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Performance degradation of helium refrigerator for cryogenic hydrogen system at J-PARC

At the 1-MW spallation neutron source of Japan Proton Accelerator Research Complex (J-PARC), a cryogenic hydrogen system including a helium refrigerator has been in operation to generate a liquid-hydrogen-circulation flow (20 K, 1.4 MPaG, 185 g/s) as a cold-neutron-moderator. The helium refrigerator has a refrigeration power of 6 kW at 17 K under an operating pressure of 1.5 MPaG and a flow rate of 270 g/s.
Since January 2015, a pressure drop gradually increased between heat exchangers and an adsorber (ADS) in the helium refrigerator, forcing us to stop the operation in 2016 because its cooling performance was degraded. To investigate the cause of the performance degradation, impurities accumulated in helium gas was measured with some devices such as a gas chromatography and a quadrat mass spectrometer. However, no significant amount of impurities was observed. It was also measured that the oil contamination at outlet of the oil separator was around 10 ppb, which was design value. By cleaning inside of the heat exchangers and replacing ADS with new one, the refrigerator performance could be restored. The amount of oil extracted through the cleaning was c.a. 150 g, that is equal to the amount estimated after the operating period of 18,000 h with an oil contamination rate of 10 ppb. As a result of dismantling the replaced ADS, we found that oil was locally accumulated in membranous form onto the felt at the helium entrance side. This might cause the pressure drop because the frozen oil during cooling down obstructed helium flow. The felt is generally used for retaining the active charcoal inside ADS. However it played a role of an oil filter in this case. This phenomenon was confirmed by an elementary test using cold nitrogen gas flow, too. There are still some doubtful relation between the pressure drop and the performance degradation at the heat exchanger. Actually, the pressure drop at the ADS was c.a. 7-8 times of magnitude higher than that at the heat exchangers. However, it would be too early to conclude that large pressure drop at the ADS deteriorates the performance of heat exchanger. We are still making effort to investigate the cause.

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