FIRST EXPERIMENTS WITH THE VERTICAL LITHIUM LIMITER IN THE T-11M TOKAMAK

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Introduction. The successful experiments with lithium limiters on the basis of capillary – porous structures (CPS) were carry out earlier on T-11M and FTU tokamaks [1,2]. In all these experiments rail limiters were positioned horizontally at the bottom of the plasma column and the tokamak vessel. However the vertical arrangement of the lithium limiter at high field and low field sides of the plasma column can be used in the development of lithium limiters for steady state tokamak reactors and volumetric neutron sources on the tokamak basis. The main advantage of such geometry of Li-limiter in T-11M was a possibility to increase the length of region plasma limiter interaction by the fact that the size of T-11M horizontal port (Fig.1) is longer up to 2 times than the vertical one. As result, the ability of collecting of lithium ion flows from the active part of the CPS limiter can be increased. For this purpose the vertical lithium CPS limiter was created, installed in the T-11M and successfully tested in the operating mode. This vertical limiter allowed approximately 2-fold increase of the "cold" collector area of the lithium limiter as compared to the previous horizontal rail limiter [1]. The first misgiving about the vertical geometry of CPS limiter with liquid metal was probability of metal outflow during tokamak disruptions to the low part of the limiter. The second misgiving of such (Fig.1) limiter geometry can be a high probability of runaway electron impact on the CPS limiter located at the low field side. Both opportunities were tested experimentally on T-11M.

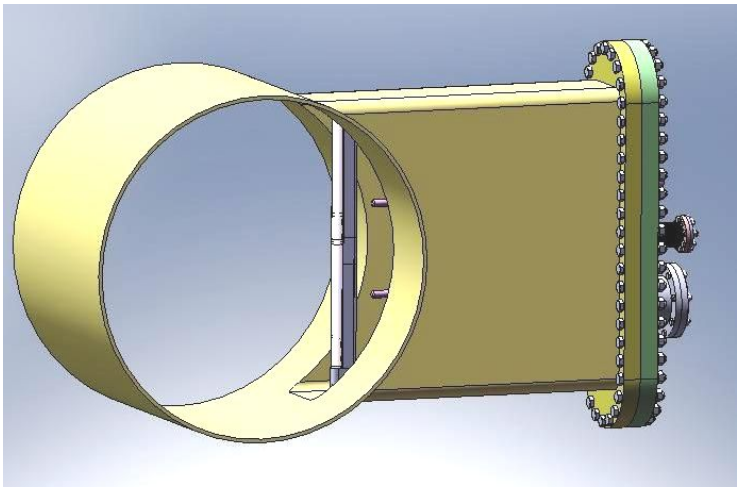

Fig.1. View of vertical lithium limiter in the vacuume vessel of T-11M tokamak

This paper presents the first results obtained in this resent experiments with the vertical lithium limiter upright on T-11M tokamak with R=0.7m, a=18-20cm [1].

Experiments and diagnostics. The experiments were performed at toroidal magnetic field of 1T and the current of 60ч100kA. The working gases were deuterium and hydrogen. The initial (preheating) temperature of the limiter with liquid lithium was 200°C. The limiter was made from stainless steel tube (outer diameter of 25 mm and length of 320 mm) coated with a thin (≈1mm) layer of capillary-porous (pore radius of 15 mkm) material impregnated with lithium and provided with a heater. The vertical limiter was installed in the horizontal port

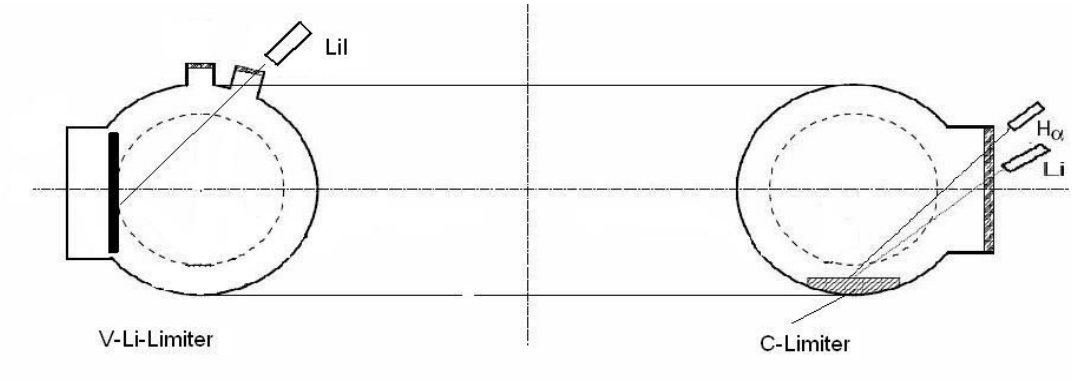

Fig.2. The position of limiters and optical diagnostics sensors on the vessel of T-11M in the experiments

(Fig.1) vertically at the distance of 20 cm from the axis of the tokamak vessel. The vertical limiter could be moved horizontally by 6 cm. Optical photodiode detectors with narrowband LiI (λ=670,8nm) and Hα (λ=656,3nm) high-contrast interference filters were used to determine the intensity of and Hα lines near the C limiter (graphite limiter) and in oder to determine radial profile of ion fluxes of lithium and deuterium in the SOL. The distribution of lithium ions and deuterium fluxes measured by the method of a recombination probe (scanning a graphite limiter) is described in more detail in the paper [3,4].

Results. The stable discharges with higest density $6\cdot10^{19}m^{-3}$ and duration up to 230ms were obtained by use the vertical lithium limiter. The radial distributions of longitudinal fuxes of ions of deuterium and lithium in the SOL region (the shadow of the vertical limiter) for various plasma densities in the ohmic mode with vertical lithium limiter were investigated. It was found that the distributions of ion fluxes are somewhat different from the distributions obtained earlier (fig.3 dotted line, black squares) [3,4], and have an exponential form in the middle part of curve with e-fold lengts λ_1=3.5cm for lithium and λ_2=5.1cm for deuterium plasma with density of $1.5\cdot10^{19}m^{-3}$ (Fig.3). When plasma density is close to Greenwald limit ($6\cdot10^{19}m^{-3}$), e-fold lenghts λ increase to more than 10 cm for deuterium, with almost constant ratio between them about $\lambda_2/\lambda_1 \approx 1.6$. The behavior of the radial distributions in the marginal areas is different from exponential due to the presence of additional elements in the vessel.

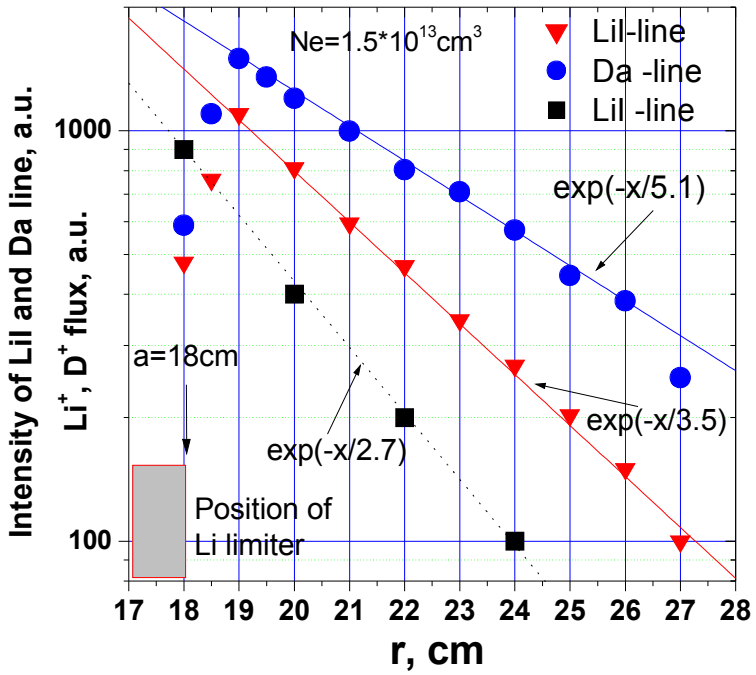

Fig.3. Radial profile of D^+ and Li^+ ions fluxes in the SOL of T-11M tokamak

The highest density close to Greenwald limit (Fig.4) was achieved in an almost stable T-11M regime with H-like mode development, which was only sometimes observed earlier with horizontal rail limiter with rare repetitions. In this mode a reverse H-L transition was observed when plasma density reached Greenwald limit. A single ELM-like phenomenon was odserved at the moment of the end of H-mode. Similar H-like modes with improved confinement were observed in the FTU tokamak after lithizition [5].

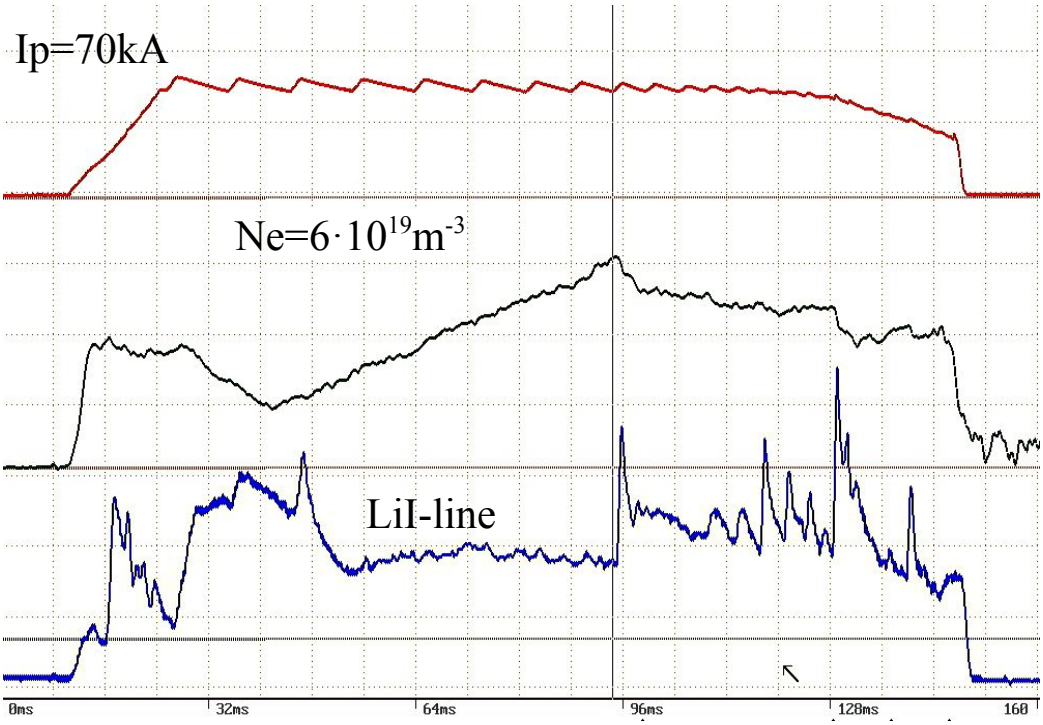

Fig.4. Current, plasma density and intensity of LiI line from the Li-limiter surface in the ohmic H-mode

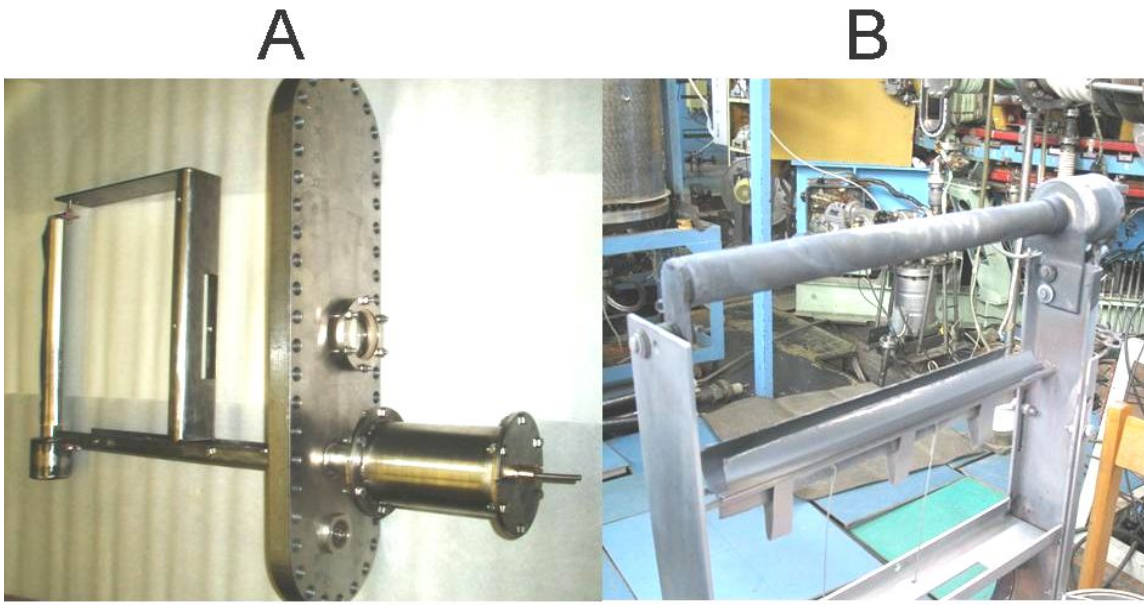

Fig.5. View of vertical lithium limiter with the mechanism for positioning before (A) and after (B) tokamak plasma exposition during1000 discharges

Conclusion. The vertical limiter was tested in 1000 shots campaign of T-11M with approximately 20% disruptive shots on the finale stage of current pulse without the some signs of visible metal outflow to low part of limiter (Fig.5B). Small traces of electron runaway were observed on the middle part of the vertical limiter after the experimental campaign. Obviously that is some evidence to strengthen middle part of vertical limiters positioning at the low field side of tokamak plasma column. Stable ohmic modes were obtained with extremely high densities close to Greenwald limit. Radial distributions of lithium and deuterium ions fluxes were studied in the SOL of the vertical lithium limiter. These distributions allowed to make estimates of propagation of lithium, returning to the surface of the vertical lithium limiter. They gave the value of the return of lithium on the limiter more as 75%. The work was performed in the frame of the state contract number H.4f.45.90.11.1013 of the State Corporation Rosatom.

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