§38. Beam Steering for Laser Fusion

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Beam steering with target injection have been developing for laser fusion. The main progress of it is polystyrene target injection. A spherical polystyrene target set in an aluminum sabot is accelerated up to 40 m/s by the gas gun. The sabot is decelerated by a permanent magnet array for separation the target from the sabot. The target injection accuracy is evaluated as dispersion of shot position.

As shown in Fig.1, the aluminum sabot is traveling in the permanent magnet array composed of doughnut shape Neodymium magnets. The magnetic force F acting on the sabot is

$$F = \int\int_{r_{si}}^{r_{so}} 2\pi r(B\times i_s)\,dr\,dz$$
$$= \frac{-2\pi v_s}{\rho}\{\frac{z}{2}-\frac{\lambda}{8\pi}\sin(\frac{4\pi z}{\lambda})\}\int_{r_{si}}^{r_{so}} rB_0^2(r)\,dz \qquad (1)$$

where r_{si} and r_{so} are inner and outer radii of the sabot. B is the magnetic flax density distribution in the array. i_{S} is the inducted current in the sabot. λ is periodical length of the magnetic field. We found the deceleration rate is constant as follows:

$$\frac{dv_s}{dz} = \frac{F}{mv_s} = \frac{-\pi n\lambda}{m\rho}\int_{r_{si}}^{r_{so}} rB_0^2(r)\,dr = -k \qquad (2)$$

where m is the mass of the sabot and n is the sabot length multiple of λ. The estimated k is 63.1m/s/m in the experiment.

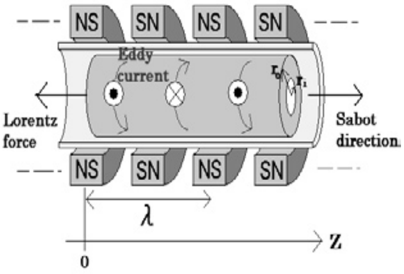


Fig. 1. Sabot deceleration by the permanent magnet array.

Target injection apparatus is shown in Fig. 2. A polystyrene target radius of 4.0mm was shot for ten times. The velocity of sabot was measured by pick up coils winding between the each permanent magnet. The target velocity and shot position were observed by the two high-speed cameras. The target with sabot was accelerated up to 40m/s and sabot was decelerated by the permanent magnet array as shown in Fig. 3. The measured deceleration rate 63.6m/s has good agreement with theoretical value.

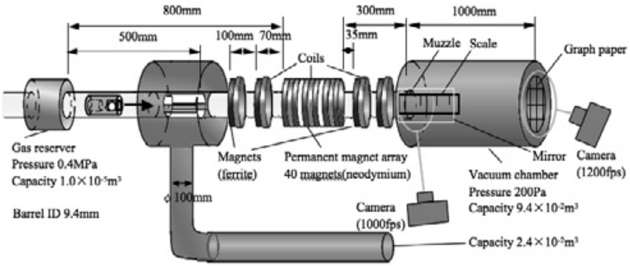


Fig. 2. Target injection apparatus.

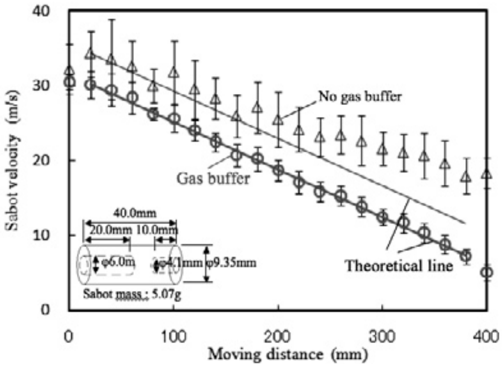
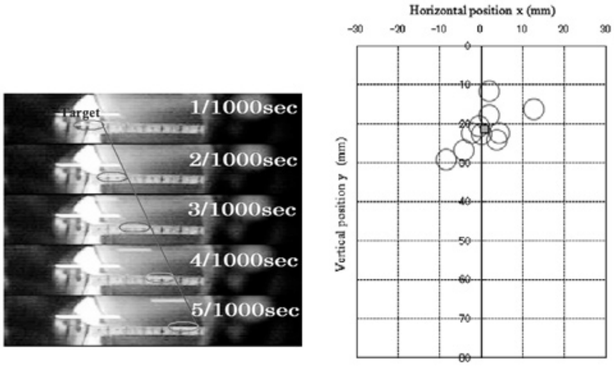


Fig. 3. Sabot velocity in the permanent magnet array.

As shown in Fig.4.(a), the target is separated from the sabot. The distribution of its shot position is evaluated as $\sigma_x{}^2$ 28.5 and $\sigma_y{}^2$ 23.4. In our previous experiments, the injection accuracy depended on the sabot design. The inner shape of the sabot should be improved in continuous research.



(σ_x^2 28.5, σ_y^2 23.5)

(a) Injected target (b) Distribution of target shot position

Fig. 4. Evaluation of target injection.

1) Yoshida, H., Makino, R., Niwa, T.: Tokai-Section Joint Conference on Electrical and Related Engineering (2010) Pol-19.