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

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In a fast ignition laser fusion reactor, non-spherical targets with guide cones are injected into the center of the reaction chamber. Targets should satisfy following conditions: ±1 mrad in the pointing, ±0.35 rad/s in the "tumbling speed" or yawing and pitching, 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 Fig. 1. Tumbling speed was not achieved in previous work.

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.

After these trials, the tumbling speed in 2013 experiments became 6.6±5.4 rad/s, but this result was far from our goal.

In 2014, we tried to reveal the mechanism that causes the initial torque which leads to tumbling by following experiments.

(1) Change the target material from Aluminum to Duracon (polyacetal). The Lorentz force caused by magnets for sabot removal is suspected to give the target initial torque.

(2) Rotate the target and the sabot to gyro direction. Initial attitude of the target would be preserved by gyro effect.

(3) Reduce friction coefficient between the target and the sabot by applying MoS_2 coat on contact surface. The friction force may cause the initial torque.

To give the target gyro rotation, roof-tile-type magnets was put on the acceleration tube spirally. The principle of an induction motor was applied to this method. The coefficient of dynamic friction between the target and the sabot was reduced from 0.15 to 0.04 with MoS_2 coat. Base shots, using aluminum targets, without gyro rotation or MoS_2 coat, were carried out for comparison.

The results of these experiments are shown in Table.1. Tumbling speed in experiment (1) was less than in base shot. This result means that magnets for sabot removal cause the initial torque. If the center of the acceleration tube and that of the target is deviated due to the clearance between the acceleration tube and the sabot, the balance of moment of the Lorentz force is broken. Experiment (2) showed worst tumbling speed. This is why the axis of gyro rotation was different from the central axis of the acceleration tube, resulted in fostering imbalance of moment stated above. The result of experiment (3) was almost the same as of base shot. This result suggests that the friction force doesn't cause the initial torque.

In conclusion, the initial torque is mainly caused by magnets for sabot removal. In 2015, we will directly observe the instance of the target removing from the sabot.

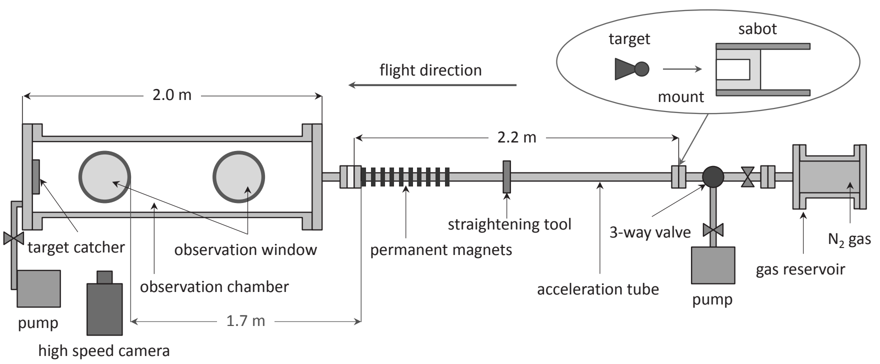

Fig.1 Single-shot-base target injection system.

Table.1 The comparison of the tumbling speed.

	experiment (1)	experiment (2)	experiment (3)	base shot
tumbling speed [rad/s]	8.9±6.6	37.9±23.2	18.2±26.2	16.4±25.0