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Development of Composting System

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Abstract

A simple compost windrow-forming car and a compost turner were designed to develop low-cost manure management systems. The compost windrow-forming car enables the formation of windrows in a short time. In order to pulverize and mix manure by upper and lower beaters in the process of windrow-forming, conditions such as aerobic respiration and mixing of materials which play a major role in composting were fulfilled. This car can also be utilized as a manure spreader by folding the windrow-forming cover. The compost turner is equipped with a tractor on the rear right side. Main specifications are 2.5 m working width, overall length of 3.3 m and conveyor inclination angle of 45°. Two beaters for mixing and pulverization are attached to the front parts. Windrows with a width of 2.5 m and height of 1.5 m are turned at the speed of 4.5-5.1 m/min. Combination of the compost windrow-forming car and the compost turner enables to construct a simple composting system for individual farmers at a low cost.

Discipline: Agricultural machinery
Additional keywords: compost, turner, windrow

Introduction

With the enlargement of the livestock scale and specialization or progression of regionalization in Japan, the amount of manure per administrative unit is increasing. In taking account of the importance of environmental protection, environmental pollution caused by dairy farming is increasing, leading to the pollution of the water system, etc. The lack of manpower sometimes compels farmers to reduce the number of animals to limit the management of manure. From the viewpoint of environmental protection and dairy management, the development of a simple manure management system at a low cost for material circulation is the most important problem (Fig. 1).

In this report, the development of the compost windrow-forming car and the compost turner for

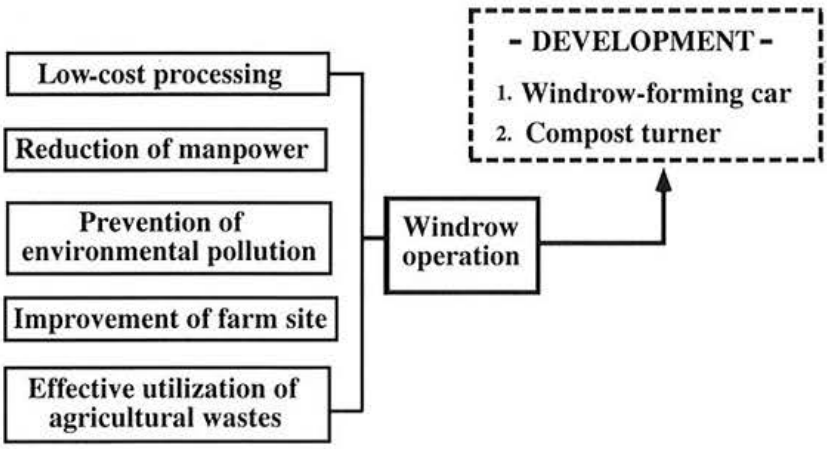

Fig. 1. Design concept

individual farmers is outlined.

Development of the compost windrow-forming car[2-4]

In order to manage manure efficiently in a small area, it is important to pile it in a fixed form. Therefore, the windrow-forming car designed for piling manure in a fixed form in a short time was eventually developed (Plate 1). This machine is a modification of the manure spreader which is widely used. The modifications involve the floor conveyor speed for unloading and the cover of the spreading part. The conveyor speed increases by about 10 times at the time of manure spreading and to prevent a scattering of manure and to regulate the windrow shape, a removable cover is attached to the manure discharging parts. Two machines with a maximum carrying capacity of 1.5 m^3 and 8 m^3 were developed. Formation of windrows was possible in a short time (20 s/1.5 m^3, 52 s/8.0 m^3). A cross-section of the windrows reveals a roughly semi-circular diameter of 2.5 m, 3.7 m.

Plate 1. Windrow-forming system

As manure materials are pulverized and mixed by upper and lower beaters at the time of windrow-forming, necessary conditions for composting such as the mixing of air and uniform mixture of materials are fulfilled. When manure materials have been piled with a bucket loader, etc., if a compost turner is used, the middle of the windrows must be divided and high power is needed. If manure materials are piled in the windrow orderly, to avoid the use of power for dividing the middle of the windrows, turning work is easy. Moreover, this machine can be also utilized as a manure spreader by folding the windrow-forming cover and changing the speed of the floor conveyor. In addition, it can also be used in a composting storage or a simple composting house where the mobility of a loader, etc. is limited and work is difficult. Since manure can be piled as it is, if the frontage of composting storage is 7 m, 2 windrows can be formed at an interval of about 2 m between windrows for vehicle traffic. Windrow-

Plate 2. Turning operation

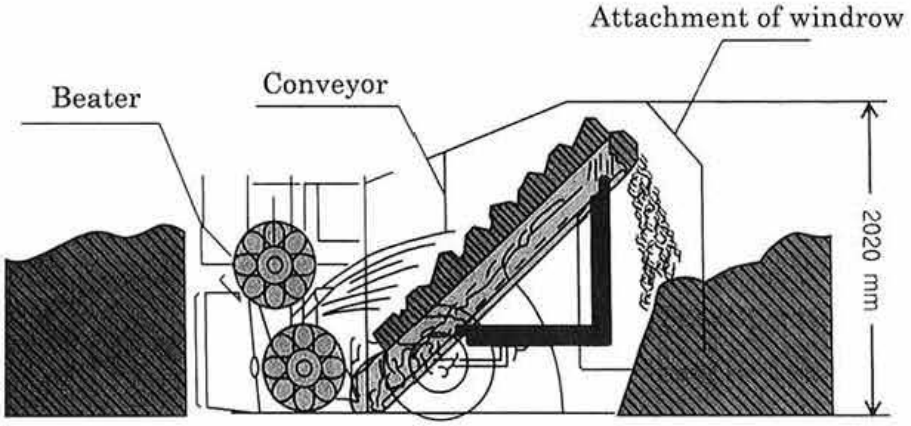

Fig. 2. Turning mechanism

turning is essential for composting and this machine was designed for the introduction of a compost turner.

Development of the compost turner[2-4]

In the composting process, appropriate moisture content and aeration are essential. Manure is piled for pulverization and uniform mixture by the machine. As aerobic respiration declines with time, appropriate ventilation for composting is prevented. Moreover, unevenness of microbial activity also occurs[1]. Therefore, it is necessary to improve the aeration conditions by mixing and turning, which requires the addition of a compost turner.

The developed compost turner is attached to the rear side of a tractor, and the turner is fitted with 2 beaters for pulverization and raking and a conveyor for discharge. Compost materials are raked in by the 2 beaters and are transported by the conveyor. These materials are discharged from the conveyor edge at a height of 2 m. By forming windrows with adequate mixture and pulverization by the beaters and the conveyor, the progression of composting can be achieved. This machine is designed for a compact format. Dimensions are as follows: 3.31 m for total length, 2.50 m for total width, 2.02 m for total height and 1,500 kg for total mass. The fitting to a tractor is easy and the machine can be set up in the rear part of tractors at the time of movement. Working speed ranges from about 4.5-5.1 m/min for windrows with a 2.5 m width and 1.2 to 1.5 m height. Required power is about 30 kW. The power could be decreased since the materials were already pulverized at the time of windrow-forming. Drawbar power was slightly less than 1 kW on a dry road surface (Fig. 2, Plate 2).

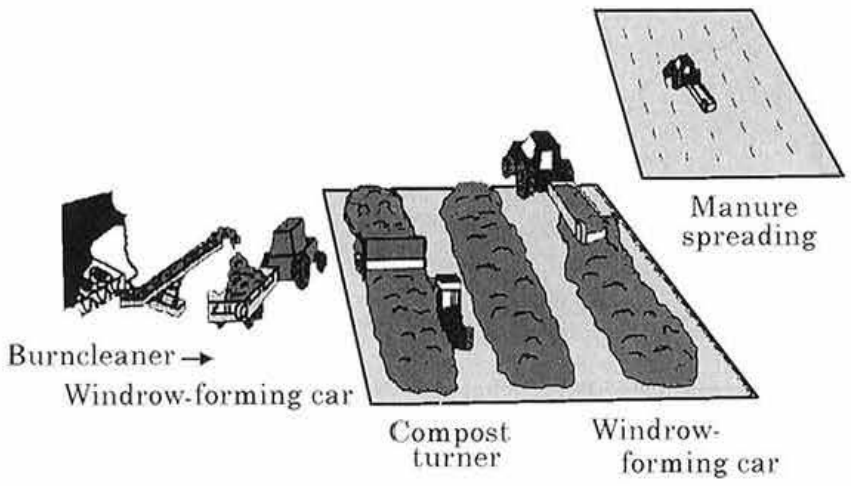

Fig. 3. Composting system

Tests

1) Open air tests

A composting pad using materials for soil hardness was constructed and a systematic composting test was carried out by the combination of the windrow-forming car and the compost turner in open air (Fig. 3). Two experimental wards were set up for the moisture control of the cattle raw materials used.

The temperature which started to increase immediately after piling reached 79°C on the 6th day in the ward with the moisture control materials (organic soil improvement materials), and 58°C on the 4th day in the ward without moisture control materials (see Fig. 4, temperature profiles). These observations indicate that the microbial activity was

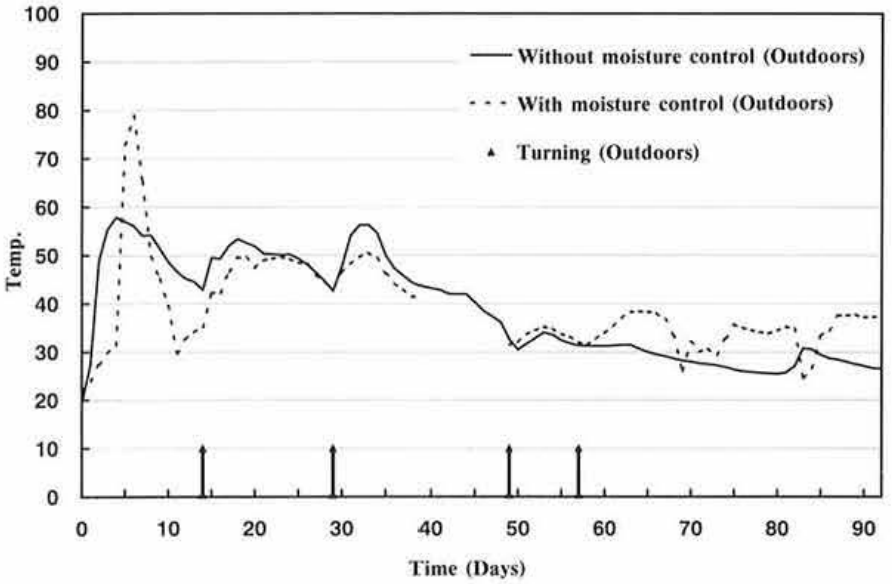

Fig. 4. Temperature profiles (open air)

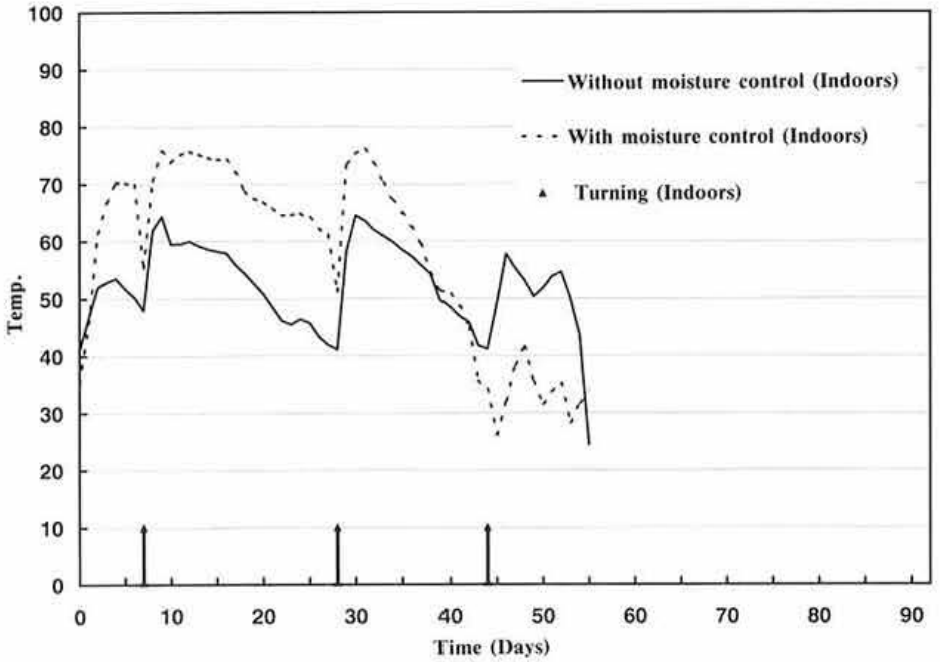

Fig. 5. Temperature profiles (steel frame house)

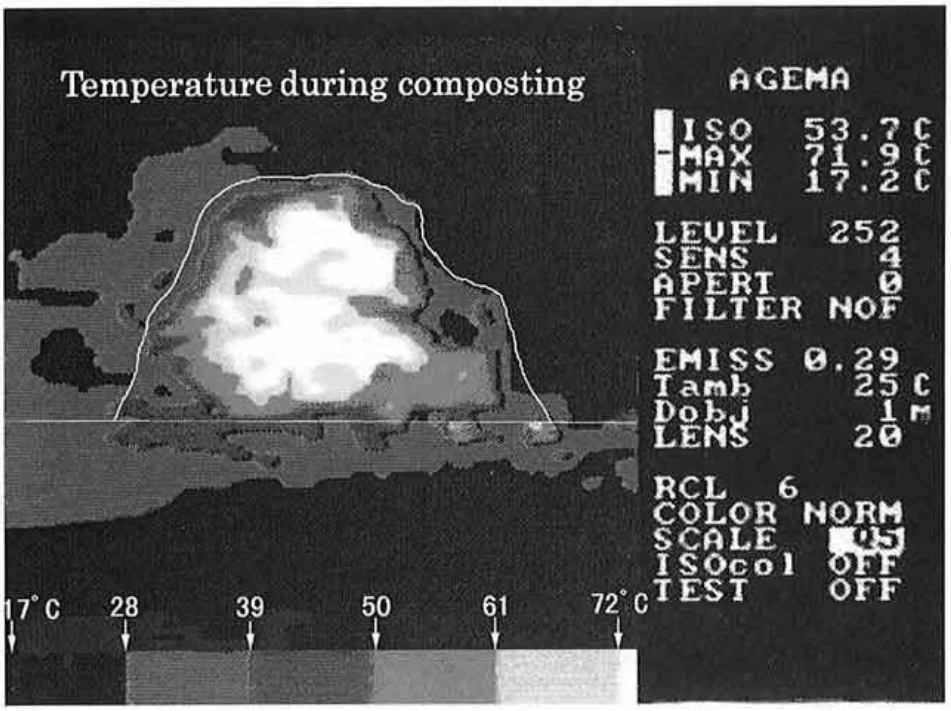

Plate 3. Temperature in the windrow

adequate due to the pulverization and mixing at the time of piling. Afterwards, 3 turning operations were performed every 2 or 3 weeks and compost maturity was estimated based on the color, stability of temperature, decrease of C/N ratio, decrease of ammonia nitrogen content, increase of nitric acid nitrogen content and nitrous acid nitrogen content.

2) Tests in a steel frame house

In the case of a steel frame house, the temperature in the windrow remained high during the composting process (Fig. 5). As a result, after 2 turning operations, composting was completed. Compared with the open air condition, the turning frequency was reduced to 1 time and the duration of the composting period was shortened to about 10 to 15 days.

Plate 3 shows the temperature in the windrow 7 days after piling. The temperature increased uniformly in the windrow, suggesting that the interior of the windrow showed the appropriate conditions for composting.

Area requirements

The area required for the composting pad depends on the volume of materials handled, windrow shape and length and the space needed to move the equipment. Moreover, the windrow shape was

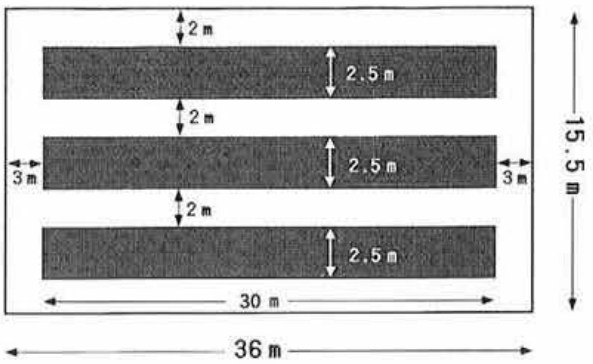

Fig. 6. Windrow layout and required space

determined by the composting method and equipment used to form and turn windrows. Here, the required area was calculated for the use of the windrow-forming car and the compost turner.

The daily volume of materials to be composted from 70 cattle (mean value in Hokkaido) is approximately 4 m^3. Based on the experimental results, if the duration of the composting period is 60 days, total material volume is 240 m^3. Assuming that the site is 30 m long and that the windrow-forming car can build windrows 1.5 m high and 2.5 m wide, the windrow volume is about 75 m^3. As the total volume to be composted is 240 m^3, 3 rows of windrows are required. Assuming that an interval of 2 m between windrows (aisle space) is required for operating the

equipment and that 2 m space is required in the pad periphery, the pad width is 15.5 m. Assuming that a 3 m space is required for the operation of the machine, the pad length is 36 m. Accordingly, since the area required for the composting pad is 558 m^2, it is necessary to provide a 600 m^2 space (Fig. 6).

Conclusions

As stated above, by combining a windrow-forming car with a compost turner, a simple composting system was developed. Materials to be composted from the barn cleaner are received in the windrow-forming car and are piled to the composting pad and turning work is repeated in the composting process.

In the investigations which have been carried out outdoors and in a steel frame house, necessary conditions for composting were maintained during the composting period. The duration of the composting period was approximately 50 to 60 days after 3 turning operations outdoors. When a steel frame house was used, the period was shortened to about 10 to 15 days.

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