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Status and Plan of Versatile Experiment Spherical Torus (VEST) toward Advanced Tokamak Study

Yong-Su Na[1], T. S. Hahm[1], Y. S. Hwang[1], and VEST team[1]
[1] Department of Nuclear Engineering, Seoul National University (SNU), Korea

VEST (Versatile Experiment Spherical Torus) [1, 2] has been operating as a low cost, educational device for basic researches for the realization of fusion energy (see figure 1 and table 1). Ohmic operation of VEST has been successfully carried out, generating plasma currents of up to 100 kA with pulse duration of ~15 ms at the toroidal magnetic field of 0.1 T on-axis. The elongation and edge safety factor of the low aspect ratio plasmas (R = 0.4 m and a = 0.3 m) are estimated to be 1.6 and 3.7, respectively from equilibrium reconstruction based on the magnetic diagnostics. Efficient Electron Cyclotron heating (ECH) assisted plasma start-up scheme utilizing the trapped particle configuration (TPC) [3], a mirror like magnetic field configuration, has been developed as a new approach to improve the conventional start-up scenario using the field null configuration. TPC significantly enhances the pre-ionization with the enhanced particle confinement due to its mirror effect. Furthermore, the stable decay index inherent in this configuration enables the prompt plasma current initiation by efficient force balance. Consequently, TPC demonstrates robust tokamak start-up with lower loop voltage with lower volt-second consumption as well as wider operation ranges in terms of the ECH pre-ionization power and the hydrogen filling pressure. Direct mode conversion of X-mode to EBW (Electron Bernstein Wave) from the low field side is successfully utilized to enhance the ECH pre-ionization by generating over-dense plasmas beyond the L-cutoff density, which will be utilized for the solenoid-free start-up initiated from the outboard limiter. To study advanced tokamak regime with a high beta and high bootstrap current fraction, high power neutral beam heating of up to 600 kW has been newly installed along with various profile diagnostics such as multi-channel interferometer, Thomson scattering, and charge exchange spectroscopy. EBW and low hybrid fast wave heating and current drive will be tested for current density profile control. In the meantime, ohmic plasmas will be improved to provide proper target plasmas for high power neutral beam injection by increasing plasma density with higher plasma current at longer pulse length with higher magnetic field. Status and plans of VEST toward this advanced tokamak study will be presented.

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References

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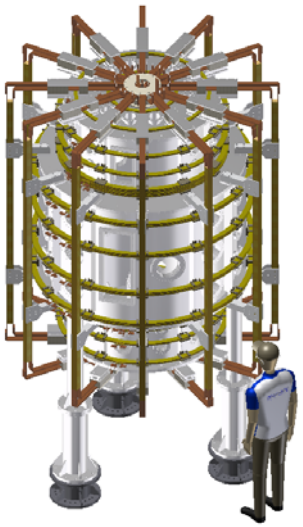

Figure 1. Schematic view of VEST

Chamber Radius [m]	0.8: Main Chamber 0.6: Upper & Lower Chambers
Chamber Height [m]	2.4
Toroidal B Field [T]	0.3
Major Radius [m]	0.4
Minor Radius [m]	0.3
Aspect Ratio	>1.3
Plasma Current [kA]	100
Elongation	3.3
Safety factor, q_a	6.7

Table 1. Main parameters of VEST