§30. Development of a Coil Gun for Fast Ignition

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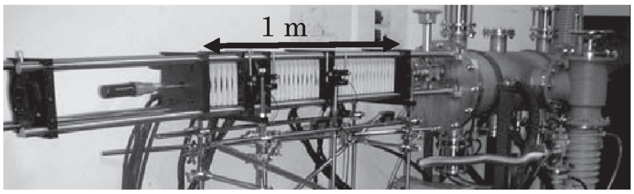
An IFE reactor has to be equipped with a target injector. A coil gun has been designed and tested for the target injector. In our previous studies of the coil gun, the acceleration had reached the maximum value of 580G limited by the target mechanical strength. A conceptual experiment was carried out for demonstration of a target tracking without mechanical movements.

1. Target Injection

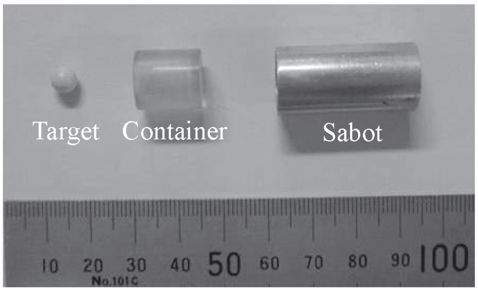
The coil gun is composed from three kinds of coils: acceleration ones, rotating field ones, deceleration ones. The acceleration ones are energized by capacitors in three phase fashion with a certain time sequence to generate a traveling magnetic field. Propelling force simultaneously acts on the sabot by the interaction between the traveling magnetic field and the induced currents in the sabot. A sabot (1-mm-thick aluminum cylinder, 8.86 grams, outer diameter 15 mm, and 75 mm long) can be accelerated at certain acceleration up to 580G by tuning of each coil currents timing. The rotating field coils generate a rotating electromagnetic field which spins the sabot to decrease tumbling of it. For sabot removal, the deceleration coils generate the backward traveling electromagnetic wave which causes negative force on the sabot. The mechanically accelerated target with sabot was sent into the sabot remover. Fig. 1(a) shows a target (6.0mmϕ, 0.2g), a target container, and an aluminum cylinder (15mmϕ×30mm) used as the sabot. An optical fiber sensor was used for synchronizing the sabot arriving timing and generation of deceleration electromagnetic wave. The target and the sabot were monitored by the high-speed camera (KODAK, EKTAPRO 1540) with time resolution of 9000fps. As shown in Fig. 1(b), the target is successfully released from the sabot.

2. Target Tracking

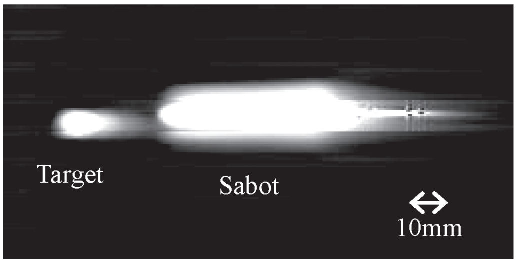
The amplifier-SBS mirror apparatus was tested for a beam steering method. The probe laser beam was provided by a Q-switched Nd:YAG oscillator (τ=6ns, E<50mJ). The apparatus; an amplifier (G = 1~20), a converging lens, and the SBS cell (FC-72) were arranged in a series. The reflected and/or scattered probe beam from target was amplified and was converged into the SBS cell. An HR mirror was used for a target in this experiment. The achieved reflectivity of the SBS cell was ~30%. As shown in Fig.2, the probe beam reflected from the SBS cell was amplified again at energy of 500 mJ and was back-propagated to the target. Target configuration and surface condition are key parameters in this experiment.



(a) Photograph of the coil gun.

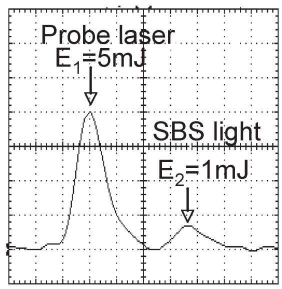


(a) a target, a container, and a sabot

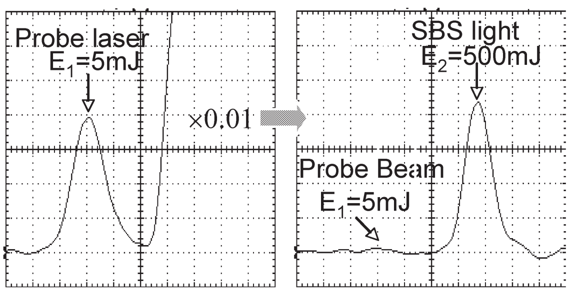


(b) a released target from a sabot
(*v*=30m/s, 9000 fps, KODAK, EKTAPRO 4540)

Fig.1 Coil gun system.



(a) no amplification



(b) amplification (G = 20)

Fig. 2 Amplification of the probe laser beam by the amplifier-SBS mirror apparatus.

Reference

1) T. Norimatsu, D. Harding, R. Stephens, A. Nikroo, R. Petzoldt, H. Yoshida, K. Nagai, Y. Izawa, Fus. Sci. Tech., 2006, 49, 483.