§41. Study for a Protection of Laser Beam Port in the Laser Fusion Reactor KOYO-F

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The laser fusion power plant (KOYO-F) driven with cooled-Yb:YAG, ceramic lasers was conceptually designed by Norimatsu et al.[1)] The design of this reactor is based on the Fast-Ignition scheme. The KOYO-F is a more realistic power generation plant with smaller power output than the previous plant KOYO.[2)] One of important design issues is a design of a chamber. Damage of the first wall by irradiation of low velocity alpha-particles is the most serious problem. [2)] As a protection of the first wall, LiPb liquid wall chamber has been proposed. On the other hand, naked laser beam ports are not protected.

A possible method for protecting beam ports and laser sources from alpha particles which are produced by a nuclear fusion in the Fast Ignition Laser Fusion Power Plant (KOTO-Fast) is proposed[3)]. Two simple dipolar magnetic fields generated by two coils installed at the tip of the beam port (only this coil is used in Case A) and at the side of the beam port (both coils are used in Case B) are used for protecting the alpha particles coming into the inside of the beam port and colliding to the tip surface of the beam port. To calculate the behavior of alpha particles in the magnetic field, we use a 3D hybrid numerical simulation code.

As a result, in case for using only main coil, the coil current of 180 [kA・turn] and 0.9 [T] at the center of coil is enough for achieving the 10 % reduction of the alpha particles colliding to the tip surface of the beam port as shown in Fig. 1 for Case A and Fig. 2.

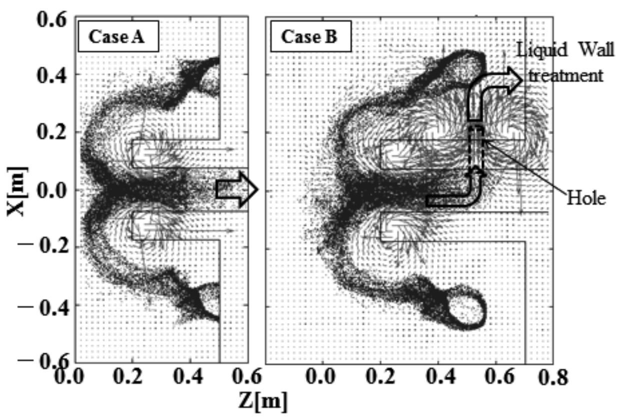

Fig. 1. The vector plot of magnetic field and alpha particle distribution projected onto the XZ plane at 0.53 [μ s].

However, in Case A, a lot of alpha particles coming into the beam port impinge to the inside surface of the cylindrical beam port since the direction of the magnetic field vector in the beam port is the direction to the wall of beam port. In Case B shown in Fig. 1, alpha particles coming into the beam port can be guide to the outside of the beam port since the strong x-component of magnetic field which is generated by the additional coil. The intensity of 1.35 [T] of the magnetic flux density at the center of the additional coil which is installed at the side of the beam port can guide the alpha particles coming into the inside of the beam port to the outside liquid wall through the drilled hole perfectly as shown in Fig. 1 and Fig. 2. The definition of the places (Surface, Inner port, Region A) is shown in Fig. 3. The parallel magnetic field to the tip surface generated by the additional coil prevents the LiPb liquid on the tip surface of laser beam port from detaching by the Lorenz force between the eddy current in LiPb and the magnetic field generated by main coil. As the future work, it is necessary for improvement of the protection of the beam port to clarify whether such a large electric current can be sent to the coils and the cooling of these coils can be realized effectively.

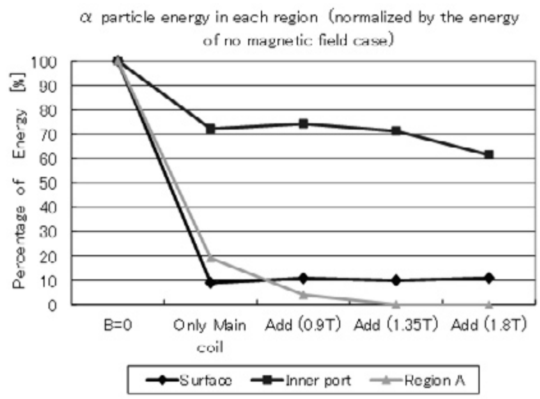

Fig. 2. The percentage of the energy of alpha particles in each region normalized by the each energy in the case without magnetic field.

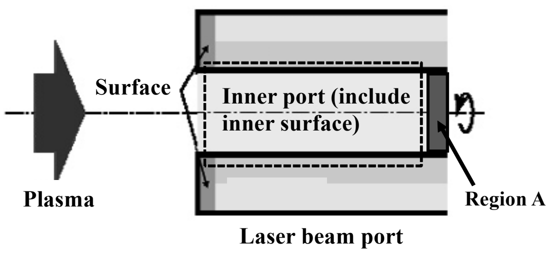

Fig. 3. The definitions of the places.

1) Norimatsu, T et,al. : Fusion Science and Technology, 52, 4, (2007), 893-900.
2) Kozaki, Y. et,al. : J. Plasma Fusion Res. 82, 12, (2006), 819-822.
3) Kajimura, Y. et al. : 20th Toki Conference, o-11, (2010).