Ultra-High Density Ozone Generation Technology

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It is known that ozone with its highly oxidative effect can effectively treat excess sludge produced through wastewater treatment, but it is not widely used due to the high cost. Mitsubishi Electric Corporation proposes the application of an ultra-high density ozone generation system consisting of Mitsubishi Electric's exclusive high-efficiency ozonizer and ozone concentration storage device to significantly reduce the cost of sludge disposal.

1. Configuration of the Ultra-High Density Ozone Generation System

Figure 1 illustrates the configuration of the entire ultra-high density ozone generation system. The system consists of an ozonizer and an ozone concentration storage device. The ozonizer produces ozone gas using oxygen as the source gas and the ozone concentration storage device concentrates the ozone gas to an ultra-high density and supplies the concentrated ozone gas to the target.

2. High-Efficiency Ozonizer

Mitsubishi Electric's exclusive technology of narrow gap discharge has made it possible to efficiently generate high-density ozone. Figure 2 shows the running costs of Mitsubishi Electric's ozonizers in relation to the ozone density.(1) The running cost of an ozonizer is broadly divided into the electric power cost due to electric discharges and the cost of oxygen gas (raw material). At a certain ozone density, the cost becomes minimum due to the balancing of the two types of costs. The high-efficiency ozonizer can generate high-density ozone with electrical power consumption equal to that of the conventional ozonizer, as shown in the figure, so the running cost can be reduced compared to the conventional ozonizer. While the conventional ozonizer is most efficient at an ozone efficiency of 150 g/Nm^3, the running cost of the high-efficiency ozonizer becomes minimum when the ozone density is 210 g/Nm^3.

3. Ozone Concentration Storage Device

To concentrate ozone, the adsorption and desorption action of silica-gel is used. One of the characteristics of silica-gel is the selective adsorption of polar molecules, which means that it can selectively adsorb ozone molecules in ozonated gas. In addition, decompressing the silica-gel after adsorption allows preferential desorption of oxygen with weak adsorption power, so the ozone can be concentrated.

Operation of the ozone concentration storage device is described using Fig. 3. In the adsorption process (i), silica-gel packed in the adsorption tower selectively adsorbs ozone molecules. At that time, oxygen that was not adsorbed by the silica-gel is guided into the front section of the ozonizer by the circulation blower installed at the rear section of the adsorption tower, and this oxygen is reused as the source gas. In the concentration process (ii), the silica-gel in the adsorption tower that adsorbed ozone is decompressed

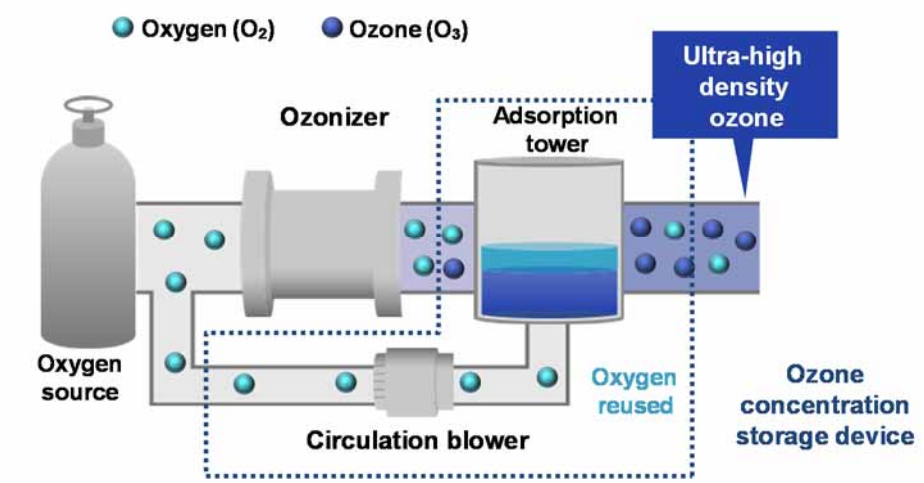

Fig. 1 Composition of ultra-high density ozone generation system

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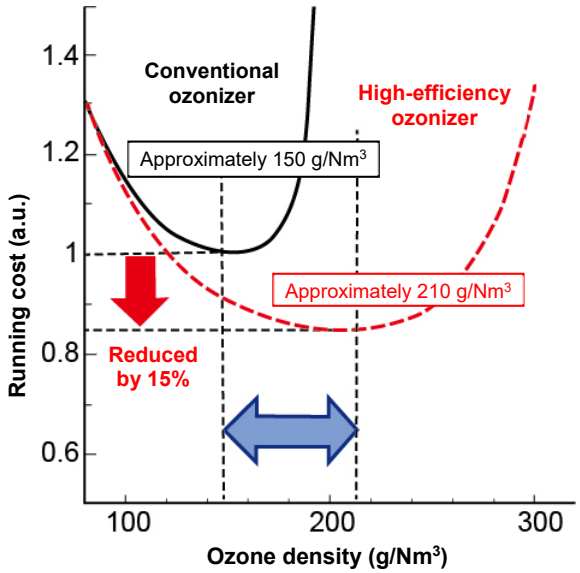

Fig. 2 Running cost as a function of ozone generation density

by suction to preferentially desorb oxygen. Through this process, the ozone adsorbed by the silica-gel is concentrated to ultra-high density. In the supply process (iii), ozone desorption is accelerated through gas displacement by oxygen purging to supply ultra-high density ozone gas.

The biggest advantage of using ozone concentration storage devices is that the oxygen cost can be significantly reduced by recycling the oxygen. In the conventional sludge disposal methods where only ozonizers are used, the percentage of oxygen that can be effectively used is approximately 10%. On the other hand, for example, when the density of ozone to be supplied to the sludge is increased to approximately 1,000 g/Nm^3 by concentrating the ozone, the percentage of oxygen that can be effectively used is increased to approximately 50%. Therefore, when the same quantity of ozone is supplied, using an ozone concentration

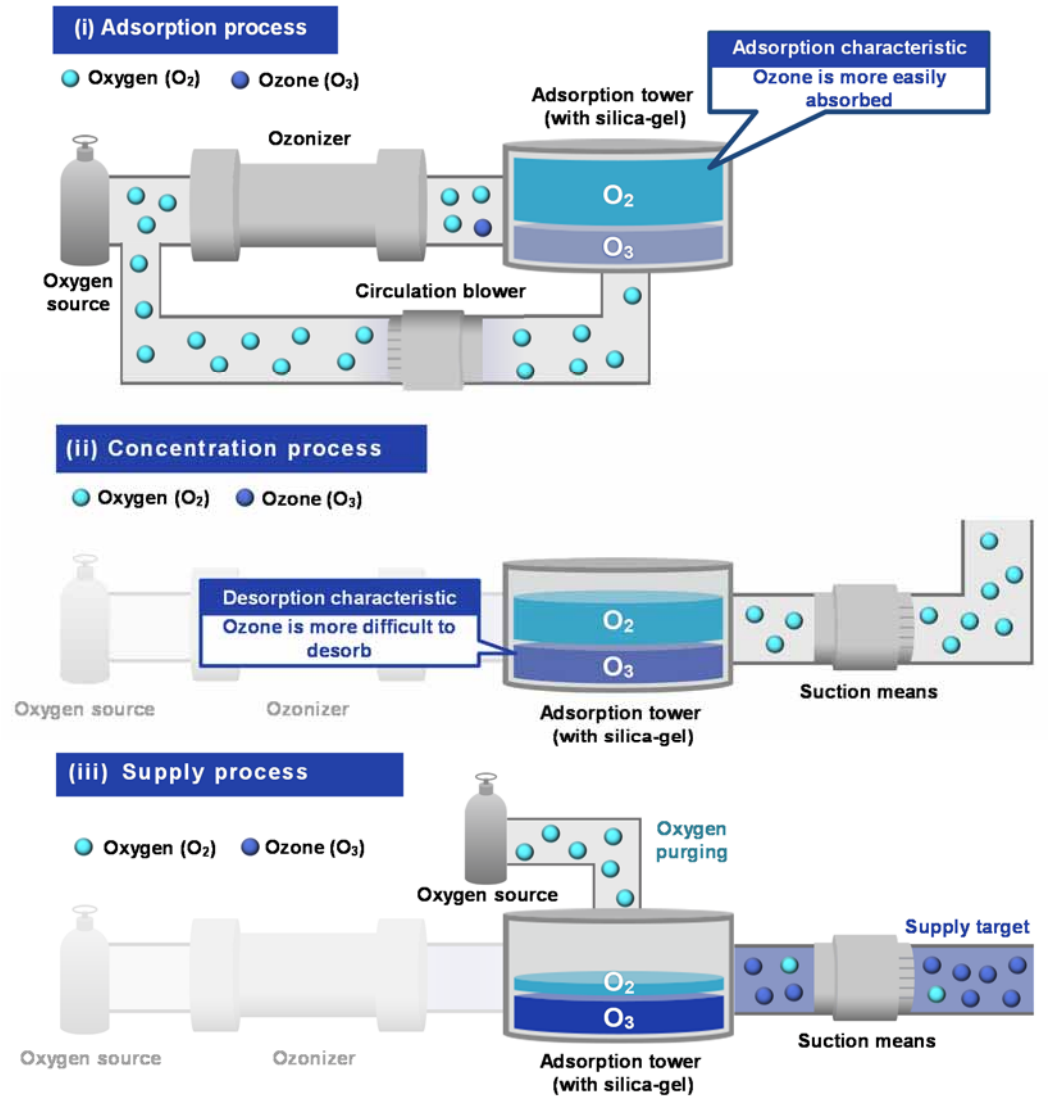

Fig. 3 Operation flow of ozone concentration storage device

storage device can significantly reduce the oxygen cost to 20% of that in the conventional method, allowing operation at a low cost.

4. Technology for Efficiently Generating Ultra-High Density Ozone

For Mitsubishi Electric's high-efficiency ozonizers, the ozone density at which the cost is minimum increases to 210 g/Nm^3 from the conventional 150 g/Nm^3. This highly efficient generation of high-density ozone further produces a synergy effect in combination with the ozone concentration storage technology.

Figure 4 shows the relationship between the pressure in the adsorption tower in the concentration process of ozone concentration storage devices and the output ozone density. The graph shows that an increase in the ozone density to be input to the ozone concentration storage devices in the adsorption process significantly changes the output ozone density's dependency on the pressure. When a high-efficiency ozonizer is used, the output ozone density increases up to 1,600 g/Nm^3, approximately 1.4 times that of the conventional ozonizer.

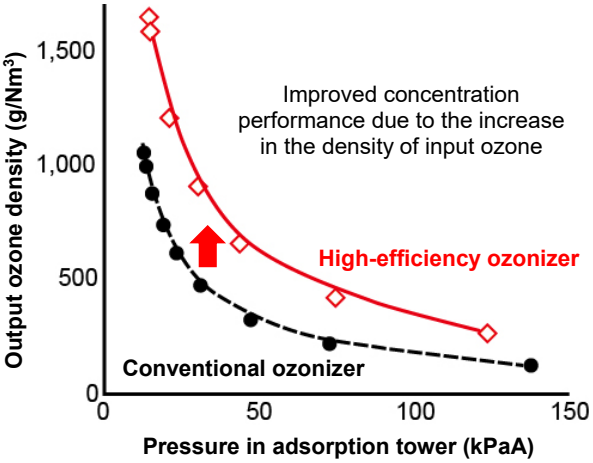

Fig. 4 Ozone desorption characteristics as a function of ozone input density

Applying high-efficiency ozonizer can supply higher density ozone to the ozone concentration storage device, so the quantity of oxygen consumed by the system is expected to be further reduced. As mentioned above, when the conventional type ozonizer is applied (input ozone density: 150 g/Nm^3, output ozone density: approximately 1,000 g/Nm^3), the oxygen cost can be reduced to 20% compared to operation with only a high-efficiency ozonizer. When a high-efficiency ozonizer is applied (input ozone density: 210 g/Nm^3, output ozone density: approximately 1,600 g/Nm^3), the cost can be significantly reduced to 12.5%. When making a trial calculation for the entire ultra-high density ozone generation system, applying a high-efficiency ozonizer and ozone concentration storage device can reduce the running cost to approximately 70% compared to operation with only an ozonizer.

Applying ultra-high density ozone to the process for reducing the volume of excess sludge can significantly reduce the cost of sludge disposal. This technology will help solve environmental problems with sludge disposal in China and emerging Asian countries.

Reference

(1) Noboru W., et al.: High Density Tubular Type Ozone Generator by Narrow Gap Discharge, Mitsubishi Denki Giho, 81, No.4, 59–62 (2007)