Theoretical and experimental studies of confinement in high field Spherical Tokamak.

M Gryaznevich for TE Ltd team.

Tokamak Energy Culham Science Centre Abingdon OX143DB UK

High field spherical tokamak ST40 (R=0.4-0.6m, R/a=1.6-1.8, I_{pl}=2MA, B_t=3T, k=2.5, τ_{pulse}~1-10sec, 2MW NBI, DD and DT operations) is now operating and experiments and simulations are carried out to study transport properties in ST at high TF, low collisionality and plasma parameters close to burning.

Transport simulations with the ASTRA, NUBEAM and NCLASS codes have been performed to model ST40 expected parameters and to support the physics basis of the compact high field ST path to Fusion. We show that high confinement regimes with the collisional (neoclassical) transport can be expected even with the ohmic heating. In an auxiliary heating regime, as low as 1 MW of the absorbed heating power may result in a hot ion mode with the 10 keV range of temperatures. Issues connected with specific features of the high field ST are discussed, i.e. limitations of applicability of confinement scalings for prediction of performance of ST40. These limitations are general but are strongly exposed in high field STs. However, we show that if performance achieved on other spherical tokamaks can be extended to ST40 conditions, up to 1 MW of Fusion power can be expected in DT operations.

Studies of transport of fast ions and alpha particles, heating, current drive, torque deposition and momentum transport have been performed using ASCOT, NUBEAM, Monte Carlo code NFREYA and Fokker - Planck code NFIFPC. Different NBI energies and launch geometries have been studied and optimized. The NBI deposition profiles of the current, torque and power show the expected energy and launch geometry dependences. Both, the full gyro and the guiding center description allow to estimate the first orbit losses of the α - particles, the generation of which depends on the profiles of the plasma parameters. The confinement of thermal alphas in ST40 3T/2MA scenario is studied with full orbit following due to the large alpha particle gyro radius. The first orbit losses are seen to be almost 60% even in the high-performance scenario illustrating that the alpha confinement in a small device is very difficult even at the highest available fields. However, experiments on ST40 will provide useful information for verification of such simulations.

ST40 uses merging-compression plasma formation method. Simulations of this start-up scenario have been performed using TSC and results will be compared with experimental observations.