The Research Evolution of Reversed Field Pinch Plasmas on SWIP-RFP Device*

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The reversed field pinch (RFP) plasma is one of the most actively studied alternatives at present. SWIP-RFP (Major radius R/minor radius a=0.48 m/0.1 m, R/a=0.48 m/0.09 m with molybdenum limiters) was a small dimension RFP device in Southwestern Institute of Physics (SWIP). It was put into operation in 1991 and shut down in 1998. The typical discharge parameters obtained for RFP and Ultra Low safety factor q(ULQ) configurations were: plasma duration≈0.9 ms (≈1.2 ms for ULQ), plasma temperature $T_i \approx T_e \approx 80$ eV, RFP sustainment time≈0.4 ms, global energy confinement time $\tau_E \approx 0.03$ ms and peak plasma current $I_p \approx 80$ kA(≈100 kA for ULQ). Because there was no effective apparatus for plasma pre-ionization, a capacitor bank was used to activate a negative pulse of I_p just before the positive pulse of I_p for physical research. The ULQ confinement was studied with the toroidal field control, we found that the ULQ plasmas were stable with different edge q values. Because the plasma temperature was low, the RFP sustainment time was limited during relaxation process. The plasma sustainment time was twice as long as the RFP sustainment time. Many wall-conditioning methods were used. Evident fluctuations were detected on the waveform of the edge toroidal field. To achieve more stable RFP confinement, a high plasma toroidal voltage V_ϕ was required. Large V_ϕ drove large I_p and resulted in very large plasma pinch factor Θ (maximum value about 2.5). From the viewpoint of plasma relaxation, higher Θ accompanies larger magnetic helicity loss. Then the reduction for V_ϕ on SWIP-RFP was important for RFP confinement improvement. The time evolutions of plasma relaxation parameters such as the original helicity K (= $\int A \cdot B \mathrm{d}V$, where B is the field, A the vector potential), the total helicity K_{totol} (=$K-\Phi\Psi$, where Φ is the toroidal field flux, Ψ the poloidal field flux through the major torus) and the magnetic energy U_m have been calculated. The results showed that though K and U_m increased, K_{total} decreased. The calculation results indicated that these parameters did not meet the relaxation theory requirements. The increases of K and U_m were caused by the enhancement of the poloidal field produced by large I_p. So, if we wanted to conserve K_{total}, V_ϕ had to be decreased (as $\Psi = \int_0 V_\phi \mathrm{d}t$). Above results indicated that the device required modifications for V_ϕ reduction. But it is difficult to do this because V_ϕ relates with many factors such as energy confinement, plasma temperature, plasma pre-ionization, plasma equilibrium, magnetic symmetry, vacuum chamber structure, etc. Because SWIP-RFP was a small device, it was difficult to choice between modifying it and stopping operation. We finally chose the later. But the further studies on RFP theory and experimental data are going on.

Two-Dimension Investigation of HL-2A Tokmak Divertor Plasma

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Recently, attention has been drawn to the particle and energy transport of the divertor plasma and Scrape-off Layer plasma in TOKAMAK. The crucial tasks faced by the divertor can be divided into four main aspects:

1. Exhausting plasma power from main plasma;
2. Removing fuel and helium ash from system;
3. Eliminating and reducing impurity production;
4. Screening impurity.

In addition, all of these must be sufficiently performed while maintaining good core confinement a relatively high plasma density to enhance fusion reactivity.

This paper studies the transport of particle and energy of Scrape-Off layer and plasma. The two dimensional (2-D) model combines particle in code EDG2D which simulates Coulomb collision and charged/neutral interactions (charge exchange and electron impact ionization). HL-2A divertor is taken as an example of divertor configuration. The results are compared with other SOL transport models.