An Experimental Study on the Pelletization of Powdered Radioactive Waste Using the Roll Compaction System

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1. Introduction

Among radioactive waste unfit to be disposed of, powdered radioactive waste can be solidified using various mixing methods and solidification agent. But the mixed solidification process has a greater volume than the existing solidification process. To solve this problem, we can propose a method of turning them into disposable forms by compression-forming powdered radioactive waste into pellets to reduce the volume, and filling them with liquid solidifying materials like epoxy to solidify them.

This study tries to reduce the volume of powdered radioactive waste as much as possible by pelletizing it.

2. Experimental

2.1 Experimental materials

The bentonite, used for the pelletization experiment, is the Active Bentonite, sold by Company L, whose particle size is 85~100 ㎛ Active Bentonite. As a high-adhesion polymer, which can adjust the viscosity of the solution when the solidification agent is made, and tightly fasten the pellets after hardening, was needed, Company K's YD-128-epoxy, G1034-hardener and LGE-diluent were selected.

2.2 Experimental equipment

To form particulate fine powder into pellets, the Roll Compaction System, shown in Table 1, was selected. The conditions for system selection are intended to ensure the integrity of volume reduction and compact, and usability in nuclear facilities, and the high-volume-reduction forming device, including this system, is as shown in Fig. 1.

Table 1. Conditions for selecting the Roll Compaction System

No	Item
1	Possibility of forming pellets without using forming agent
2	Whether the pellet size is uniform
3	Possibility of forming high-density pellets (high volume reduction)
4	Whether it is possible to make it with a size and structure making it easy to install and maintain
5	No ancillary device should be necessary before and after pelletization.

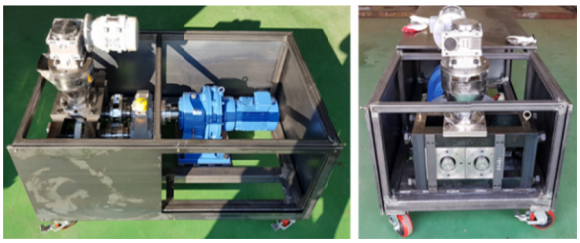

Fig. 1. Pellet forming device – side (L), front(R).

2.3 Pellet making experiment

The high-volume-reduction forming device was used to form the bentonite into rectangular pellets. At a constant powder feed rate and roll speed, the compressive force was increased to measure the gap distance and pellet compaction as illustrated in Fig. 2. As the forming compressive force increased, the gap decreased, and the compaction of the pellets was very good.

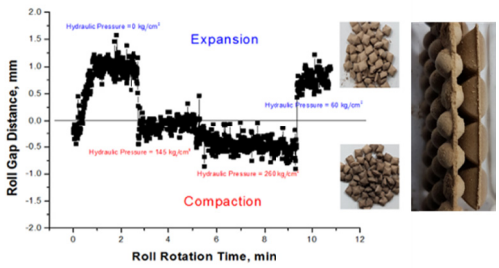

Fig. 2. Gap distance and compaction depending on the compressive force.

Secondly, the operating standards of the device were determined, and changes in the mass of the pellets were measured when operating parameters like the roll rpm (a), the powder feed rate (b) and the forming compressive force (c) were changed as shown in Fig. 3.

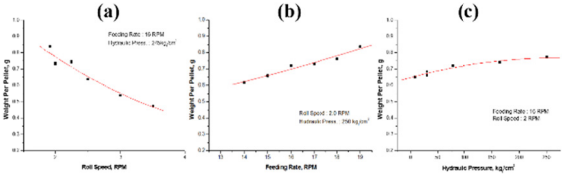

Fig. 3. Changes in the weight of the pellets depending on changes in the operating parameters.

The best forming conditions for making pellets were roll speed 2 rpm, powder feed rate 14.0 rpm, and forming compressive force 245 kg_f/cm^2.

2.4 Comparison of the standard volume reduction rate of the powder and the solidification agent

The weight of each formed pellet was 0.4739 g ~ 0.8644 g. From the conservative viewpoint, which maintains the shape of the pellet and has a constant strength, the weight of one pellet was 0.5847 g, and it was used for evaluating the volume reduction rate. To calculate the volume reduction rate of the powder, the pellet density of one pellet was divided by the density of the powder as shown below.

Volume reduction rate of the powder

$$\frac{\boldsymbol{Density\ of\ the\ pellet}(\mathbf{2.00\ g/cm^3})}{\boldsymbol{Density\ of\ the\ powder}(\mathbf{0.87\ g/cm^3})} = \mathbf{2.30}$$

To evaluate the volume reduction rate of the final solidification agent, the powder polymer solidification agent, mixed in the normal way, and the pellet polymer solidification agent were made, and the volume reduction rate was evaluated. The pellet and the powder polymer solidification agent look as shown in Fig. 4, and details of each solidification agent are shown in Table 2.

Fig. 3. Powder Solidification agent(L) and Pellet Solidification agent(R).

Table 2. Technical specifications by type.

Sample Type	Sample Size (mm)	Weight(g)			Sample volume(cm^3)
		powder	Epoxy	Total	
Pellet Solidification agent	H=100.03 D=49.90	228.41	85.74	314.15	195.52
Powder Solidification agent	H=104.59 D=50.23	56.75	161.99	218.74	207.15

When the solidification agent volume reduction rate is evaluated, the weight ratio of the powder itself and the pellet, which was injected for the same solidification agent volume, can be viewed as the volume reduction rate, and the formula is as shown below:

Volume reduction rate of the solidfication agent

$$\frac{\boldsymbol{Weight\ of\ the\ powder\ in\ the\ pellet\ solidification\ agent}(\mathbf{228.41\ g})}{\boldsymbol{Weight\ of\ the\ powder\ in\ the\ powder\ solidification\ agent}(\mathbf{53.56\ g})} = \mathbf{4.26}$$

3. Conclusion

The results of the experiment show that the volume reduction rate of the powder was 2.3 times higher, and the volume reduction rate of the solidification agent was 4.26 times higher. The authors will contribute to solving the problem related to the excessive waste disposal cost and disposal of inadequate waste by conducting additional experiments, e.g. measuring the mixing ratio of epoxy, changes in the form of pellets, thermal properties and strength of the solidification agent.

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