Heat Leak Measurement of Multilayer Insulation under different Wrapping Strength

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Abstract

One of the thermal insulation methods used for the cryogenic pipes which transport low temperature liquified gases is vacuum insulation using Multilayer Insulation (MLI). Since the thermal insulation performance of MLI depends on the thermal contact resistance between its layers, the heat leak through MLI can be affected by the wrapping strength. In fact, the heat leak variation has been observed experimentally by changing wrapping methods. Omori reported an analytical formula for contact pressure between layers in a self-compression of the MLI films which are wrapped over a horizontal cylinder without any external forces except for gravity. We investigated the effect of the wrapping strength to the heat leak by using a horizontal boil-off calorimeter, which simulates cryogenic pipes installed in horizontal configurations, and compared the result with the formula presented by Omori.

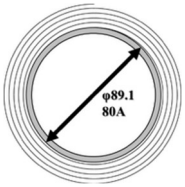

Figure 1 A Schematic Diagram of Swiss Roll Type Method

In the experiment, seven layers of MLI were wrapped around the inner tank of the calorimeter using Swiss roll type method, in which a single film of MLI was wrapped continuously from the innermost layer to the outermost layer as shown in Figure 1. The heat leak was measured by changing the circumferential length of the innermost layer. Each successive outer layer was made 1 mm longer than the previous layer. Obtained results were sorted by a non-dimensional excess circumference parameter $S_e^* = S/2\pi r - 1$, where S is the circumferential length of an MLI film and r is the inner tank radius, and compared with the non-dimensional contact pressure parameter presented by Omori. At the outer vessel temperature of 30℃, the heat leak per 1 m of the inner tank was measured to be 0.73 W at $S_e^* = 3.9 \times 10^{-4}$, and 0.44 W at $S_e^* = 3.6 \times 10^{-2}$.

References

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