ABSTRACT

• Spherical Tokamak (PST), a medium size tokamak, is in the conceptual and physics design phase. Purpose of this device is to explore plasma parameters for Steady State Operation in the limit of aspect ratio (A=2).
• To meet the volt-sec requirement, current in CS is estimated. Whereas using TOSKSEN code, equilibrium is generated to estimate location, current and number of turns in compensation and poloidal field coils.
• Two different configurations of TF coils are used as case study. In this study the ripple factor is calculated using FEM method for both TF assemblies by varying location of outer limbs of TF from 80 cm, 85 cm, 90 cm, 95 cm and 114.5 cm.

BACKGROUND

• Spherical Tokamak research gained attention due to natural elongation, high β (<1/A) and being economical.
• Pakistan Spherical Tokamak (PST) some of its basic parameters are; major radius R = 0.5 cm, minor radius r = 0.25 cm, Aspect ratio A = 2.0, Elongation ε = 2.0, Toroidal Magnetic Field Bt = 0.5T.
• There are mainly three coils systems in PST; central solenoid (CS) along with compensation coils (CC) used to produce toroidal E-field, poloidal field (PF) coils to keep the plasma in equilibrium and away from the tokamak walls, and toroidal field (TF) coils to stabilize the plasma.
• Toroidal magnetic field has importance due to the fact that volumetric fusion power density varies with ^2.
• Present study focuses on the design of magnetic coils system of PST considering magnetic equilibration in tokamak.

CS and PF COILS SYSTEM

MHD safety factor, qa = 2.5 is considered which is well above the disruptive Kink safety limit. With this safety factor and toroidal field, the plasma current is estimated as 310 kA. Similarly plasma beta (β) is estimated as 9% with incorporating effect of elongation (ε). Equilibrium is generated using TOSKSEN code. Double null equilibrium configuration with up down symmetry has been generated considering elongation 2. In this equilibrium configuration CS and CC are connected in series so that the current with similar profile will flow from these coils which will help in reducing error field. Additionally this configuration will help in reducing the nos. of power supplies. The simulation is performed with top bottom divertor, inner and out limiter and vacuum vessel.

TF RIPPLE FACTOR

TF coils study mainly focuses on the ripple factor in spherical tokamak. The relation for the ripple factor is .

\[ \delta = \frac{B_{\text{max}} - B_{\text{min}}}{B_{\text{max}} + B_{\text{min}}} \]

\( B_{\text{max}} \) is the field at the mid position of coil width, and \( B_{\text{min}} \) is the field between two adjacent coils. The ripple factor is calculated using FEM method for both TF assemblies by varying location of outer limbs of TF from 80 cm, 85 cm, 90 cm, 95 cm and 114.5 cm.

Conclusions

• The toroidal field coils have been designed for 0.5 T, the ripple factor for both 16 coils (16x11) and 12 coils (12x2) is within the allowed limit.
• Ripple factor for both coils systems decreases significantly with increase in the radius of outer limb.
• The current 52 kA/torrn required for 12 coils (12x2) is smaller than the current 78 kA/torrn for 16 coils (16x1). Therefore the 12 coils (12x2) save more energy for the same magnetic field.
• Furthermore under same condition the current profile has more flat top region for 12 coils (12x2) system.
• Hence the 12 coils (12x2) system is relatively more suitable for PST.