Wave Period of Free-Surface Waves on High-Speed Liquid Lithium Jet for IFMIF Target

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Wave period of free-surface waves on a high-speed liquid lithium (Li) jet is very important to investigate for the validation of Li target of the International Fusion Materials Irradiation Facility (IFMIF). In the IFMIF, intense neutron fields for testing candidate fusion materials will be generated by a nuclear stripping reaction between deuteron (D^+) and Li. A high-speed liquid Li plane jet, which is called the IFMIF Li target, flowing along a concave backwall at the velocity of 15 m/s (up to 20 m/s) is irradiated with two D^+ beams. Stability of the jet is of crucial importance for generating high-quality neutron field and maintaining safety of the IFMIF itself. Thus, characteristics of free-surface waves on the jet must be studied in detailed. We have developed a contact-type liquid level sensor for investigating characteristics of the waves, and measured the wave amplitude and wavelength [1,2].

In this study, the wave period which is one of major wave characteristics has been experimentally investigated. This experiments were conducted at a Li loop in Osaka University. In this loop, a plane Li jet of 70 mm in width and 10 mm in depth simulating the IFMIF Li target can be controlled at the velocities of up to 15 m/s at the operation temperature of 573 K. In measurement of the wave period, the contact type liquid level sensor called an electro-contact probe [1] was used. The sensor has two probes for measurement and position calibration, and it can electrically detect the contacts between the measurement probe and liquid surface. The probe position can be moved vertically in a step of 0.1 mm by a stepping motor. The sensor was installed at the position of 175 mm downstream from the exit of nozzle. This position corresponds to the center of the D^+ beam irradiation area in the IFMIF. Sampling frequency and recording time were set to be 50 kHz and 30 s, respectively.

From the recorded contact signals, the wave period could be converted as time period between each contact at a center of free-surface oscillation. Probability density distribution of the wave period was nearly equal to the log-normal distribution, and it showed a broad peak located around the wave period of 0.5 x 10^{-3} s at 15 m/s. The wave period at the peak was shorter in the conditions with higher velocities. The fact that the wave period distribution is nearly equal to the log-normal distribution has been already identified in the ocean waves which are known for its random property. As our previous reports showed [3], amplitude distribution of the waves on the Li jet has a similar property to the ocean waves. In addition, from present experimental results, it was concluded that random wave property developed for the ocean waves can apply to the free-surface waves on the Li jet.

[1] T. Kanemura, et al., Fusion Engineering and Design, 82, 2007, pp.2550-2557.
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