First Wall Design for the Ignitor Machine

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Introduction

Ignitor is a compact, high magnetic field tokamak (13T) aimed at reaching ignition conditions in a DST plasma [1]. The first wall (FW) of the Ignitor machine (plasma currents of 11 MA) covers the entire surface of the Plasma Chamber (PC) with the exception of the port regions. Ignitor has been conceived as a “limiter” machine where the FW acts as “hopper limiter” or “whole limiter” [2]. Under ignition conditions, a maximum thermal load of 1.8 MW/m² is found when plasma movements of 1.1 cm around the equilibriums configurations are considered (the expected average heat flux is 0.7 MW/m²). The Poloidal Field System of Ignitor can produce X-point configurations in addition to the optimized limiter ones to allow an easier access to H-mode regimes. The double-null just inside the first wall results in a reduced plasma currents of 9 MA.

The accuracy of the position of the tiles is prescribed to be better than 2 mm all around the torus. The attachment system of the FW at the PC has been designed to avoid unerooting or losing the preload due to vibration and temperature gradient and to comply with the requirements of remote maintenance.

Electromagnetic loads on FW

The simulation of the worst disruption event in IGNITOR has been performed using the MAXFIA code. The assumed reference plasma disruption was a Vertical Displacement Event (VDE) of the plasma column with a slowly decreasing current, followed by the appearance of halo currents when the safety factor q_sh decreases below 2. The thermal quench and then the first plasma current quench phase are assumed to occur when q_sh falls below 1.5.

The 2D analysis of the excitation loads during the downward Vertical Displacement Event (VDE) showed that the most loaded region is the inboard lower quarter of the poloidal section. A detailed 3D finite elements model of this region has been developed in order to evaluate the electromagnetic loads during the reference VDE. An EM zooming procedure allowed the replacement of the out-of-model plasma, poloidal coils and passive structures with current filaments around the modelled region, reproducing the same field configuration. The obtained model extends along the toroidal direction for half a tile carrier (5 degrees) and includes one and half tile sides for each row.

The study performed with ANSYS Code in non-linear analysis has been developed in order to evaluate the electromagnetic loads during the reference VDE. The study performed with ANSYS Code in non-linear analysis. The results show a temperature increase up to 341 °C (peak value 1.8 MW/m²) for a single run of 4 sec. The stresses and deformations on the component which is undergone to a cycle are in the limit of the allowable values. The lay out of the first wall has been finalized taken into account all requirements of the IGNITOR Machine.

Magnetic Diagnostic

Electromagnetic diagnostics are adopted to measure plasma parameters such as current, loop, voltage, horizontal and vertical plasma, plasma beta, toroidal and poloidal modes. The limited space available between tiles and vessels in Ignitor leads to geometrically tight magnetic probes (Fig. 3), and the very intense neutron flux expected in Ignitor demand the use of fully non-magnetic insulating materials. The magnetic coils system must be closely integrated with the plasma chamber before the welding of the individual sectors. An adequate level of redundancy is being considered.

The electrical diagnostic placed inside the plasma chamber have been included in the tile carrier design. The first wall has been tailored related to ICRH Faraday Shield (Fig. 6) and to clear the view through vertical port openings.

The tiles surrounding the horizontal port do not obscure the line of sight to view the plasma. The first wall of the poloidal area surrounding the sector joining welding, which has to be installed after the torus completion, has been envisaged.

First Wall Design

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