§7. Cryogenic Seal with Metal Gasket

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Gaseous helium (GHe) sealing at a cryogenic environment is an important issue for laser fusion experiments because solid fuel targets are cooled by GHe. It must be bolt-free sealing system because of an experimental requirement. Its design has to be strong enough to keep GHe leak tightness with a low heat load. One solution would be metal gasket seal. To incorporate stable sealing performance within a cryogenic system for laser fusion experiments, not the optimum but a required load to keep He leak tightness is substantial for the system design. We designed and constructed a preliminary seal and loading system for cryogenic use. The required load on a metal gasket is discussed.

Metal gaskets possess stable seal performance when an industrial product is manufactured to high tolerances. Fig. 1 represents an example of a metal gasket. It consists of a spring and jacket. The elasticity of the spring and the plasticity of the jacket make the metal gasket a high performance seal. Fig. 2 shows a characteristic curve. There is a hysteresis effect because of permanent deformation of the spring and jacket. The leak rate will have dropped below the required level when a load reaches F0 on the compression curve. Applications of the optimum compression load F2 are recommended according to instructions. Then decompressing the load below F1 results in the leak rate exceeding the required level again. The compression load between F0 and F2 would be a design point.

A metal gasket U-TIGHTSEAL® with an inner diameter of 81 mm and a height of 3.1mm (see Fig.1) is employed for our tests. We select an indium plated copper jacket gasket for cryogenic use. The indium coating must ensure He leak tightness. The announced optimum linear compression load is 110 N/mm along its circumference; requiring a total compression of 29.0 kN on the gasket. Highly rigid structures would be required to be proof against a load of this magnitude. To combine structural design with high cooling performance, a metal gasket should be used at a low compression load range. Its possibility is investigated.

Fig. 3 shows the diagram of He leak tests. The gasket was compressed in the range of 8.6 N/mm to 27 N/mm. GHe was filled in the GHe chamber at ~1 kPa. Its sealing performance was evaluated using a He leak detector (HELEN A-221M-LD, Anelva Corporation) which can measure a leak in the range of 10^{-5} to 10^{-12} Pa m^3/s. The threshold intrinsic He leak rate was decided to be 1.0 x 10^{-11} Pa m^3/s. The measurements were systematically conducted at room temperature and in a cryogenic environment (~7 K).

Despite the optimum compression linear load of 110 N/mm, the required load for cryogenic use is found to be 27 N/mm, and therefore high rigid structure is not demanded. Furthermore it possesses the potential for multi time use. High cooling performance would be combined with a metal gasket sealing system.

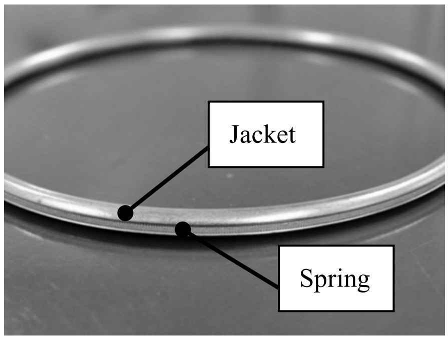

Fig. 1. Metal gasket, U-TIGHTSEAL® with an inner diameter of 81 mm and a height of 3.1mm. It is a gasket with an indium plated copper jacket.

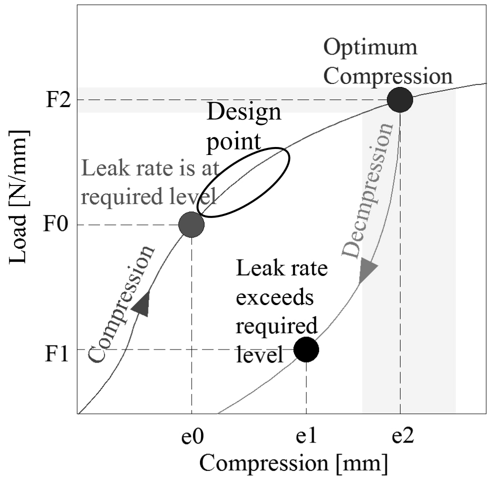

Fig. 2. A characteristic curve of metal gasket. After a cycle of compression and decompression, permanent deformation of a spring and jacket remains.

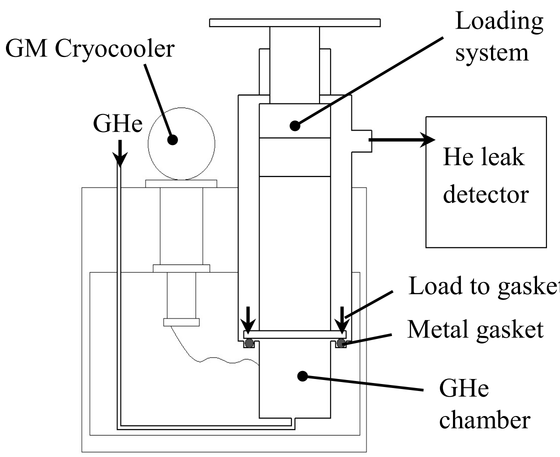

Fig. 3. Diagram of He leak test at room temperature and in a cryogenic environment.