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FIRST OHMIC EXPERIMENTS ON KTM TOKAMAK

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The research on the physical and mechanical properties of structural and functional ma-terials of future fusion reactors has been actively conducting for many years in the Republic of Kazakhstan [1, 2].
Specialized KTM tokamak is being developed in Kazakhstan to research the behavior of candidate materials of the first wall under the conditions of high heat flows comparable to those in future thermonuclear reactors [9-11]. This is the tokamak with aspect ratio equal to 2, single-zero divertor plasma configuration, maximum plasma current of 750 kA, toroidal mag-netic field of 1 T, and duration of a purely inductive discharge scenario with basic parameters of τpulse≤1 second, and up to 5 seconds using an additional RF plasma heating system with a maximum heating power of 5 MW. The maximum design capacity of the thermal load on the receiving divertor plates is 20 MW / m2, which is comparable to the expected loads in the di-vertor area of the ITER thermonuclear reactor [12].
The main qualitative difference between the KTM tokamak and similar installations is the presence of transport-gateway and receiving-divertor devices. This allows replacing the test samples in the shortest possible time, without depressurizing the vacuum chamber (VC), which increases the experimental capabilities of the KTM tokamak.
Figure 1 shows the KTM tokamak appearance.

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At the end of 2019, an experimental campaign was conducted to implement the KTM tokamak physical start-up. The experiments resulted in the plasma discharge of working gas hydrogen with the discharge duration of 65 ms and the maximum plasma current of about 100 kA with the toroidal field of 0.9 T. The KTM Tokamak physical start-up of was carried out using standard sources of pulsed power supply of the KTM tokamak electromagnetic system (EMS) coils [5, 6].
The analysis of the plasma initiation stage in the KTM tokamak was performed using TRANSMAK code [7]. According to the calculations the area of a breakdown has size of about 0.5 m with the magnetic field modulus value equal to 5 GS and is situated at the inner bypass with the center at R=0.6÷0.7 m radius. The value of the electric field intensity in the breakdown area is about 1.6 V/m, which at a radius of 0.7 m equals to 7 V voltage at bypass.
Before the experiments on obtaining plasma the KTM tokamak VC was lined with graphite tiles of FP 479 brand in two diametrically opposite poloidal sections.
The VC preparation for the experiments included vacuuming using two turbomolecular pumps with a pumping speed of 2000 l/s each and heating the VC at a temperature of 130 ºC for 8 days with subsequent treatment for 48 hours with a glow discharge in a hydrogen, helium and argon medium. Cleaning the VC with a glow discharge was also carried out at nights during the inter-start-up period. The maximum level of the residual gases pressure ac-cording to the results of the VC preparation was 2·10-7 Torr.
Starting systems, registering and processing the data during discharges was carried out using the standard KTM tokamak experiment automation system [8, 9].
Figure 2 shows parameters of one of the plasma discharge (discharge No.3669) with the maximum plasma current value of about 100 ka and the average electronic plasma density of about 1.5·1019 m-3 (the linear plasma density nedl is no more than 8·1018 m-2). In the discharge No. 3669 the plasma current growth rate is about 2.5 MA/s.

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Figures 3 shows video frame of the plasma discharge No. 3669 observed by the KTM video camera system [10] and frame of the plasma position and shape reconstructed from magnetic measurements. The current thread method with a fixed position [11] was used to reconstruct the current, position, and shape of the plasma. Eddy currents induced in the con-ductive structures of the installation were taken into account in the process of solving the re-construction problem.

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The synopsis describes the main experimental results of obtaining plasma discharges in the KTM tokamak. The KTM tokamak physical start-up was carried out in November 2019. The hydrogen plasma was obtained with maximum plasma current of about 100 kA, discharge duration of 65 ms and an average electronic plasma density of about 1.5·1019 m-3. Plasma dis-charges was carried out in the ohmic mode without the use of additional methods of preioni-zation and additional heating. The synopsis describes the work on preparing the KTM toka-mak for the physical start-up, the experiments conditions, and achieved results. The physical start-up has demonstrated the performance of the main KTM tokamak systems and the plasma obtaining possibility.

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