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Optimization of magnetic confinement for quasi-snowflake divertor configuration

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1. Introduction. Tokamak devices are created to produce the high performance and high magnetic confinement plasma current. One of the confinement efficiency parameters is poloidal beta β_p [1, 2], which depended on the distribution of the toroidal plasma current profile. Increasing the current density at the magnetic axis of the plasma is conducive to the improvement of β_p. However, it will cause the high decrease of the safety factor q at magnetic axis (q_0) that may result in the disruption of the plasma. Gourdain et al. [3] has proposed the method to achieve high β_p plasmas by means of horizontal shifting of the magnetic axis under an equilibria stability way. When a large Safranov shift is presented to realize high β_p, the plasma current profile is modified to ensure the stability of classical ideal magnetohydrodynamic criteria as well as resistive high-n ballooning modes.

Nevertheless, in quasi-snowflake (QSF) configuration [4], the second order null point is separated into two first order null points, first X-point (X_1) and second X-point (X_2). And the flux expansion of outside and inside strike points, $f_{\rm mout}$ and $f_{\rm min}$ (measure of the capability of reducing the heat load of the plasma on divertor plates) are influenced by the distance between these two points [4, 5]. In addition, because of the carrying capability of poloidal field (PF) coils, the PF currents are allowed to vary around −12 to 12 KA. And the currents of PF5/6, PF13/14 are increased into high level in QSF configuration [6]. Accordingly, the effect of PF currents is essential to be considered when the axis is shifted.

In this Paper, the analyzed method is developed on fixed-boundary solver [7], when the plasma current density at magnetic axis is fixed, with the radial shifting of the axis and the modification of plasma current profile, the varying curve of the coordinates of X_2 point, β_p,

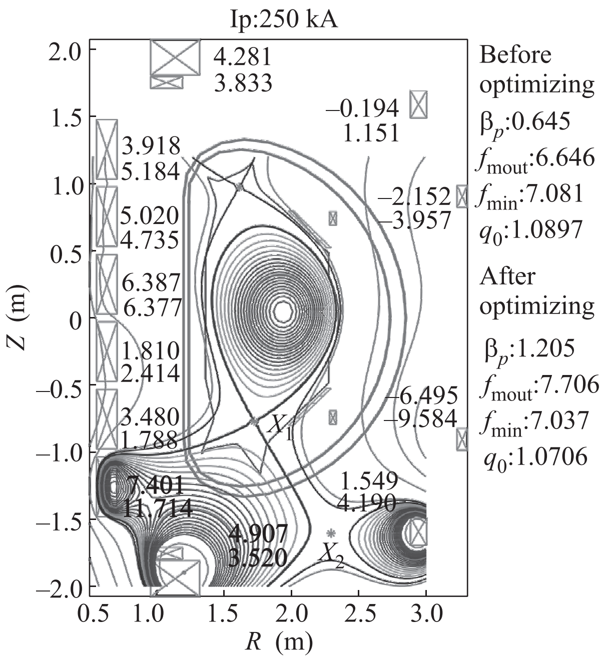

Fig. 1. (Color online) Optimized plasma configuration, and the computed results after optimizing are compared with the value of the parameters before optimizing

$f_{\rm mout}$ and $f_{\rm min}$, PF currents and q profile can be calculated. Finally, according to the analyzing results, an optimization scheme of the lower single-null QSF configuration has been presented.

2. Optimizing results. In this Paper, the lower single-null QSF configuration shoot 70386 at 3 s is set as the reference configuration. The vertical coordinate of the magnetic axis and the current density at the magnetic axis are fixed and the radial position (r_p) is altered from 1.9242 to 1.9412 m. The optimizing results are shown in Fig. 1.

As Figure 1 shows, after optimizing, β_p has an increase of 86.96 %. $f_{\rm mout}$ has an increase of 15.95 % and $f_{\rm min}$ has a decrease of 0.62 %. Besides, q_0 has a decrease of 1.75 % which is still above 1. All PF currents are

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below the current limits. In general, the magnetic confinement of the plasma is strengthened, and the heat load on divertor plates is reduced.

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