Globus-M2 Design Peculiarities and Status of the Tokamak Upgrade


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Abstract. The Globus-M spherical tokamak has demonstrated practically all of the project objectives. The increasing of the magnetic field up to 1.0 T together with the plasma current up to 0.5 MA should significantly enhance plasma performance. The Globus-M2 project is aimed at new tokamak design changes, both in the magnetic system and the supporting structure. Various Globus-M2 Design Peculiarities and Status of the Tokamak Upgrade are described. The complete 3D finite element model is used for the full-scale prototyping of the magnetic system. Plasma scenarios were developed with the help of routine IPB96(j.2) scaling using Globus-M experimental database.

Key Points of the Tokamak Upgrade

- Design of the magnetic system and supporting structure is substantially revised in order to increase the toroidal magnetic field up to 1.0 T together with the plasma current up to 0.5 MA.
- Vacuum vessel, in-vessel components and diagnostics remain the same. That allows keeping the full set of plasma magnetic configurations available on Globus-M.
- All special conductors for the TF rod, TF coil outer limbs, PF coils and central rod mockup were wound in situ over TF coil central joint. The original conductor was used.
- A full-scale prototype of central solenoid coil was wound in situ over TF coil central joint with a 1 mm gap. The original conductor was used.
- Flexible bas bars are placed outside of the maximal stresses zone.
- Support structure is redesigned.
- Water cooling is applied to all poloidal field coils.
- The conducting area of TF coil inner segments is increased whereas the solenoid coil upper joint was redesigned.
- The conducting area of TF coil outer segments is increased whereas the solenoid coil upper joint was redesigned.
- The conducting area of TF coil outer segments is increased whereas the solenoid coil upper joint was redesigned.

In Globus-M2 toroidal field ripple near plasma boundary will be reduced approximately by a factor of 2.

In Globus-M the TF ripple near plasma boundary is sufficiently high (20–40%). In Globus-M2 the radius of TF coil outer limbs will be increased from 600 cm to 640 cm.

The increase of TF coil overall diameter requires manufacture of two pairs of outer PF coils (PF1, PF3). Nevertheless, their coordinates remain practically unchanged, which allows keeping the full set of plasma magnetic configurations available on Globus-M.

Central column arrangement was optimized with the help of thermal analysis.

- The conducting area of TF coil inner segments is increased whereas the solenoid coil upper joint was redesigned.
- The gap of 10 mm between the column and the vessel inner cylinder in Globus-M allows an increase of the total column diameter in Globus-M2 reducing the gap value to 2 mm.
- Flexible bars are placed outside of the maximal stresses zone.
- Support structure is redesigned.
- PF1 and PF3 coils are redesigned.

The complete 3D finite element model was developed and applied for mechanical and thermal stress analysis.

- Maximal displacement of the TF coil in toroidal direction does not exceed 2.2 mm under the highest possible operation loads ("B-lim" regime, disruption at the end of TF plateau).
- TF coil bending creases undergo a pulling force of 6.3 kN and compressing one up to 4.6 kN. Minimal tensile stress in the coil is equal to 420 MPa.
- The operating limit of the upgraded tokamak is estimated as 2000 shots, including at least 500 shots with maximal values of the toroidal magnetic field and plasma current.

The Globus-M2 design differs from Globus-M one in significant details.

- Flexible bars are placed outside of the maximal stresses zone.
- Upper supporting ring and it load-bearing transverse sections are added.
- TF coil joints are made of high grade copper (ρ = 200 MPa).
- Water cooling is applied to all poloidal field coils.
- Central column is redesigned completely.
- Support structure is redesigned.
- PF1 and PF3 coils are redesigned.

Current Status of the Tokamak Upgrade

- Manufacturing of new magnetic system was started successfully in the beginning of 2014.
- All special conductors for the TF rod, TF coil outer limbs, PF coils and central solenoid were manufactured and delivered to the Ioffe institute.
- Flexible bars are placed outside of the maximal stresses zone.
- Upper supporting ring and it load-bearing transverse sections are added.
- TF coil joints are made of high grade copper (ρ = 200 MPa).
- Water cooling is applied to all poloidal field coils.
- Central column is redesigned completely.
- Support structure is redesigned.
- PF1 and PF3 coils are redesigned.

The detailed design of tokamak upgrade has been completed.

- All special conductors for the TF rod, TF coil outer limbs, PF coils and central solenoid were manufactured and delivered to the Ioffe institute.
- Central column is redesigned completely.
- Support structure is redesigned.
- PF1 and PF3 coils are redesigned.

Globus-M2 magnetic system will be constructed by the end of 2015.

References:

Technical schedule for Globus-M2 electromagnetic system construction

This report emerged the results, which have been obtained with the help of the unique scientific device spherical tokamak Globus-M. This work is financially supported by the Ministry of education and science of Russia. The unique ID of the project is RFMEFI61914X0001.

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