There are high levels of ponderomotive forces acting on the electromagnetic system in thermonuclear equipment of tokamak type because it is necessary to obtain plasma with with temperatures, pressures, and retention times. This requires careful analysis of the mechanical stresses on the elements and on the structure as a whole, in particular for the system providing the toroidal magnetic field. Interest in this topic has increased substantially recently, and numerical methods have been used in analyzing components, as a rule the finite-element method FEM [1-5].

A major factor determining the deformation of the coils producing the toroidal magnetic field in the type of support, which must withstand the forces pulling the coils towards the symmetry axis of the magnetic system. One form of support is the wedge type applied to the partially skewed coils near the axis, which also provides adequate rigidity.

Here we examine the arch part of a system of 20 skewed coils of D shape (Figs. 1 and 2) in one of the forms of toroidal magnetic system in the TB-0 tokamak [6]. The apparatus produces a toroidal field of strength 30 kOe at a radius r = 172 cm with the duration for the equivalent square pulse of 13.3 sec.

Figure 2 shows the sections of the coils but does not show the cooling channels for the conductors, which naturally give rise to local stress concentrations, which are not considered here. Figures 2a and 3 employ arcs of circles instead of the chords for convenience in describing the elements of the coil section.

There are elastic couplings applied from the truncated parts of the diverging coils and the external frame to the arch part. We consider the effects of the ponderomotive forces applied to the conductors and due to the toroidal field. Also, the resistive coils are subject to a temperature distribution due to the heating of the conductors. The forces and temperatures are highest in the skewed part. Figure 2a shows the distribution of the ponderomotive forces and temperature in the cylindrical region of the arch part, while Figs. 1a and 3 show the directions of action of the forces.

Because of the geometrical structure and the loading, we have here a three-dimensional problem in thermelasticity in determining the state of stress in the coil system for the toroidal magnetic field, and this is cyclically symmetrical. There are numerous design components in the coils, which makes the solution very complicated. Therefore, two-dimensional deformation models were used (axisymmetrical and planar with given axial deformation), where effective two-dimensional FEM schemes have been devised [7, 8].

According to the axisymmetrical scheme, the arched part of the coil system is represented as a three-layer body of rotation with inhomogeneous filling between the steel shells of orthotropic material with constant principal anisotropy axes. The constants of the material were determined by a method used in the mechanics of composites [9], and the calculations incorporated all the components of the structure in the cross section of the coils. The temperature distribution in the ponderomotive forces were considered applied to all the filling. The design as a whole is symmetrical with respect to the I—I section and, therefore, we considered only half of the meridional section of the arch part and introduced the conditions $u_z=0, \tau_{rz}=0$ on the symmetry line.

The elastic couplings were not fully incorporated into the calculations. We considered the form in which the effects of the external (truncated) parts of the coils were completely transmitted by the radial forces at the ends of the arch part (section II—II). Against the background of the bulk forces, these reactions had a marked effect only on the toroidal parts of the arched section.

The structure of the coils in various cross sections and distributions of the ponderomotive forces and temperature: 1 and 2) internal and external steel shells; 3 and 4) radial and intersection insulation; 5) steel baffle; 6) circumferential insulation; 7) copper wire; 8) insulation between layers.