§53. Stability of Fast Ignition Target after Release from Sabot

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In a case of a laser-fusion power plant based on fast ignition, non-spherical targets with guide cones are injected into the center of the reaction chamber with designated accuracy of ±1 mrad in the pointing, ±0.7 rad/s in the "tumbling speed", 100±1 m/s in the injection speed, and at the repletion rate of 4 Hz. Our goal is to demonstrate such injection at a single-shot base using equipment shown in Figs. 1 and 2. Dummy targets made of aluminum were used. Aluminum was chosen because the total mass was close to that of real target consisting of a LiPb cone and a plastic fuel shell.

Although we demonstrated the separation of sabot and subsequent flight with designated pointing and speed in 2012, the tumbling speed was 10±43 rad/s which was far from our goal. Furthermore, we found that tumbling angles observed at the view port were smaller than those at the muzzle in 50% of whole shots. This result indicated that targets received large torque during the release of the sabot and some recovering force during the flight through the magnet array. Feasible candidates for the initial large torque are considered as follows.

(1) Gravitational force during the slipping of the target out of the sabot.

(2) Vibration of sabot in the acceleration tube due to (a) rough inner surface and/or (b) non-concentric magnetic field.

In 2013, we concentrated on mitigating the tumbling by

(1) Relax the mechanical stress near the muzzle of the acceleration tube. The stress came from in-accurate assembling of the acceleration tube and the chamber. The stress would make a bend of the tube.

(2) Optimize the clearance between the tube and the sabot, and/or that between the sabot and the target.

(3) Improve the straightness of the tube by using an adjustable middle support.

To relax the stress, a flexible tube was used to connect the acceleration tube to the chamber. A 50-μm-thick coating with metal powder was applied on the sabot surface to minimize the clearance between the tube and the sabot. This coating endures 300 °C that would come from the friction between the tube and the sabot. The straightness of the acceleration tube was measured by using a He-Ne laser and we found that the straightness in 2012 experiments was 1.1 mm over 2.2 m. This value was improved to 0.1 mm over 2.2 m in 2013 campaign.

After these trials, the tumbling speed in 2013 experiments became 6.6±5.4 rad/s. The repeatability was much improved from that in 2012 campaign, but this result was still far from our goal. In 2014, we will concentrate on finding the mechanism that causes the initial torque.

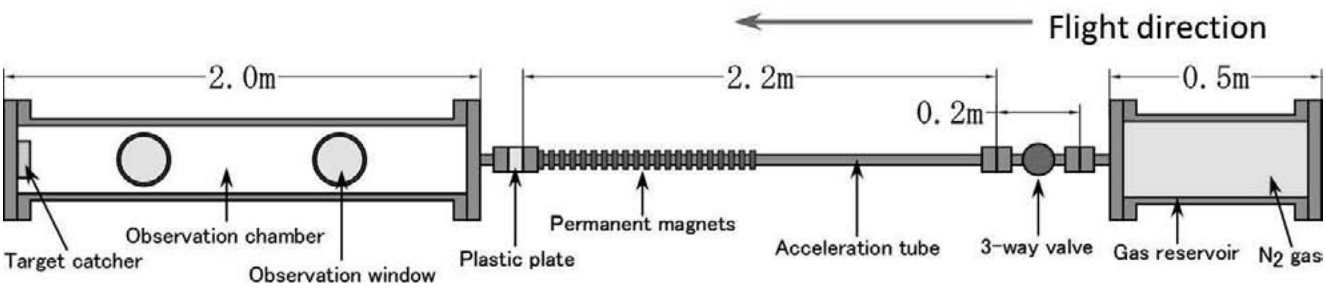

Fig. 1 Single-shot-base sabot-release system for fast ignition target.

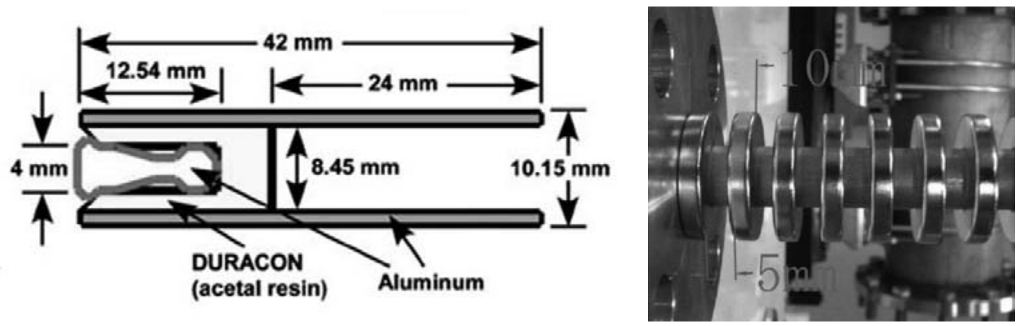

Fig. 2 Dummy target in sabot (left) and magnet array (right).