Technology

# Vacuum sealing method by laser welding

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## 1. Introduction

Metal vacuum bottles have a double-wall structure consisting of inner and outer shells, and the space between them is kept in a vacuum state. Due to this structure, a high heat insulating effect is attained.

One of the most important manufacturing processes of vacuum bottles is vacuum sealing for creating a vacuum between the inner and outer shells. The existing vacuum sealing method evacuates a large number of products in a batch using a large vacuum chamber (Figure 1), so it is difficult to integrate the manufacturing process into the line or automate the process.

We have renewed the existing vacuum sealing method and developed a new one where the manufacturing process can be integrated into the line and the process can be automated. This paper reports on the developed vacuum sealing method.

## 2. Vacuum sealing method using laser welding

### 2.1 Existing vacuum sealing method

The flow of the existing vacuum sealing method is described below and shown in Figure 2.

1) Make a double-wall bottle with a vacuuming hole and put brazing material on the vacuuming hole.
   Place a getter in the space between the inner and outer shells of the double-wall bottle. The getter is activated when heated and then adsorbs residual or released gas to maintain the vacuum state of the vacuum bottle.
2) Put a batch of a large number of bottles in a large vacuum chamber to evacuate them.
   The space between the inner and outer shells is also evacuated through the vacuuming hole.
3) Apply heat to melt the brazing material for closing the vacuuming hole and to activate the getter.
4) Cool the bottles in the vacuum chamber to solidify the brazing material in order to keep the space between the inner and outer shells in a vacuum state. Then take the bottle out of the vacuum chamber to complete the vacuum sealing process.

Figure 1: Large vacuum chamber

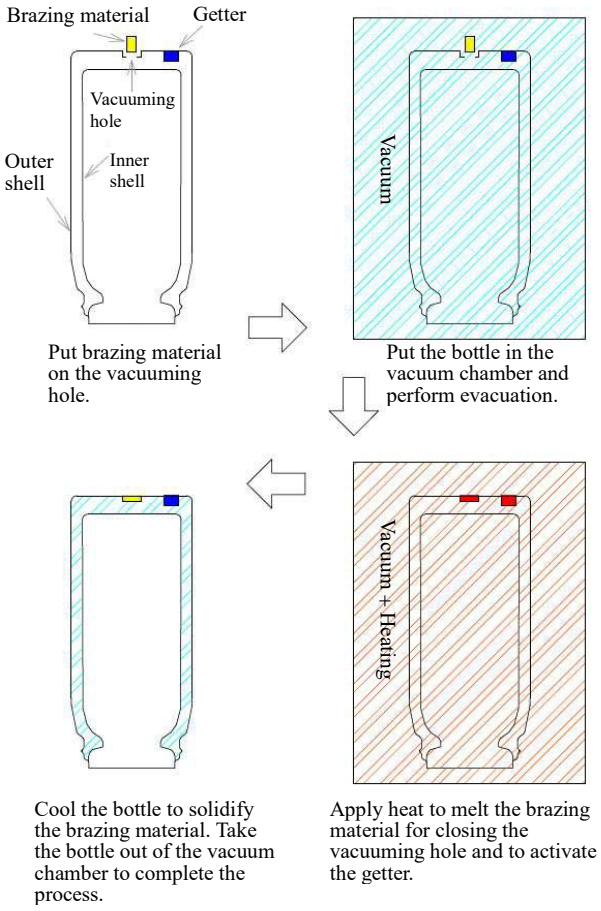


Figure 2: Existing vacuum sealing method

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The existing vacuum sealing method heats many products in a vacuum, so the processing time is long and the increase in the equipment size is inevitable, which makes it difficult to integrate the manufacturing process into the line or automate the process.

### 2.2 New vacuum sealing method

The flow of the new vacuum sealing method is described below and shown in Figure 3.

1) Make a double-wall bottle with a vacuuming hole having a shape that can be closed by laser welding in the later process.
2) Put the bottles one by one in a small vacuum chamber to evacuate them one by one. The space between the inner and outer shells is also evacuated through the vacuuming hole.
3) Apply laser light to the vacuuming hole to laser weld and close it in order to keep the space between the inner and outer shells in a vacuum state.
4) Take the bottle out of the vacuum chamber. Separately, apply heat locally to the getter to activate it. Now the vacuum sealing process is completed.

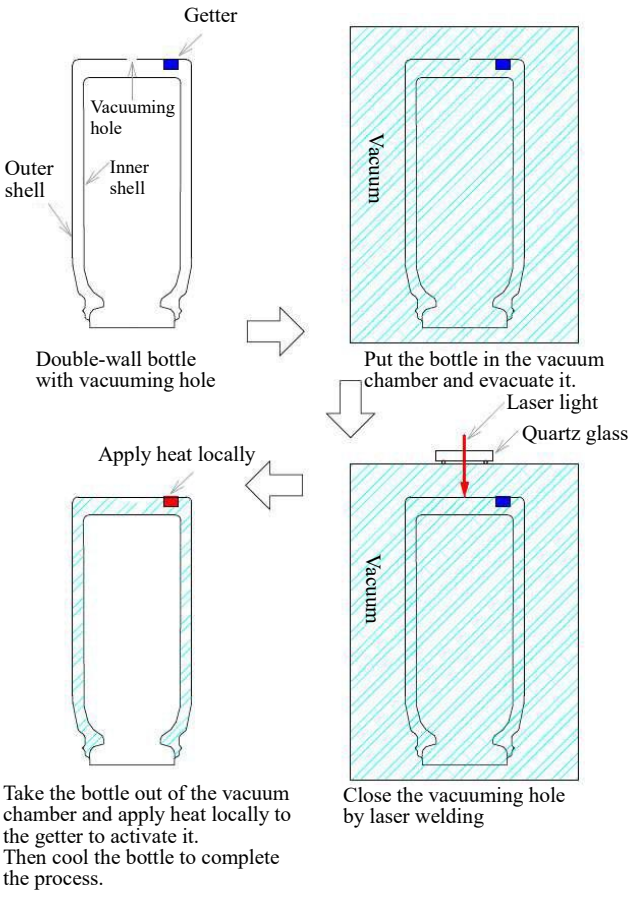


Figure 3: New vacuum sealing method

The new vacuum sealing method uses laser welding to close the vacuuming hole without using brazing material, and therefore does not require heating to melt the brazing material and the subsequent cooling in the vacuum chamber, so great reduction of the processing time is made possible. As a result, unlike the existing vacuum sealing method, bottles need not be vacuum sealed in a large-quantity batch and can be manufactured one by one. In addition, the equipment can be made smaller and its footprint decreases, which makes it easier to proceed with process integration into the line and process automation.

## 3. Side benefit of new vacuum sealing method

The new vacuum sealing method has many side benefits as follows.

### 3.1 Cost reduction

Since the new vacuum sealing method does not use brazing material, manufacturing costs can be reduced due to material saving, machine-hour saving, etc.

### 3.2 No need to develop brazing material optimal for product material

Blazing material used for vacuum sealing must have characteristics such as melting temperature, coefficient of thermal expansion, and wettability that are optimal for the outer shell material. Therefore, when developing a vacuum bottle using a new material, the brazing material needs to be newly developed as well. In addition, depending on the new brazing material to be used, it may lead to increase in the cost or need a special sealing method. By eliminating the use of brazing material, these problems are eliminated.

### 3.3 Weight reduction of products made of titanium material

We also manufacture vacuum bottles made of titanium material. The existing vacuum sealing method requires the use of brazing material that melts at 800°C, while titanium material is annealed at 600°C and becomes soft. Therefore, the wall thickness of the titanium vacuum bottle needs to be thicker than that of standard stainless steel vacuum bottles in order to secure strength, which causes the product not to fully utilize the inherent merit of titanium: lightness.

On the other hand, when the new vacuum sealing method is used, the bottle is subjected to heat load only in the getter activation process, and the process finishes without causing its body section to be exposed to high

temperature. As a result, annealing of the titanium material can be minimized and thin-wall, lightweight titanium bottles can be manufactured.

## 4. Conclusion

We would like to introduce Vacuum Insulated Titanium Bottle FJN-500T, our new product manufactured using the new vacuum sealing method and launched in October 2021. This product is a vacuum bottle that features lightweight and compact design as well as high corrosion resistance (Figure 4).

Vacuum bottles are manufactured through a variety of processes, including pressing, drawing, welding, vacuum sealing, and painting. We will continue to develop more optimal manufacturing methods, not permanently depending on the existing manufacturing methods.


FJN-500T
TGY: Titanium Gray

Figure 4: New product FJN-500T

Reference

1) Kenichi Miyaji, Development of Stainless Steel Vacuum Bottle (1989, Vol.32, No.12), pp.869-874.