Overview of Globus M results

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The Globus-M spherical tokamak was put into operation at the Ioffe Institute in 1999. The project is dedicated to basic spherical tokamak (A = 1.5) physics research, with emphasis in auxiliary heating and current drive using various RF methods. Main methods are: ICH (1-1.5 MW, 10-15 MHz), HHFW (0.7 MW, 30-50 MHz), LH schemes (<0.5 MW, 2.45 GHz), as well as traditional method of NBI (~1 MW, 30 keV). Important research tasks are investigation of plasma wall interaction and plasma facing materials behavior. The Globus-M parameters: R=0.36m, a=0.24 m, aspect ratio 1.5, vertical elongation 2.2, and maximum toroidal field B=0.62 T. The design current is up to 0.5 MA and the pulse duration is up to 0.3 s. Machine design provides good access for auxiliary power launch (NBI and RF antennas). Globus-M operation begun with a limited diagnostic set (magnetic probes and loops, SXR, interferometer) and more diagnostics were added later.

Vacuum vessel wall conditioning technology predominantly defines the ultimate values of plasma current, which could be achieved at the fixed loop voltage value. The walls boronization minimizes the impurity influx and leads to formation of the amorphous B-C film with a typical B/C ratio of 3/4-3/5. The physical properties of the B-C coating are like semiconductor one (forbidden gap width, high specific resistance, etc.). Film properties are discussed. Usually boronization results in ~30% of current amplitude increase.

Plasma start-up is inductive with magnetic flux built up by the central solenoid (CS). The double swing regime of CS supply was used to achieve plasma current up to 0.36 MA, with the current ramp-up rate of ~ 17 MA/s. The pulse length has been increased up to 85 ms. Current density obtained to be more than 1 MA/m^2, giving high specific power deposition. Together with high magnetic field achieved (B_T = 0.55 T) this help to increase plasma density to 7-8 $10^{19}m^{-3}$ that is close to the Greenwald limit $n/n_G \approx 0.8$. The central electron temperature estimated by SXR measurements is in the range of 500-700 eV. The estimate of the energy confinement time, which is below 7 - 8 ms (depending on density) is more likely in accordance with Neo-Alcator scaling.

Operational space and stability limits investigation were performed. High-density limit behavior in OH regime looks similar to other spherical tokamaks, e.g. START. Density increase to Greenwald limit was limited, presumably, by resistive, low n MHD modes. Low-density boarder of operational space is defined by runaway behavior. Specific features of runaways behavior in STs are discussed. Record low $q_{cyl} = 5a^2B_T/RI_P < 0.9$, $q_{95} = 2.1$ was obtain in toroidal field ramp-down experiment, together with toroidal beta ~10%. This was due to formation of magnetic configuration stable to localized ballooning and external kink modes (n =1,2,3) in conditions with flat pressure profile, during field ramp down.

Plasma performance improvement is connected with new fuelling tool – special kind of unmagnetized Marshall gun for plasma jet injection. First results are presented. Other methods of plasma performance increase (digital feedback control, vessel walls protection) are briefly described.

NBI and ICRH HHFW systems are commissioned and first tests are performed. Significant amount of new diagnostic systems are coming into operation this fall. Among them are: bolometer, radar reflectometer, radar refractometer, Thomson scattering, and NPA. SXR pin-hole cameras will be available next year.

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