Disruptions in ITER

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Electro-magnetic force on the in-vessel components and vacuum vessel due to the induced eddy current and halo current during plasma disruptions and vertical displacement events (VDE) imposes various constraints on the design of ITER. Careful design consideration has been given to perform a robust design against electro-magnetic force in ITER.

In this paper, we present several representative cases of disruptions and VDEs calculated by the DINA code, which solves plasma transport and 2D free boundary plasma equilibrium simultaneously with circuit equations for the vacuum vessel and PF coils [1]. The cases include (i) Major disruption (thermal quench at the nominal location), (ii) and (iii) Upward and downward VDE with fast current quench. An Example of plasma evolution for the Major disruption case is shown in the figure.

In the calculations of these representative cases with the DINA code, plasma characteristics such as time-averaged current quench rate under various discharge conditions, detailed wave form of the current, edge safety factor $q$ at the onset of thermal quench during a VDE, change of parameters after the thermal quench and others, must be properly based on the existing experimental data. We examine these plasma characteristics in detail in JT-60U and other divertor tokamak experiments. Their interpretations and their extrapolations to ITER are incorporated into the DINA code.

We also present the consequent electro-magnetic forces and proper adjustments of the design to withstand these forces at disruptions for these representative cases. Vertical location of the plasma center in the ITER design is also discussed in conjunction with the neutral point, which has been proposed to mitigate the vertical movement after the thermal quench[2].