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Fuel pellet alignment control in heavy-ion inertial fusion reactor

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In inertial confinement fusion, the scientific issues include the generation and transport of driver energy, the pellet design, the uniform target implosion physics, the realistic nuclear fusion reactor design, the uniform target implosion physics, the realistic nuclear fusion reactor design, etc.[1] In this paper, we present a pellet injection into a power reactor in heavy ion inertial fusion (HIF).

A HIF reactor chamber is filled with a chamber gas. Since a fuel pellet is affected by the gravity and the gas drag force during the injection, a precise control is required in the pellet longitudinal and transverse injection velocity. We propose the magnetic field correction to make the target injection system robust [2]. The fuel pellet is covered by Pb and is cooled down by a liquid He. The cryo pellet coated by Pb becomes a superconductor, when its temperature is below 7.2K. The permanent magnets repel the superconductor due to the Meissner effect. We employ this effect to correct the fuel pellet injection velocity. The results presented in Fig. 1 demonstrate that the magnetic correction system is quite effective to reduce the pellet alignment error dr against the transverse velocity error dVr [2]. However, the magnetic correction system in Fig. 1 is not effective for the longitudinal velocity error dVx. We propose a couple of electromagnets and magnetic shields. If the detected velocity error dVx is small beyond the allowance limit of the longitudinal velocity error, the electromagnets in front of the permanent magnets are switched on. A part of magnetic field lines is shielded by the magnetic shields and just the magnetic force in the acceleration direction is applied on the fuel pellet. As a result, the fuel pellet is accelerated to reduce the pellet alignment error at the reactor chamber center as in Fig. 2(a) and vice versa (see Fig. 2(b)). We also check the integrated correction effect on the pellet alignment error including all the magnetic fields by the permanent magnet and the electromagnets shown in Fig. 3. The integrated results of the pellet velocity error correction by the electromagnets and the permanent magnets are shown in Figs. 4.

We confirmed that the magnetic field correction is effective to reduce the pellet transverse displacement error dVr, and the acceleration / deceleration electromagnets and magnetic shielding system widened the longitudinal velocity error dVx allowance window. The magnetic control system proposed in this paper





would provide a new robust way to control the pellet alignment in the fusion reactor.



Figure 2. The longitudinal velocity error allowances with the magnetic correction. (a) The pellet speed is slower than expected, and the pellet is accelerated. (b) The pellet speed is faster than expected, and the pellet is decelerated.



Figure 3. Integrated pellet velocity error correction.



Figure 4. The vertical velocity error allowances with the magnetic correction: (a) Acceleration case, and (b) deceleration case.

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References

[1] S. Kawata, T. Karino, A.I. Ogoyski, "Review of heavy-ion inertial fusion physics", *Matter and Radiation at Extremes*, vol. 1, no. 2, pp. 89-113, March 2016

[2] R. Tsuji, "Trajectory adjusting system using a magnetic lens for a Pb-coated superconducting IFE target", *Fusion Engineering and Design*, vol. 81, no. 23-24, pp. 2877-2885, Nov. 2006.

[3] T. Kubo, T.Karino, H. Kato, S.Kawata, "Fuel Pellet Alignment in Heavy-Ion Inertial Fusion Reactor", arXiv:1808.09671, August 2018.