He gas stripper with N_2 gas-jet curtain

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The present intensity of uranium beams injected into the first stripper is reaching $\sim 10^{13}$/s at the RIBF. This has given rise to various types of difficulties in the operation of He gas stripper. A small fraction of beam loss in the He gas stripper[1,2] causes serious hardware troubles or radioactivities. The qualities of beams injected to the He stripper become worse at high-intensity operations owing to the space charge effect in the RIKEN ring cyclotron (RRC) placed 7 m upstream of the He stripper. The diameter of the orifices in the He stripper must be enlarged for the efficient transmission of high-intensity beams. In contrast, a small leak of He gas to the RRC becomes a serious problem at high-intensity operations. The RRC has only 14 cryopumps with total pumping speed of 120 m^3/s for N_2. Owing to the small pumping capacity of He gas, the leaked He gas is accumulated in the RRC gradually. Collisions between U ions and He atoms in the RRC can easily change their charges and cause beam loss. For the acceleration of high-intensity uranium beams, such beam loss induces further losses by the local pressure rise due to the gas desorption (dynamic vacuum).

To solve these inevitable problems, we invented the N_2 gas-jet curtain method. By using curtain-like nitrogen gas-jet that separates two rooms (Fig. 1), we can block the helium flow to the low-pressure side and the leaked gas is exchanged to N_2 from He.

Based on the concept, we designed and developed the actual device to make the N_2 gas-jet curtain optimized with CFD calculations. The device was installed in the He stripper and tested. Figure 2 shows the demonstrated performance of the N_2 gas-jet curtain method. It is evident that the sealing abilities significantly increased. The gas that leaked downstream was successfully exchanged to nitrogen, as we desired. In addition, the N_2 gas-jet curtain worked as a pre-stripper. Initial stripping in N_2-jet curtain ($\sim$30 μg/cm^2) reduced the required pressure of He gas up to $\sim$15%.

By utilizing the gas-jet curtain, we enhanced the orifice diameters as shown in Fig. 3. The 4D acceptance of the system is 1.5 times higher than that of previous systems.

The improved system was applied in the user runs in 2017 and 2018. The output intensities were increased with more than 25% owing to the increasing transmission efficiencies (Fig. 4). No serious pressure rise in the RRC was observed. The N_2 gas-jet curtain method was greatly contributed to the enhanced output intensity (71 pnA at 345 MeV/nucleon) achieved in 2017.

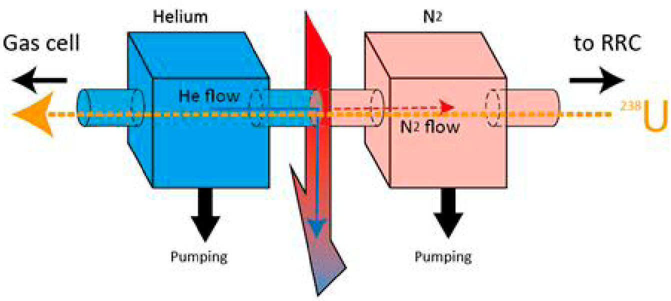

Fig. 1. Concept of N_2-jet curtain. The jet separates two rooms.

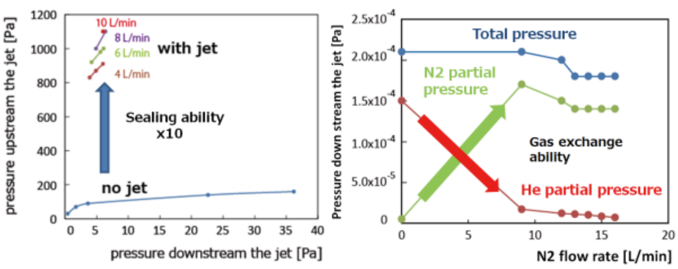

Fig. 2. Performance of N_2-jet curtain.

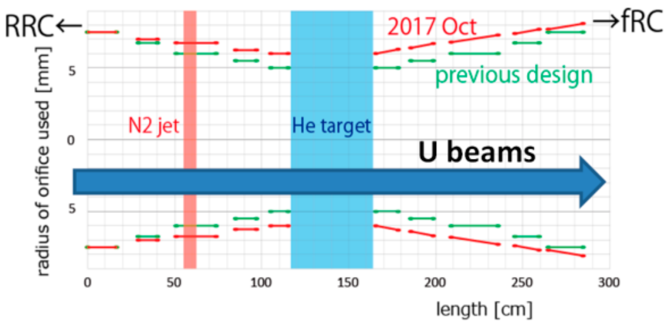

Fig. 3. Enlargement of diameters of tapered tube orifices.

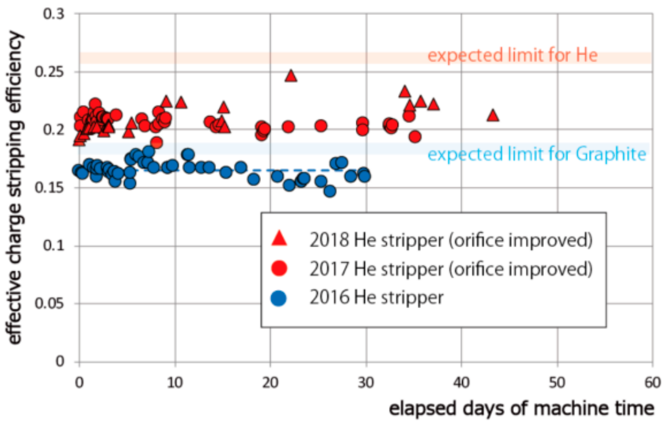

Fig. 4. Comparison of effective charge stripping efficiencies.

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References
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