DEVELOPMENT OF PHYSICAL TREATMENT TECHNOLOGY FOR STALL WASTEWATER

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ABSTRACT

Solid/Liquid(S/L) separation is crucial for biological treatment of animal wastewater. Liquid portion from S/L separation has less BOD-load and proper post-strip treatment can be obtained. Screen or declined sieve was normally used to separate the solid parts. For better separating efficiency a vibration and a cylindrical separator were constructed and tested.

The results are summarized as follows: Solids removal efficiency and moisture content of separated solid were 15-26% and 85-88%, respectively for the vibration separator. For the cylindrical separator, solid removal efficiency and moisture content of solid were 16-39% and 86 -89%, respectively. The greatest amount of drymatter was obtained when operating vibration separator with 10° inclination and 100% vibrating power. For the cylindrical separator maximum efficiency was obtained with 40rpm and 19° inclination. The vibration and the cylindrical separator have shown 21% and 26% in BOD removal, respectively. These two types of separator were proved to be applicable methods for animal wastewater separation.

Key words : Vibration separator, Cylindrical separator, Solids removal efficiency

INTRODUCTION

An increasing number of breeding livestock requires a high efficient technique in the animal waste management. The regulation about waste disposal was more strengthened from July 1st, 1996. The range of farms which permitted its activity from the government is enlarged and the BOD content in effluent is reduced from 1,500 mg/l to 350~500 mg/l for the farms which reported to the government. The animal waste is generally managed in the stall separately as dung and urine. Because the pig farms has posessed few acerable land, a purification technique of stall wastewater should be developed.

In treating the wastewater, the activated sludge process is normally used as a biological process. In this method, it is very important to keep the BOD-concentration in the influent low. Dung has as many times BOD as that of urine. How much solid part includes in the wastewater depends on the method of dung removal. In the scraper method an amount of solid part can still be remained in the wastewater. This can result in a higher contents of BOD in influent and burden the after process. Therefore it is necessary to have a high efficent solid and liquid (S/L) separator. The object of this study is to analyze the efficiency and to find characteristic of the separator and it will become a foundation for a complete system for animal wastewater treatment.

MATERIALS and METHODS

Two kinds of the separator, a vibration separator and a cylindrical separator were constructed and tested. The flow chart for the complete system of animal wastewater purification is shown in fig. 1. The animal wastewater flows from the stall into the sand settling tank. After settling the sands, the wastewater is separated into two parts, solid and liquid part by the separator before flowing into water gathering tank. In the aeration tank the wastewater is aerated by the blower. After settling the sludge in the settling tank, the purified water is discharged. The aeration is continued by a batch system (0h 7). A bedding material like straw is not used in the stall. The wastewater includes urine, cleaning water, rest of feed and some of dung. It shows a different dung removal, depending on the worker. The dry matter contents of the wastewater varies in the range of 0.4~1.3 %.

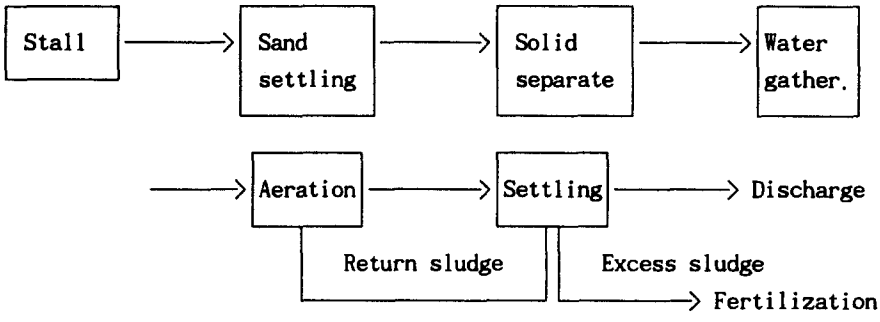

Fig. 1. Scheme of a treatment system for animal wastewater

The vibration separator has two vibration motors and a inclined sieve. A submerged pump (LG Modell PDV-400M) pumps the wastewater over the sieve. The solid part in the wastewater falls down over the sieve and the liquid part flows through the sieve into the water gathering tank.

Table 1. Specification of vibration separator

Screen	Vibration motor	Coil spring
40mesh	0.2kW×2	SUP6 ϕ9×4

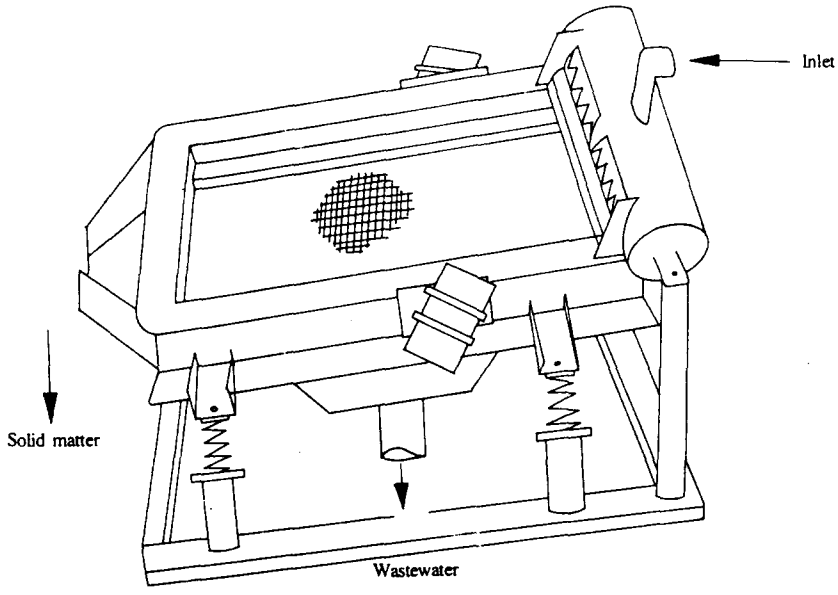

Fig. 2. Vibration separator

The specification of the vibration separator is shown in table 1 and the material flow in fig. 2. The cylindrical separator separates S/L part with the centrifugal power. When the cylinder rotates, it procreates a centrifugal power. The liquid part flows through the sieve and the solid part falls down in the cylinder. The rotation speed of the cylinder can vary on 3 step with changing the pulley in different size diameter. The specification of the cylindrical separator is shown in table 2 and a schematic in fig. 3.

Table 2. Specification of cylindrical separator

Screen	Motor	Diam. of cylinder
20mesh	1.5kW	57.5cm

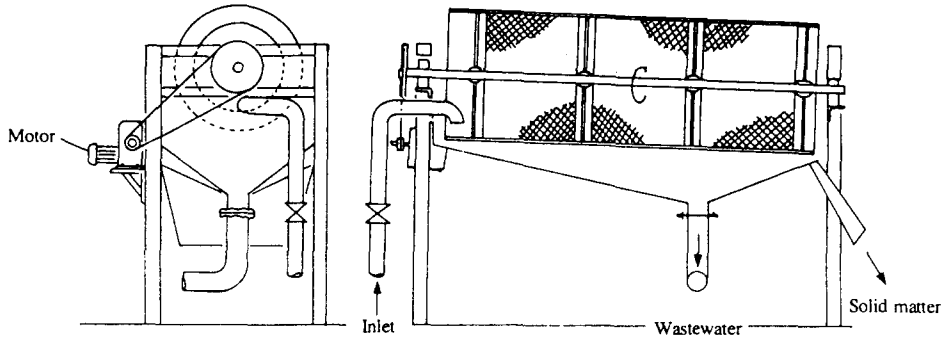

Fig. 3. Cylindrical separator

The parameters of the both separator are varied in the test shown in table 3. The vibration power of the vibration separator means the power rate which is varied with the position of the weight in the motor.

Table 3. Experimental conditions of separators

Vibration separator		Cylindrical separator	
Angle of inclined screen	5°, 10°, 15°	Angle of inclined screen	13°, 16°, 19°
Power rate of vibration motor(%)	40, 60, 80, 100	Revolution speed(rpm)	28, 40, 45

The separation efficiency can be calculated from equation 1 as comparing the dry matter content in the wastewater with the dry matter content from the liquid part. In order to measure the dry matter content, the sample is dried in the dry oven with 105° C for 48 hours.

$$\eta = \frac{Z_o - Z_1}{Z_2 - Z_1} \qquad (1)$$

Z_o : dry matter content in the wastewater
Z_1 : dry matter content in the liquid part
Z_2 : dry matter content in the solid part

The best combination of parameters can be calculated according to the maximum separated solid part. This can be calculated from the equation 2 using the separation efficiency and the dry matter content of the separated solid part.

$$\text{Recovered drymatter(g)} = \frac{\text{dry matter content separated solid}}{\text{dry matter content of wastewater}} \times \text{separation efficiency} \qquad (2)$$

The BOD removal by the separation is important because it reduces the BOD-load in the post-process. To know the BOD removal rate, BOD content is analyzed from the wastewater before and after the separating process. Manometric BOD meter is used for this purpose which indicates the expended oxygen as a vaccum.

RESULTS & DISCUSSION

1. Separation efficiency

The separation efficiency according to the inclination angle and the vibration power of the vibration separator is shown in fig 4. As the vibration power of the motor increases, the separation efficiency is generally increased from 15% to 26%. When the vibration cycle increases, the separation is accelerated. On the other hand, when the inclination angle becomes bigger, the material slips over the sieve and the separation efficiency is higher.

The difference between the parameters of inclination angle of 5° and 10° is big. But the difference between 10° and 15° is small. This means that the separation efficiency arrives at the optimum rate around the angle of 10° & 15°. Beyond that point the separation rate is somewhat reduced, even if the inclination angle increases.

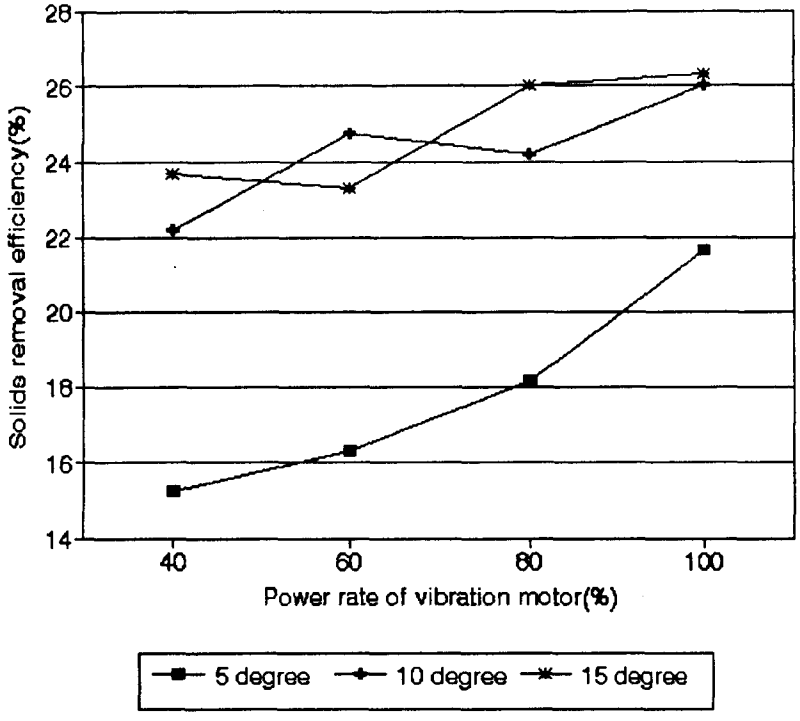

Fig. 4. Solid removal efficiency as variations of a power rate of vibration motor and a angle of inclination

The separation efficiency of cylindrical separator according to the rotation speed and the angle is shown in fig. 5. As the inclination angle of cylinder increases, the separation efficiency is increased from 16% to 39%. The greater inclination angle is, the more material slips. This means that the shorter time the solid part in the cylinder stays, the more the separation efficiency increases. When the rotation of the cylinder increases, the centrifugal power in the cylinder is bigger. Therefore it can give a negative influence on the separation efficiency. Because this test is done in the farm condition, it was difficult to keep the dry matter content in the wastewater constantly. In case of the combination of 45rpm and 13 °, the value is somewhat high because of higher content of dry matter in the wastewater.

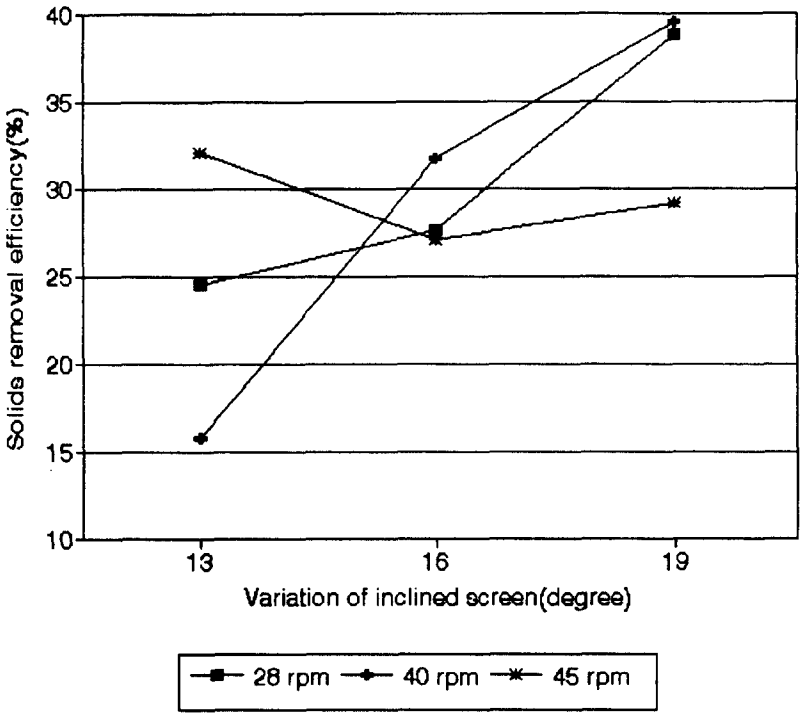

Fig. 5. Solid removal efficiency as variations of a revolution speed and a angle of inclination

In the test of S/L separation, the vibration accelerates the flow of material and the fast rotation decelerates the flow so that the efficiency is related to the angle of inclination. The separator should be set to get a higher efficiency considering these conditions.

2. Water content of the separated solid part

The water content of the solid part varies 85~88% in wet basis, shown in fig. 6. It varies more with the inclination angle than the vibration power. As the material stays longer over the sieve, the water content in the solid part decreases. The test using the inclined sieve from Flachowsky (2) showed 86% of the water content in the solid part. In the cylindrical separator, the water content of solid part according to the rotation speed and inclination angle is shown in fig. 7.

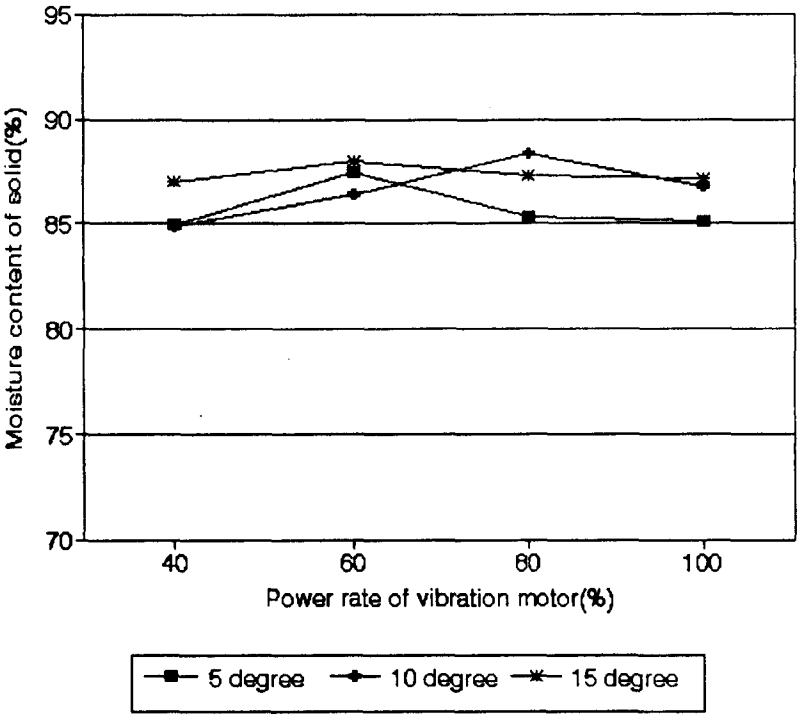

Fig. 6. Moisture contents of solid as variations of a power rate of a vibration motor and a angle of inclination

The water content from the separated solid part was in the range of 86~89% by the cylindrical separator. As the rotation speed increases, the water contents of the solid part is expected to be reduced because of the centrifugal power. From the result, the staying time on the sieve has a great influence on the separation efficiency and the water content of the solid part. Therefore, it is necessary to combine these factors, the vibration power or rpm with the inclination angle of sieve to get the maximum solid part. From the equation 2 one can get the more separated solid part, making the optimal combination. The result is shown in table 4. For the vibration separator, the maximum separated solid of 3.45g was obtained with 10 ° of inclination angle and 100% of vibration power. By the cylindrical separator, it was 4.74g with 40rpm and angle of 19°.

3. BOD removal

The BOD-removal was 21% by the vibration separator and 26% by the cylindrical separator. This value is higher than that of Glerum (3)'s 18%. Literature from Japan

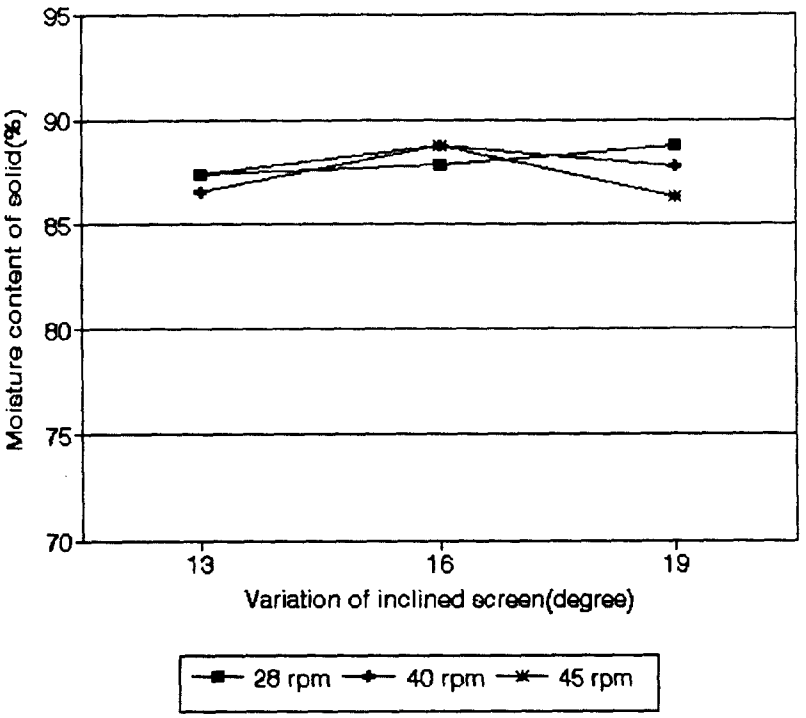

Fig. 7. Moisture contents of solid as variations of a revolution speed and a angle of inclination

Table 4. Results for optimal condition of separator

Vibration separator		Cylindrical separator	
5 ° - 40%	2.30g	28 rpm - 13 °	3.18g
60%	2.05	16 °	3.31
80%	2.67	19 °	4.26
100%	3.23		
10 ° - 40%	3.37	40 rpm - 13 °	2.05
60%	3.36	16 °	3.49
80%	2.81	19 °	4.74
100%	3.45		
15 ° - 40%	3.07	45 rpm - 13 °	4.17
60%	2.80	16 °	2.97
80%	3.30	19 °	4.08
100%	3.39		

(8) showed the BOD-removal rate 23% and 21% respectively. The BOD-removal has shown less higher in the vibration separator than that of cylindrical one. The BOD of separated liquid has shown 1,680mg/l and 2,070mg/l respectively. The vibration separator has a lower value. It could be caused by the difference of the sieve mesh. In the practical use, the vibration separator has a self-cleaning function whereas the cylindrical separator requires a extra cleaning device.

Table 5. Removal rate of BOD

	BOD of wastewater (mg/l)	BOD of separated liquid (mg/l)	Removal efficiency (%)
Vibration separator	2120	1680	21%
Cylindrical separator	2810	2070	26%

CONCLUSIONS

As a former step of waste treatment, a separation is required. The result of the separation efficiency is as follows: By the vibration separator, the separation efficiency shows from 15% to 26%, The water content of separated solid part was 85~89%. By the cylindrical separator the separation efficiency shows from 15% to 39%. The water content of solid part was 86~89%. The maximum amount of separated solid part can be obtained by 10° of inclination angle and 100% of vibration power for the vibration separator and for the cylindrical separator it was 40 rpm of rotation speed and the 19° of inclination angle. The BOD-removal rate was 26% by the cylindrical separator and was higher than 21% of the vibration separator.

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