Structural Analysis of the Advanced Divertor EXperiment's Proposed Vacuum Vessel

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Abstract

COMSOL Multiphysics® software has been used to study the loading on the vacuum vessel in the design for the Advanced Divertor eXperiment (ADX) (Fig. 1). ADX is a compact high field, high power density tokamak (a device used to study magnetic confinement of plasma for nuclear fusion) proposed by PSFC and collaborators to test divertor configurations with power densities at next step fusion devices. The ADX will also test innovative concepts for RF heating of the plasma, including deploying RF launch structures on the high-field side for the first time.
The ADX vacuum vessel (VV) must be designed to incorporate these new technologies while still accommodating the magnetic field coils and the ability to change the coil set if needed to produce a new divertor shape.
To this end, a new feature of the ADX design is that instead of the vacuum vessel being welded into a solid cylinder, it will be built of 5 separate shells and an inner cylinder bolted together (Fig. 2). This unique design allows the flexibility to change the coil sets if needed, but there are other benefits as well. Instead of being restricted to limited access ports for initial installation, the ADX configuration allows for parts of the vessel to be demounted, creating much easier access for installation of new equipment.
A major structural concern in a tokamak is the loads resulting from a disruption. A disruption is when the plasma rapidly loses its current, in ADX up to 1.5MA, which causes changing magnetic fields, eddy currents and large Lorenz forces in the surrounding conductive structures. A model of the vessel, coils and plasma is built in COMSOL, and using the 'mf' physics interface, the plasma current and coil currents are input as a function of time to predict the fields, eddy currents and loads acting on the vessel during a disruption where the plasma moves up towards the top of the vessel before losing its current. These loads are then used in the 'solid' physics interface to predict the stresses seen by the vessel. The results show this new design can withstand a disruption with ADX plasma parameters.

Reference

[1] B. LaBombard, et. al, “ADX: a high field, high power density advanced divertor and RF tokamak,” Nuclear Fusion. Vol. 55, pp1-25, May 2015.

[2] Vieira, R.F., et.al, “Novel Vacuum Vessel & Coil System Design for the Advanced Divertor Experiment (ADX)” 26th Symposium on Fusion Engineering --SOFE 2015, Austin, Texas, USA, May 31-June 4, 2015, unpublished.

[3] J. Doody, et al, “Structural analysis of high-field-side RF antennas during a disruption on the Advanced Divertor Experiment (ADX)” 26th Symposium on Fusion Engineering --SOFE 2015, Austin, Texas, USA, May 31-June 4, 2015, unpublished.

Figures used in the abstract

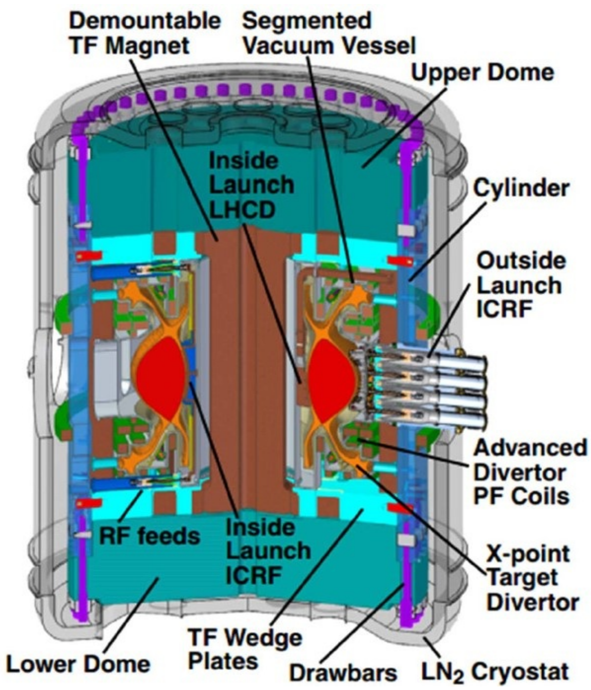

Figure 1: Cutaway of ADX with plasma, ICRF antennas, vessel, coils and support structure shown

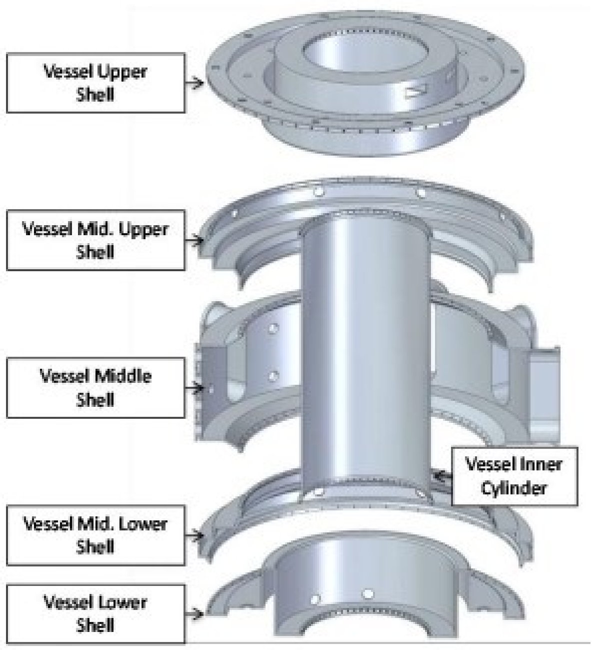

Figure 2: Breakout diagram of ADX vessel showing the six components that are bolted together to form the vessel

Figure 3

Figure 4