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Computational Design of Next Generation Fusion Reactor FFHR

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Conceptual design of the next generation of force-free helical fusion reactor (FFHR) has been conducted based on the achievement of the large helical device (LHD) in National Institute for Fusion Science (NIFS), Japan. FFHR is required as a stationary fusion reactor capable of steadily holding high-performance plasma for one year. [1][2][3]

A candidate of demonstration fusion reactor is FFHR-c1 model whose magnetic configuration with field strength of ~8 T at the plasma center is similar to LHD, and whose size is 2.8 times larger than LHD. Blanket modules in this model have enough shielding performance to protect the superconducting magnet coils from the neutron irradiation for 30 years of operation. So scenario of exchanging these assemblies recommends robot operation system.

We focus on computation design of FFHR-c1, which includes (1) detailed three-dimensional (3D) design of the superconducting magnet support structures, 3D neutronics analyses, where the diverter targets can be efficiently shielded from fast neutrons, and 3D-MHD equilibrium, (2) path-planning of carrying assemblies by using robot operation, (3) holistic management toolkit with mixed-reality technology from the inner module scale to the reactor building scale.

By using CATIA, which developed by Dassault Systems, the detailed design of each module which includes vacuum vessel, blankets, and divertor components with magnetic field line structure. The analysis of assemblies, where the parts interact and are connected, allows for more realistic and accurate simulation about the loading and restraints acting on an individual part. Including solids, surface, and wireframe geometry, assemblies made up of parts with specification analysis. A comprehensive set of tools is available to interaction model between each other including frictional contact, welding, and user-defined connections. In addition, the seamless integration of design and analysis allows connection properties.

A robot manipulation is required as radiation safety operation the inside/outside of FFHR. Firstly, the enlarged modules/assemblies with high temperature have to be decomposed into simpler parts. Secondly, each part is picked up and carried outwards FFHR with high precision. Finally, each parts are replaced and FFHR are reconfigured. A mixed-reality toolkit with human-machine interface has been developed.

For intuitively understanding the physics of plasma and the reactor design, images of plasma simulation results (MHD equilibrium, magnetic structure, particle diffusion, etc.), reactor assemblies, and peripheral devices are represented in the virtual-reality space, interactively. [4]

In this presentation, the current status of the computational design for FFHR-c1 is reported.

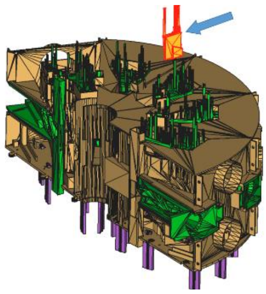

Fig.1. Schematic diagram of carrying assemblies by using a robot operation. Path-planning carry an assembly out of FFHR-c1 model.

References

[1] J. Miyazawa, et al, Maintainability of the helical reactor FFHR-c1 equipped with the liquid metal divertor and cartridge-type blankets, https://doi.org/10.1016/j.fusengdes.2018.04.118

[2] J. Miyazawa, et al., Cartridge-Type Helical Blankets Aiming at Easy Construction and Maintenance for the FFHR-d1, Plasma Fusion Res. 12 (2017) 1405017(20 pp)

[3] T. Goto, et al., Estimation of Pumping Power of the Liquid Metal Divertor REVOLVER-D for the LHD-type Helical Fusion Reactor FFHR-d1, Plasma Fusion Res. 12(2017) 1405016 (4 pp)

[4] H. Ohtani, et al, Applications of virtual-reality technology to fusion science and engineering, 36th JSST Ann. Conf. Simulation Tech. (2017) 194