Temperature measurements of the high power beam dump of the BigRIPS separator

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The high-power beam dump[1,2] that stops intense primary beams from the super-conducting cyclotron SRC is one of the crucial devices of the BigRIPS fragment separator. The beam dump consists of the side dump and the exit dump. The two exit beam dumps, for an intense ^{238}U beam and for the other beams, were designed to handle various ion beams with intensities up to 1 pμA.[2] Two exit dumps had the same structure except for the distance from the dump surface and the cooling channel; 1 mm for ^{238}U and 3 mm for the other. The latter exit beam dump and the side dump were constructed in 2007. Since then, it has been successfully operated with various beams including a ^{238}U beam although the available beam intensity was low. The design of the beam dumps was based on the sophisticated thermal model simulation[1,2] and its validity has not been verified because the available beam intensity was not so high. Recently the intense ^{48}Ca beam became available. As the first step of the evaluation of the cooling capacity of the beam dump, the temperature measurements of the exit beam dump were performed with the intense ^{48}Ca beam.

The inner-side exit beam dump[1,2] that was made by the Cu-Cr-Zr alloy and the M8 screw threads were formed as the cooling channels was irradiated by the ^{48}Ca beam with an energy of 345 MeV/n and intensity of 460 pnA. Cooled water with a temperature of 13 ℃, pressure of 1.0 MPa, and flow speed of 10 m/s were supplied to the dump as the coolant. Temperatures are measured by using a thermocouple (T. C.) mounted on the dump at 3 mm behind the dump surface. By changing the position of the dump, horizontal distribution of the temperature was measured against the beam spot. Various beam heat densities were obtained by tuning the first superconducting quadrupole triplet STQ1 located upstream of the dump. The spot sizes of the beam at the dump were estimated from the primary beam profile (size and angle) measured separately at the second focus F2 located at the downstream of the dump. The first order matrix of the ion optics of the BigRIPS separator was used for the estimation.

In Fig.1, the observed temperatures are shown for three different beam spot sizes, resulting in the different heat densities. The results of finite element calculations using the ANSYS code[3] are also shown in the figure. In the calculations, thermal conductivity was assumed to be a constant at 375 W/mK. The heat transfer coefficient of the cooling channel was also assumed to be 90 - 130 kW/m^{2}K for wall temperatures of 15 - 180℃, which corresponded to three times larger values of that of smooth tube with same diameter (ϕ8).[4] The heat transfer coefficient of the smooth tube was calculated with the JAERI formula.[5] As seen in the lower panels of Fig. 1, a good agreement was obtained between the results of the thermal model simulation and the observed temperatures. It suggests that the estimation of the cooling capacity of the beam dump is reasonable since similar model calculations were made in the estimation.

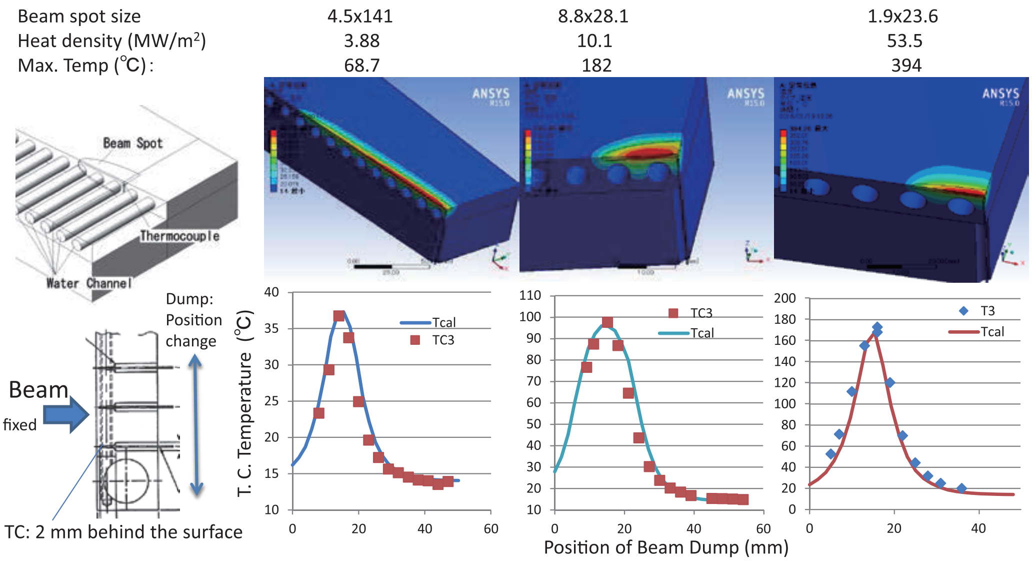

Fig.1 Beam dump temperatures for various beam sizes. Dots are measured values and lines and 2D figures are the results of the ANSYS calculations.

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References
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