DYNAMIC RESPONSE OF THE ITER TOKAMAK DURING ASYMMETRIC VDES

T. Schioler[1], C. Bachmann[1], G. Mazzone[1], G. Sannazzaro[1]

[1] *ITER Organization, CS 90 046, 13067, St. Paul lez Durance Cedex, France*

Corresponding author: tyge.schioler@iter.org

During the operational life of ITER, it is expected that a number of Vertical Displacement Events (VDEs) will occur. A sub-class of these events, 'slow' asymmetric VDEs, is of particular interest from a structural point of view. This is because the forces generated during such events are both substantial and sufficiently long-lasting to significantly excite the structure. It is necessary to establish that the absolute and relative displacements of components, as well as internal and external forces stay within acceptable limits during these events.

Given the time-scale of the applied loads, it is necessary to take dynamic effects into account in order for these values to be calculated accurately. In addition, the complexity of the machine means that Finite Element Analysis (FEA) is the only practical solution method. Previous studies have investigated this problem using relatively simple models and non-rotating loads. Changes in the design of the tokamak and the specification of the loads required the analyses to be repeated, and the opportunity was taken to create a new model which included a greater level of detail.

Increasing the detail results in greater accuracy. It also allows a greater number of results to be extracted, including, for example, the displacement of the ducts relative to the adjacent Toroidal Field Coils (TFCs). Another major improvement in the new model is the inclusion of the electromagnetic interaction between the Vacuum Vessel (VV) and the TFCs.

The loads defined in the asymmetric VDE load specification are rather complex, as they have to represent all possible evolutions of the plasma parameters and plasma behaviours. Careful selection of load options is necessary in order to be confident that all significant load cases are investigated and that the worst loads for each component have been considered. In order to keep the total time of the investigation to a reasonable value, a two-tier approach was adopted. Firstly, a large number of linear analyses were performed using the mode-superposition method. This simplified method allows a good selection of load parameters to be investigated, but at the expense of solution accuracy.

In addition, a number of fully transient analyses were performed. These analyses accurately take various non-linear effects into account, such as non-linear springs and gaps in supports. Whilst they are inherently more accurate than mode superposition analyses, they are also, computationally, much more intensive. The purpose of these analyses is to validate the mode superposition analyses, as well as to obtain the most accurate results possible for the worst-case scenarios identified using the mode-superposition method.

A number of results are presented in this paper. These include reaction force envelopes for internal and external supports, and critical displacements of major components. Whilst different disruptions were found to be critical for different components, a non-rotating VDE3 up with a TPF of 2.78 was found to cause the most severe relative radial displacements between the VV and the TFC. During such a VDE, the distance between the VV and the TFC at the inboard wall can decrease by as much as 13mm at the equatorial plane.