The spherical tokamak path to fusion power, revisited

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Compact spherical tokamaks (ST) with major radius $R \sim 0.5$ m have been proposed by Stambaugh et al, 1996, as a pilot plant for an ST power reactor; and by Hender et al, 1998, as a powerful neutron source in this case with $Q_{\text{fus}} (P_{\text{fus}}/P_{\text{input}})$ approaching one. With new advances in ST physics and technologies, we revisit these proposals on the ST path to fusion power. Recent results from ST confinement studies suggest a very favourable dependence on toroidal field (TF), which may increase $Q_{\text{fus}}$ in Hender’s design up to $Q_{\text{fus}} \sim 3 – 4$. Progress with the development of high-temperature superconductors (HTS) may allow an increase in TF above the 2.5 T proposed by Hender, resulting in even higher performance. This also makes Stambaugh’s pilot plant design more realisable due to a significant reduction in the resistive dissipation in the magnets and also may leave more space in the central stack for neutron shielding, although the diameter of the central post in a reactor will need to be significantly increased to accommodate the necessary shielding of the HTS and other components of the magnet.

We report on our results of the first application of High Temperature Superconducting (HTS) materials in compact tokamak magnets, progress in construction of the first full-HTS tokamak ST25-HTS, recent advances in the development of the physics basis for an ST pilot plant and initial results of our conceptual studies of a compact high field ST pilot plant. We will show that the development of fusion technologies, advances in fusion engineering and innovations in design and processing methods for fusion reactor materials can make full use of the favourable physics of the spherical tokamak to offer the chance of an early exploration of a high Q fusion plasma.

We will also report on the results of the conceptual studies and progress with the engineering design of a compact fusion neutron source based on a high field ST and outline plans for its construction.

T C Hender, G M Voss, N P Taylor, FED 45 (1999) 265
R Stambaugh et al, Fusion Technology, 33, (1998) 1