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Study on the High Volume Reduction of Radioactive Wastes

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1. Introduction

It is very difficult for a briquetting machine, which is very popular in general industry, to apply to the nuclear fields because of his rough characteristics. So the machine must be modified sophisticatedly for the volume reduction of powdered radioactive wastes in consideration of (1) agglomeration of a powder without any binders (2) constant (formed pellets) size distribution (3) high apparent density (4) dimension and structure for easy maintenance (5) no supplementary installations. The shape (tetragonal and circular) and size of pocket and the uniform feeding method of a powder into the pockets of the roll tyre were important elements of the above considerations.

The solidification of radioactive wastes by the mixing method always increases their volume due to the limitation of incorporation ratio (waste/solidification agent). But if the powdered wastes can be compacted as the high density pellets and also the pellets can be filled up in a waste drum as much as possible while solidifying them with a very sticky solidification agent including a void formed in the filling step of pellets, it might be more desirable to reduce the waste volume as compared with the mixing method.

So in this study, we designed and manufactured a high volume reduction machine which has the special size and shape of a pellet pocket, which the pellets can be extracted from easily and filled up in a large amount in drum, a pressurizing device to press 2 rolls, and the uniform feeding device of powder to the roll tyre. Some operational parameters which affect the formation of pellets from a powder were investigated, and then the volume reduction of a powder was evaluated.

2. Methods and Results

'High volume reduction' has been evaluated with the measurement of the apparent density of the pellets produced during a performance test of the modified briquetting machine. Bentonite (particle size; 85 ~ 100 ㎛) was used as a powder for the volume reduction of a radioactive waste.

2.1 Pellet Type

Roll tyre was designed to extract pellets (< 9 mm, 0.275 ml) easily from their pockets and to maximize the volume reduction (compacted agglomeration) of powder. The shape (tetragonal and circular) and size of the pellet pocket of the roll tyre are shown in Fig. 1.

Fig. 1. The shape of the pellet pocket of the roll tyre

2.2 Effect of Roll Press

The roll press is very important to agglomerate a powder as the pellets inside the pockets where are located at the surface of each 2 roll tyres which rotate in the opposite direction. The agglomeration pressure depends on the property which corresponds to the type of a powder. As the pressure for the compaction of a powder, the hydraulic pressure (22.1 ton) and the fixed distance (0.5 mm) between 2 roll tyres except the spring type (relatively low pressure than others) were adopted in this modified machine. If the agglomeration pressure is low, the powder is not compacted to the pellets or the volume reduction is not expected due to their low strength. As a result of the state and the apparent density of the pellets obtained by changing the pressure from 0 to 286 kg_f/cm^2, the pellets were very unstable at pressure = 0, but above 148kg_f/cm^2 the pellets were very stable due to their high strength. The apparent density (g/cm^2) of the pellets was 2.63 at 148 kg_f/cm^2 (approx. 9.4 ton), and 2.68 at 286 kg_f/cm^2 (approx. 18.1 ton). The agglomerated pellets are shown in Fig. 2 ((a) unstable (b) stable).

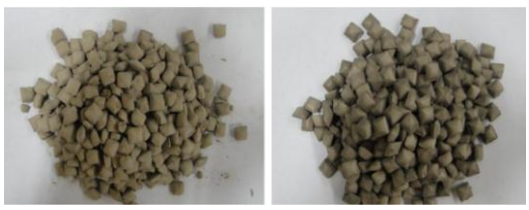

Fig. 2. (a) Unstable pellets (b) Stable pellets

2.3 Effect of Roll Speed

The roll speed (rpm) can determine the capacity (kg/h) of a briquetting machine, and depends on both the agglomeration pressure and the feeding rate. As a

result of the state and the apparent density of the pellets obtained by changing the roll speed from 1 to 4 rpm, the roll did not rotate at the 1 rpm and the pellets were not formed because the agglomeration pressure was relatively low to compact the feeding powder. But as increasing the roll speeds from 2 rpm to 4 rpm, all the formed pellets were stable, but the apparent of pellets was decreased gradually from 2.74 to 1.45 g/cm^3. It is a reason that the quantity of powder which was fed into the pockets between 2 roll tyres at 3 and 4 rpm was relatively less than that of 2 rpm.

2.4 Effect of feeding rate

The feeding rate of powder must be interrelated with the revolution of roll tyre. The revolution of the screw inside the feeding device was changed to find the effect of feeding rate at a constant of roll speed and the constant agglomeration pressure. In other words, while changing the feeding rate of a powder from 8 to 12 rpm at the roll speed = 3 rpm and 286 kg$_f$/cm^2, the state and the apparent density of pellets were investigated and the obtained result is presented in Fig. 3. In Fig. 3, the apparent density of the pellets was linearly proportional to the feeding rate from 2.18 to 2.74 g/cm^3. The reason is that the volume of powder fed inside the pockets of roll tyre at 12 rpm was relatively much and also the agglomeration pressure was sufficient to press the fed powder volume. This result gave a clue to increase furthermore the volume reduction of powder compared to the obtained results. Namely, it means that the volume reduction might be increased more if the feeding rate can be increased until the maximum limitation of the agglomeration pressure which is acceptable in this modified machine

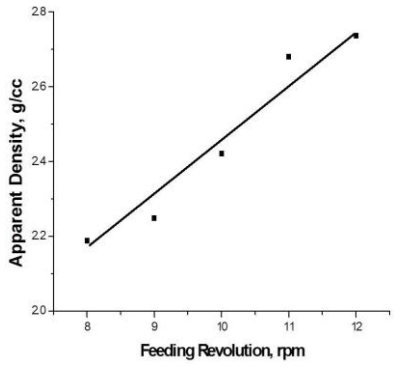

Fig. 3. Apparent density of the pellets according to the feeding rate (revolution)

2.5 Evaluation of High Volume reduction

We found the possibility of the modified briquetting machine for the volume reduction of the powdered radioactive wastes with the shape state and apparent of the pellets formed while carrying out the performance test by changing the operational parameters. Through the comparison of the apparent density between a raw powder (0.93 g/cm^3) and the obtained pellets (2.74 g/cm^3), the volume reduction was calculated as approximately 2.74/0.93 = 2.95. But it is very careful to evaluate the volume reduction of the radioactive wastes because the voids must be originated by the filled pellets inside 200L drum.

3. Conclusions

The briquetting machine, popular in general industry, was modified to apply for the volume reduction of the powered radioactive wastes (dried concentrate, sludge, spent ion-exchange resin, ash, depleted uranium powder, and etc.). In this developed high volume reduction machine, the capacity was 25 ~ 62.5 kg/h at the optimum conditions, and the estimated volume reduction was about 2.95 (2.74/0.93) on the basis of between a powder (bulk density = 0.93 g/cm^3) and the pellet (2.74 g/cm^3). But on the basis of 200L drum, the calculated volume reduction was about 1.34 in consideration of a void volume originated in the filling step of the pellets.