Evaluation of the Compression methods on the Sealing Performance of Gland Packing

1. Introduction

The gland packing serves to seal the internal fluid by tightening the packing gland with bolts and compressing the gland packing. For this reason, it has been found that the sealing performance greatly depends on the compression pressure. However, the effect of the compression method is unknown. The compression method includes batch compression in which several rings are compressed at one time and divided compression in which compression is performed several times for every two or three rings. It is thought that the divided compression increases the density of the gland packing and improves the sealing performance, but the quantitative effect is not known. In addition, batch compression is generally used because it takes time for divided compression. In this study, the effect of the compression method on the sealing performance was evaluated along with the mechanical behavior such as stress relaxation using gland packing of different materials. In addition, the operation time required for each compression method was measured and evaluated from the viewpoint of sealing performance and operating efficiency.

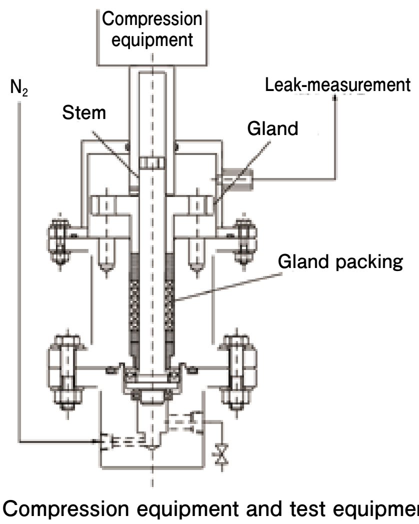

Figure1 Compression equipment and test equipment

2. Test method

2-1) Test equipment and test method

Figure1 shows a schematic diagram of the compression equipment. Using this test apparatus, the sealing performance by the compression method in the batch compression and the divided compression was compared. Furthermore, the sealing performance at the time of recompression, which has the same effect as retightening after batch compression or divided compression, was also measured. Three types of gland packing were used: carbon fiber gland packing (No. 6137), PTFE gland packing (No. 7233), and expanded graphite gland packing (No.VF-10T).

2-2) Test conditions

Compression pressure : 19.6MPa
Fluid : Nitrogen gas
Fluid pressure : 1, 5, 10 MPa
Gland packing ring number : 6 pcs

2-3) Test method

Four compression methods were used: batch compression, batch compression +recompression (hereinafter referred to as "batch +recompression"), divided compression, divided compression +recompression (hereinafter referred to as "divided +recompression"). After stress relaxation was stabilized, sealing tests were conducted.

Batch compression:

① Six gland packing rings are attached to the test equipment.
② After compressing the gland packing with compression equipment at 19.6 MPa for 30 seconds, fix the head position of the compression equipment.
③ Wait until stress relaxation stabilizes
④ Nitrogen gas (1, 5, 10 MPa) was used into the test equipment for leakage measurement
⑤ Exhaust nitrogen gas
⑥ Perform recompression (batch + recompression) under the same conditions as step ②
⑦ Carry out steps ③ to ④.

Divided compression:

① Two gland packing rings are attached to the test equipment.
② Release the compression equipment after compressing the gland packing with a compression equipment at 19.6 MPa for 30 seconds
③ ① to ② are repeated twice, a total of 6 pieces are mounted, and the head position of the compression equipment is fixed
④ Wait until stress relaxation stabilizes
⑤ Nitrogen gas (1, 5, 10 MPa) was used into the test equipment for leakage measurement
⑥ Exhaust nitrogen gas
⑦ Perform recompression (divided + recompression) under the same conditions as step ②
⑧ Carry out steps ④ to ⑤

3. Test Results and Discussion

3-1) Carbon fiber gland packing (No.6137)

Figure2 shows residual stresses after stress relaxation of carbon fiber gland packing (hereinafter, carbon fiber). The order of the lowest residual stress was as follows: batch compression < divided compression < batch +recompression < divided +recompression.

Figure3 shows the sealing test results after stress relaxation. The order of large amount of leakage was as follows: batch compression > divided compression > batch +recompression > divided +recompression. Since the leakage decreases with the compression method with high residual stress, it can be concluded that there is a correlation between residual stress and leakage.

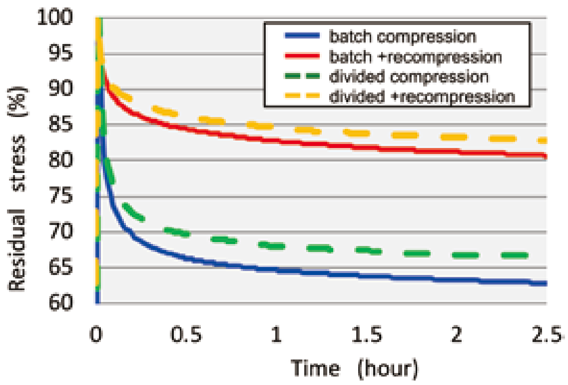

Figure2 Residual stresses of carbon fiber (No.6137)

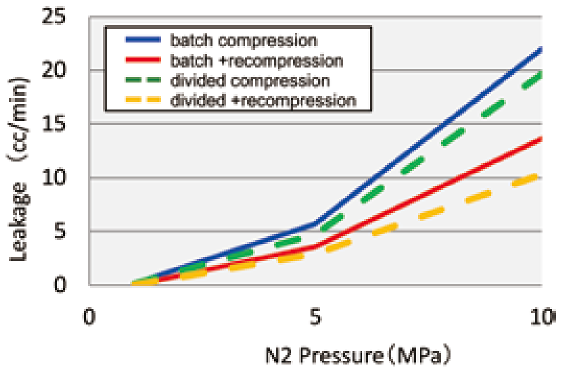

Figure3 Leakage of carbon fiber (No.6137)

3-2) PTFE gland packing (No.7233)

Figure4 shows the residual stress after stress relaxation of PTFE gland packing (hereinafter, PTFE) and Figure5 shows the sealing test results after stress relaxation. The residual stresses of batch compression and divided compression became almost the same, and batch +recompression and divided +recompression also became almost the same. However, the difference was found in each sealing performance.

This is because, as shown in Figure6, In the case of one-time compression , the number of times the compression is pressed against the sealing surface is small, and the gap between the sealing surface and the gland packing becomes large, so leakage increases but for divided compression, the gap between the gland packing and the sealing surface was filled by the three times compression, and the leakage was reduced.

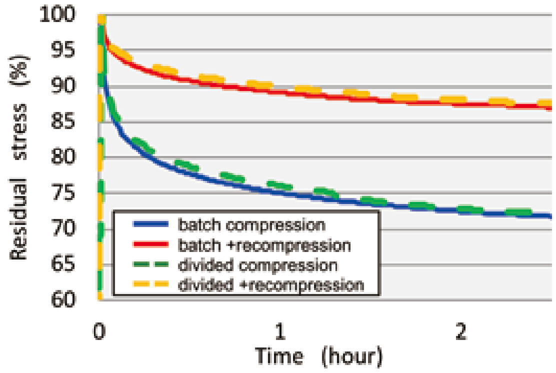

Figure4 Residual stress of PTFE (No.7233)

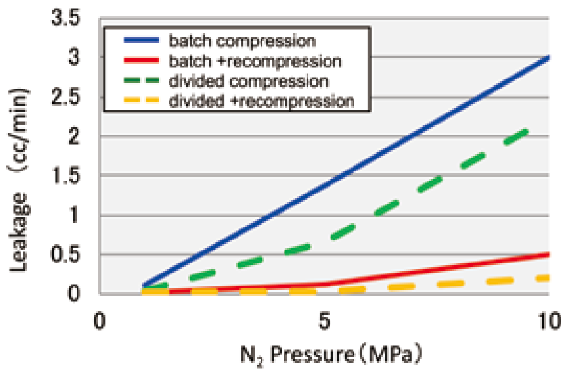

Figure5 Leakage of PTFE (No.7233)

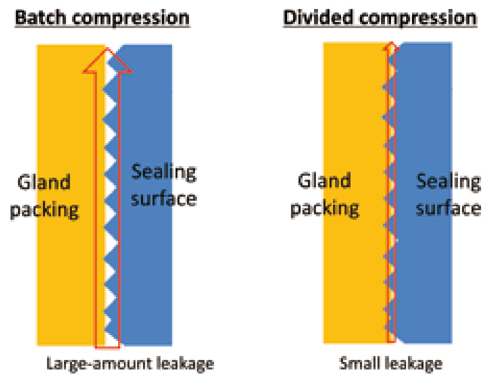

Figure6 Relationship between compression method and gap

3-3) Expanded graphite gland packing (No.VF-10T)

Figure7 shows the residual stresses after stress relaxation of the expanded graphite gland packing (hereinafter, expanded graphite). Expanded graphite originally had small voids and high density, so stress relaxation was small and the residual stress is as high as 95% or more in all compression methods, the difference between compression methods was also small. There was almost no difference in the residual stress between the compression methods, but there was a difference in the sealing performance.

Figure8 shows the sealing test results after stress relaxation. Carbon fiber and PTFE leaked less in batch + recompression than divided compression, whereas expanded graphite leaked less in divided compression than batch + recompression. In the case of the divided compression, the compression is released once to insert the next gland packing. Since the expanded graphite is obtained by pressing and solidifying the powder, it is difficult to recover even if the compression is released by divided compression, the leakage of divided compression is less likely to occur because deterioration of density and conformity of the sealing surface is smaller than batch +recompression.

Since the fibrous carbon fiber and PTFE are easily restored, it is considered that the density of the gland packing is reduced and the conformity to the sealing surface is easily deteriorated, and the effect of the split compression is considered to be smaller than that of the expanded graphite.

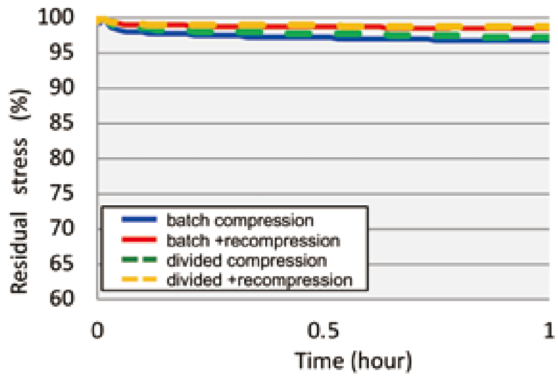

Figure7 Residual stresses of expanded graphite (No. VF-10T)

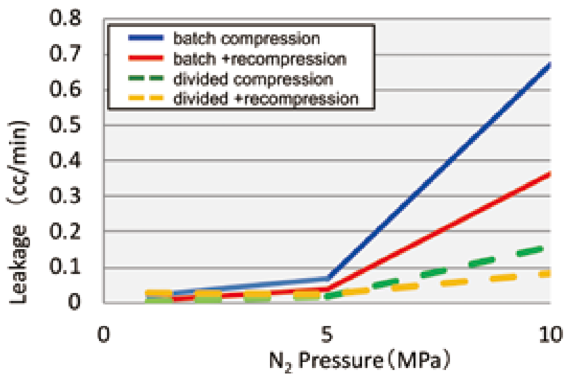

Figure8 Leakage of expanded graphite (No. VF-10T)

3-4) Effect of compression method for each packing type

Figure9 shows a graph comparing the effects of the compression method for each packing material. The vertical axis of the graph represents the rate of change of the leakage of the other compression methods when the leakage of the batch compression of the blue bar is 100%. Divided+recompression was the least leaking compression method for all types of packing.

Comparing batch +recompression and divided +recompression, the difference in carbon-fiber and PTFE leakage was 10-14% and the difference due to compression methods was small. On the other hand, the difference in leakage of expanded graphite was 43%, and the difference by the compression method became large. As described in 3-3) , carbon fiber and PTFE are fibrous and easily recovered, whereas expanded graphite is hard to recover because it is manufactured by solidifying powder. As a result, it is unlikely that the density is reduced and the conformity to the sealing surface is not easily deteriorated. Therefore, it is considered that the effect of the divided compression is remarkably obtained in the expanded graphite.

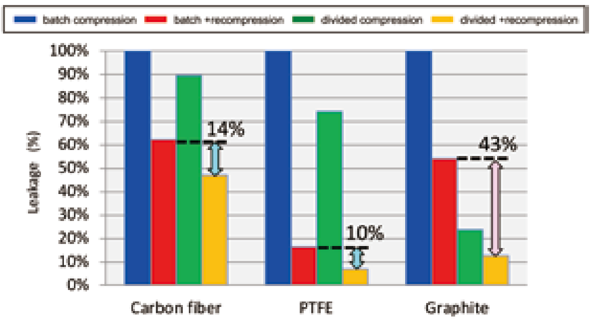

Figure9　Differences in leakage amount due to compression methods

3-5)　Operation time for each compression method

Figure 10 shows the operation time for each compression method. The time required for the divided + recompression was 3.6 times that of the batch + recompression. Performing divided + recompression with carbon fiber and PTFE with a 10-14% difference in leakage is considered to be inefficient.

Divided + recompression with expanded graphite showed 43% better sealing performance than batch + recompression. Division + recompression took 3.6 times operation time than batch + recompression, so it is recommended for applications requiring high sealing performance.

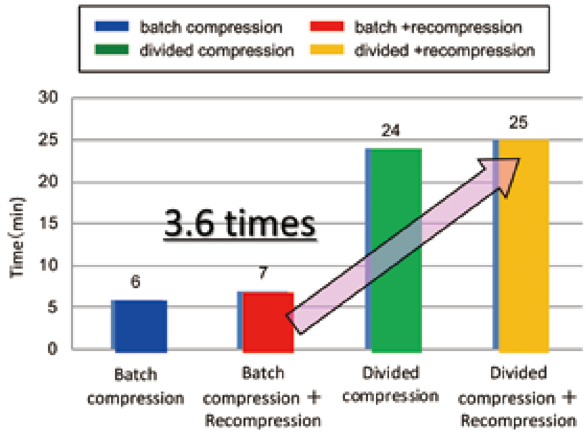

Figure10　Operational　time　of　compression　methods

4. Conclusion

This study was able to evaluate the relationship between sealing performance and operation time due to differences in compression methods. Under the present test conditions, in the case of carbon fiber and PTFE, since there was no significant difference in the leakage of batch + recompression and divided + recompression, it is recommended to perform additional tightening after batch tightening from the viewpoint of operational efficiency. In the case of expanded graphite, if the operational efficiency is prioritized, perform retightening after batch tightening, and if prioritizing sealing performance, use retightening after divided tightening. It has been observed that the desired effect can be selected by using an appropriate compression method.

It takes a lot of time to attach and detach the gland packing and to tighten it in the plant site. We hope that this study will help improve the tightening efficiency of the gland packing.

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