ACTIVE TOROIDAL FIELD RIPPLE REDUCTION SYSTEM IN FAST

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FAST (Fusion Advanced Studies Torus) has been proposed [1, 2] as a flexible and cost effective machine able to support the development of ITER and DEMO operating scenarios exploiting some innovative technology solutions and to investigate the physics of burning plasma conditions in a dimensionless parameter range close to ITER. The proposed design [3] is based on a compact, high toroidal field tokamak, able to operate in a variety of scenarios ranging from the high performance H-Mode (B_T up to 8.5 T, I_P up to 8 MA) to the Advance Tokamak operation (I_P up to 3 MA, B_T from 6 to 8T, not inductive current ratio up to 100%). The toroidal field in FAST is produced by 18 Toroidal Field copper coils, cooled by 30 K Helium gas. This configuration has been chosen to make available enough space to accommodate a NNBI heating system and a quantity of diagnostic measurements, but certainly it produces, together with the compactness of the machine, an increase of the Toroidal Field Ripple and then requires the adoption of a proper system to reduce it.

In fact the amplitude of the Toroidal Field Ripple is a major concern in the design of a high performance tokamak, due to the role it plays both on the plasma operations and on the confinement of high energy particles whose study is one of the main features of FAST.

Two different approaches to reduce the Toroidal Field Ripple in FAST have been evaluated [4]: a classical, ITER-like, system based on the use of ferromagnetic inserts between plasma and the Toroidal Field Coils and an active, adjustable system that exploits the effect of current flowing in proper designed coils, placed between plasma and the Toroidal Field Coils and fed in the opposite direction. This system could allow an extreme flexibility in adjusting the Toroidal Field Ripple to the chosen value, both in high and low toroidal field operations. Moreover, otherwise than with ferromagnetic inserts, this system could permit the fine tuning of the ripple correction taking into account possible asymmetries between toroidal sectors, as those due to the ferromagnetic material content in the NNBI shielding box.

This Active Ripple Reduction System has been in-depth analyzed, by using proper 2D and 3D Finite Elements Models, and the position and size of the coils have been optimized. The maximum ripple on the plasma separatrix has been reduced to a level acceptable for the operations both at lower and higher toroidal field, feeding the coils with currents sustainable during the whole scenario (about 1/10 of the current flowing in Toroidal Field Coils). A possible choice for the geometry of the electrical and cooling connection of these Active Coils to the supply has been also investigated, evaluating the suitability of the solution regard to thermal effects, EM loads induced and stray fields produced on the plasma and on the magnetic measurement probes.

[1] A. Pizzuto et al., Proceedings 22nd IAEA Fusion Energy Conference, 2008, FT/1-5
[2] F. Crisanti et al., this conference, 2010
[3] A. Cucchiaro et al., this conference, 2010
[4] G. Calabrò et al., Fusion Engineering and Design, **84**, 2009, 522-525