OPTIMIZATION OF PASSIVE AND ACTIVE MAGNETIC FIELD REDUCTION SYSTEMS FOR ITER DIAGNOSTIC AND HEATING NBI

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Abstract:
In ITER up to 3 Heating Neutral Beam's (HNB) and one Diagnostic Neutral Beam (DNB) of 1 MeV and 100 keV respectively are foreseen. In all cases the neutral beam is produced by the neutralisation of an accelerated negative ion beam, D^- (HNB) or H^- (DNB). At the positions of the HNBs and the DNB the stray field from ITER ranges in magnitude from ≈350 G to 150 G under "standard" conditions. In order to avoid an unacceptable deflection of the charged particles before neutralisation, this field has to be reduced substantially in the space occupied by the beam between the exit of the accelerator and the exit of the neutraliser, to mean values of ≈1 G for the HNB and ≈0.25 G for the DNB. This reduction has to be achieved by the Magnetic Field Reduction System (MFRS), which consists of a Passive Magnetic Shields (PMSs) made of 150 mm of iron enveloping each injector, and 3 pairs of coils, the Active, Correction, Compensation Coils (ACCCs), located above and below the PMS. Due to the very large stray field present in the working area of these components an accurate design of the PMSs together with a very good optimization of the currents in the ACCCs is needed to reduce the residual field to meet the requirements.
For the work to be reported, which was performed in the frame of the ITER Contract ITER/CT/08/382, a very accurate numerical finite element model of the PMS and the ACCCs has been developed using the ANSYS code, for both the DNB and the HNBs. The effect of changing the PMS configuration and materials have been evaluated and the optimisation of the currents in the ACCCs has been carried out. To perform the analysis an automatic optimization procedure has been developed that, starting from an estimated current distribution in the coils, through successive iterations, reaches a stable minimum of the average field in the critical region achieving the requirements for both the DNB and HNB. The results of simulations and optimisation of several, practical, configurations of the PMS for the DNB will be given, and it will be shown that a somewhat sophisticated shield configuration with three nested layers of iron separated by two air gaps gives the best result.
Due to the unpredictable nature of discontinuities in the PMSs (gaps between iron plates increasing the residual field in the critical region by more than a factor ten), and to the precision of the numerical models, a numerical optimization based on pure mathematical parameters cannot be entirely relied upon. Indeed the experimental optimisation is considered necessary, which must be based on experimental verification of the required parameters. In practise only a finite number of field measurements placed at the beam region boundary will be possible. Therefore simulations have been carried out to confirm that the limited set of data from those sensors will be sufficient to verify the required performance of the magnetic field reduction system. It is found that the measurements, if placed at the appropriate position along the beam path can allow a precise evaluation of rectilinear integral of B along the path.

Keywords: ITER, NBI, diagnostics, electromagnetic analysis