Orbit following calculation of energetic ions for design of ferritic insertion on JT-60U

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The toroidal field (TF) ripple induces loss of energetic ions due to local mirror trapping (ripple trapped loss) and/or due to luck of symmetry of banana orbit (banana diffusion). Such enhanced transport of the energetic ions reduces the efficiency of the heating and current drive. To avoid such enhanced transport due to the ripple induced loss, installation of ferritic steel was proposed. The first experiment was carried out on JFT-2M to investigate the reduction of energetic ion loss by using ferritic steel. And the reduction of NB ion loss and the compatibility of ferritic steel with high performance plasmas were demonstrated [1, 2].

Through the valuable experience and results on ferritic insert experiments on JFT-2M, ferritic insertion on JT-60U was decided. The TF ripple reduction by the ferritic insertion is expected to contribute to the steady-state high-beta plasmas research, because the reduction of energetic ion loss brings: 1) enhancement of the heating and current drive "effective" efficiency, 2) extended pulse length of RF injection due to the reduced heat flux on antennas and improved coupling between antennas and a plasma with a smaller gap, 3) availability of wall stabilization without losing heating power, and 4) possibility of enhanced availability of the rotation control to improve the MHD stability and transport.

The design work of the ferritic insertion was carried out in 2004, and its installation is in progress and will be finished by the middle of autumn in 2005. The design work was carried out aiming at effective, machine-safe, and short-term installation. In the design work, the enhanced confinement of energetic ions and absence of the large heat flux on the first wall has been assessed for the NB ions (two co- tangential, two counter-tangential, seven perpendicular positive ion-based neutral beams and one co-tangential negative ion-based neutral beam) by using the Fully three Dimensional magnetic field Orbit-Following Monte-Carlo code, which was developed under the ferritic insert program in JFT-2M. We investigated several configurations of ferritic insertion. In the final design, the loss power ratio to the injected NB power is reduced by larger than 10 % in a large volume plasma.

[1] K. Shinohara, et.al. , Nucl. Fusion **43**, 586 (2003)
[2] K. Tsuzuki, et.al., Nucl. Fusion **43**, 1288 (2003)