An Experiment on Pellet Manufacturing Using the High-Volume-Reduction Forming Device Based on the Roll Compaction System

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1. Introduction

If powdered radioactive wastes are compacted into high-density pellets of the same size, pores will be formed between particles, and polymers can penetrate them more easily, and even in case of solidifying the wastes by filling the pores with liquid agents, the volume will not increase. Rather, this roll compaction system, which reduces the bulk density of radioactive wastes first and further reduces the volume by improving the filling rate in the drum, can drastically improve the operation of the conventional solidification process, and greatly reduce the cost of disposal. Accordingly, to form particulate fine powder into pellets, the Roll Compaction System was used to make the high-volume-reduction forming device [1]. This study will select the optimal operating standards for the high-volume-reduction forming device to improve the filling rate during solidification, and conduct a preliminary experiment to ensure the soundness of the compression-molded pellets.

2. Experiment

2.1 Experimental materials and equipment

The particle powder in use is Active bentonite sold by company L. Its particle size is 85 ~ 100 ㎛. The particle size distribution and the shape of the powder are as shown in Fig. 1.

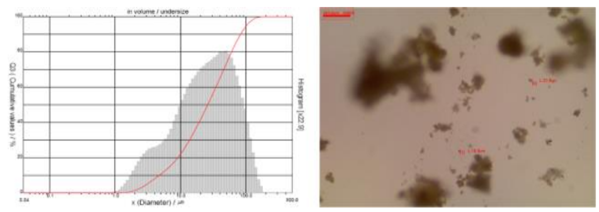

Fig. 1. Particle size distribution (L) and form of powder (R).

To make the particulate fine powder into rectangular pellets, the high-volume-reduction forming device in Fig. 2 was used.

Fig. 2. Pellet forming device – side (L), front (R).

2.2 Experimental method and details

To determine the device operating standards, operating variables, such as the rotational speed of the roll, the powder supply speed, and the forming compression, were changed to check the changes in the mass of the pellets and their status depending on the situation.

2.2.1 Roll Speed. If the rotational speed increases, the amount of the powder injected into the pocket will decrease, and the weight of the pellets cannot but be reduced as shown in Fig. 3. Accordingly, the powder supply speed had to be increased as well to increase the amount of processing per unit time.

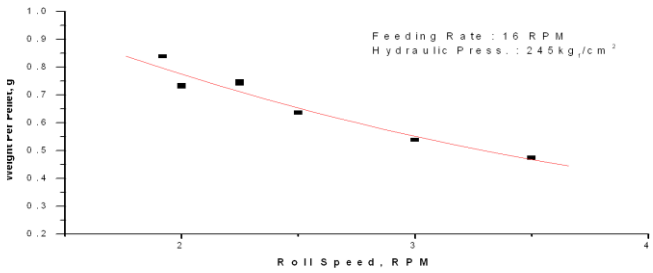

Fig. 3. Changes in the mass of the pellets depending on the variables - Roll Speed.

2.2.2 Feeding rate. Fig. 4 shows that the increased powder supply speed is proportional to the weight of the pellets. Due to the limitations in equipment design, however, if the powder supply speed is 19 rpm or higher, the torque of the motor will not be able to withstand the force, and stop [2].

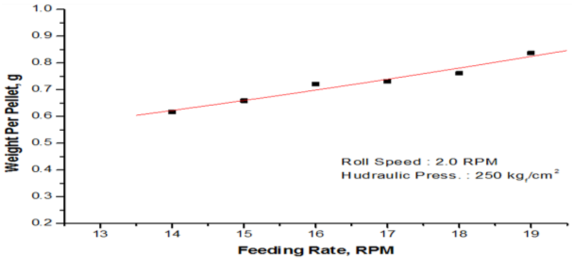

Fig. 4. Changes in the mass of the pellets depending on the variables - Feeding Rate.

2.2.3 Hydraulic Pressure. As the powder supply speed increases, the amount of powder supplied to the pocket will increase. At this time, the hydraulic pressure must be increased so that the force keeping the gap between rolls can be maintained as shown in Fig. 5.

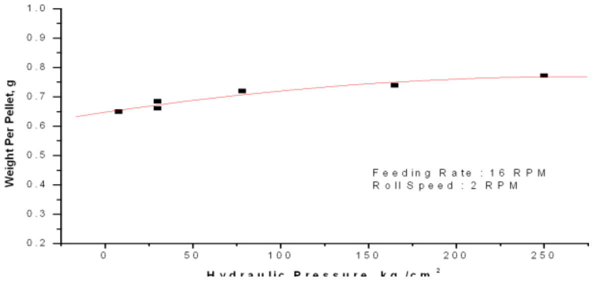

Fig. 5. Changes in the mass of the pellets depending on the variables - Hydraulic Pressure.

3. Result and discussion

The experiment found that forming compression was very important to ensure the soundness of the pellets while increasing the amount of processing of the forming device per unit time and the powder reduction ratio, and Fig. 6 illustrates that as hydraulic pressure increases, the compression state of the pellets and the widening of the gaps will be improved.

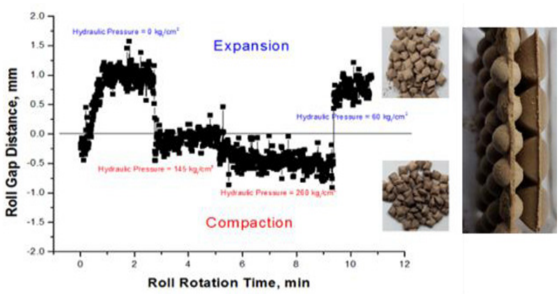

Fig. 6. Gap distance and compaction depending on the compressive force.

As a result, the optimal operating standards of the forming device were selected as roll speed 2 rpm, powder supply speed 14.0 rpm, and hydraulic pressure 245 kg_f/cm^2. The shape of the pellets made under these conditions is shown in Fig. 7, and the per-unit-time processing amount of the forming device can be expressed by Formula (1), and the volume reduction ratio of powder pelletization by Formula (2).

Fig. 7. The appearance of the pellets – Tertragonal shape (L), Circular shape (R).

$$\left(\frac{0.5847\mathrm{g}}{\mathrm{Pellet}}\right)*\left(\frac{264\mathrm{Pellets}}{\mathrm{Roll}}\right)*\left(\frac{2\mathrm{RPM}}{\mathrm{min}}\right)*\left(\frac{60\mathrm{min}}{\mathrm{hr}}\right) = 18.374\ \mathrm{Kg/hr} \quad (1)$$

$$\frac{Density\ of\ the\ pellet(2.00\ g/cm^3)}{Density\ of\ the\ powder(0.87\ g/cm^3)} = 2.30 \quad (2)$$

4. Conclusion

The result of the experiment shows that the optimal operating standards of the high-volume-reduction forming device were applied, and high-quality pellets with a 2.3 times higher volume reduction rate could be made. If additional experiments on the influence of the particle size of the powder and the particle size distribution, and the influence of moisture contents on pellet formation are conducted and the soundness of formed pellets is secured, a high filling rate will be secured during solidification of powdered wastes, and excessive disposal costs and saturation problems will be solved.

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