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HIGH-TEMPERATURE SUPERCONDUCTORS IN ELECTROMAGNET SYSTEMS OF ADVANCED CONTROLLED THERMONUCLEAR FUSION FACILITIES (SPARC, TRT, ST-HTC PROJECTS, ETC.) *)

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Along with the continued implementation of the ITER project being at the forefront of development of national and international controlled thermonuclear fusion programs based on the achievements of the industrial stage of elaboration of low-temperature superconductors (LTS), the world observes an increased interest to the compact controlled thermonuclear fusion facilities with superconducting electromagnet systems (EMS) which operate at the higher levels of magnetic fields. This tendency is formed mainly by two factors. Firstly, the results of technical and economic analysis of investment projects aimed at creation of future industrial facilities such as power plants indicate the necessity of financial cost reduction and facility construction acceleration. Secondly, the progress in the development of second-generation high-temperature superconductors (2G HTS) confirmed by successful manufacturing of the superconducting magnets with the operating values of magnetic field induction up to 30 T gives grounds to speak about the technical feasibility of ambitious projects and startups with the following target parameters: structural current density in superconducting coils is ~ 70-100 A/mm^2, magnetic field induction on the coil is ~ 18-22 T, superconductor operating temperature is ~ 10-25 K.

The construction of the compact high-efficiency controlled thermonuclear fusion EMS based on 2G HTS requires novel approaches to solving the traditional tasks of coil designing. The key issue is to provide the required current density and mechanical strength of the coil structure. There are other, equally important tasks, i.e., designing the electrical contact joints and high-voltage insulation system for the structural elements of the coils, selection of the design and operating characteristics for the 2G HTS winding conductors (current, magnetic field induction, temperature and deformation) ensuring the required system performance margin, justification and selection of the principles for diagnostics and protection of the superconducting EMS with estimation of heat release in the 2G HTS conductor and elaboration of the requirements to the cryogenic support system.

By comparing the technical solutions used when constructing a number of modern facilities such as SPARK, TRT, ST-HTS [1-3], etc., and the test results for the full-scale mockups of the coils and for the test samples of the 2G HTS winding conductors produced and tested in support of these projects, as well as by analyzing the latest results of the preliminary design of the new Russian Tokamak of Reactor Technology (TRT), the authors of the paper have tried to specify the main principles and criteria for designing the modern compact EMS with high magnetic fields which use 2G HTS advantages.

*) abstracts of this report in Russian