Technology for Dry Decontamination and Volume Reduction of Contaminated Dirt

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ABSTRACT

The Fukushima Dai-ichi Nuclear Power Station accident, caused by The Great East Japan Earthquake, has resulted in leakage of radioactive materials and contamination of the environment. Separating highly-contaminated dirt from the total amount of dirt removed for decontamination makes it possible to reduce the volume of dirt that needs to be stored.

In cooperation with Ube Machinery Corporation, Ltd., Fuji Electric developed technology for dry decontamination and volume reduction of contaminated dirt. This technology combines the dry sorting and grinding equipment used in general industry with a radiation measurement device, enabling mass processing. Verification tests using actual contaminated dirt have demonstrated that radiation levels are reduced to less than half after crushing and separation.

1. Introduction

Fukushima Daiichi Nuclear Power Station accident, caused by the Great East Japan Earthquake, has resulted in leakage of radioactive materials and contamination of the environment. The released radioactive materials are mainly cesium, which adheres to soil and woodlands. The government is planning to decontaminate certain areas so that the radiation dose from radioactive materials released by this accident becomes 1 mSv or less annually.[*1]

In the decontamination plan, the authorities are reviewing how to scrape away and decontaminate the top few centimeters of soil in contaminated fields of rice and other crops. Doing so will generate a large amount of soil as contaminated waste. This soil (original soil) is to be temporarily placed in an appropriate location and is planned to be disposed of permanently after being placed in interim storage. However, the area to decontaminate is very wide and in order to store all this soil, an extensive area is necessary. As a result, there is a difficult issue to overcome in terms of securing such an area and decontamination work is making slow progress.

The scraped off original soil is not all contaminated, and thus separating highly-contaminated parts from the total amount of soil removed for decontamination makes it possible to reduce the volume of soil that needs to be stored. Accordingly, Fuji Electric has developed dry decontamination and volume reduction technology for contaminated soil. This paper describes the characteristics and demonstration of this technology.

*1: "Act on Special Measures pertaining to measures against contamination of environment by released radioactive substances due to the accident of nuclear power station caused by The Great East Japan Earthquake that occurred in March 11, 2011" issued in August 2011

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2. Characteristics of Technology for Dry Decontamination of Contaminated Soil and Volume Reduction

According to public and private research institutions, it is reported that soil contamination caused by radioactive cesium is concentrated in a few centimeters of the surface layer and among the soil, most of the radioactive cesium is adhered to the grain section such as clay and silt.

In cooperation with Ube Machinery Corporation Ltd., Fuji Electric developed technology for dry decontamination and volume reduction of contaminated soil.

2.1 Dry decontamination and volume reduction process flow

The processing flow based on this technology is described in Fig. 1. The point of this technology is section A and the details are as follows:

(a) Grinding superficial coarse particle by mill

Grind the soil, which has become coarse particles superficially as a result of the grain hardening, by using the mill.

(b) Peel-off of grain

Strip off the grain that is adhered to the surface of the coarse particles by means of grinding using a mill.

(c) Grinding surface layer of coarse particles

Strip off the surface layer of coarse particles to which the radioactive cesium is adhered by means of grinding using a mill.

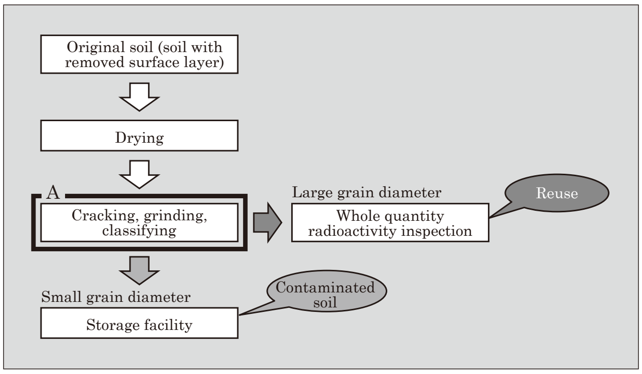

Fig.1 Dry decontamination and volume reduction process flow

(d) Dry classification

Sort the grains by grain diameter by means of dry classification.

With this series of processes, soil is classified into soil which has high contamination and soil which has low contamination.

2.2 Characteristics of dry decontamination and volume reduction process

This technology has been developed by combining proven dry classification and grinding equipment used in general industry with a radiation measurement device, enabling mass processing of soil. The characteristics are as follows:

(1) Method of processing that does not require water and chemicals

Compared to the soil wet processing method, for which prior research has been conducted for volume reduction of contaminated dirt, water and chemicals are not used; therefore, the cost and effort for secondary waste processing is eliminated. In addition, because chemical treatment and high-temperature treatment are not performed, the original characteristics of the original soil are not easily lost.

(2) Classification treatment, volume reduction and space-saving of storage location

Dry classification technology allows the volume reduction process to be performed appropriately for various types of soil because it is possible to set an arbitrary classification threshold for reuse of soil. Applicability for soil in paddy fields, to which it is difficult to apply the wet process, was demonstrated by a basic test.

The volume of the soil which is categorized into soil to be stored as contaminated waste is expected to be reduced further by deairing and compressing it. As a result, it is possible to aim at reducing the amount of space needed for storage.

(3) Ensuring safety and security by whole quantity measurement of radioactive concentration of reusable soil

With the soil monitor for which Fuji Electric applied the principle of the "Food radiation measurement system" that Fuji Electric has already commercialized, the whole quantity of radioactive concentration of reusable low contaminated soil is measured continuously.

Although it takes a few days to obtain the result when outsourcing analysis of radioactive concentration, efficient operation can be performed with this technology because the measurement result can be obtained in real time. This technology is so effective that even when changing settings by condition of classification according to the type of soil and decontamination method, an operator can immediately confirm how much radioactive concentration has changed.

(4) Low cost

A trial calculation of the process cost was made by considering the initial cost and running cost. This technology does not require contamination water treatment and secondary waste disposal cost; therefore, it lowers the costs to between one thirds and one fourth the amount of the wet decontamination method.

3. Dry Decontamination and Volume Reduction Plant

For a dry decontamination and volume reduction plant, two types are planned: movable type and stationary type.

As for the movable-type plant, by mounting the necessary devices on trailers, it will be possible to move the plant to the required location. Since installation and removal of the plant are easy, we expect it will be possible to gain understanding from local people and facilitate the decontamination work. We assume it will be applied in relatively high radiation dose areas because the equipment configuration aims for a decomposition effect. A conceptual image of the movable plant is shown in Fig. 2 and the process flow is shown in Fig. 3.

As for the stationary-type plant, we assume it will be used to decontaminate a large volume of soil in relatively low radiation dose areas because the equipment configuration aims for throughput and volume reduction. Figure 4 shows a conceptual image of a stationary-type plant and Table 1 shows the specifica-

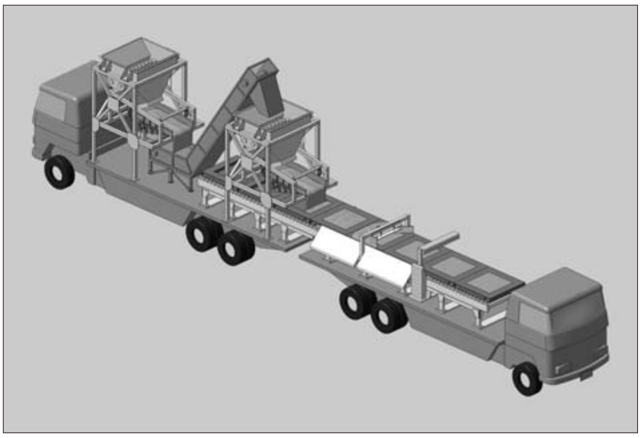
Fig.2 Conceptual image of movable-type plant

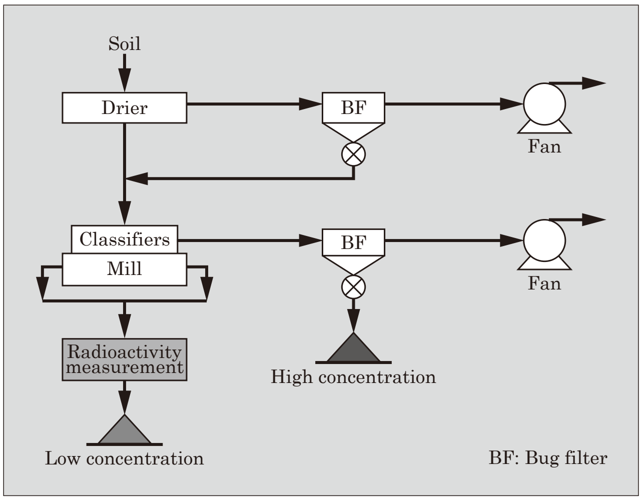

Fig.3 Process flow of movable-type plant

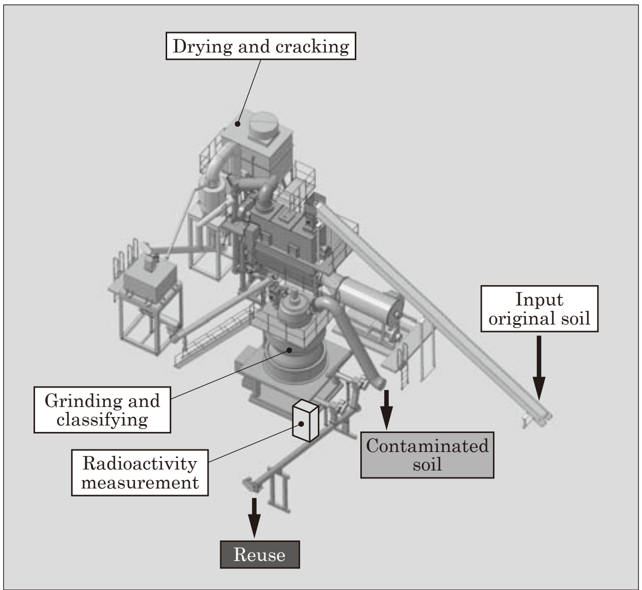

Fig.4 Conceptual image of stationary-type plant

Table1 Specifications of dry decontamination and volume reduction plant

	Movable type	Stationary type
Decontamination rate*1	50 to 86%	20 to 60%
Reduced rate*2	30 to 50%	50 to 70%
Throughput(WB)	3 t/h	20 t/h
Installation space	W18×H7.5×D28 (m)	W20×H10×D35 (m)
installation motive power	350 kW (Generator light oil)	650 kW (Fixed power supply)
Drying room	Kerosene	Kerosene

*1: Decontamination rate: Decreasing rate of radioactive contamination against original soil of reusable soil after treatment
*2: Reduced rate: Rate of mass for original soil of reusable soil after treatment

tions of the dry contamination and volume reduction plant. The ratio of mass against the reusable original soil after treatment is called the reduced rate. The numerical value in the table is an example of the result of a basic test for soil decontamination and volume reduction. The effective classification of particle diameter (threshold to classify by grain diameter) and decontamination performance differ because the state of contamination differs depending on the type of soil and location. In the future, it is expected that data on each type of soil will be accumulated.

4. Demonstration

In order to demonstrate the basic principle of this equipment, a demonstration using actual contaminated soil was carried out in the “Decontamination Technology Demonstration Test Project in FY2011” (Ministry of the Environment).

4.1 Characteristics of soil

In order to grasp the difference in effect of decontamination and volume reduction depending on soil property, three samples — fine grain brown lowland soil (paddy field), rudaceous brown lowland soil (field), and fine grain brown forest soil (forest) — were collected and a decontamination and volume reduction test was conducted. As one test result example, Fig. 5 shows the decontamination effect per type of soil when the particle diameter of classification point is set as 75 µm. Radioactive concentration per particle diameter before grinding and after grinding and classifying is indicated. In all cases, the radioactive concentration of each particle diameter after grinding and classifying was reduced to half or less at the coarse grain side. In this way, it was possible to confirm the basic principle of this equipment including (a) Grinding of superficial coarse grain, (b) Peel-off of grain, (c) Grinding surface layer of coarse grain and (d) Dry classification are feasible.

4.2 Classification point and decontamination effect

Figure 6 shows the result of organizing radioactive concentration of soil before and after grinding using classification points as the parameter.

After grinding the original soil with radioactive concentration of 8,000 Bq/kg, classifying by 45 µm was performed; as a result, radioactive concentration was reduced to 4,000 Bq/kg. In addition, after classifying was performed with 75 µm, radioactive concentration was reduced to 2,000 Bq/kg. However, when the classification particle diameter becomes small, the reduced rate becomes lower.

When soil with low contamination is reused, it is possible to estimate the reusable radioactive concentration of soil and the amount of materials by creating a chart as in Fig. 6 for the soil, which becomes the target. Although we have to wait to see future trends of regulation reference values, it is possible to draw up a detailed decontamination plan while considering the contamination state of original soil.

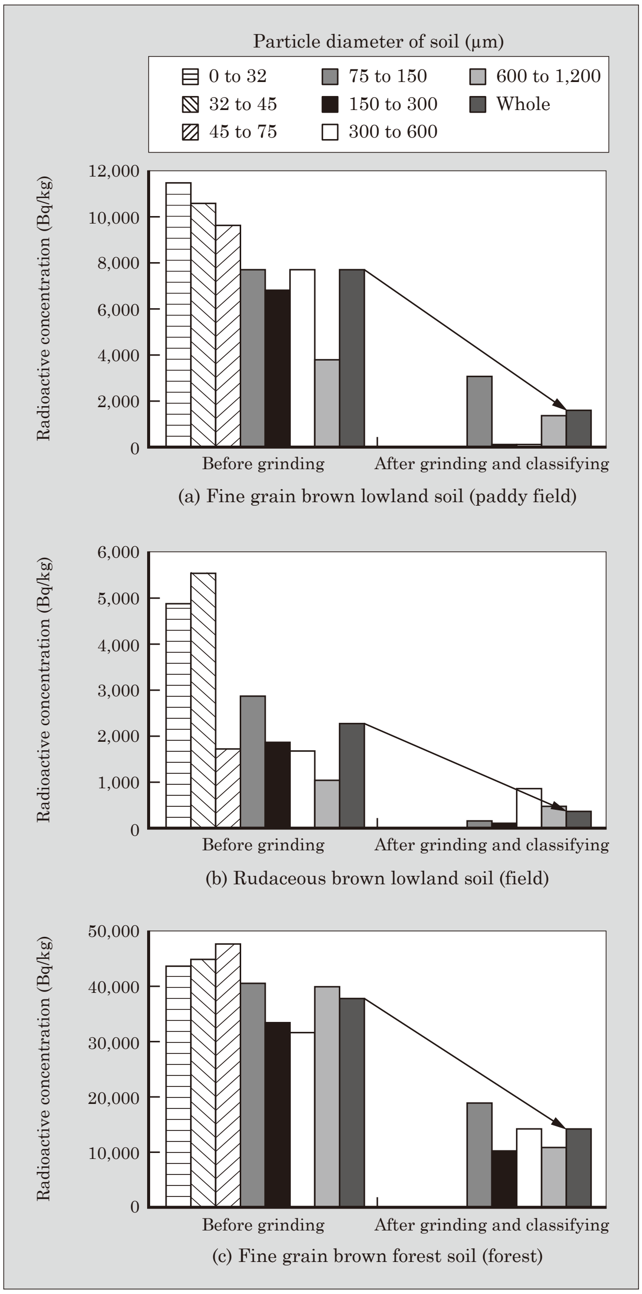

Fig.5 Decontamination effect for each soil (particle diameter of classification point 75 μm)

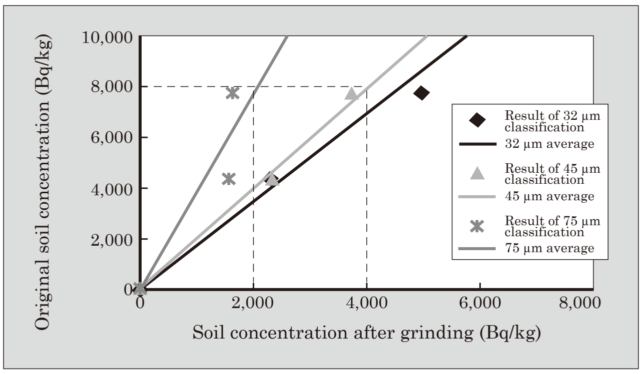

Fig.6 Decontamination effect by classification point (fine grain brown lowland soil: paddy field)

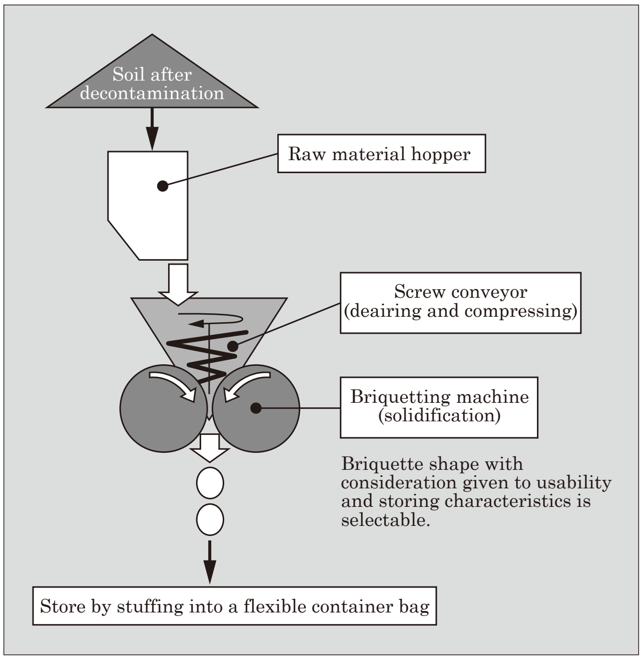

Fig.7 Example of volume reduction flow of high dose soil

5. Future Development

By adding processes for deairing, compressing and solidifying soil with a high radioactive concentration after decomposition treatment (see Fig. 7), further volume reduction can be expected. As a result, a further reduction in the space necessary for temporary storage at the interim storage facility can be expected. In order to evaluate the comprehensive effect of dry decontamination, it is necessary to grasp the volume reduction effect by deairing, compressing, and solidifying.

6. Postscript

This paper described technology for dry decontamination and volume reduction of contaminated soil caused by radioactive substances. In the future, we will develop technologies that can contribute towards recovery and restoration from the Great East Japan Earthquake and Fukushima Daiichi Nuclear Power Station accident.

Fuji Electric has conducted the demonstration as “Decontamination Technology Demonstration Test Project in FY2011” of the Ministry of Environment under Fuji Furukawa Engineering & Construction Co., Ltd. We express our gratitude to the Ministry of Environment and the Japan Atomic Agency, which provided us with guidance.