Solenoid-free Startup Experiments in DIII-D

J.A. Leuer[1], G. Cunningham[2], D. Mueller[3], N.H. Brooks[1], N.W. Eidietis[1], D.A. Humphreys[1], A.W. Hyatt[1], G.L. Jackson[1], J. Lohr[1], P.A. Politzer[1], R.I. Pinsker[1], R. Prater[1], P.L. Taylor[1], M.L. Walker[1], R.V. Budny[3], D.A. Gates[3], A. Nagy[3], S-H. Hahn[4], Y-K. Oh[4], S-W. Yoon[4], J.H. Yu[5], M. Murakami[6], J.M. Park[6], and A.C. Sontag[6]

[1]*General Atomics, P.O. Box 85608, San Diego, California 92186-5608, USA*
[2]*Euratom/UKAEA Fusion Association, Culham Science Centre, Abingdon, UK*
[3]*Princeton Plasma Physics Laboratory, Princeton, New Jersey, USA*
[4]*National Fusion Research Institute, Daejeon, Korea*
[5]*University of California-San Diego, La Jolla, California, USA*
[6]*Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA*

Abstract. A series of DIII-D experiments was performed to investigate the potential for initiating plasma current using only poloidal field coils located outside the DIII-D central solenoid, i.e. "solenoid-free". Plasma current to 166 kA was achieved using 2–3 MW of electron cyclotron (EC), heating and was limited by coil and power supply constraints. Flux conversion to plasma current was similar to standard DIII-D startup with some degradation at higher plasma current associated with stray fields and vertical stability issues. In preliminary solenoid-free experiments, neutral beam (NB) current drive (CD) levels were small and attributed to reduced CD efficiency associated with low electron temperature produced by the low current, low confinement plasma. Lack of plasma radial position control also contributed to a reduction of NBCD. Similarly, ECCD was small owing to low plasma temperature and outside EC launch which is required in the solenoid-free scenario. Synergistic experiments were carried out using standard solenoid initiated plasmas in order to study noninductive current drive in limited, L-mode plasmas, typical of that generated by solenoid-free startup. While substantial noninductive current can be driven, self-sustaining levels of noninductive current have not yet been achieved with our present six-source co-injection NB system combined with EC and fast wave systems. At low plasma current and high levels of localized EC heating, substantial MHD is generated and this was seen to severely limit plasma performance. Although further optimization is possible in the limited plasma regime, full noninductive, steady-state operation may require diverted plasma with H-mode quality confinement. Discharges obtained during the solenoid-free campaign are compared with results of previous DIII-D campaigns aimed at achieving a steady state, noninductive current drive solution.

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