INVESTIGATION OF DEFORMATION OF PARTS BY THE METHOD OF HOLOGRAPHIC INTERFEROMETRY

V. P. Shchepinov and V. V. Yakovlev

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Holographic interferometry is a high-sensitivity contactless method which makes it possible to investigate the character of the development of the deformation of the surface of real parts and constructions, which is very important for evaluating their service life. By comparison of two states of the surface in different stages of loading, in the general case, the method of double exposure determines the increase in the elastoplastic deformation, and, with a comparison of the surface in its initial state with its state after loading and total failure, the residual deformation is measured. Recording the waves from four states of the surface with loading and unloading of a part, a comparison can be made and, simultaneously, the increments of both the total and residual deformation can be determined. Under these circumstances, if the value of the increment of the load is constant, it is possible to compare also the pictures of the interference bands obtained with different levels of the loading. As a result, it becomes possible to determine the value and the character of the development of a shock deformation, the boundary of the transition into the region of elastoplastic deformation, and the value and the character of the development of the initial residual deformation. All this taken together gives an idea of the kinetics of the deformation of the part.

To carry out the required pairwise comparison of the light waves, it is convenient in practice to use two sections of one photoplate [1]. The scheme of the exposure of such a photoplate, arbitrarily divided into two parts (upper and lower) for the n-th stage of loading is shown in Fig. 1. The light wave from the nonloaded object O_n is recorded with a first exposure on the lower section of the photoplate. The second and third exposures on the upper section of the photoplate record, respectively, light waves from the initial P_n and final P_{n+1} states of the surface of the loaded part. The wave scattered by the object after complete unloading O_{n+1} is recorded in the lower section with the fourth exposure. Thus, two double-exposure holograms are obtained on one photoplate.

The picture of the interference bands observed with regeneration of the waves, recorded on the upper hologram in the general case, contains information on the increment of the deformation wave, while the picture of the bands observed through the lower hologram reflects the increment of the residual deformation. The absence of interference bands with observation of the lower holograms attests to the fact that, in the given stages of the loading, there is only elastic deformation. A conclusion with respect to the character of the deformation, and particularly, with respect to its linearity, can be drawn from a comparison of a number of interferograms, obtained with a constant value of the increment of the load.

The amplification with which interference bands are first observed through the lower hologram corresponds to the boundary of the transition into the region of elastoplastic deformation. The picture of the bands formed with a consideration of the holograms (O_n; O_{n+1}) with further stepwise loading shows the process of the accumulation of residual deformations.

It is most expedient to apply holometric interferometry in problems with a known direction of the vector of the displacements of the points of the surface, since, in this case, for interpretation of the picture of the bands, one direction of observation is sufficient [2].

The method under discussion is suitable for study of the bending of a round plate made of alloy D16T, clamped along its contour, and loaded by a uniformly distributed load. A plate with a diameter of 70 mm and a thickness of 10 mm has an annular recess with a depth of 6 mm and a width of 8 mm at its point of attachment. In the optical scheme for obtaining the holographic interferograms the direction of illumination and observation coincide [3].

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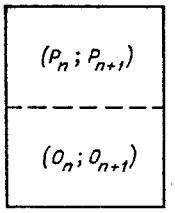

Fig. 1

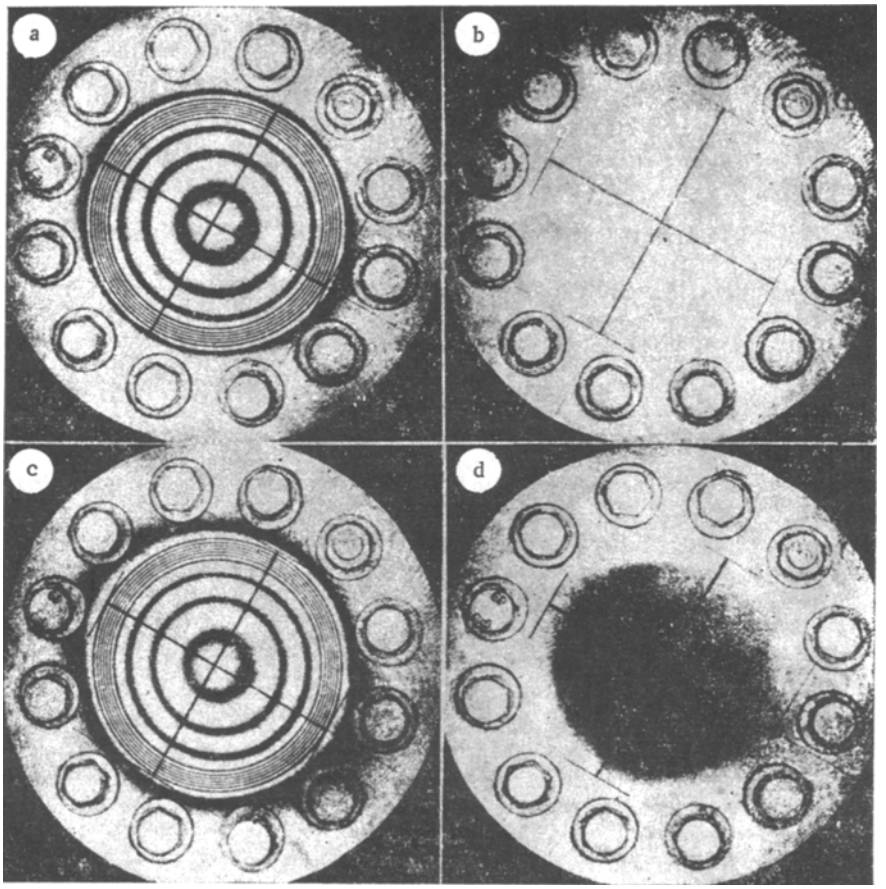

Fig. 2

Thanks to this, the greatest sensitivity is attained for deflections, equal to half the wavelength of the light source ($\lambda/2$ = 0.315 μm), and the form of the surface is conserved, which, in turn, simplifies analysis of the interferograms.

The light waves from the surface of the plate in different states of loading were recorded using a system of masks [4], covering the individual sections of the photoplate in a determined order. The selected increment of the load, equal to 0.96 atm, assured good resolution of the interference bands in the zone of the annular recess, with a sufficient number of bands.

The pictures of the bands, obtained in the first ten stages of the loading, are identical, and attest only to the elastic character of the deformation of the plate, since interference bands, reflecting an increment in the residual deformations, are not observed. The images of the plate, observed with regeneration of the waves, recorded on the upper and lower holograms, for the tenth stage of loading, are shown in Fig. 2a and b: (P_9; P_{10}) and (O_9; O_{10}), respectively. The large number of bands in the section of the recess reflect its considerably greater deformation in comparison with the central part of the plate. Interferograms of the increments of the total and residual deformations for the eleventh stage of the deformation are shown in Fig. 2c and d: (P_{10}; P_{11}) and (O_{10}; O_{11}). The appearance of the first band, shown in Fig. 2d, attests to a transition of the plate into the region of elastoplastic deformation with a given load.

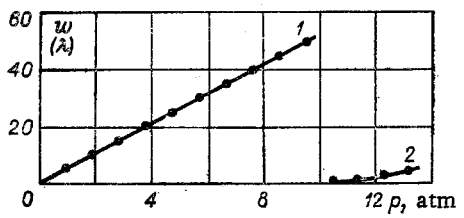

Fig. 3

The dependences of the value of the maximal deflection on the plate w on the pressure p for elastic 1 and residual 2 deformation are plotted in Fig. 3. The curves attest to a linear character of the elastic deformation, and to a nonlinear process of the accumulation of the residual deformations in the initial stage of plastic deformation.

The high sensitivity of the method of holographic interferometry limits the range of measured values of the displacements to one stage of loading. With a considerable value of the elastic deformation, interferograms can be recorded only in individual states, but necessarily with a constant increment of the load.

In conclusion, it must also be noted that the method under consideration makes it possible to investigate the process of the deformation of parts, taking account of their constructional special characteristics, the mechanical properties of the material, and the fabrication technology.

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