Surface temperature measurements of the high power beam dump of the BigRIPS separator

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The surface temperatures of the high-power beam dump[1,2] of the BigRIPS separator were measured during the irradiation of the ^{48}Ca beam with a beam power of 8.3 kW in order to evaluate the cooling power of the beam dump. The beam dump consists of the side dump and the exit dump. The two exit beam dumps with 1 mm and 3 mm wall thicknesses were designed to handle various ion beams up to ^{238}U with intensities of up to 1 pμA.[2] The exit beam dump with 3 mm wall thickness and the side dump were constructed in 2007. Since then, they have been successfully operated with various beams. The design of the beam dumps was based on the sophisticated thermal model simulation;[1,2] however, its validity has not been well verified because of the limitation of available beam intensity. With the intense ^{48}Ca beam, which recently became available, temperatures of the inner-side exit beam dump were measured by using the thermocouples mounted on the dump.[3] The observed temperatures were consistent with the thermal model simulations, indicating that the beam dump has the expected cooling power. However, the results have some ambiguity. The highest temperature in the beam dump is expected at the beam impinging surface, but the thermocouples measure temperatures 3 mm behind the dump surface. In order to obtain clearer results, measurements of the surface temperature are highly desired.

The surface temperature of the outer-side exit dump was measured with the compact thermo-viewer camera IP160 manufactured by OPTRIS. The camera was placed at the side window of the beam dump chamber, as shown in Fig. 1. A vacuum window made out of BaF_2 was used to observe the infrared image of the dump surface, which was irradiated with the ^{48}Ca beam having an energy of 345 MeV/n and intensity of 500 pnA. The beam size on the dump surface was estimated to be 20 mm (X) and 30 mm (Y) from the separately measured beam emittance. A BaF_2 crystal with a thickness of 13 cm was placed between the vacuum window and the camera to reduce radiations (γ-rays and neutrons) from the beam dump. For further reduction of radiations, 20 cm thick concrete shielding blocks surrounded the camera. Cooled water, with a temperature of 13°C, pressure of 1.0 MPa, and flow speed of 10 m/s, were supplied to the dump as the coolant. The temperatures were also measured by using a thermocouple (TC) mounted on the dump 3 mm behind the dump surface.

The observed thermal image is shown in Fig. 2. The beam hitting portion of the beam dump is seen as a hot spot. Its size is about 30 mm (X) × 10 mm (Y), and the temperatures are 62 and 23°C according to the beam on and off. The temperatures of the TC are 15.4 and 13.6°C. The temperatures observed by the camera need to be corrected for the emissivity and the attenuation of the vacuum window and the BaF_2 crystal. The calibration data was taken by changing the temperatures of the cooling water in off-line condition. The observed temperatures varied from 23 to 32°C when temperatures of the dump varied from 15 to 45°C. With the assumption of the linear relation between both the temperatures, the observed temperature 65°C corresponds to an actual temperature of 147°C.

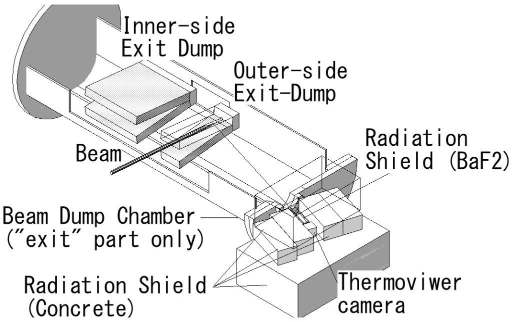

Fig. 1. Setup for the surface temperature measurement of the beam dump.

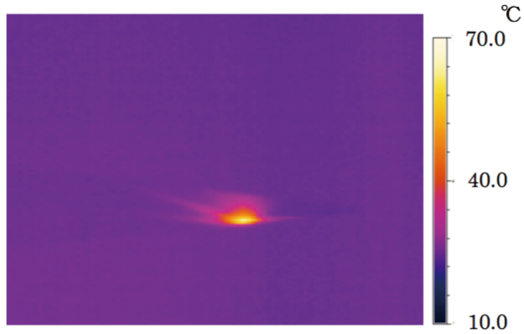

Fig. 2. Thermal image of the beam dump with 8.3 kW ^{48}Ca beam irradiation.

ANSYS[4] simulation for this condition shows that the spot temperature is 170°C and the temperature at TC is 46°C. Both temperatures are higher than the observed ones. The observed temperatures can be reproduced by modifying the beam size to 30 mm (X) and 22 mm (Y) and shifting the center of the beam 0.6 mm downward (this corresponds to 6 mm shift on the dump surface). The observed spot size is also reproduced by the modification.

References

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