24P-3F-09

Use of virtual coils in the 2D MHD model to reconstruct internal magnetic field during the merging experiment in spherical tokamaks

AHMADI Tara [1]
ONO Yasushi [2]
CAI Yunhan [1]
TANABE Hiroshi [2]

[1]Graduate School of engineering, University of Tokyo
[2]Graduate School of frontier sciences, University of Tokyo

This work discusses a novel model able to reconstruct the internal magnetic configuration inside a spherical tokamak by using the external magnetic field measurements done by magnetic probe array system installed in the University of Tokyo TS-6 (TS-3U) device.

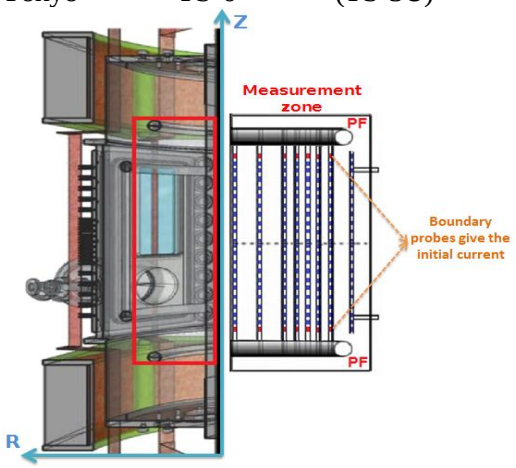

Figure 1 TS-6 schematic view along with the magnetic probe array system

In merging start-up, two plasma rings are formed inductively around the in-vessel poloidal field coils (PF) during the current ramp-down phase. When coils current damps to zero, a pair of plasma rings are separated from the coils are moving toward each other mainly due to the mutual attraction of the parallel current. At the mid-plane, these plasma rings merge together through the magnetic reconnection process forming single stable plasma at the mid-plane. This start-up method has been investigated in many devices proving itself as an optimal method not only to initialize the plasma current, but also the high plasma heating as the magnetic reconnection is known to convert the magnetic energy into the plasmas thermal and kinetic energies. This method has been used actively in low aspect ratio spherical tokamaks in the last three decades. Various plasma diagnostic systems are available to measure the plasma parameters. Yet, the direct measurements are highly limited due to the high plasma temperature inside the vacuum chamber of some devices. Therefore, the external plasma diagnostic systems such as magnetic probe arrays, flux loops, ion Doppler tomography and etc. are widely used in the tokamak devices. At this moment, there are reconstruction methods providing the internal plasma parameters from these measurements.

In the case of the magnetic field, EFIT model is able to reconstruct the internal magnetic field at the equilibrium state, yet there is no information regarding the internal magnetic field during the merging. This work presents a 2D MHD based fitting model which is able to reconstruct the internal magnetic configuration at any stage by using the limited magnetic probes. A 2D magnetic probe system is installed in TS-6 measuring both external and internal magnetic fields enabling a high accuracy comparison between the reconstructed and measured parameters.

In this model, a series of virtual coils are implemented in a 2D toroidal R-Z plane responsible to produce magnetic field equal to the magnetic field measured by the external probe arrays. Including the other plasma parameters, the 2D MHD system of equations is solved at each time step resulting in the magnetic configuration reconstruction during the merging process with high accuracy.

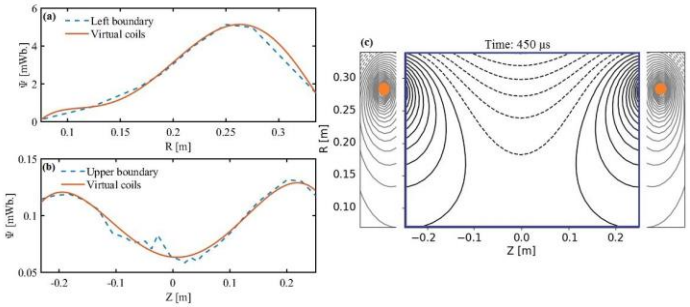

Figure 2 The comparison of the poloidal flux produced by the virtual coils and calculated from the magnetic field measurements during the plasma formation