Laser Fusion Experimental Reactor LIFT
Based on Fast Ignition and the Issue

Takayoshi NORIMATSU[1], Yasuji KOZAKI[1], Hiroshi SHIRAGA[1], Hisanori FUJITA[1], Kunihiko OKANO[2], Hiroshi AZECH1 and members of Design Committee for Laser Fusion Experimental Reactor.

1 Institute of Laser Engineering, Osaka University, 2-6 Yamada-Oka, Suita, Osaka 565-0871 Japan

2 Central Research Institute of Electric Power Industry, 2-11-1 Iwadokita, Komae, Tokyo 201-8511, Japan

norimats@ile.osaka-u.ac.jp

We proposed a conceptual design of the laser fusion commercial reactor KOYO-F[1)] based on fast ignition scheme in 2006. In 2012, we organized a design committee for a laser fusion experimental reactor to clarify critical issues in demonstrating electric power generation by laser fusion. The committee consists of a supervisor team, a simulation and theory for core plasma team, a laser team, a fueling team and a chamber and system team. Fifty-one members including researchers from universities and companies were engaged in this activity. We are now preparing an final report to fix consistent system parameters.

Our plan for the experimental reactor is divided into 3 phases. The mission of the phase I is to demonstrate repetitive fusion burns in a burst mode. Physics on the burn efficiency must be clarified to fix the specifications of Phase II system. The repetition rate is 1Hz and the total shot number in one burst is 100. This value comes from the total target number prepared in one batch of cryogenic DT targets. The chamber is a simple vacuum vessel without a blanket and the cooling system. The operation will be stopped when the average temperature of the chamber exceeds 200 ^{o}C. Estimated radiation dose is 100mSv/h where limited access is possible after 1 hr cooling.

The mission of the phase II is to show the production of electric power. The operation will be continued for a couple of days at 4 Hz. The chamber is a dry wall chamber with solid blanket. Although the final goal is a wet-wall chamber with liquid LiPb blanket, the dry wall was chosen to shorten the time for power generation. The heat cycle has a tritium recovery system but reuse of the tritium during operation is optional. After demonstration of electric power generation, development of liquid wall chamber will be started. Liquid wall is the key scheme to realize a commercial power plant. Technical issues related to the liquid first wall and the liquid blanket will be tested in this phase.

The mission of phase III is to clarify reliability and economics of the liquid wall chamber. Tritium breeding and material test will be also included in the mission. The chamber is a small prototype of KOYO-F that is a commercial power plant based on the fast ignition [1]. All equipment necessary for a fusion plant will be installed to this system. The final goal of this system is continuous operation close to one year and production of tritium necessary to start a demo plant. The laser system is a Laser-diode-pumped, cooled Yb:YAG ceramic-laser whose output power is 400 to 600kJ for compression beams and 200kJ for the ignition beam. This laser system will be used commonly in all phases.

There are 3 issues in the Phase I. One is the efficiency of the heating laser. If the heating efficiency is less than 20%, design of final optics would be difficult. The second is the tumbling of injected-, fast-ignition target and the third is the dumping of a large steering mirror. Later two issues can be settled with improved existing technology.

In Phase II, safety related to tritium and activation would be the issue. Control of tritium diffusion in the cooling cycle without spoiling the system efficiency is quite severe issue in future commercial power plant[2]. In a case of an experimental reactor, this issue can be skipped because system efficiency is out of interest. We, however, had to demonstrate technical feasibility in this phase. The radiation dose at the surface of LiPb after operation is estimated to be 300Sv/h. No person can access. Development of a robot is necessary for repair or maintenance of the chamber and the 1st cooling loop. In phase III, the life of final optics would become critical. Current candidates are to exchange periodically conventional mirrors during short halt of laser operation and gracing-incident metallic mirrors. In the latter case, swelling of metal by neutrons must be discussed in a view point of 1/10λ surface finish, which is required for standard laser optics.

References

[1] Y. Kozaki et al., J. Plasma and Fusion Res., 82 817-837 (2006) (in Japanese).

[2] T. Norimatsu, H. Saika, H. Homma, M. Nakai, S. Fukada, A. Sagara and H. Azechi, Fusion Science and Technology, Vol.60, pp893-896, (2011).