\[ \Delta \Gamma^o = \frac{1}{4} \left( 3\Delta \Gamma + \frac{\Delta T}{\mu} \right); \Delta T = \Delta T^0; T = T^0. \]  

Curve \( T^0_{23} - \Gamma^0_{23} \) (Fig. 4) is drawn with a dashed line through the points of curve \( T^0 - \Gamma^0 \) for this specimen. As can be seen, most of the points of curve \( T^0 - \Gamma^0 \) lie on the dashed line, and only the final two points lie above it.

**CONCLUSIONS**

1. Strain-hardening of the material is anisotropic in character.

2. With additional loadings \( \Delta T > 0 \), the shear moduli are determined by the stress state achieved and are the elastic shear moduli of the base dependence \( T^0_{23} - \Gamma^0_{23} \).

3. The theory of plasticity of an anisotropic strain-hardening medium quite adequately describes the character of plastic deformation of the material.

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**LITERATURE CITED**


**EVALUATION OF THE THERMAL AND STRESS-STRAIN STATE OF AN INTERNAL COMBUSTION ENGINE PISTON BY THE FINITE-ELEMENT METHOD**

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One of the most complicated parts of an internal combustion engine (ICE) governing reliability and endurance is the piston. The modern tempo of national economic development necessitates the creation of rapid methods for studying the thermal and stress state of basic ICE parts making it possible to shorten the time for their design and introduction. The difficulty of piston design increases markedly with the introduction of oil cooling to reduce the operating temperature of an ICE hopped-up for power and speed. The main difficulty arises in designing with fins introduced into the structure to relieve individual zones of the piston or to increase heat dissipation.

An ICE piston is generally a spatial three-dimensional structure. However, piston design in a three-dimensional problem with complete evaluation of the actual configuration and differences in boundary condition distribution is currently a very complicated problem requiring computers with a large operating memory and increased operating speed in comparison with existing computers.

In view of this it is desirable to design pistons with axisymmetric and plane situations. As a criterion for the validity of this approach it is necessary to use comparison of calculated results with typical variations of piston structural damage for which operating experience has been accumulated. In order to produce these calculations the finite-element method (FEM) holds considerable prospects [1, 2].

The most frequent piston damage in operation was experienced by a hopped-up two-stroke diesel type D100 manufactured by the Kharkov Production Combine "Zavod imeni Malysheva." Large numbers of this type of diesel operate in locomotives, ships, power generation, and gas stations. Pistons of D100 type diesels
have a composite structure, copious oil cooling, and a radial fin joining the central part of the piston head with the side wall. Piston diameter is 206.85 mm. The central part of the ITs (5) piston head has a supporting collar with diameters of 150 and 170 mm which joins the side wall of the head with six radial fins 24 mm wide and 20 mm high. The piston body is made of gray iron alloyed with chromium (0.4%), nickel (0.8%), molybdenum (0.4%), and copper (0.3%). Mechanical properties of this iron are given in Table 1.

The main types of crack arising in D100 type diesel pistons and their service lives were considered in [3].

Evaluation of D100 type diesel pistons was performed by the finite-element method in three stages; the first stage considered a meridional section passing through a radial fin (Fig. 1a), the second considered the same section, but located in the space between radial fins, and the third stage considered a plane section passing through the central plane of a fin (Fig. 1b).

The meridional section of the piston was represented by 859 triangular elements with 541 nodal points. In order to evaluate the thermal state of the piston (temperature determination at the nodal points) consideration was given to the condition of the minimum functional equivalent of the Laplace thermal conductivity equation. After setting up the coordinate functions in the functional expression and its subsequent minimization, a set of linear algebraic equations was obtained.

\[
[A]r = \{R\}, \quad (1)
\]