Progress Towards Compact Fusion Reactor

M Gryaznevich
Tokamak Energy Ltd, Culham Science Centre, Abingdon, OX14 3DB, UK
Mikhail.gryaznevich@tokamakenergy.co.uk

Two main issues of a Compact Fusion Reactor on a Tokamak Energy Ltd path to advancing development of the Fusion Power are addressed in this talk: optimisation of the current drive (CD) for steady-state operations and development of advanced superconducting magnets using High Temperature Superconductors (HTS) of the 2nd generation.

Advances in the development of high temperature superconductors (HTS) [1], recent demonstration of a 24h discharge in ST25-HTS tokamak with all-HTS YBCO magnets [2], and encouraging results on a strong favourable dependence of electron transport on higher toroidal field (TF) in Spherical Tokamaks (ST) [3] open new prospects for a high field ST as a very compact fusion reactor. The combination of the high β (ratio of the plasma pressure to magnetic pressure), which has been achieved in STs [4], and the high TF that can be produced by HTS TF magnets, opens a path to lower-volume fusion reactors, in accordance with the fusion power scaling proportional to $\beta^2 B_t^4 V$. A compact ST is also a promising candidate for an intense and efficient neutron source [5].

Feasibility of a low-power compact ST reactor and physics and engineering challenges of the ST path to Fusion Power will be discussed. Results from steady-state (continues) tokamak operations on ST25-HTS tokamak and of design studies for a compact ST with TF up to 3T (ST40, under construction) will be also discussed in detail. Update on the construction status of ST40 will be given.

New approach to optimization of the current drive in a Compact ST Reactor is based on a possibility to produce significant toroidal rotation in an ST using optimized neutral beam injection. Comparison of optimization of the NBI for direct CD and for the torque, using several full-orbit codes NUBEAM, NFREYA, FIFPC and ASCOT will be presented to show that these conditions are quite different in the optimized beam energy and the launch geometry. Optimization also includes the aim to reduce fast ion losses in a compact ST.

The demonstration of reliable steady state operations in a compact high field ST even at the level of a few MW Fusion output as a first step will significantly advance not only the mainstream Fusion for the Energy research, but also the commercial exploitation of Fusion and will the an important step on development of the Fusion Energy.

[1] GRYAZNEVICH, M., et al, "Progress in applications of HTS in Tokamak Magnets" (2013) *Fus Eng & Des* **88** 1593–1596. [2] GRYAZNEVICH, M., et al, 24th IAEA FEC St Petersburg 13-18 October 2014 OV/P-04. [3]. VALOVIC, M., et al, (2009) *Nucl Fus* **49** 075016. [4] GRYAZNEVICH, M., et al, "Achievement of Record beta in START Spherical Tokamak"(1998) *Phys Rev Lett* **50** 3972. [5] GRYAZNEVICH, M., et al, "Options for a Steady-State Compact Fusion Neutron Source" (2012) *Fus Science & Tech* **61** 1T 89.