Development of the Techniques to Mitigate the Cavitation Damages in the J-PARC Mercury Target

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For the mercury target of a pulsed spallation neutron source of J-PARC, cavitation damage of the target vessel wall which is caused by the pressure wave in mercury induced by high power pulsed proton beam of 1 MW is the crucial issue [1].

In order to mitigate the cavitation damage, a microbubble injection technique has been developed to reduce the intensity of the pressure waves. A microbubble generator to generate microbubbles with a diameter less than 100 μm in mercury was developed and has been used in the mercury target system of J-PARC since October 2012. The effect of microbubble injection into mercury was verified by measuring the displacement velocity of the target vessel vibration caused by the pressure wave using a laser Doppler vibrometer (LDV). The measured data showed that the displacement velocity of the target vessel was reduced to 1/3 in average with injecting microbubble with a volume ratio of 1×10^{-3} at the proton beam power of less than 300 kW.

For further development of the high power target, we focused on the mercury flow effect to mitigate the cavitation damage [2]. In order to realize this effect into the target design of J-PARC, we adopted doubled-walled structure to the beam window of the target vessel. The mercury flow channel with a narrow gap of 2 mm was made by adding an inner wall to just inside of the beam window. In order to investigate the mercury flow distribution and flow field, numerical simulations were carried out using the conventional code, ANSYS FLUENT. While the mercury velocity outside of the narrow channel was 1.2 m/s, the mercury velocity in the narrow channel increased to almost 4 m/s, which was promising to suppress the cavitation damages. The effect of the inner wall failure of the narrow channel on the mercury flow was also evaluated assuming that the round hole with a diameter from 10 mm to 60 mm was created on the inner wall at the center of the beam window. The simulation results indicated that the effect of rapid mercury flow to mitigate the cavitation damage is kept even if the damage hole is created on the inner wall of the narrow channel. The double walled target will be installed this year.

References

[1] M. Futakawa, et.al., Nucl. Instr. and Meth., A 562, 676-679 (2006).

[2] M. Futakawa, et.al., J. Nucl. Sci. Technol., Vol. 45, No. 10, p. 1041–1048 (2008)