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Improvement of the operational settings of a helium purifier, leading to a higher purity of the recovered gas

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Abstract

The internal purifier operating conditions of commercially available helium liquefiers are determined by adjusting the cold end temperature, the cold flow, the regeneration completion temperature and the heater temperature. By changing the cold end temperature of the internal purifier from 32.5 K to 22 K, it was possible to improve the purity of the helium gas recovered from the purifier from 33.5 to 99%. The current internal purifier regeneration operation settings are as follows: cold end temperature 22 K, cold flow rate 180 ℓ/min, and regeneration completion temperature 145 K. This paper describes how the internal purifier system of a helium liquefier was improved.

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Keywords: internal purifier; cold end temperaturer; purity meter

1. Introduction

In recent years, several universities that renewed their helium liquefier system have reported that solid hydrogen was mixed with the liquid helium produced by a helium liquefier [1-3]. The University of Tsukuba has also installed a Linde L280 helium liquefier system in October 2010. Similar to other universities, cases where the helium flow of cryogenic equipment with flow impedance (equipment to control temperature while limiting the flow of helium by a filter and capillary) was blocked began to be reported around March 2012. In this paper we focused on the internal

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purifier of the helium liquefier for the problem where solid hydrogen is mixed in the liquid helium produced by a helium liquefier.

We adopted a new method to monitor the purity of the gas recovered from the internal purifier with a simple helium gas purity meter. This enabled us to improve the purity of the recovered gas from 33 to 99 % by changing the cold end temperature of the purifier from 32.5 to 22 K. From this, we have found that it is possible to reliably determine the internal purifier operating conditions, which are the solution to the problem where solid hydrogen is mixed, and this is reported below.

2. Internal purifier of helium liquefier

Normally, the internal purifier operating mode of a helium liquefier starts purification by going through the processes of purge, cool down 1, standby, and cool down 2 and then performs regeneration and goes into purge mode once again. As shown in the internal purifier flow diagram [4] in Fig. 1, the internal purifier operating condition of a helium liquefier is determined by adjusting the cold end temperature TI3475, cold flow F3410, regeneration completion temperature TI3465, and heater control output R3470.

When helium flow blockage occurred in the cryogenic equipment with flow impedance owned by the University of Tsukuba, the operating conditions were set to cold end temperature TI3475=32.5 K, cold flow F3410=120 ℓ/min, regeneration completion temperature TI3465=140 K, and heater control output R3470=18%. Therefore, we considered monitoring the recovery purity of the recovered gas during regeneration operation under these conditions.

We attached a Pirani type simple purity meter at the part shown as a small square in the helium gas recovery line in the internal purifier flow in Fig. 1 and monitored the purity of the helium gas recovered from the internal purifier. The result showed that the purity of the recovered gas has dropped down to 33.7% under the set purification condition. This means that when purification is continued under this condition, impure recovery gas keeps accumulating in the recovered gas curdle without being removed. Thus impurity separation which is a normal purification operation is not performed.

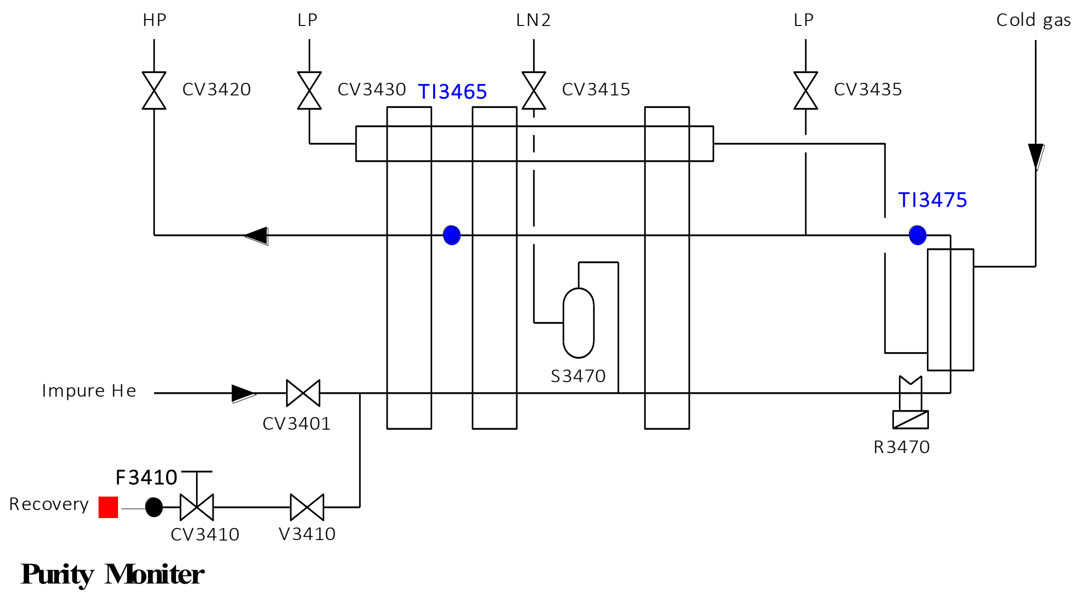

Fig. 1. Internal purifier flow for Linde L280 system.

Therefore, we initially changed the cold flow F3410 from 120 ℓ/min to 180 ℓ/min and monitored the purity of the recovered gas during regeneration without changing any other settings in order to improve the recovered gas purity during regeneration of the internal purifier. As a result, the recovered gas purity during regeneration improved from 33.7 to 65.0%. Thereafter, the recovered gas purity during regeneration did not improve even when the cold flow F3410 was increased. Next, we monitored the recovered gas purity during regeneration by fixing the cold flow F3410 to 180 ℓ /min and changing the cold end temperature TI3475. The result is shown in Fig. 2.

From this result, we were able to improve the recovered gas purity during regeneration from 33.5 to 99% by changing the cold end temperature TI3475 of the internal purifier from 32.5 to 22 K. Ultimately, the settings were set to cold end temperature TI3475=22.0 K, cold flow F3410=180 ℓ/min, regeneration complete temperature TI3465=145 K, and heater control output R3470=24%. In other words, by decreasing the original cold end temperature TI3475 by 10.5 K, we succeeded in improving the recovered purity during regeneration by 65.5% from the initial recovered purity.

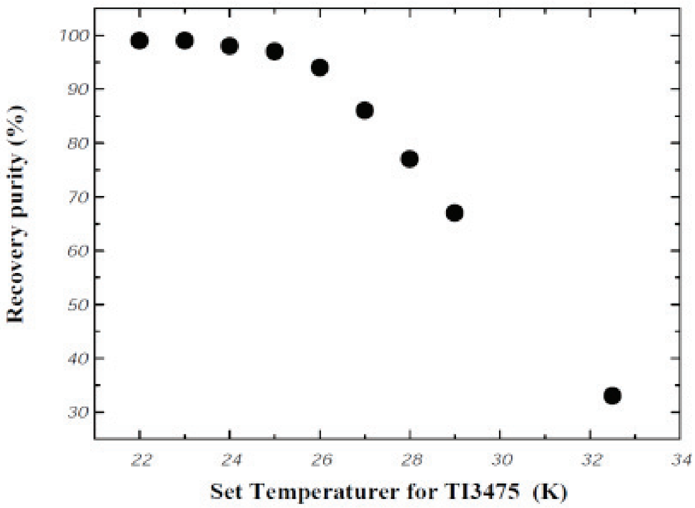

Fig. 2. Monitored the recovered gas purity during regeneration by fixing the cold flow F3410 to 180 ℓ /min and changing the cold end temperature TI3475.

This method to monitor the recovered gas purity with a simple purity meter can be considered to be the best method to accurately determine the operating condition of the internal purifier.

3. Gas chromatograph mass spectrometer impurity analysis

Since the operating condition of the internal purifier was improved by adjusting the cold end temperature TI3475, cold flow F3410, regeneration complete temperature TI3465 and heater control output R3470, we performed an impurity analysis inside the helium liquefier with a gas chromatograph mass spectrometer. Fig. 3 shows the cold end temperature TI3475 and the liquefier system internal high-pressure system gas analysis values three days after stopping the liquefier. From this result, it was confirmed that the impurity peak value decreases as the cold end temperature TI3475 decreases as shown from the result of the gas chromatograph analysis of the liquefier system internal high-pressure side gas.

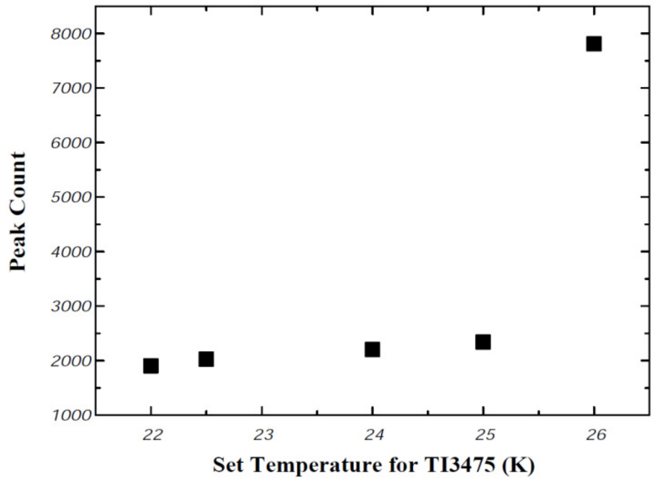

Fig. 3. Gas chromatograph mass spectrometer impurity analysis of helium liquefaction machine.

4. Conclusion

The purifier operating conditions of commercially available helium liquefiers are determined by adjusting the cold end temperature, the cold flow, the regeneration completion temperature and the heater temperature. As a new method to determine the purifier operating conditions, we monitored the purity of the gas recovered from the purifier and succeeded in improving the recovered gas purity during purifier regeneration operation from 33 to 99%. This enabled us to reliably determine the internal purifier operating conditions.

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