

SPECIFICATION

Composting apparatus

The present invention relates generally to treatment of refuse and, more particularly, to a

5 composting apparatus for converting organic materials in municipal refuse, such as kitchen refuse, into compost.

There have been various approaches to treatment of municipal refuse. In view of the fact that using refuse as landfill or incineration of

10 refuse causes secondary problems, recent practical methods of municipal refuse treatment have been to reduce the volume of refuse or to treat the refuse for reuse as a resource.

15 Particularly, the method of sorting municipal refuse for reuse has become more and more prevailing. Kitchen refuse which has been sorted out by the sorting method or kitchen refuse collected initially as such can be effectively converted into compost. Obviously the treatment capacity of a composting

20 apparatus per unit area required for installing the apparatus can be made higher by increasing the height of the heap of the material. In practical operation, however, when the heap of the material is too high the material packs down into a mass in

25 which air permeability is reduced, thereby retarding aerobic fermentation therein. This tendency is significant in material having a relatively high water content, such as kitchen refuse, organic sludge, and the like. The known

30 multistage vertical cylindrical composting apparatus comprising a plurality of horizontal floors in which material is allowed to fall successively to the floor below can reduce the

35 height of composting material on each floor relative to the height of the heap in a single-stage composting apparatus and can, accordingly, eliminate some of the disadvantages mentioned above and increase the treatment capacity of the

40 apparatus.

However, the conventional multistage vertical cylindrical composting apparatus, in which the material is moved by a rake rotating about a cylindrical shaft in conjunction with some

45 agitation, has disadvantages in that substantial agitation of the material is not performed and relatively much power is required to rotate the rake of a large radius while shearing the material between the rake and the floor. Another

50 disadvantage of the material raking operation on the floor is that it tends to consolidate the material into dense masses resulting in insufficient agitation particularly in material of high water content, thereby retarding fermentation of the

55 material. Consequently, in the conventional composting apparatus it is impossible to increase the height of the material in each stage expecting the agitation effect provided by the rake.

One object of the present invention is to provide a composting apparatus obviating the

60 above disadvantages of the conventional composting apparatus — that is, reducing the amount of power required, preventing packing and massing of the material, and enabling efficient

65 composting of material having a high water content.

The present invention provides a multistage composting apparatus comprising a plurality of horizontal floors and a multistage vertical

70 cylindrical tank allowing composting material to fall successively from one floor onto the floor below, each of said horizontal floors being provided with at least one agitator unit having beaters rotatable around a respective axis of the

75 agitator unit substantially parallel to the horizontal floors and said horizontal floors and said agitator units being supported so as to be rotatable relative to each other about the central vertical axis of said cylindrical tank.

80 The present invention will now be described with reference to the drawings, in which:—

Fig. 1 is a vertical sectional view of an embodiment of the present invention;

85 Fig. 2 is a sectional view taken along the line II—II of Fig. 1;

Fig. 3 is a developed view of a section taken along the circle III of Fig. 2;

Fig. 4 is a view illustrative of operation of beaters;

90 Fig. 5 is a view illustrative of operation of the beaters of a modification of said embodiment in which two stages of agitator units are provided;

Fig. 6 is a vertical sectional view of another embodiment of the present invention;

95 Fig. 7 is a sectional view taken along the line VII—VII of Fig. 6;

Fig. 8 is a view taken in the direction of the arrow VIII of Fig. 6; and

Fig. 9 is a view illustrative of operation of beaters of the embodiment of Fig. 6.

100 Figs. 1 to 4 show a multi-stage composting apparatus comprising a series of horizontal floors 3 each floor having a compost-falling opening 2. The floors 3 are fixed inside a vertical cylindrical tank 1 to make a corresponding number of stages.

105 A rotary agitator shaft 8 is disposed above each horizontal floor 3 and parallel thereto. Beaters 7 revolve about the agitator shaft 8, and a vertical rotary main shaft 6 supports said agitator shafts 8 and rotates about the vertical axis of said vertical cylindrical tank 1. The vertical rotary main shaft 6 which is supported through upper and lower bearings 4 and 4' is provided along the central axis of the vertical cylindrical tank 1 and is rotated by a driving device 5. A plurality of the beaters 7 is attached to each of the horizontally rotating agitator shafts 8 in the longitudinal direction thereof corresponding to horizontal axes (a), (b),

110 --- (h) above the horizontal floors 3, respectively. The agitator shafts 8 are hung from the main shaft 6 and are supported by bearings 10 and 10' integral therewith to form an agitator unit 9 over each of the horizontal floors 3. A plurality of the agitator units 9 may be used in radial arrangement for each stage of the horizontal floors 3.

The agitator shafts 8 are not exactly radial but "substantially radial" with respect to the main shaft 6 because the agitator shafts 8 are, as shown in Fig. 2, attached thereto with a slight

degree of eccentricity E. The axes of the agitator shafts 8 are, when seen in plane projection as shown in Fig. 2, disposed out of phase and with substantially equal pitch phase distance so that the agitator shafts 8 are rotated in the direction of the arrow A (in the anticlockwise direction) by the rotation of the main shaft 6.

The compost-falling opening 2 in each of the horizontal floors 3 is provided for allowing the compost to fall successively to the next lower stage of the floors 3. The compost-falling openings 2 are, when seen in plane projection, out of phase as shown in Figs. 2 and 3 in the same manner as are the agitator shaft axes so that, assuming that the direction of advancement (indicated by the arrow A) of the agitator unit 9 is positive, the compost-falling openings 2 of the successively lower horizontal floors 3 are disposed in the positive direction relative to compost-falling openings 2 of the successively upper horizontal floors 3. In this embodiment, since the pitch of the agitator shafts 8 is the same as the pitch of the compost-falling openings 2, the agitator shafts 8 are simultaneously brought to the positions above the compost-falling openings 2, respectively, as shown in Figs. 2 and 3.

The agitator shafts 8 are connected to and driven by a driving motor 14 for revolving the beaters through helical gears 11 and 12 and a driving shaft 13. The driving shaft 13 is supported concentrically with the main shaft 6 through bearings 15, 15' and 15''.

Numeral 16 denotes a material charging hole, 17 denotes a compost discharge screw, and 18 denotes a blower for supplying air through the interior of each floor 3 to a plurality of air holes 19 provided in the upper surface of each of the horizontal floors 3.

The state shown in Figs. 2 and 3, namely the state in which an axis, for example, the axis (b) is in an advanced position relative to the axis (a) of the upper stage with respect to the direction of rotation is herein referred to with the meaning that the axis (b) is in the positive direction of rotating relative to the axis (a) in the sense of polar coordinates.

The operational effects of the embodiment of the construction described above will now be explained. When the main shaft 6 is rotated in the direction of the arrow A by the main shaft driving device 5 and, at the same time, the central shaft of the rotary agitator unit 9 is rotated in the direction of the arrow B by the motor 14, material 20 for compost on each of the horizontal floors 3 is scraped up by the beaters 7 and is thrown back along the paths D shown in Fig. 4 so that it receives sufficient agitating effect and is displaced in the direction of arrow C, opposite to the direction of the arrow A. In this way, the compost material 20 supplied through the material charging hole 16 is moved gradually around each horizontal floor 3 until it falls through the falling opening 2 to the lower floors 3 successively and is finally discharged out of the cylindrical tank 1 by the discharge screw 17. This operation is

schematically illustrated in the developed drawing of Fig. 3, in which the material 20 charged through the hole 16 onto the uppermost floor 3 is moved in the path shown by the broken line in the direction of the arrow C around the floor until it falls through the falling opening 2 onto the next lower floor 3 successively where the same operation is repeated until it finally reaches the discharge screw 17.

Accordingly, even in the case where the composting material is piled up so high or for so long a period of time as to pack down into an air-impermeable mass as frequently happens with material containing a high percentage of water, the material is scraped up by the tips of the beaters 7 and broken into small lumps having considerably increased surface areas so as to be sufficiently aerated by the upward air flow from the air holes 19 while flying in the air, and then piled on the floor very slowly and loosely with the result that the material particles are brought into uniform contact with the air supplied from the air holes 19 and very satisfactory aerobic fermentation can be carried out. The slow and loose piling of the material provides an advantage of reduction in air resistance, namely reduction in the power required for the blower 18. The penetrating depth of the beaters for scraping up of the composting material 20, i.e. lump size of the scraped composting material 20 can be arbitrarily varied by suitably selecting the speed of rotation of the beater central shaft 8 relative to the speed of rotation of the main shaft 6. Further, since the composting material 20 is lifted up by the revolving beaters 7, the rotational resistance of the main shaft 6 is significantly reduced, resulting in a substantial reduction in the power required compared to the conventional apparatus with a rake.

A plurality of agitator units 9 and 9' may be provided for each stage of the floors as shown in Fig. 5 for the purpose of increasing the height of the composting material to be heaped on each stage of the floors. The operational effect accomplished by this modification is similar to that of the embodiment described above.

Figs. 6 to 9 illustrate another embodiment of the composting apparatus according to the present invention, comprising a vertical cylindrical tank 21, multi-stage horizontal floors 23 rotatable about the vertical axis of said cylindrical tank 21 and each having a compost-falling opening 22, and beaters 27 provided on the horizontal rotary agitator shafts 28 above the horizontal floors 23, respectively, the shafts being journaled on the vertical cylindrical tank 21 and revolvable about their axes, which are stationary with respect to the ground.

At the centre of the vertical cylindrical tank 21 is provided a main shaft 26 supported by upper and lower bearings 24 and 24' to the vertical cylindrical tank 21 and rotated by a main shaft driving device 25. A plurality of the horizontal floors 23 is fixed to the main shaft 26. The upper surface of each of the horizontal floors 23 is

provided with air holes 29 through which air is supplied by a blower 18 through an air passage (not shown) in a rotary coupling 35 and in the centre of the main shaft 26. The compost falling openings 22 are provided in the horizontal floors 23 at positions out of phase by an equally spaced pitch successively from stage to stage as in the aforescribed embodiment. Above each of the horizontal floors 23 is a rotary agitator unit 39 comprising a horizontal agitator shaft 28 and beaters 27. The agitator shaft 28 of said unit is supported by a bearing 30 to the cylindrical tank 21 and is rotated by a motor 34 through sprocket wheels 31 and 32 and a chain 33 arranged as shown in Fig. 8. In the drawings, numeral 36 denotes a material charging hole and 37 denotes a compost discharge screw, respectively.

In operation, when the main shaft 26 is rotated by the main shaft driving device 25 in the direction of an arrow A' and, at the same time, the agitator shafts 28 of the agitator units 39 are rotated by the motor 34 in the direction of an arrow B', the composting material 20 heaped on each of the horizontal floors 23 is scraped up by the beaters 27 as in the aforescribed embodiment, thrown back in the path D' shown in Fig. 9, and displaced in the direction of A', namely in the direction of an arrow C' around the horizontal floor 23 until it falls through the compost-falling opening 22 to the lower floors 3 successively and is finally discharged out of the cylindrical tank 21 by the compost discharge screw 37. The effects provided by this operation are the same as those explained with respect to the aforescribed embodiment.

Results of experimental operations of the apparatus according to the present invention will now be described.

The material used in the experimental operations was municipal refuse having the components shown in Table 1:

Table 1

	(dry base %)
Kitchen refuse	33.0
Paper	43.9
Glass	10.8
Metal	0.6
Plastics	7.0
Other	4.7

An apparatus of the type corresponding to that of Fig. 1 was used. Dimensions of the apparatus used in the test operations were as follows:

Cylindrical tank:	
Inside diameter	6 metres
Height	7.5 metres

Number of stages: 4

Speed of rotation of the main shaft:
15 minutes per revolution

Speed of rotation of the driving shaft:
140 r.p.m.

Amount of air blown: 0.2 m³/min.

Each day, five hundred kilograms of the material having the components shown in Table 1 were divided into three batches and charged in the apparatus having the dimensions mentioned above. For each batch, the apparatus was operated for the period of time required to make one rotation of the main shaft. The depth of each batch heaped on the floor was approximately 600 millimetres. The experimental operation was carried out for the period of fourteen days with the results shown in Table 2:

Table 2

Charged Material

Total weight	6.9
Total volume	15.6 m ³
Apparent specific gravity	0.44 ton/m ³
Water content	54.5%

Discharged Material

Total weight	4.5
Total volume	7.9 m ³
Apparent specific gravity	0.57 ton/m ³
Water content	52.2%

Amount of change

Lost weight	2.4 ton
Ratio of weight reduction	65%
Ratio of volume reduction	51%
Weight reduction (dry base)	68%

In the experimental operation, the temperature of the material fell by 10 to 15°C during agitation, but the temperature of the material was restored to the same as that sensed before the agitation in approximately five hours. The highest temperature of the material sensed during the experimental operation reached 77°C.

In composting municipal refuse having the components shown in Table 1, those components not suitable for compost such as metal, glass and the like must, of course, be separated from the

material for compost.

The aforementioned dimensions of the apparatus and the conditions used for the experimental operation such as the number of revolutions, period of time of operation interval of operation, and the like are solely for illustrative purposes and can be changed in accordance with the specific requirements.

While the apparatus according to the present invention has been described hereinabove in connection with the case of composting of municipal refuse, such as kitchen refuse, it is to be clearly understood that this description is made only by way of example and not as a limitation on the type of material to be treated thereby. In fact, the apparatus according to the present invention is applicable to any organic material that is suitable for composting. Thus, the present invention provides an improved composting apparatus having significant advantages in that the treatment capacity per unit installation area of the apparatus can be considerably increased, the amount of power required therefor can be reduced, and packing down and densification of the material can be prevented to thereby permit sufficient agitation and enable efficient composting of material even with high water content.

CLAIMS

1. A multistage composting apparatus comprising a plurality of horizontal floors and a multistage vertical cylindrical tank allowing composting material to fall successively from one floor onto the floor below, each of said horizontal floors being provided with at least one agitator unit having beaters rotatable around a respective axis of the agitator unit substantially parallel to the horizontal floors and said horizontal floors and said agitator units being supported so as to be rotatable relative to each other about the central vertical axis of said cylindrical tank.

2. A composting apparatus as claimed in Claim 1, in which said horizontal floors are fixed to said cylindrical tank and said agitator units are supported so as to be rotatable about the central axis of said cylindrical tank.

3. A composting apparatus as claimed in Claim 2, in which said agitator units are attached to a vertical rotary shaft provided coaxially with the cylindrical tank.

4. A composting apparatus as claimed in Claim 1, in which said horizontal floors are supported so as to be rotatable about the central vertical axis of said cylindrical tank and the axes of said agitator

units are fixed.

5. A composting apparatus as claimed in Claim 4, in which said horizontal floors are attached to a vertical rotary shaft provided coaxially with said cylindrical tank, said cylindrical tank being fixed and said agitator units being supported by said cylindrical tank.

6. A composting apparatus as claimed in any of Claims 1 to 5, in which each of said agitator units is provided with a plurality of beaters attached to a rotary horizontal shaft; said beaters being distributed longitudinally along said horizontal shaft.

7. A composting apparatus as claimed in Claim 6, in which said rotary horizontal shafts of said agitator units are disposed radially or substantially radially relative to the central vertical axis of said cylindrical tank.

8. A composting apparatus as claimed in Claim 7, in which said rotary horizontal shafts are disposed in different phases in plane projection from each other on each of said horizontal floors.

9. A composting apparatus as claimed in Claim 8, in which the horizontal rotary shafts of lower stages are disposed in a positive direction with respect to the horizontal rotary shafts of upper stages.

10. A composting apparatus as claimed in any of claims 1 to 9, in which each of said horizontal floors is provided with an opening through which the composting material can fall to the horizontal floor below and said falling openings are slot-like openings disposed radially or substantially radially with respect to the central vertical axis of said cylindrical tank.

11. A composting apparatus as claimed in Claim 10, in which said slot-like openings are disposed in different phases in plane projection from each other on each of said horizontal floors.

12. A composting apparatus as claimed in Claim 11, in which the phases of said slot-like openings are such that the slot-like opening of a lower horizontal floor is disposed in a position in advance of that of the phase of the slot-like opening of the horizontal floor immediately above said lower horizontal floor, with respect to the advancing direction of said agitator units relative to the horizontal floors.

13. A composting apparatus as claimed in any of Claims 1 to 12, in which each of said horizontal floors is provided with a plurality of sets of agitator units arranged in the vertical direction.

14. A composting apparatus constructed and adapted to operate substantially as herein described with reference to and as illustrated in the drawings.



material for compost.

The aforementioned dimensions of the apparatus and the conditions used for the experimental operation such as the number of revolutions, period of time of operation interval of operation, and the like are solely for illustrative purposes and can be changed in accordance with the specific requirements.

While the apparatus according to the present invention has been described hereinabove in connection with the case of composting of municipal refuse, such as kitchen refuse, it is to be clearly understood that this description is made only by way of example and not as a limitation on the type of material to be treated thereby. In fact, the apparatus according to the present invention is applicable to any organic material that is suitable for composting. Thus, the present invention provides an improved composting apparatus having significant advantages in that the treatment capacity per unit installation area of the apparatus can be considerably increased, the amount of power required therefor can be reduced, and packing down and densification of the material can be prevented to thereby permit sufficient agitation and enable efficient composting of material even with high water content.

CLAIMS

1. A multistage composting apparatus comprising a plurality of horizontal floors and a multistage vertical cylindrical tank allowing composting material to fall successively from one floor onto the floor below, each of said horizontal floors being provided with at least one agitator unit having beaters rotatable around a respective axis of the agitator unit substantially parallel to the horizontal floors and said horizontal floors and said agitator units being supported so as to be rotatable relative to each other about the central vertical axis of said cylindrical tank.

2. A composting apparatus as claimed in Claim 1, in which said horizontal floors are fixed to said cylindrical tank and said agitator units are supported so as to be rotatable about the central axis of said cylindrical tank.

3. A composting apparatus as claimed in Claim 2, in which said agitator units are attached to a vertical rotary shaft provided coaxially with the cylindrical tank.

4. A composting apparatus as claimed in Claim 1, in which said horizontal floors are supported so as to be rotatable about the central vertical axis of said cylindrical tank and the axes of said agitator

units are fixed.

5. A composting apparatus as claimed in Claim 4, in which said horizontal floors are attached to a vertical rotary shaft provided coaxially with said cylindrical tank, said cylindrical tank being fixed and said agitator units being supported by said cylindrical tank.

6. A composting apparatus as claimed in any of Claims 1 to 5, in which each of said agitator units is provided with a plurality of beaters attached to a rotary horizontal shaft, said beaters being distributed longitudinally along said horizontal shaft.

7. A composting apparatus as claimed in Claim 6, in which said rotary horizontal shafts of said agitator units are disposed radially or substantially radially relative to the central vertical axis of said cylindrical tank.

8. A composting apparatus as claimed in Claim 7, in which said rotary horizontal shafts are disposed in different phases in plane projection from each other on each of said horizontal floors.

9. A composting apparatus as claimed in Claim 8, in which the horizontal rotary shafts of lower stages are disposed in a positive direction with respect to the horizontal rotary shafts of upper stages.

10. A composting apparatus as claimed in any of claims 1 to 9, in which each of said horizontal floors is provided with an opening through which the composting material can fall to the horizontal floor below and said falling openings are slot-like openings disposed radially or substantially radially with respect to the central vertical axis of said cylindrical tank.

11. A composting apparatus as claimed in Claim 10, in which said slot-like openings are disposed in different phases in plane projection from each other on each of said horizontal floors.

12. A composting apparatus as claimed in Claim 11, in which the phases of said slot-like openings are such that the slot-like opening of a lower horizontal floor is disposed in a position in advance of that of the phase of the slot-like opening of the horizontal floor immediately above said lower horizontal floor, with respect to the advancing direction of said agitator units relative to the horizontal floors.

13. A composting apparatus as claimed in any of Claims 1 to 12, in which each of said horizontal floors is provided with a plurality of sets of agitator units arranged in the vertical direction.

14. A composting apparatus constructed and adapted to operate substantially as herein described with reference to and as illustrated in the drawings.