RECONSTRUCTION OF STRESS-STRAIN STATE IN THE STRESS CONCENTRATIONS OF THE HOLLOW AND SOLID CYLINDRICAL SPECIMENS

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The stress concentrations in machine components and constructional elements are the areas where the fatigue cracks and brittle fractures appear, which propagation finally proceeds to failure. Many researchers have obtained as a result, that the residual stresses have a positive impact on the strength of products with the stress concentrations. To increase the fatigue strength of such products the pressure residual stresses are applied at the potential areas of failure during the creation, generally by the methods of the additive technology of the surface affecting.

In the paper, we consider the problem of reconstruction (mathematical modeling) of the stress-strain state in the smooth cylindrical specimens and in the specimens with the stress concentrations in form of radial cuts, after the different additive technologies of the surface treatment:

– isotropic surface plastic hardening (air shot peening and hydraulic shot peening, ultrasonic peening, nitriding, etc);
– anisotropic hardening (rolling, diamond smoothing, mandreling, etc);
– forward surface plastic hardening (the specimen is hardened, then the stress concentrations are made).

We use our phenomenological method \cite{1,2} for the reconstruction of the residual stress and plastic strain fields in the cylindrical specimens by the empirical relation of the circumferential and/or axial components of the residual stress tensor. This method has been experimentally verified for isotropic and anisotropic surface plastic hardening of the elements in great depth and has shown good results.

For the reconstruction of the stress-strain state in the cuts of hollow and solid cylindrical specimens after the forwarding surface plastic hardening we use the method of calculation of residual stress by the given initial strain, which distribution can be obtained from the solution of the problem for the smooth cylindrical specimens.

For this research we use reducing of the given problem to the imaginary thermoelasticity problem \cite{3}, its subject is to make an analogy between the
residual plastic strain and elastic strain in the non-homogeneous temperature field with the non-homogeneous anisotropic field of the thermal-expansion coefficients tensor. Such approach (relation between initial strain and thermoelastic strain of material) allows us to use modern calculating finite element sets to solve the problem of the residual stress distribution in the arbitrary smooth elements with the stress concentrations after the additive technology surface treatment.

In contrast to the well known methods for solving the considered problem, the shown method allows us to take into account the real non-homogeneous by radius distribution of the residual plastic (initial) strain. Also, our method allows to reconstruct full three dimensional pattern of the stress-strain state in the hardened cylindrical elements (both smooth and having the cuts as stress concentrations).

We studied of the distribution of the residual stress in the hollow and solid cylindrical specimens made of EI961 alloy and St. 45 steel. At first these specimens were hardened, then the set of semicircular cuts were made. The influence of the radius of the cut and the anisotropy parameter on the distribution of the residual stress in the smallest section of cylindrical specimens was studied. We compare our numerical solutions with the known solutions (independent) of other authors for some partial cases of location of the stress concentrations. Our results correlate well with the solutions of other authors.

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References

