Initiatives to Apply Small Scale CO_2 Capture System to Industrial Emission Sources

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Mitsubishi Heavy Industries, Ltd. (MHI) Group has delivered its proprietary CO_2 capture process, KM CDR Process™, to coal-fired power plants and chemical plants so far. Based on this technology, MHI is advancing the development of small-scale CO_2 capture systems to respond to the needs for the reduction of CO_2 emissions at smaller-scale CO_2 emission sources such as gas engines, biomass boilers and refuse incinerators.

1. Introduction

In the recent trends toward decarbonization and CO_2 emissions reduction, goals have been set for a reduction in anthropogenic CO_2 to one third in 2040 (compared to 2014) and for the achievement of so-called carbon neutrality in 2060. **Figure 1** shows the CO_2 emissions reduction required for the realization of the 1.5℃ scenario under the Paris Agreement(1). To achieve these goals, it is necessary to reduce emissions concurrently in various fields as well as reducing emissions at large-scale emission sources such as thermal power plants. In addition, needs for the reduction of CO_2 emissions at smaller-scale CO_2 emission sources such as gas engines, biomass boilers and refuse incinerators have arisen.

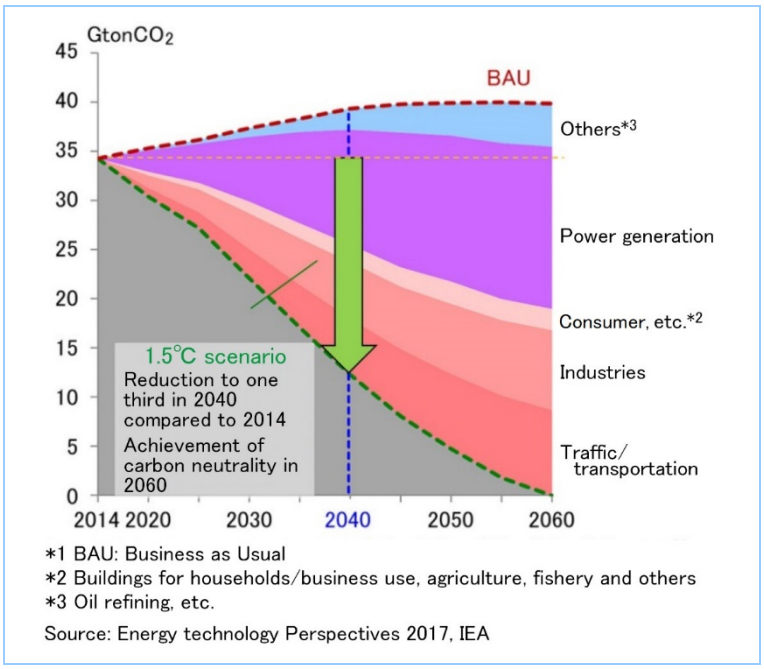

Figure 1 CO_2 emissions reduction required for the realization of the 1.5℃ scenario (Comparison between BAU[*1] and 1.5℃ scenario by IEA)

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Mitsubishi Heavy Industries Engineering, Ltd. in the MHI Group has delivered a proprietary CO_2 capture process, KM CDR Process™, to coal fired power plants and chemical plants. The scale of plants delivered so far is approximately 500t-CO_2/day or larger.

Based on this technology, MHI is advancing the development of small-scale CO_2 capture systems to realize the concurrent CO_2 reductions and also respond to the reduction needs at small-scale CO_2 emission sources.

2. Features of small-scale CO_2 capture systems

The basic process of a small-scale CO_2 capture system under development is the same as that of a large-scale plant, but the following features are required for a small-scale system:

(1) Applicable to many emission sources
(2) Installable at a limited area
(3) Operable without full-time operators

In order to respond to various inquiries, we adopted a standard design of small-scale systems, not a design according to each customer's specification adopted in conventional large-scale plants. In addition, we realized a system with a compact design by modularization so that it can be installed at a smaller area. The modularization can produce the effects of reducing field works and advancing the commencement of system operation. Furthermore, it eliminates the need for storage sites for construction materials, etc.

The small-scale system is equipped with an automatic operating and remote monitoring system, thereby allowing operation without any full-time operator.

We built a lineup of standardized systems with the scales of 0.3, 3, 30, 100 and 200t-CO_2/day as shown in Table 1 (**Figures 2** and **3**). Selection of a system from this lineup will allow quick delivery and installation of the system because only pretreatment equipment such as dust removal device is newly designed.

Table 1 Lineup of products

Type	Standard CO_2 capture amount (*1)
A	0.3 tonnes/day
B	3 tonnes/day
C	30 tonnes/day
D	100 tonnes/day
E	200 tonnes/day

*1: CO_2 capture amount may be changed by inlet gas conditions.

Figure 2 Small-scale CO_2 capture system (0.3t-CO_2/day)

Figure 3 Small-scale CO_2 capture plant (30t-CO_2/day)

3. Automatic operating/remote monitoring system

Conventional large-scale CO_2 capture plants have been delivered to chemical plants or coal-fired power plants. At these plants, there are many workers involved in the operation and it is relatively easy to secure operators for a newly installed CO_2 capture plant. On the other hand, for a combustor to which a small-scale CO_2 capture system is installed, only a few workers are involved in the operation and if they have to operate a newly installed CO_2 capture system, their workload will be increased. Also, it is difficult to add new operators in many cases. Besides, there are

problems that most of customers using small-scale combustors are unfamiliar with CO_2 capture systems and do not have know-how about its operation and system management.

In addition, the start and stop operation is different between a combustor to which a small-scale CO_2 capture system is installed and a chemical plant or coal-fired power plant. A small-scale combustor is frequently started and stopped and often operated in DSS (Daily Start & Stop) mode, while a chemical plant or coal-fired power plant is less frequently started and stopped and operated with little load change for a long time in most cases. At a large-scale plant, a CO_2 capture plant is required to deliver stable performance in a long-time operation, while at a small-scale combustor, it is required to start and stop easily and operate at a necessary load when needed.

To address such needs, our small-scale CO_2 capture system is equipped with an automatic operating and remote monitoring system (**Figure 4**) as standard, reducing field operations to a minimum. The system can be started and stopped only by pressing the start/stop button and it can automatically operate when the temperature or pressure in the system changes.

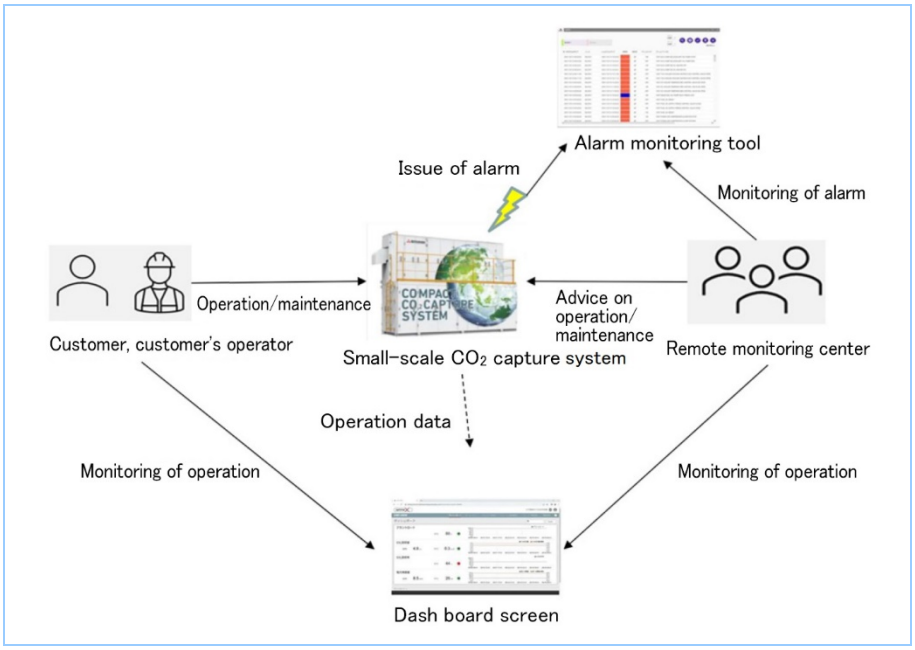

Figure 4 Overview of the remote monitoring system

Concerning the remote monitoring system, we are developing a reliable system without much new design by using the systems developed for conventional large combustors. Specifically, TOMONI®, which is used for thermal power plants, is used to monitor the operation of CO_2 capture plants. We also set up a remote monitoring team and have commenced a test operation to prepare for full-scale operation in the near-future. Thus, it becomes possible to monitor and check the operation status of the system with a small number of workers. With the acquisition of operation data over time as well as the alarm monitoring for various abnormal values, we plan to implement management of the absorbing solution, which will be needed in the medium and long terms.

4. Dealing with properties of gases

The properties of gases generated from the CO_2 emissions sources such as gas engines, marine engines, biomass boilers and refuse incinerators, to which the small-scale CO_2 capture systems are installed, are different from those of gases from chemical plants or coal-fired thermal plants. To deal with such properties of gasses, we have been conducting application tests in sequence. For the tests, the smallest-scale system of 0.3t-CO_2/day in the standard lineup is used.

We conducted tests for marine engines and biomass boilers and extracted issues (on removal of dust, etc.) to be addressed for application of the systems[(2)]. We have also conducted tests for application to gas engines at our Sagamihara Machinery Works Sagamihara Plant since July 2022 (**Figure 5**). In the tests for gas engines, validation of the previously described automatic operating/remote monitoring system has also been conducted. So far, the operation status has been

favorable and it has been demonstrated that the system can achieve a satisfactory CO_2 capture. We will continue further tests and evaluate the applicability to exhaust gas from gas engines. In addition, we are conducting application tests for cement kiln in cooperation with Tokuyama Corporation.

A demonstration test for refuse incinerator in Yokohama City is also being planned.

Figure 5 Small-scale CO_2 capture system (for gas engine)

5. Conclusion

The MHI Group has been advancing the development of small-scale CO_2 capture systems based on its proprietary CO_2 capture process, KM CDR Process™. In the development, we have been studying aiming at development of products suited to the needs of small-scale systems by (1) offering a lineup of products with standard specifications, (2) making products compact and reducing field works by modularization and (3) installing an automatic operating/remote monitoring system.

To validate the applicability to actual small-scale combustors, we are implementing and planning demonstration tests with gas engines, marine engines, biomass boilers, refuse incinerators, etc.

Many of these small-scale combustors are manufactured within the MHI Group and MHI Group companies have cooperated in developing optimal systems including CO_2 capture plants.

References

(1) Energy technology Perspective 2017, IEA

(2) Senba et. Al, CO_2 Capture Technology Applied for Varied Fields such as Manufacturing Industries and Energy-related Facilities, Mitsubishi Heavy Industries Technical Review Vol. 59 No. 1 (2022)