Replacement of a 5000 L/s turbomolecular pump for RILAC

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RILAC has supplied the stable beams to the GARIS-III experiment, and will supply beam to Radio Isotope production experiments or RRC as an injector in the future.[1)] However, it is facing serious issues related to aging with the requirement of frequent repairs for failures in components such as vacuum pumps and gauges. As part of our aging mitigation efforts, we have decided to replace the existing 5000 L/s water-cooled turbomolecular pump (TMP), which is installed in the normal-conducting cavity of RILAC, with a more cost-effective and compact, any-orientation type 2400 L/s TMP. This is adopted due to the following two reasons. First, the 5000 L/s TMP plays a crucial role in RILAC and RRC. However, due to their high cost and extended delivery times, the availability of spares are limited, leading to the potential risk of long downtimes. Second, the 5000 L/s TMP is not any-orientation type; therefore, it requires an L-shaped tube, leading to a reduction in the exhaust efficiency. Based on simple calculations, connecting the original 5000 L/s TMP results in an estimated distance of approximately 1.1 m from the tank duct to the turbo pump inlet, with a predicted exhaust capacity of 1950 L/s. By contrast, connecting the 2400 L/s TMP directly to the duct reduces the distance to approximately 0.55 m, resulting in an estimated exhaust capacity of 1550 L/s, maintaining 80% of the current performance.

In August 2023, the butterfly valve, L-shaped duct, and 5000 L/s TMP on RILAC tank ♯4 were replaced with a gate valve and 2400 L/s TMP as a first trial (See Fig. 1). First, we confirmed the vacuum levels after pressure is instantly increased. The pressure changes following cryopump regeneration are depicted in Fig. 2 with data in 2022 before TMP replacement for comparison. In these data, the rapid decline in vacuum levels corresponds to the timing of activating the cryopump. The exhaust speed of the 2400 L/s TMP is slightly faster than that with the 5000 L/s TMP, though it is known that this speed is strongly dependent on the duration for which these tanks are exposed to the atmosphere before pump activation. Concerning the attained vacuum levels solely utilizing TMPs, the vacuum level achieved with the 2400 L/s TMP, 5.5×10^{-5}, is approximately equal to that with the 5000 L/s TMP, 5.2×10^{-5} Pa. Upon cryopump activation, the vacuum levels reached 1.2×10^{-5} Pa both before and after the replacement of the TMP. We also examined the changes in vacuum levels during the regeneration of the cryopump after several months of operation. This was conducted to verify if the decrease in the exhaust capacity had increased the load on the cryopump.

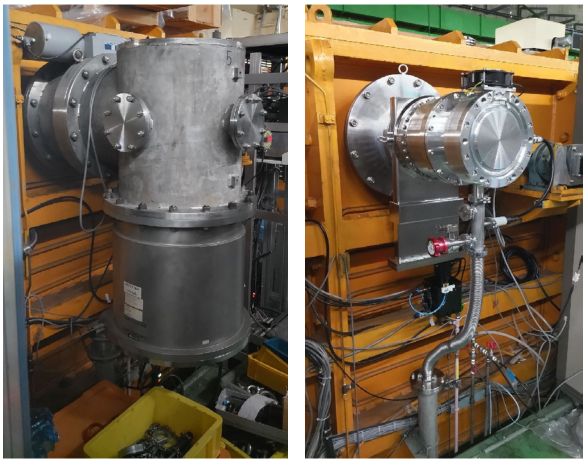

Fig. 1. Photograph of the 5000 L/s TMP (left) and the 2400 L/s TMP (right) attached to tank ♯2 and ♯4.

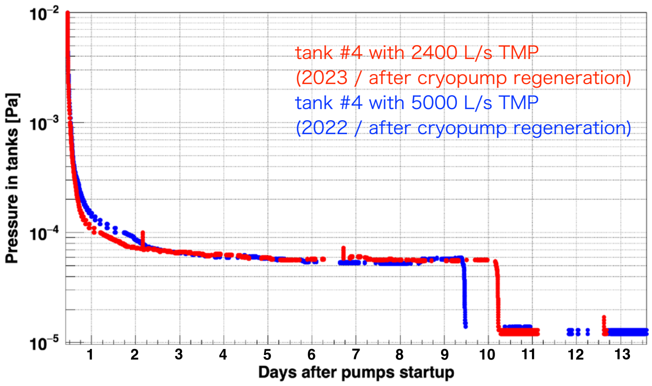

Fig. 2. Vacuum levels after starting the vacuum pump with the 2400 L/s TMP (red) and the 5000 L/s TMP (blue).

We compared the vacuum level in regeneration between tank ♯4 and other tanks, in which 5000 L/s TMPs are still utilized. No significant difference was observed in the increase in vacuum levels corresponding to He, N_2, and H_2O between tank ♯4 and other tanks.

Consequently, we succeeded in replacing of the TMP for the normal-conducting tank in RILAC with a smaller TMP while maintaining its performance. Additionally, the replacement improved accessibility around the pump and enhanced maintenance capabilities for the tank. We plan to replace TMPs attached to other tanks in the future.

Reference

1) A. Yusa *et al.*, in this report.

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