Center-Solenoid-Free Merging Start-up of STs by Outer PF coils in UTST

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A center-solenoid-free [1] merging start-up scheme for spherical tokamak plasmas was developed in a University of Tokyo spherical tokamak (UTST) experiment by using outer poloidal field (PF) coils. Null points are formed transiently in the upper and lower sections of the UTST vacuum vessel by combination of outer PF coil currents and wall eddy currents. Torus breakdown was successfully initiated at the null points and two spherical tokamak plasmas with a total current up to 80 kA were simultaneously generated by induction from outer PF coils [2]; however, only 40 % of the vacuum magnetic flux at the null point was conserved in the ST plasma. Low flux utilization efficiency and high electric field of >40 V/m required for breakdown are the weak points to be improved and optimization of the plasma initiation process is under investigation by using numerical modeling of torus discharge at a transient null point.

Merging process of the two ST plasmas provided substantial ion and electron heating by magnetic reconnection. It was found that about 30 % of the initial poloidal magnetic energy was released during merging. Then, about 80 % of the released energy was converted to ion thermal energy and 20 % to electron thermal energy. The obtained dependence of heating on plasma current suggests that high temperature and high-current plasma suitable for neutral beam injection is attainable under the realistic conditions in the merging start-up method.

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