

Computing scheme of poloidal-coil current in task/equ

- Variables:

- Marker point position: $\mathbf{r}_j^s = (R_j^s, Z_j^s)$; $j = 1..J^s$
- Poloidal coil current (initial value): I_k^{v0} ; $k = 1..K^v$
- Poloidal magnetic flux generated by unit coil current: ψ_k^v ; $k = 1..K^v$
- Weight of marker points: w_j^s ; $j = 1..J^s$
- Weight of poloidal coil current: w_k^v ; $k = 1..K^v$
- Poloidal magnetic flux generated by the plasma current: ψ^p
- Poloidal magnetic flux prescribed at the marker points: w_j^s ; $j = 1..J^s$

- Condition to be satisfied:

- Poloidal current I_k^v ($k = 1, K^v$) is determined by minimizing the variation

$$\delta W(I_k^v) = \sum_{j=1}^{J^s} w_j^s \left(\psi^p(\mathbf{r}_j^s) + \sum_{k=0}^{K^v} I_k^v \psi_k^v(\mathbf{r}_j^s) - \psi_j^m \right)^2 + \sum_{k=1}^{K^v} w_k^v (I_k^v - I_k^{v0})^2$$

- Additional constraints:

- Usually the marker points are set on the plasma surface, and the poloidal magnetic flux at the marker points are given as $\psi_j^m = 0$. For this purpose, we set $\psi_0^v = 1$ and an unknown constant I_0^v is introduced for ψ to be 0 on the plasma surface.
- If we define the poloidal magnetic flux $\psi = 0$ at the torus center $R = 0$, I_0^v corresponds to the poloidal magnetic flux on the plasma surface.
- When a poloidal coil current is fixed to a constant externally, it is better to include the poloidal magnetic flux generated by this coil current into the poloidal magnetic flux generated by the plasma current, and exclude it from the variation target, rather than increasing the weight w_k^v of the poloidal magnetic flux.
- When the analysis is based on the magnetic measurement data, the marker points can be set at the measurement position, and the measured magnetic flux is set as the poloidal magnetic flux at the marker points. Then the analysis becomes a completely free-boundary problem.

- Additional comments for analyses coupled with transport

- When the plasma position is controlled, the marker points should be external input parameters.
- When necessary, such as the plasma current ramp-up phase, the poloidal coil current usually fixed may be pre-program controlled.
- In the present analysis, the toroidal magnetic flux on the plasma surface is assumed to be constant. Therefore the plasma surface may be expanded or compressed in time so that the surface current due to the toroidal magnetic field is canceled.