§11. Experimental Study on Liquid Lithium Flow for IFMIF Target

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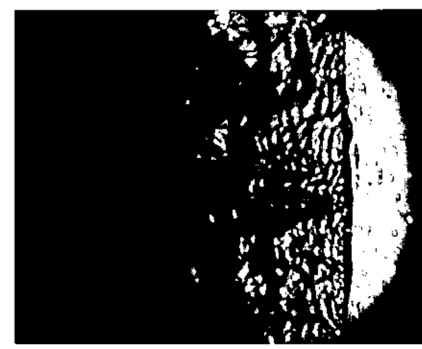
In the present design of IFMIF, liquid metal lithium is employed to the D^+ beam target, and neutrons are generated by D^+- Li nuclear stripping reaction. The present experiments were carried out with the lithium loop at Osaka University for investigating hydrodynamic behavior and flow characteristics of liquid lithium. The loop consists of an ALIP type electromagnetic pump (EMP), a test section and void separation tank, an air cooler module, and an electromagnetic flow meter. The free surface test section includes a honeycomb section and three perforated plates, the two-stage contraction nozzle, and a 70mm wide flow channel. The nozzle geometry is almost the same as the JAERI design.

Figure shows pictures of lithium free surface taken by a CCD camera with a strobe which half width of emission is approximately 20 micro seconds. The free surface motions are clearly captured in the exposure time. Flow directions are from right to left in the pictures. Longitudinal disturbances with small angle to flow direction, that is called surface wake, were observed. Those are caused by interference of waves generated from the nozzle by chemical compounds of lithium and nitrogen. At the lower velocity, the surface was fully smooth and there were few waves on the surface. As increasing velocity, waves started to appear on the surface and finally covered the surface completely. In the velocity range of 3 to 8 m/s, periodic 2 dimensional waves were observed in the short distance from the nozzle as is shown by the picture of 7.0 m/s. The waves that have periodic structure to the flow direction were reported on water and lithium jet experiments [1], [2]. The waves are considered to be the result of instability on free shear layer. The observed wavelengths were 2 to 1.5 mm, and decreased as increasing velocity. In velocities more than 9.0 m/s, the two dimensional waves were not observed, and the surfaces were covered non-periodic waves as shown in the picture of 9.0m/s. In this velocity region, it is considered that boundary layer along the nozzle wall transit laminar to turbulent as described by Itoh[2].

Thickness variation of the flow is a major design issue for the IFMIF target, because it affects neutron flux variation in time or space directly. It is necessary to develop a measurement method of the thickness for monitoring the target condition during the operation of IFMIF, and to measure the thickness experimentally to validate the present design parameters. In our experiments, we proposed grating pattern projection method[3], [4] to measure the lithium flow surface height. It is studied and being developed as non-contact 3-D shape measurement technique. This technique is applied to our case and, it is successful to measure the surface height distribution due to surface wakes. The results will be published in near future.

Lithium flows at huge flow rate of 130L/s in the case of IFMIF. To design the loop, it is important to prevent cavitaion at electromagnetic pumps. To investigate this characteristic, cavitation experiments were conducted at the lithium loop with cooperating researchers of ENEA, Italy. Cavitaions were detected by accelerometer developed by ENEA. The results indicated the accelerometer can be used to detect the cavitaion noise at the three pressure parameters.



(a) Um=7.0 m/s

(b) Um=9.0 m/s

Figure. Pictures of lithium flow surface

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[2] K.Itoh, Initial Free Surface Instabilities on a High-Speed Water Jet Simulating a Liquid-Metal Target, Fusion Tech., Vol.36, 1999, p69
[3] M.Takeda. H.Ina and S.Kobayashi, Fourier-transform method of fringe-pattern analysis for computer-based topography and interferometry, J. Opt. Soc. Am, Vol. 72, No1, January 1982
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