Development of Ice/Oil/PCB Elimination Technology using DME

Background

There is a pressing need for low-cost dewatering of high-water-content solids such as coal and sewage sludge. Pre-existing technologies consume a great amount of energy due to their reliance on high temperature to evaporate the water content out of solid substances. In this research, we turned our attention to coal and sewage sludge; using dimethyl ether (DME)[*1]. In this method, the water contained in coal is extracted into liquefied DME for separation from coal. After dewatering, DME is depressurized and subsequently vaporizes, thereby leaving the water to be separated at room temperature. There is already a clear advantage in energy efficiency, according to full-scale performance test calculations for the DME dewatering process. At the present time, we are focusing on understanding the technology's suitability for cold-weather regions, as well as its ability to eliminate substances such as oil and PCB.

Objective

Our objective is to verify the practicable possibilities for expanding first the elimination of ice in cold-weather regions, and later the elimination of oils and PCB at room temperature, using the DME desiccation method on materials other than the traditional target material, water.

Principal Results

1. Potential to remove ice from frozen coal and wood pieces in a sub-zero environment

We installed a test-tube level (10 ml/batch) DME desiccation test device (Fig. 1) in an environment kept at a constant temperature of -10℃, and were then able to use liquefied DME to extract 44.5% of the icy moisture content from sub-bituminous coal (particulate diameter: 4-8 mm, moisture content: 42.4 wt%). Similarly, we were able to use liquefied DME to extract 53.5% volume of ice from frozen cedar chips (length: ~1 cm, thickness: 1-3 mm, moisture content: 68.9 wt%) in an environment kept at a constant temperature of -23℃.

2. Capability of removing a variety of oils from a variety of materials at room temperature

We let vacuum pump oil to adsorb into an artificial oil-absorbing sheet, and then used our laboratory's prototype to bring liquefied DME into contact with the oil-soaked sheet. We estimated that this would be the most difficult form of oil removal, but the results of our experiment showed that we succeeded in removing all the oil from the absorbent sheet at room temperature. Furthermore, we also succeeded in removing all the oil from glass, wood pieces, paper and metal that had been covered in insulating oil. In addition, we succeeded in removing both the moisture content and the oil, simultaneously, from damp soil that had been permeated with heavy oil (Fig. 2).

3. Room-temperature PCB removal from high moisture content sediment polluted with PCB

We brought PCB-polluted river sediment[*2] with a high moisture content into contact with liquefied DME. At room temperature, we were able to remove more than 99% of the PCB from the high moisture content sediment, and were simultaneously able to remove the moisture content (Fig. 3), thereby succeeding in cleansing the sediment of PCB such that PCB density levels were at or below environmental standard levels (dioxin poison volume 150 pg-TEQ/g).
(The PCB-removal research was carried out in conjunction with Associate Professor Takaoka and Assistant Professor Oshita of Kyoto University, Faculty of Engineering, Urban and Environmental Engineering.)

Future Developments

We will continue to study the practical applications of the DME desiccation technology verified on the removal targets of the current experiments.

Main Researcher: Hideki Kanda, Ph. D.,
Research Scientist, Fuel Reforming Engineering Sector, Energy Engineering Research Laboratory

Reference

Affiliated Reports: H. Kanda, and H. Makino., 2008, "The development of room-temperature oil-removal processes using recycle extraction-use liquefied DME", CRIEPI Report: M07009; "Evaluation of the suitability of liquefied DME dewatering technology for frozen solid fuel desiccation at sub-zero temperatures", CRIEPI Report: M07013

＊1：Standard boiling point: -25℃; boiling point at 0.5MP: 20℃. Not only water, but also ice, oil and PCB were dissolved into the liquid-state DME. In China, it is rapidly being propagated as a cheap alternative to imported LPG, and is a next-generation green fuel.

＊2：Due to past illegal discarding and dumping, there are rivers in which slime has been detected with PCB in excess of allowed levels. Although there have been studies on the use of acetone in PCB removal, the water in slime interferes with this process, in addition to which, the acetone remaining behind as residue in the soil gives rise to a new set of problems, all of which make this method difficult to implement.

Awards won since last year's annual report: Environmental Technology/Project Award, Environmental Engineering Forum, Japan Society of Civil Engineers; The Chemical Society of Japan Award for Young Chemists in Technical Development for 2007; Fuji-Sankei-Business-I Award (Vice-Grand Prize), 22nd Advanced Technology Award established by Kenichi FUKUI.

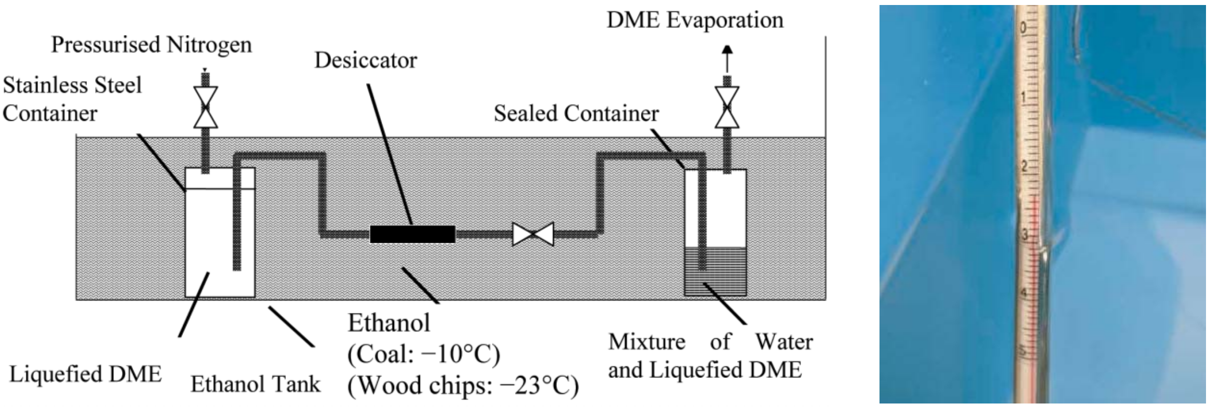

Fig.1 Left: Overview of the Test Device; Right: Photograph showing ethanol temperature (−23°C for wood chips)

Coal is produced in abundance even in overseas northern climes and inland cold-weather areas. In these cold-weather regions, the temperature in winter falls below the freezing point of water. For this reason, using DME to directly remove icy moisture from frozen coal slurry without having to melt the moisture itself is an effective desiccation method. The results of this experiment verified this practical possibility.

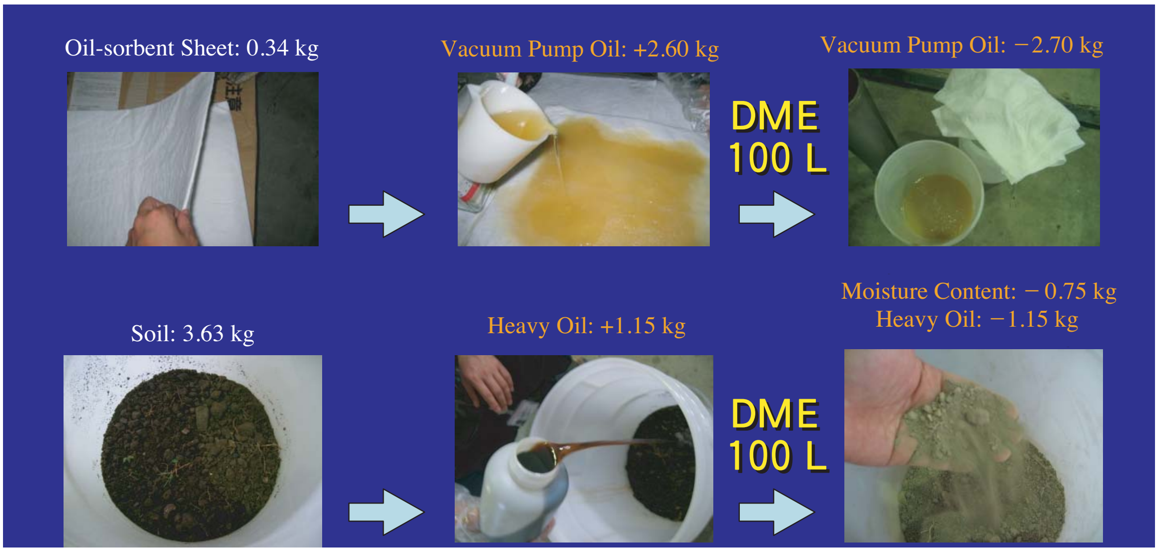

Fig.2 Removal of oil from oil-absorbent sheets and moist soil

Fig.3 River sediment from which PCB has been removed with the help of DME (left: before DME contact; middle: after DME contact; right: waste liquid including PCB) (Photographs courtesy of Associate Prof. Takaoka and Assistant Prof. Oshita of Kyoto Univ., Urban and Environmental Engineering)

After PCB has been removed with DME, sediment becomes paler in color and shrinks. This is because the slime is also desiccated simultaneously, which has a moisture content of 60%. Because DME is a gas at normal temperatures and pressures, it does not leave any residue. For this reason, it has clearly become a candidate for application as an environmental cleansing technology.