Recent progress in low-A RFP plasma research in RELAX

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The reversed field pinch (RFP) is a compact, high-beta magnetic confinement concept, characterized by self-organization of the magnetic configuration and dominated by magnetic fluctuations excited by resistive magnetohydrodynamics (MHD) instabilities. An equilibrium analyses have shown that mode rational surfaces are less densely spaced by lowering the aspect ratio ($A = R/a$) of the RFP configuration, where R (a) is the major (minor) radius of the plasma column, therefore simpler MHD mode dynamics is expected in low-A RFP. It is also expected that trapped particle fraction also increases in low-A. Moreover, in low-A equilibrium, self-induced bootstrap current tends to increase[1], which may cause a reduction of the external electric current source.

In order to study these attractive characteristics of low-A RFP configuration, experimental study has been carried out in REversed field pinch of Low Aspect eXperiment (RELAX)[2] device with R=0.51 m/a=0.25 m, $A = 2$. The device is operated with a 4 mm SS vacuum vessel (field penetration time $\tau_w < 3$ ms). Recent experimental results have shown that low-A RFP plasmas have been obtained with plasma current I_p of up to 100kA and loop voltage V_l of down to ~30V, and the pinch parameter Θ (=$B_p(a)/\langle B_t \rangle$) from ~2.0 to 3.5, with field reversal ratio F (=$B_t(a)/\langle B_t \rangle$) from slightly positive (~0.1) to deep reversal of ~-1.0. In low-A RELAX plasmas, the configuration tends to relax to a quasi-single helicity (QSH) state with low current. A high-speed camera diagnostic has revealed simple helix structure in the visible light image[3]. In the extreme case, rotating Helical Ohmic equilibrium state has been realized[4]. The pressure driven bootstrap current fraction is shown to be less than 5% of the total current in the present RELAX plasmas[5].

Recent progress of confinement includes a test of feedback control of field errors with saddle coils at an insulated poloidal gap. It has been demonstrated that our controllers have the capability of compensating for the vertical and horizontal field errors, resulting in increased plasma current with longer discharge duration up to ~2 ms. Details of the above-mentioned characteristic behaviors of low-A RFP plasmas will be discussed.

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