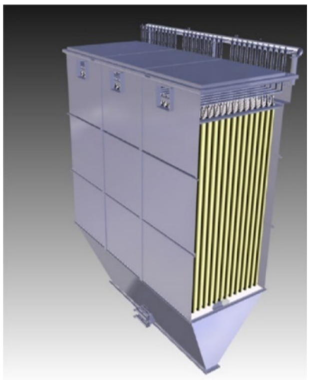
Commercialization of Hybrid Bag Filter® (HBF) Made of Polytetrafluoroethylene (PTFE) with Capability of Decomposing Dioxins and Reducing Environmental Impact



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Ahead of their competitors, Mitsubishi Heavy Industries, Ltd. (MHI) and MHI Environmental & Chemical Engineering Co., Ltd. (MHIEC) have developed and made commercially available a V-Ti catalyst-supported bag filter called the Hybrid Bag Filter® (HBF). HBF simultaneously enables, desalination, desulfurization, dust removal, denitrification and removal of dioxins (DXNs) (by means of filtration, adsorption, and catalytic decomposition)[(1)-(6)]. Recently, we have succeeded in developing the filter cloth base material of HBF from conventional glass fiber to polytetrafluoroethylene (PTFE), and verified the high level of performance when used in an actual unit.

1. Introduction

Although the filter cloth to support the catalyst is conventionally made of glass fiber, the durability is expected to improve if PTFE, which has superior chemical stability and wear resistance, can be used instead. However, because of its strong water repellency, PTFE has difficulty in supporting the catalyst on the filter cloth with the conventional catalyst slurry coating technology.

MHI has successfully developed an original technology to support the catalyst on PTFE filter cloth. The HBF made of this PTFE filter cloth was then applied in an actual unit. The results, which indicate its high level of operational performance, are presented in this report.

2. Hybrid Bag Filter® (HBF)

In HBF, the filter fabric is coated with the catalyst using our original technology. While retaining the capability to remove harmful substances generally expected in waste incinerator applications, our HBF, which is a highly functional filter cloth, further removes gaseous DXNs and decomposes NOx (denitrification). **Figure 1** gives a microscopic view of HBF, while **Figure 2** is a conceptual diagram of its functions. HBF's conditions and manufacturing method are adjusted depending on the required performance of flue gas treatment, thus making it possible to use different types of HBF accordingly, that is, either one dedicated to removing DXNs or the other that also has denitrification capabilities.

This report focuses on the type of HBF used for DXNs removal only. The applications of this type of HBF have been increasing in recent years.

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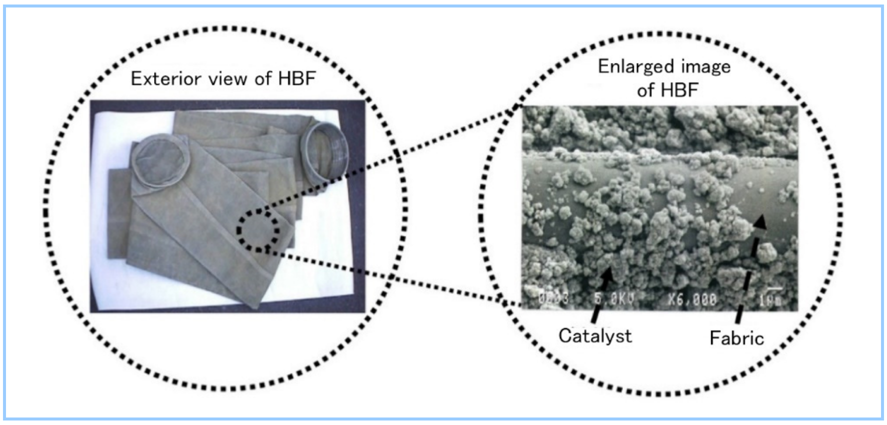

Figure 1 Microscopic view of HBF

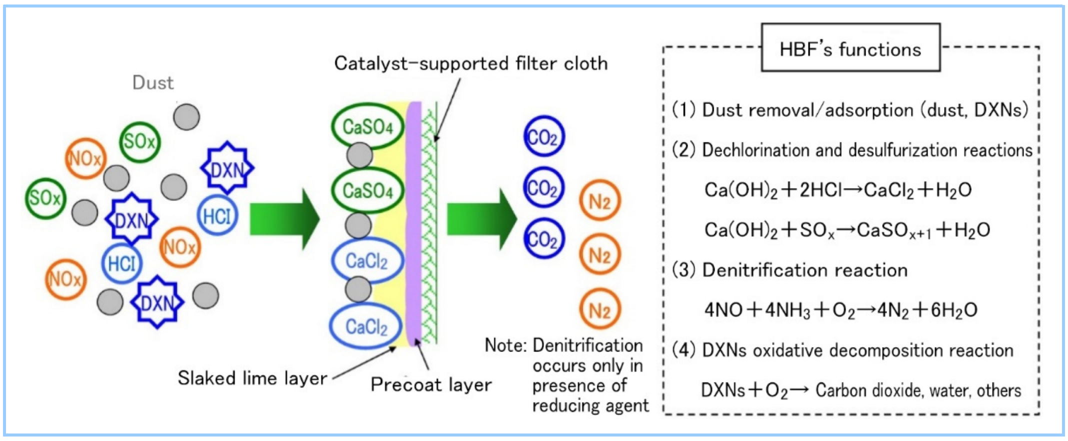

Figure 2 Conceptual diagram of HBF

3. Background to development and performance assessment

3.1 Advantages of PTFE as filter cloth over glass fiber

As for the filter cloth of bag filters generally used in waste incinerators, glass fiber has been mostly used so far. However, the applications of PTFE have been increasing in recent years. This in part is attributed to their differences in strength. **Figure 3** shows the test results of tensile strength over time for both PTFE and glass fiber filter cloths in an actual unit. When comparing their residual rates of tensile strength, PTFE is superior to glass fiber. We therefore took up the challenge to make it possible for this superior durability of PTFE filter cloth to be utilized fully in the HBF application as well, and started developing an HBF made of PTFE.

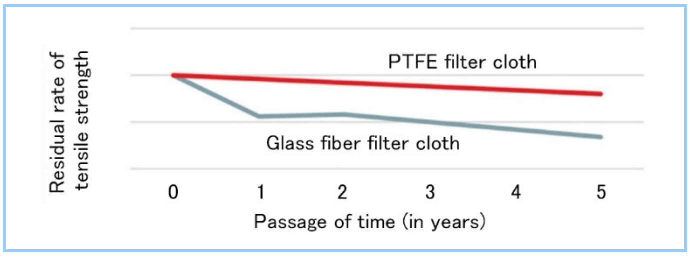

Figure 3 Residual rates of tensile strength of filter cloths used in actual unit

3.2 Challenge of supporting catalyst on PTFE filter cloth

In the case of glass fiber HBF, a catalyst slurry prepared in water medium is applied. However, as PTFE is strongly water repellent, this application method cannot achieve adequate penetration of the slurry into the PTFE filter cloth, making it impossible for a sufficient amount of catalyst to be supported uniformly on the cloth.

3.3 Our solution to problem

Since the affinity with the filter cloth needs to be improved for the successful application of catalyst slurry onto the strongly water-repellent PTFE, our approach focuses on the contact angle of catalyst slurry (**Figure 4**). As the conventional catalyst slurry is water-based, its application onto the filter cloth is not good enough to allow the slurry to penetrate into the cloth, and instead results in the formation of aggregates on the surface of the cloth. Therefore, uniform supporting of a sufficient amount of catalyst is impossible.

However, we found out that the contact angle of catalyst slurry can be controlled by adding a surfactant to the slurry. As shown in **Figure 5**, the contact angle can be considerably reduced in this way. When this catalyst slurry is applied, the catalyst can penetrate about five times deeper than the conventional one (**Figure 6**).

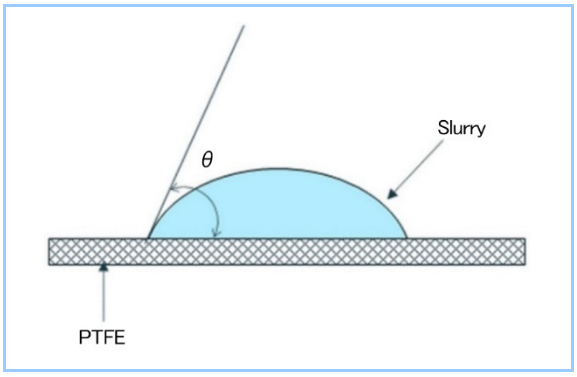

Figure 4 Conceptual diagram of contact angle

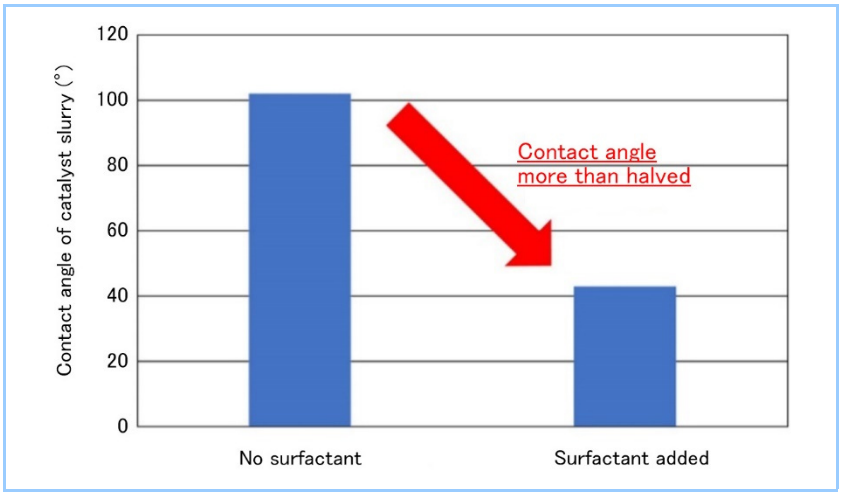

Figure 5 Relationship between surfactant concentration and contact angle of catalyst slurry

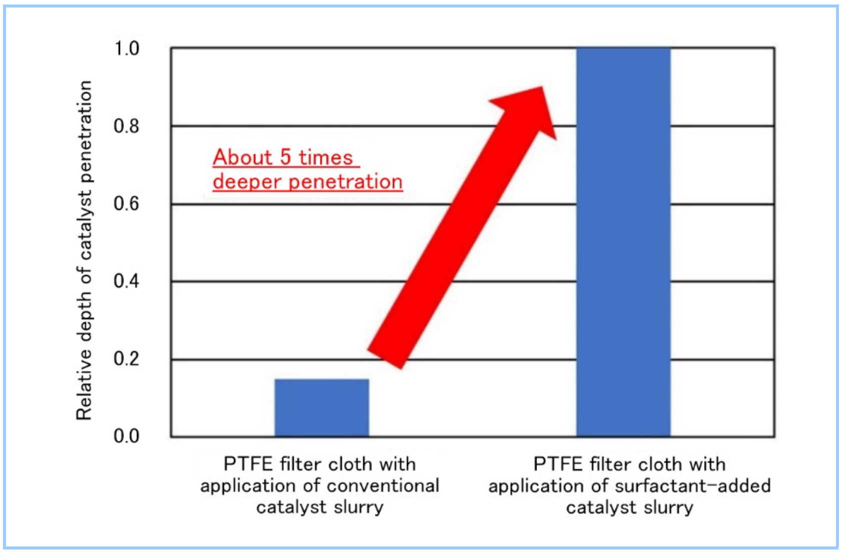

Figure 6 Depths of catalyst penetration into HBFs produced with two catalyst supporting methods: newly developed and conventional

3.4 Performance assessment method for HBF made of PTFE

The prototyped PTFE HBF was assessed in terms of differential pressure, denitrification rate. In this assessment, various data on performance were obtained by passing a gas that simulates the waste incinerator flue gas through a portion of the PTFE HBF filter cloth.

3.5 Performance assessment test results and interpretation

Given in **Figure 7** are the assessment results of differential pressure and denitrification rate.

According to the differential pressure results, a 48% reduction can be achieved by PTFE HBF when compared with the previous model (i.e., glass fiber HBF).

PTFE HBF can improve the denitrification rate by 53% from the level of the previous model.

As described above, all the obtained results indicate that the superiority of the new model over the previous one. In this test, the denitrification rate has been assessed, although the new model is intended for use to remove DXNs in actual operations. This is because it is not possible to measure the DXNs removal rate with the use of simulated gas.

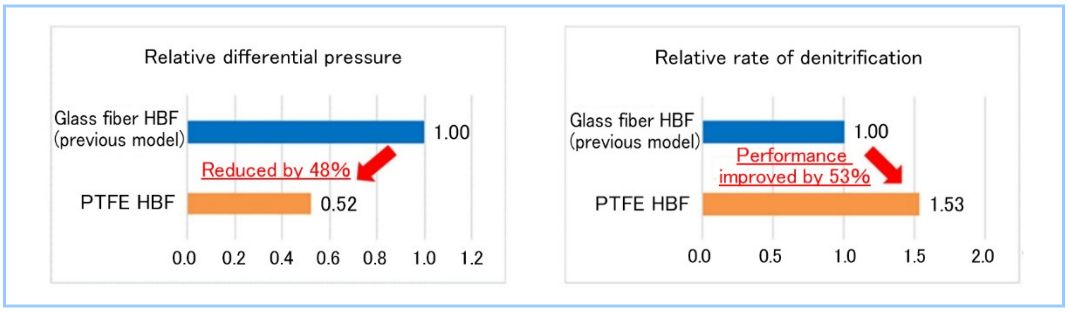

Figure 7 Simulated gas test results of differential pressure, denitrification rate, and rate of catalysts detaching

4. Actual unit applications and status of their operations

4.1 Plants with the use of PTFE HBF

We mass-produced PTFE HBFs and applied them to domestic plant A (a general waste incinerator with the treatment capacity of 75 t/24 h), and overseas plant B (a general waste incinerator with the treatment capacity of 1,050 t/24 h). The DXNs removal performance and temporal changes in differential pressure were assessed.

4.2 DXNs removal performance

Table 1 gives the DXNs removal rate results obtained by simultaneously measuring at the inlet and outlet of the bag filter of domestic plant A. Both particulate and gaseous DXNs were analyzed. The results show that the removal rate of either DXN type is 99% or higher, confirming the excellent removal performance.

Table 1 Removal rates of particulate and gaseous DXNs at plant A

Place of measurement	Unit of measurement	Particulate DXNs	Gaseous DXNs	Total
Bag filter inlet	[ng-TEQ/Nm^3]	0.79	1.1	1.89
Bag filter outlet	[ng-TEQ/Nm^3]	0.00038	0.0027	0.00308
Removal rate	[%]	99.95	99.75	99.84

4.3 Temporal changes in differential pressure

(1) Changes in differential pressure at domestic plant A

Figure 8 is a chart in which the differential pressure is plotted against time for the previous model and the PTFE HBF. The data were measured for 140 days after the start of operation using the differential pressure gauge installed at the inlet/outlet of the bag filter of domestic plant A. Apart from the temporary shutdowns of the incinerator, the PTFE HBF can operate in a stable manner at differential pressures that are about 20% lower than the previous model on average.

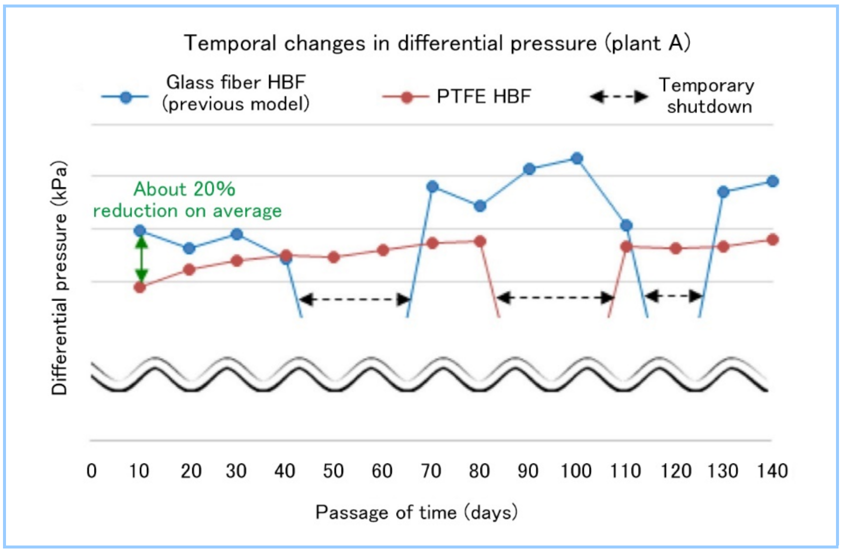

Figure 8　Temporal changes in differential pressure (domestic plant A)

(2)　Changes in differential pressure at overseas plant B

Likewise, plotted on the chart in **Figure 9** are the differential pressure changes with time regarding the previous model and the PTFE HBF. The data were measured for almost 80 days after the start of operation using the differential pressure gauge installed at the inlet/outlet of the bag filter of overseas plant B. When compared with the previous model, the PTFE HBF can operate in a stable manner at differential pressures that are about 33% lower on average.

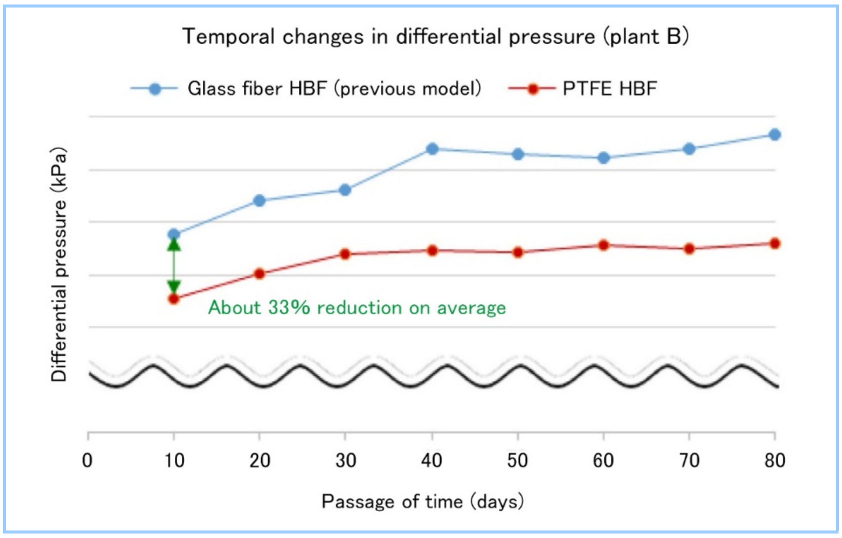

Figure 9　Temporal changes in differential pressure (overseas plant B)

As described in (1) and (2), the use of PTFE HBF in actual units also produced better results in terms of differential pressure, which allows backwash to be performed less frequently, while maintaining the backwash air pressure lower than the previous model. This in turn causes less friction between the HBF and the metal part of the retainer, when the passage of gas is resumed after backwash. The wear of HBF can thus be minimized. Higher durability can therefore be expected.

5. Effects of running cost reduction and fewer CO_2 emissions

5.1 Running cost reduction effect

In the case of another domestic plant C general waste incinerator (treatment capacity: 175 t/24 h), in which the glass fiber HBF is currently in use, it has been estimated that replacing it with the PTFE HBF can cut the running costs of a flue gas treatment facility by 57%, based on the following three improvements:

(1) The service life is expected to double, because of the improved durability of HBF.

(2) The consumption of electricity by the downstream induced draft fan can be reduced by 27%, as a result of the lowered operating differential pressure of the bag filter.

5.2 CO_2 emissions reduction effect

As described in section 4.3, replacing the glass fiber HBF with the PTFE HBF can reduce the differential pressure, which leads to less power required for the induced draft fan. This means that reduction of CO_2 emissions can eventually be expected. The effect in this regard was estimated.

With regard to the flue gas treatment facility, the effect of CO_2 emissions reduction resulting from the replacement by the PTFE HBF was estimated based on the actual operational data before/after the replacement and the reduction rate of differential pressure. The results show that domestic plant A can reduce the emissions by 20% and overseas plant B by 29%.

6. Conclusion

Having developed a manufacturing technology that enables the catalyst slurry to be applied onto water-repellent PTFE, we obtained the following results:

(1) The results of operating the PTFE HBF in actual units have confirmed that the removal rates of both particulate and gaseous DXNs are as high as 99% or more, exhibiting excellent removal performance.

(2) The operating differential pressure of PTFE HBF is about 20% lower than that of glass fiber HBF, achieving stable operation for 140 days from the start of operation (excluding the temporary shutdowns) at domestic plant A. Overseas plant B has also been in stable operation for nearly 80 days from the start of operation at a differential pressure about 33% lower.

(3) With regard to domestic plant C in which the glass fiber HBF is currently in use, it has been estimated that a 57% reduction in the running costs of a flue gas treatment facility is possible, if the glass fiber HBF is replaced by the PTFE HBF.

(4) According to the estimations of CO_2 emissions from the flue gas treatment facility, domestic plant A is expected to reduce emissions by 20% with the use of PTFE HBF and overseas plant B by 29%.

The addition of this newly developed PTFE HBF to our product portfolio enables us to make a more tailor-made proposal according to a customer’s needs including the required performance, durability and price, by selecting a suitable one from the available product options of normal bag filter, glass fiber HBF and PTFE HBF. As at March 2024, the operation of PTFE HBF at a differential pressure lower than the glass fiber HBF was continuing in a stable manner at both of the domestic and overseas plants. Further expansion of its application is therefore expected.

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