

§41. Development of a Full-Scale Model of a Target Injection System for Laser Fusion

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Laser-fusion research is now in a stage where reactor engineering is important. In laser fusion, a cryogenically-cooled fuel capsule, which we call a target, is injected into the center of a reactor at high speed, and then irradiated by laser beams. Therefore, a unique target-injection system is needed to be developed. A target-injection system must inject a target

- (1) at required flight speed,
- (2) to required position,
- (3) with required target attitude, and
- (4) quickly diagnose the flight condition of the target, and
- (5) send flight data to the final-mirror drive unit for laser irradiation.

So far, a gas gun as a main target-accelerating device was developed at Hiroshima University,¹⁾ a coil gun as a flight-speed adjuster and a sabot remover was developed at Gifu University,²⁾ and an optical diagnostic system was developed at Ibaraki University,³⁾ individually. This joint research was started intending to integrate such individual researches. The objectives of this research are to join the individually-developed technologies, construct a full-scale target-injection system, and demonstrate the feasibility of repetitive laser irradiation of targets. This year, the first year of this joint research, we discussed the development strategy, the specifications of the system we will construct in the first development stage.

The development strategy is as follows. The final goal of this research is to demonstrate repetitive highly-precise injection of cryogenically-cooled targets into a chamber filled with high-temperature low-density gas, with same scale as a future laser-fusion reactor. In order to reach the final goal, we set four development stages:

- (1) single-shot-based highly-precise injection of a room-temperature target into a chamber filled with room-temperature low-density gas, with same scale as a future laser-fusion reactor,
- (2) repetitive highly-precise injection of room-temperature

targets into a chamber filled with room-temperature low-density gas, with same scale as a future laser-fusion reactor,

- (3) single-shot-based highly-precise injection of a cryogenically-cooled target into a chamber filled with high-temperature low-density gas, with same scale as a future laser-fusion reactor,
- (4) repetitive highly-precise injection of cryogenically-cooled targets into a chamber filled with high-temperature low-density gas, with same scale as a future laser-fusion reactor.

In the first development stage, we will construct a target injection system with the following specifications.

- Flight speed: 100 ± 1 m/s
- Precision of flight direction: ± 1 mrad
- Precision of target attitude after 5-m flight: ± 2 degree
- Precision of target irradiation by laser: ± 20 μ m
- Maximum acceleration: 250×9.8 m/s²
- Target: 1.36-mm-diam. sphere with a cone of 30 degree
- Sabot: 10-mm diam., made of aluminum alloy (shape and length are to be determined in the development)

The target injection system developed in the first stage consists of “acceleration module,” “speed adjuster & sabot remover,” “diagnostic module,” “flight tube,” and “laser-irradiation module” shown in Fig. 1. The experiment space is 14 m \times 3 m, which is in the L-building of the Institute of Laser Engineering, Osaka University. The acceleration module is a gas gun, where room-temperature nitrogen gas is used. On the speed adjuster & sabot remover, we begin with sabot-removing experiments by using permanent magnets, and after that, introduce a coil gun for flight-speed adjustment. On the diagnostic module, we adopt an Arago-spot-image type optical diagnostic system with four sets of optical windows every 1 m. In the laser-irradiation module, a flying target is irradiated by a small pulse laser. In the first development stage, we use dummy targets made of plastic.

- 1) Sakae, S., Hayashi, H., Kitabatake, T., Matsumura, T., Endo, T., and Norimatsu, T.: Plasma and Fusion Research 4 (2009) S1006.
- 2) Yoshida, H.: Annual Report of ILE Joint Research (2010) 61.
- 3) Sakauchi, H. and Tsuji, R.: Plasma and Fusion Research 4 (2009) S1012.

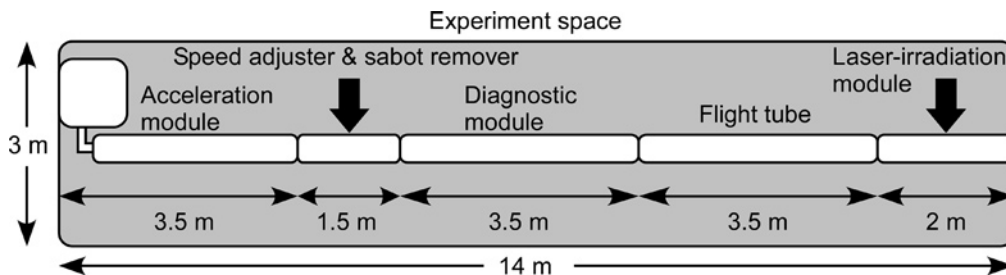


Fig. 1. The target injection system developed in the first stage.