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CATIA-V 3D Modeling for Design Integration of the Ignitor Machine Load Assembly* A. BIANCHI, B. PARODI, F. GARDELLA, ANSALDO Ricerche, Italy, B. COPPI, M.I.T. — In the framework of the ANSALDO industrial contribution to the Ignitor engineering design, the detailed design of all components of the machine core (Load Assembly) has been completed. The machine Central Post, Central Solenoid, and Poloidal Field Coil systems, the Plasma Chamber and First Wall system, the surrounding mechanical structures, the Vacuum Cryostat and the polyethylene boron sheets attached to it for neutron shielding, have all been analyzed to confirm that they can withstand both normal and off-normal operating loads, as well as the Plasma Chamber and First Wall baking operations, with proper safety margins, for the maximum plasma parameters scenario at 13 T/11 MA, for the reduced scenarios at 9 T/7 MA (limiter) and at 9 T/6 MA (double nul). Both 3D and 2D drawings of each individual component have been produced using the Dassault Systems CATIA-V software. After they have been all integrated into a single 3D CATIA model of the Load Assembly, the electro-fluidic and fluidic lines which supply electrical currents and helium cooling gas to the coils have been added and mechanically incorporated with the components listed above. A global seismic analysis of the Load Assmbly with SSE/OBE response spectra has also been performed to verify that it is able to withstand such external events.
*Work supported in part by ENEA of italy and by the US D.O.E.

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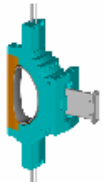

IGNITOR Machine Load Assembly: CATIA V 3D Modeling for Machine Mechanical Integration

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Abstract

- In the frame of the ANSALDO industrial contribution to the IGNITOR Fusion machine Detailed Engineering, extensive design has been carried out on all the main components of the machine core, the Load Assembly.
- The machine Central Post, the Central Solenoid, the Shape and Equilibrium coils, the Vacuum Vessel and supported First wall, the surrounding mechanical structures, the Vacuum Cryostat and supported Polyethylene Boron composite sheets for neutron shielding have been checked to confirm they can withstand with a proper margin both the normal and off-normal operating loads coming from the maximum current scenario 11MA/13T, the reduced scenarii at 6MA/9T and 7MA/9T, the Vacuum Vessel and First Wall baking operations.
- A global seismic analysis of the Load Assembly with SSE/OBE response spectra has also been performed in order to verify that the machine is able to withstand such external event.
- In parallel to this design activity, 3D/2D drawings of all the previous single components have been produced with the use of the Dassault Systems CATIA V software; finally, once their design has been assessed and accepted from ENEA, the customer, they have been all assembled in a unique 3D CATIA model of the Load Assembly, at this stage also the electro-fluidic and fluidic lines which supply electric current and gaseous helium to the coils have been added and mechanically integrated with the previous components.

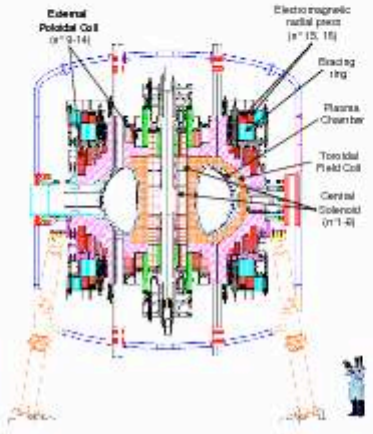


Figure 1. Vertical Section of the IGNITOR load assembly

Introduction

The complexity and extreme compactness of the Ignitor machine Load Assembly (Fig. 1) has required a 3D modeling of all the components which mechanically interact each other. In parallel to the design activity, 3D/2D drawings of all the single components have been produced with the use of the Dassault Systems CATIA V software; finally, once their design has been assessed they have been all assembled in a unique 3D CATIA model of the Load Assembly, at this stage also the electro-fluidic and fluidic lines which supply electric current and gaseous helium to the coils have been added and mechanically integrated with the previous components.

This 3D model has the following main functions:

1. verify the assembly sequencies of the components;
2. point out mechanical clearances/inconsistencies at the interfaces between them;
3. identify the better layout of the electric and fluidic lines and their supports on the Load Assembly;
4. identify the layout of the machine electro-magnetic diagnostics;
5. verification of the design of the In vessel Remote Handling System through the simulation with the use of virtual reality techniques of the remote maintenance of First wall tile carriers, ICRH and Faraday Shields components, machine diagnostics.

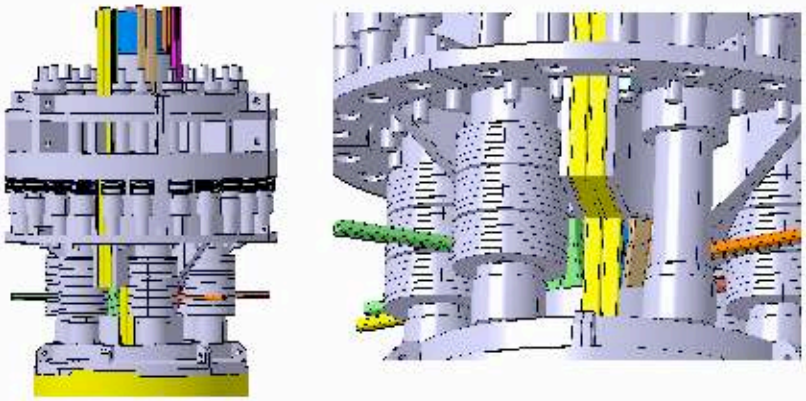
Central Solenoid Coils Sub-Assembly

The CS coils are assembled around the central steel post of the machine (Fig.2). The adopted mechanical design allows for:

- an easy assembling and disassembling of the central solenoid and their related components;
- a proper arrangement of the electrical and hydraulic lines ensuring suitable constraints.

The CS coils (upper and lower) are maintained under compression by means of two heads equipped with two spring washer systems: the first system to preload all the coils and the second to set the position of the central solenoid with respect to the magnetic system and keep it relatively fixed.

The 3D model has allowed a detailed study of the assembly of the CS 14 coils on the Central Post and on the axial spacer discs, the check of the proper clearances between the axial electrical and hydraulic lines on the grooves machined on the Post and the study of their crossing through the upper and lower heads.



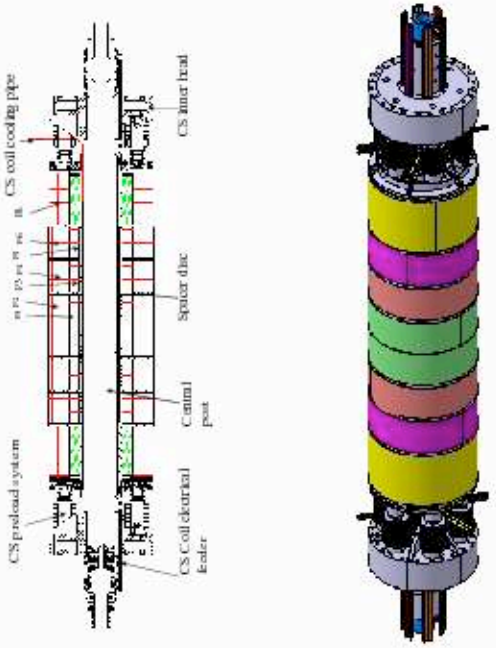


Figure 2. Central solenoid Assembly with details of upper head and electric busbars

Machine Unit Module Sub-Assembly

The second step on the set-up of the global 3D model has been the 3D drawing of the machine 30° toroidal extension unit module (Fig.3); it includes 4 C-Clamps (7.5° extension), two toroidal field coils, a vacuum chamber sector with supported First Wall and the radial and vertical supports. During the installation on site the machine is assembled by 12 unit modules (Fig.3).

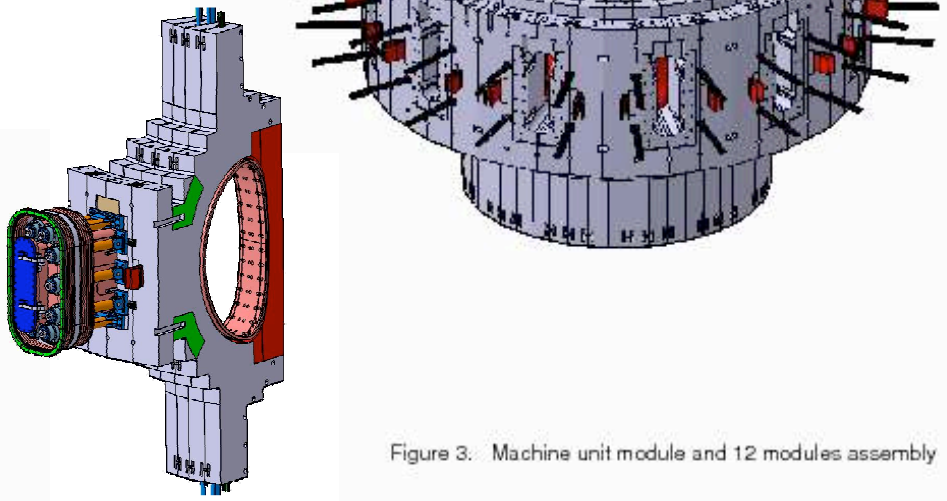
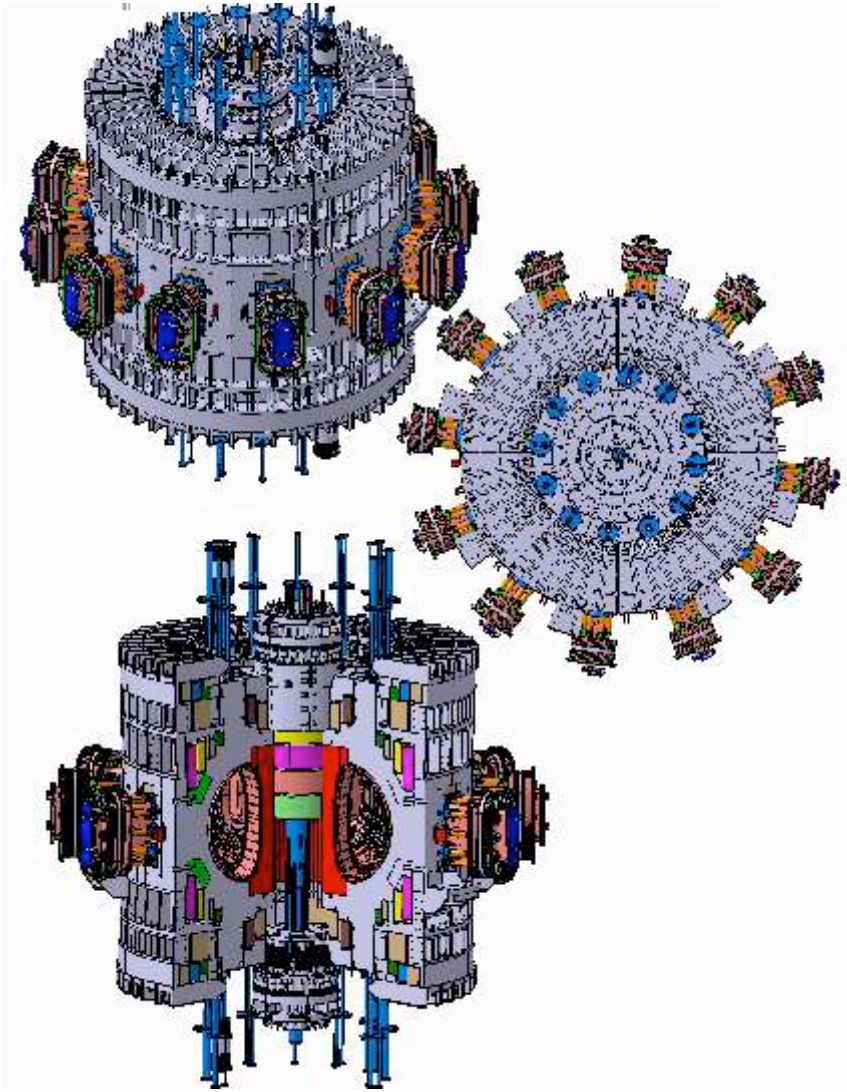
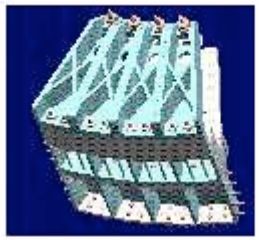


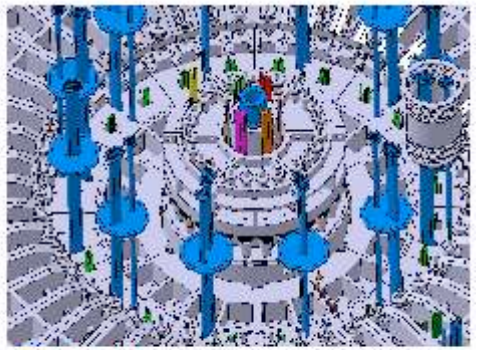
Figure 3. Machine unit module and 12 modules assembly

Machine External coils and Mechanical Structures Assembly

Following the machine on site assembly sequence, once set-up the 12 unit modules 3D model, the poloidal external coils, the mechanical structures, the radial preloading system and the CS assembly are added. Fig.4 shows some views of the radial preloading system supports, the whole 3D assembly obtained, a view with 3 modules removed for a better understanding of the inside structures and some details at the Central solenoid assembly upper head and Vacuum Chamber equatorial ports







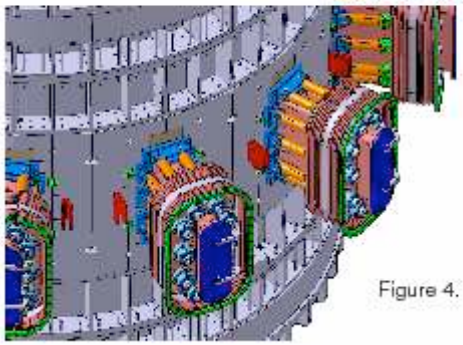
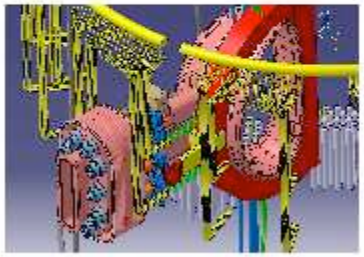


Figure 4. Machine intermediate Load assem

Machine Cryostat and Electro-Fluidic lines

To complete the Load Assembly 3D model, the Vacuum Cryostat and supported Polyethylene Boron composite sheets for neutron shielding and the electro-fluidic and fluidic lines inside the cryostat are set-up (see fig.5,6,7 for some details).



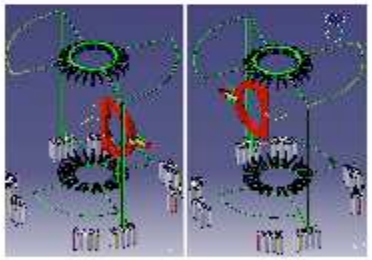


Figure 5. Toroidal Field coils inlet/outlet cryogenic pipes

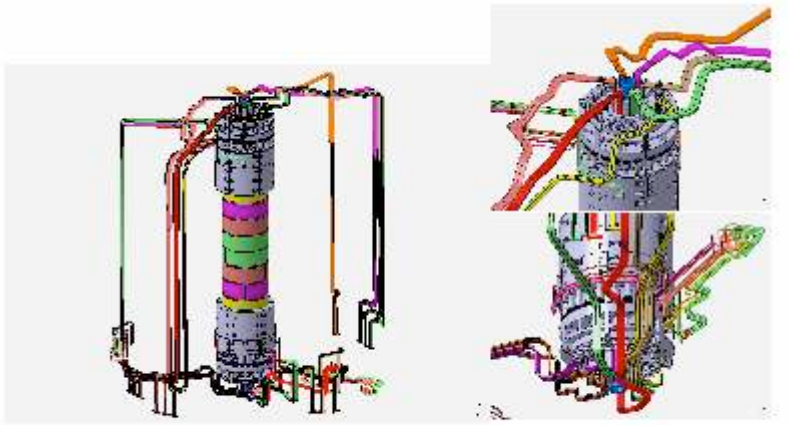


Figure 6. Central solenoid electric bus bars and cryogenic pipes

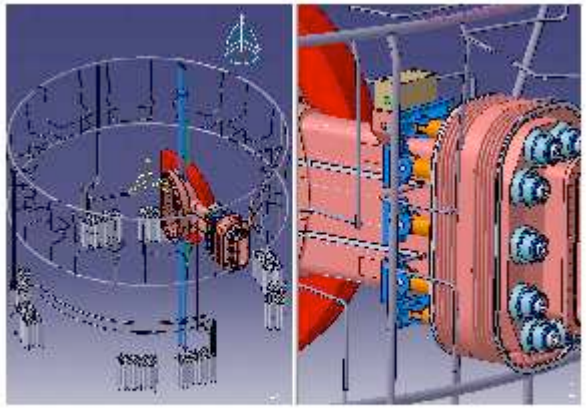


Figure 7. Vacuum Chamber cryogenic pipes

Machine Load Assembly 3D Model

The final 3D model of the IGNITOR Machine Load Assembly is the result of the previous sub-steps; Fig.8 show some pictures of the model:

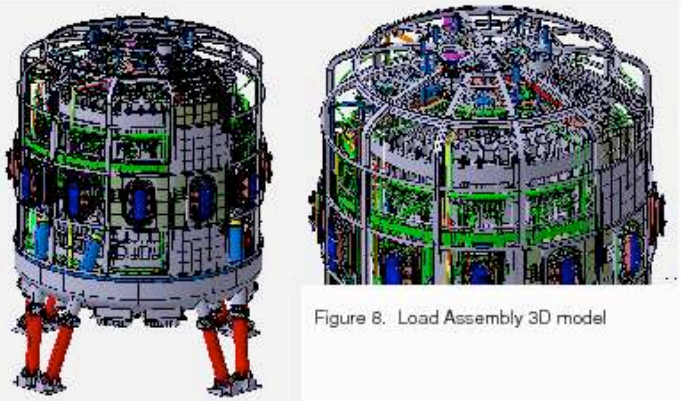
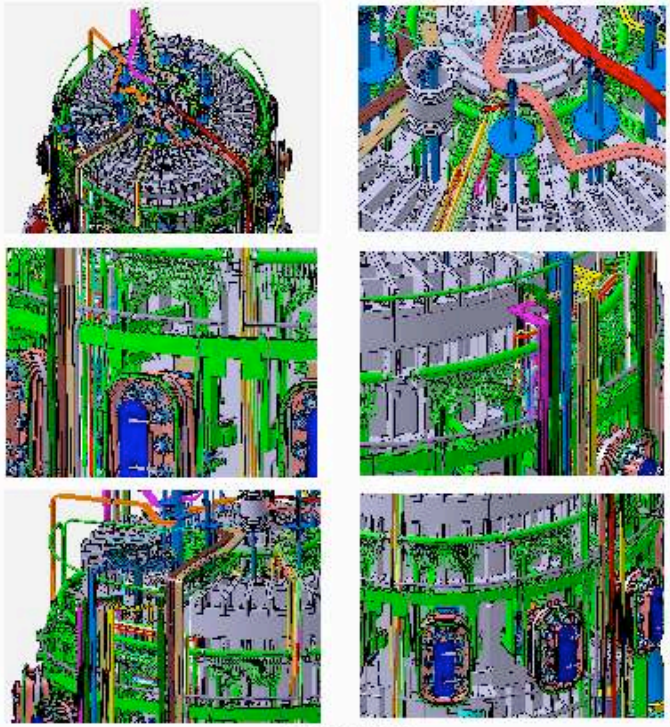


Figure 8. Load Assembly 3D model



Conclusions

The IGNITOR machine 3D CATIA model of the Load Assembly has been set-up resulting an useful and absolutely necessary tool to design such kind of structures; its use for machine mechanical integration has proved the feasibility of the design/assembly/in vessel remote handling operations of the machine.