

Super Energy-Saving Dewatering of Sewage Sludge using DME

Background

There is a growing need for the economical dewatering of solids containing large amounts of water, for example, coal, waste, and biomass. The principle underlying the conventional dewatering method is to heat the solid to a high temperature to evaporate the water contained in it, but this approach consumes a considerable amount of energy. We have developed a method to remove water by using dimethyl ether (DME)*¹, which liquefies by utilizing slight compression at ordinary temperatures; it is primarily applicable to low-grade coal with high water content. In this method, the water contained in coal is extracted into liquefied DME for separation from the coal. After dewatering, DME is depressurized and subsequently vaporizes, thereby leaving the separated water.

Objectives

This DME-based dewatering method should be extended to a smaller scale practical application for materials. Assuming that these applications can be progressively scaled up, we believe that the proposed dewatering method will facilitate the dewatering of coal.

Principal Results

1. Successful dewatering of various solids with high water contents

We have applied the proposed DME-based dewatering method to such wastes as sewage sludge, food residue, flowers, and biomass, and have confirmed that the dewatering performance was high for each application. We selected sewage sludge dewatering as the most promising application.

2. Sewage sludge dewatering test conducted using a prototype test machine

Liquefied DME was passed through 3.2 kg of a sewage sludge cake*² (water content 78%) charged in a prototype test machine that we designed and developed. As a result, the water content of the sewage sludge decreased sharply to 30%. Post dewatering, the color of the sewage sludge changed from black to brown (Fig.1), and it became odorless. Since grease, which is a source of the odor, moves to waste water, the waste water was confirmed to have become a muddy black (Fig.2) with a strong foul odor. Based on the above result, we devised a waste water cleaning method by taking advantage of the fact that grease, which is insoluble in water, is soluble in DME, and our basic experiment was thus successful.

3. Estimation of the performance of the pilot plant based on DME dewaterization

Following the abovementioned successful experiment, we developed a process (Fig.3) with an estimated dewatering capacity of 76 tons/day (114 tons/day of brown coal and 97 tons/day of sewage sludge), which is similar to the dewatering capacity of a commercial plant. A part of DME remains in the evaporator (i)*³. In the next process stage of the DME/water separator, grease dissolves in only the liquefied DME layer; but no grease dissolves in the water layer. By extracting the water layer from this separator, the waste water can be purified. Further, detailed calculations of the characteristics of DME gas and a mixture of DME and water were made together with a precise estimation of the energy required for the dewatering process. As a result, dewatering with an input energy of 1109 kJ/kg-water, while keeping the loss of DME to less than 1%*⁴, was shown to be theoretically possible under ordinary conditions.

4. Possibility of operation with “zero” input energy by using sewage water heat

In the dewatering process using DME, the evaporation and condensation of DME will take place repeatedly. Meanwhile, since the temperature of sewage water is approximately constant in the range of 20-25°C (Fig.4) throughout the year, the sewage water and air can be used as sources of heat for the evaporation and condensation of DME. Thus, it is possible to perform a part of the evaporation and condensation of DME as zero-input-energy operation for one-third of the year, especially during winter.

Future Developments

After devising a highly efficient method for contacting DME with a sewage sludge cake, which is a pending issue, and confirming the feasibility of the corresponding commercial process, we will optimize each component of the dewatering process to promote early commercialization. We will also develop an energy-saving prototype dewatering plant with a dewatering capacity of more than several tons/day, which is closer to the theoretical dewatering capacity.

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Reference

H. Kanda, et al., 2007, “Conceptual Design and Required Power Estimate of Dewatering Process of High-water-content Coal by using Liquefied DME as Water Extractant,” CRIEPI Report M06004 (in Japanese)



Fig.1 Sewage sludge dewatered using DME.



Fig.2 Water extracted from the sewage sludge.

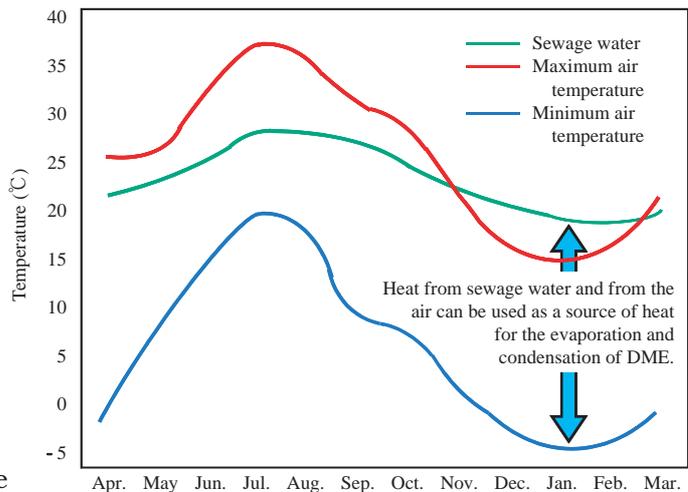


Fig.4 Annual temperature of sewage water and air.

It is epochal that the water content of the sewage sludge sharply decreased from 78% to 30% at room temperature. After dewatering, the color of the sewage sludge changed from black to brown. This is due to the movement of grease, which is a source of odor, to waste water.

Since the temperature of sewage water is approximately constant in the range of 20-25°C throughout the year, sewage water and air can be used as sources of heat for the evaporation and condensation of DME. Thus, a part of the evaporation and condensation of DME can be conducted as a zero-input-energy operation for one-third of the year, especially during winter.

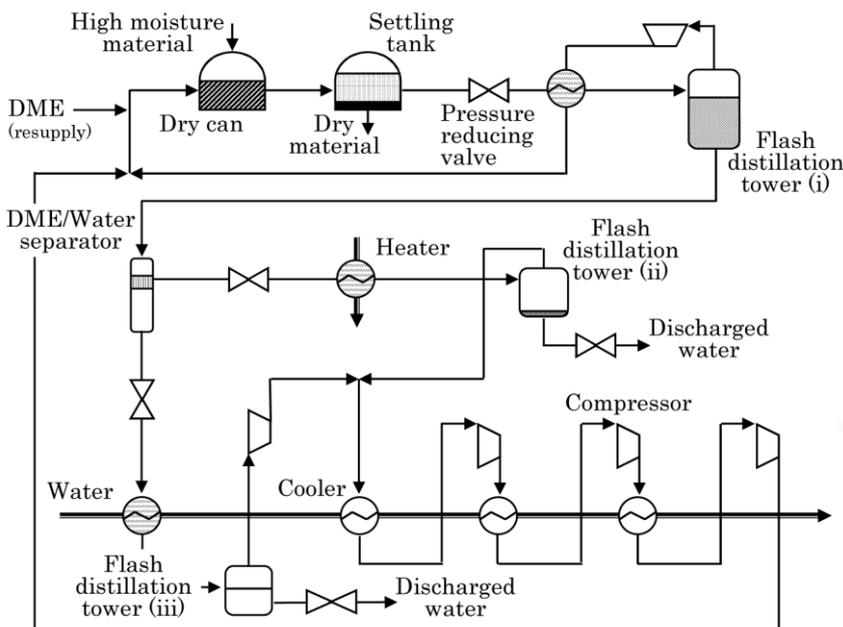


Fig.3 Configuration of the DME dewatering process.

In flash distillation tower (i), 95.2% of the total DME can be collected. In the DME/water separator, grease dissolves in only the remaining liquefied DME layer; no grease dissolves in the water layer. By extracting the water layer from this separator, the waste water can be purified.

This is an award-winning research; “Marquis Who’s Who in the World the 25th Edition 2008,” “The Chemical Society of Japan Award for Young Chemists in Technical Development for 2007,” “Environmental Technology/Project Award, Environmental Engineering Forum, Japan Society of Civil Engineers 2007,” “Marquis Who’s Who in Asia the 1st Edition 2007,” “The Chemical Society of Japan Award for Young Chemists for 2006,” “Technology Prize of Society of Powder Technology, Japan 2006,” and “The Japan Institute of Energy Award for Encouragement 2004.”

- * 1 : The normal boiling point of DME is -24.8°C, and at 0.59 MPa, it is 25°C. At normal temperature, DME dissolves 7-8% by the weight of water. DME is being mass produced in China as a raw material for coal gasification as the country lacks liquefied fuel.
- * 2 : Sewage sludge cakes are the final form of the sewage water obtained through the precipitation by microorganism treatment and flocculant addition and processes such as centrifuges and belt presses. With regard to dewatering, water content of 78% forms the lower limit, and several companies have been developing dewatering technologies to achieve performance gains of over “1%.”
- * 3 : The condensation latent heat of evaporating DME gas is smaller than the evaporation latent heat of liquefied DME; this is because liquefied DME contains water and its latent heat is lesser at higher temperatures.
- * 4 : We set the DME loss for the entire cycle at 1%. This provisional value was set because high DME loss increases the operation costs of the dewatering process, while a low DME loss increases the costs of DME synthetic processing.