (mechanical, thermal, etc.) allows revealing different types of defects (lack of penetration, cracks, lack of adhesion and other imperfections of materials), which create a local concentration of deformations under loading. The application of the above-mentioned technology of non-destructive quality control is the only possible variant in a number of cases for obtaining the valid information about the presence of defects in thin-walled structures made from metallic and non-metallic materials.

References

[1] Nondestructive testing and technical diagnostics. (2001) Ed. by Z.T. Nazarchuk. Lvov: FMI.

[2] Nedoseka, A.Ya. (2001) Principles of calculation and diagnostics of welded structures. Ed. by B.E. Paton. Kiev: Kniga.

[3] Rastorgi, P.K. (2000) Trends in optical nondestructive testing and inspection. Amsterdam-Lausanne: Elsevier.

[4] Lobanov, L.M., Pivtorak, V.A., Olejnik, E.M. et al. (2004) Procedure, technology and equipment for shearographic nondestructive testing of materials and elements of structures. Tekhn. Diagnostika i Nerazrush. Kontrol, 3, 1-4.