

Description

Microwave Rotary Dryer

Technical Field

This invention relates to a microwave rotary dryer capable of drying a food processing residue of a good quality to an optimal water content in order to use it as a raw material for dry foods or as a livestock feed. This invention is designed to dry a food processing residue to an optimal water content by charging the residue into a rotating drum, and heating it with hot air and a microwave while agitating it.

The invention is also applicable when drying various foods to produce dry foods (dry foods eaten by humans).

Background Art

In recent years, recycling of food processing residues is an important challenge for environmental protection. Instead of conventional incineration and land disposal, biotechnological treatment and drying treatment, which enable food processing residues to be reused, have attracted attention.

Expenses for leaving food processing residues up to contractors have skyrocketed, and people who run companies are more conscious of and eager to gain

ISO14001. Thus, industrial wet refuse treating machines, targeted at food processing plants, fast food and family restaurant industries, lunch cooking centers, hospitals, and welfare facilities, are expanding their market size year by year.

The currently predominant industrial wet refuse treating machines are those of the types which convert wet refuse into manure by a biological method for decomposing wet refuse with the use of microorganisms, and a carbonization method for heating wet refuse at high temperatures to carbonize it.

Food processing plants and lunch or side dish preparing plants form large amounts of food processing residues (soybean curd lees, crumbs of bread, vegetables, rice, meats, fries, pastas, etc.). At supermarkets and convenience stores, foods past their shelf-lives are recovered by delivery vans from shops into recovery sites, and then discarded. Such outdated foods make food processing residues (wet refuse). Such food processing plants and shops perform strict quality control, and keep food processing residues (wet refuse) in frozen state. Although they are called food processing residues, their quality is satisfactory, and they are neither dirty nor rotten.

Food processing residues of a satisfactory quality, occurring at food processing plants, etc., will be of a low added value, if turned into manure

(price as manure is low). The food processing residues, if converted into materials for dry foods or feeds rather than manure, would have a high added value. That is, if dry products formed by drying food processing residues can be used as raw materials for dry foods or for feed compositions, effective use of resources can be achieved. Furthermore, the dry products can be recycled as expensive commodities (raw materials for dry foods, and raw materials for feed compositions). That could also contribute to increasing the self-supply rates of livestock feeds which heavily rely on imports.

To convert food processing residues into livestock feeds, it is necessary to dry the food processing residues uniformly to an optimal water content without excessively drying them until they become carbonized. Considerations for hygiene (sterilizing effect, easy washability of the equipment concerned, etc.) are also necessary.

In light of the foregoing circumstances, the present invention has as an object the provision of a microwave rotary dryer which can dry a food processing residue to an optimal water content in order to use it as a raw material for dry foods or as a livestock feed.

Disclosure of the Invention

To attain the above object, a microwave dryer according to the present invention is composed of a rotating drum device having a rotating drum, a hot air feeder for generating hot air and flowing the hot air into the rotating drum, and a microwave feeder for feeding a microwave into the rotating drum.

More concretely, the microwave rotary dryer of the present invention is comprised of:

a rotating drum device comprising a rotating drum having axially parallel lifter blades provided at a plurality of locations along a circumferential direction of an inner peripheral surface of the rotating drum, and a drum support/drive device for rotating the rotating drum along the circumferential direction while supporting the rotating drum;

a hot air feeder comprising a duct having a duct inlet portion communicating with an end face of the rotating drum, and a duct outlet portion communicating with the other end face of the rotating drum, a hot air generator interposed in the duct for blowing a combustion gas, which has been obtained by combustion of a fuel, into the duct, and a circulating blower interposed in the duct for sending air in the duct from the duct inlet portion toward the duct outlet portion; and

a microwave feeder comprising a microwave

oscillator for generating a microwave, and a wave guide inserted into the rotating drum from the end face of the rotating drum and adapted to guide the generated microwave and project the microwave into the rotating drum.

Because of the above constitution, the invention can heat a food processing residue with hot air and a microwave in the rotating drum while agitating it to dry it to an optimal water content uniformly in a short period of time. As a result, a dry product effectively usable as a raw material for dry foods or as a livestock feed can be obtained.

The microwave rotary dryer of the invention is also composed of:

a rotating drum device comprising a rotating drum disposed with an axis of rotation thereof in a horizontal state and having axially parallel lifter blades provided at a plurality of locations along a circumferential direction of an inner peripheral surface of the rotating drum, and a drum support/drive device for rotating the rotating drum along the circumferential direction while supporting the rotating drum;

a hot air feeder comprising a duct having a duct inlet portion communicating with an end face of the rotating drum, and a duct outlet portion communicating with the other end face of the rotating drum, a hot

air generator interposed in the duct for blowing a combustion gas, which has been obtained by combustion of a fuel, into the duct, and a circulating blower interposed in the duct for sending air in the duct from the duct inlet portion toward the duct outlet portion; and

a microwave feeder comprising a microwave oscillator for generating a microwave, and a wave guide inserted into the rotating drum from the end face of the rotating drum, adapted to guide the generated microwave, and obliquely disposed so as to project the microwave obliquely toward a lower space in the rotating drum.

Because of the above constitution, the invention can heat a food processing residue with hot air and a microwave in the rotating drum while agitating it to dry it to an optimal water content uniformly in a short period of time. As a result, a dry product effectively usable as a raw material for dry foods or as a livestock feed can be prepared.

Moreover, the rotating drum is positioned horizontally, thus resulting in a simple configuration. Furthermore, the wave guide is positioned obliquely to project the microwave obliquely toward the lower space in the rotating drum. Thus, the absorption efficiency is increased.

Furthermore, the microwave rotary dryer of the

invention is composed of:

a rotating drum device comprising a rotating drum disposed with an axis of rotation thereof in an inclined state relative to a horizontal plane, having axially parallel lifter blades provided at a plurality of locations along a circumferential direction of an inner peripheral surface of the rotating drum, and also having a spiral blade provided in an inner peripheral surface portion located at an inclined lower site of the inner peripheral surface of the rotating drum, and a drum support/drive device for rotating the rotating drum along the circumferential direction while supporting the rotating drum;

a hot air feeder comprising a duct having a duct inlet portion communicating with an end face of the rotating drum, and a duct outlet portion communicating with the other end face of the rotating drum, a hot air generator interposed in the duct for blowing a combustion gas, which has been obtained by combustion of a fuel, into the duct, and a circulating blower interposed in the duct for sending air in the duct from the duct inlet portion toward the duct outlet portion; and

a microwave feeder comprising a microwave oscillator for generating a microwave, and a wave guide inserted into the rotating drum from the end face of the rotating drum, adapted to guide the generated

microwave, and having a front end opening which is obliquely downwardly open so as to project the microwave obliquely toward a lower space in the rotating drum.

Because of the above constitution, the invention can heat a food processing residue with hot air and a microwave in the rotating drum while agitating it to dry it to an optimal water content uniformly in a short period of time. As a result, a dry product effectively usable as a raw material for dry foods or as a livestock feed can be prepared.

Moreover, the front end opening of the wave guide is open obliquely downwardly. Thus, the microwave can be projected obliquely toward the lower space in the rotating drum, so that the absorption efficiency is increased.

Further, the microwave rotary dryer of the invention has a deodorization device having a condenser which withdraws a partial gas from inside the duct of the hot air feeder, and cools the withdrawn gas with cooling water for cooling the microwave oscillator to condense a vapor contained in the gas, discharges the condensate outside as drainage water, and also discharges the vapor-deprived gas outside.

If desired, the deodorization device has a deodorizing filter for passing the gas discharged from the condenser, and then discharging the filtered gas outside.

Because of these constitutions, the invention can treat a food processing residue without producing a stench.

In the microwave rotary dryer of the invention, moreover, grid panels for preventing leakage of the microwave are provided in the duct inlet portion and the duct outlet portion. Thus, no microwave leaks outside, and safety is high.

Besides, it goes without saying that the invention can be applied to the production of ordinary dry foods eaten by humans.

Brief Description of the Drawings

FIG. 1 is a front sectional view showing a microwave rotary dryer according to a first embodiment of the present invention.

FIG. 2 is a sectional view taken on line II-II of FIG. 1.

FIG. 3 is a front sectional view showing a microwave rotary dryer according to a second embodiment of the present invention.

Best Mode for Carrying Out the Invention

A microwave rotary dryer according to embodiments of the present invention will now be described in detail based on the accompanying drawings.
<First Embodiment>

A microwave rotary dryer 1 according to a first embodiment of the invention will be described with reference to FIG. 1 as a front sectional view, and FIG. 2 as a sectional view taken on line II-II of FIG. 1.

As shown in FIGS. 1 and 2, the microwave rotary dryer 1 is composed of a rotating drum device 10, a hot air feeder 30, and a microwave feeder 50 as main members. In the microwave rotary dryer 1, a food processing residue charged into a rotating drum 11 of the rotating drum device 10 is heated with hot air by the hot air feeder 30, and a microwave by the microwave feeder 50, whereby it is dried to an optimal water content. The components of the microwave rotary dryer 1 are configured as will be sequentially explained below.

The rotating drum 11 of the rotating drum device 10 is disposed rotatably, with its axis of rotation being inclined relative to a horizontal plane. In more detail, ring members 12a, 12b, called "tires", are attached to an outer peripheral surface of the rotating drum 11. On a floor surface, a rotation support roller 13a and a rotation support roller 13b are installed at displaced height positions. The rotation support roller 13a rolls in contact with the ring member 12a, while the rotation support roller 13b rolls in contact with the ring member 12b, thereby supporting the rotating drum 11 rotatably in an inclined state.

An output shaft of a drive motor 14 is connected

to the rotation support roller 13a. Thus, as the drive motor 14 makes normal rotations or reverse rotations, a rotational force is transmitted to the rotating drum 11 via the rotation support roller 13a, whereupon the rotating drum 11 makes normal rotations or reverse rotations along a circumferential direction.

The ring members 12a, 12b, the rotation support rollers 13a, 13b, and the drive motor 14 constitute a drum support/drive device.

On an inner peripheral surface of the rotating drum 11, lifter blades 15 and a spiral blade 16 are provided. The lifter blades 15 extend in a direction parallel to the axis of rotation of the rotating drum 11, and are present at a plurality of locations along a circumferential direction of the inner peripheral surface of the rotating drum 11. The spiral blade 16 is provided in a spiral form in an inner peripheral surface portion located at an inclined lower site of the inner peripheral surface of the rotating drum 11 (i.e., the right-hand inner peripheral surface portion in FIG. 1).

A fixed chamber 17 communicates with a left end face of the rotating drum 11, and a fixed chamber 18 communicates with a right end face of the rotating drum 11. A rotating bearing 19 is interposed between the fixed chamber 17 and the rotating drum 11, while a sealing material 20 is interposed between the fixed chamber

18 and the rotating drum 11. To prevent a microwave from leaking to the outside, electromagnetic wave sealing members are disposed at the site of the rotating bearing 19 and at the site of the sealing material 20.

A duct 31 of the hot air feeder 30 has a duct outlet portion 31a communicating with the fixed chamber 17, and has a duct inlet portion 31b communicating with the fixed chamber 18. That is, the duct outlet portion 31a communicates with the left end face of the rotating drum 11 via the fixed chamber 17, while the duct inlet portion 31b communicates with the right end face of the rotating drum 11 via the fixed chamber 18. Thus, a circulating air feed path is formed along the route: duct 31 → fixed chamber 17 → rotating drum 11 → fixed chamber 18 → duct 31.

A hot air generator 32 is interposed in the duct 31. A burner 32a of the hot air generator 32 is supplied with a fuel gas G and air to burn the fuel gas G. A high temperature combustion gas occurring upon combustion is blown into the duct 31. A circulating blower 33 is interposed in the duct 31 to send air inside the duct 31 from the duct inlet portion 31b toward the duct outlet portion 31a. As a result, the high temperature combustion gas flows along the above-mentioned circulating air feed path, so that the high temperature combustion gas flows in the rotating drum 11.

A microwave oscillator 51 of the microwave feeder 50 generates a microwave. A wave guide 52 is a tubular member for guiding the microwave, generated by the microwave oscillator 51, into the rotating drum 11. The wave guide 52 passes through the fixed chamber 17, and is inserted into the rotating drum 11 from the left end face of the rotating drum 11. This wave guide 52 is disposed in an inclined state relative to a horizontal plane, and an axial direction of the wave guide 52 agrees with a rotation axis direction of the rotating drum 11.

A front end opening face of the wave guide 52 is open obliquely downwardly. Hence, a microwave guided by the wave guide 52 is projected toward a lower space inside the rotating drum 11. In other words, the microwave projected from the front end opening face does not move along the axial direction of the wave guide 52, but moves along a direction which the front end opening face is facing (a direction toward the lower space inside the rotating drum 11). As a result, the microwave is efficiently incident on the food processing residue charged, as a material to be treated, into the lower space of the rotating drum 11. That is, the microwave is obliquely incident on the surface of the food processing residue, so that the microwave is efficiently absorbed to the surface of the food processing residue. The angle that the front end

opening face of the wave guide 52 makes with the axial direction of the wave guide 52 is set at 10 to 80 degrees.

A Teflon cap 53 is attached to the front end opening face of the wave guide 52. The Teflon cap 53 is formed of Teflon completely permeable to microwaves, and thus does not impede the propagation or projection of a microwave. Since the Teflon cap 53 is present, incursion of steam, filth, etc. into the wave guide 52 can be prevented.

The wave guide 52 is equipped with an isolator 54 and a power monitor 55. The isolator 54 absorbs a microwave reflected power which is the projected microwave reflected inside the rotating drum 11 and returning through the wave guide 52. Thus, the microwave reflected power does not return to the microwave oscillator 51 anymore. This prevents damage to the microwave oscillator 51 due to the return of the microwave reflected power. The power monitor 55 measures and displays the value of a microwave incident power emitted by the microwave oscillator 51, and the value of a microwave reflected power returning through the wave guide 52.

A charging hatch 60 as a charging port for the food processing residue is attached in an openable and closable manner on the peripheral surface of the rotating drum 11. A slide hatch 61 as a withdrawal port for a dry product, on the other hand, is attached to

the right end face of the rotating drum 11, and is slidable relative to the fixed chamber 18. The slide hatch 61 intimately contacts the right end face of the rotating drum 11, and a clamp 62 clamps the slide hatch 61 and the right end face of the rotating drum 11, thereby bringing the withdrawal port to a closed state. The clamp 62 is released, and the slide hatch 61 slides and leaves the right end face of the rotating drum 11, thereby making the withdrawal port open.

An exhaust pipe 71 of a deodorization device 70 is connected to the duct 31 to withdraw part of a gas (containing a vapor and an odor) from inside the duct 31. A condenser 72 is fitted to the exhaust pipe 71. The condenser 72 receives a flow of cooling water which has cooled the microwave oscillator 51 and the isolator 54. In the condenser 72, a vapor contained in the gas withdrawn from inside the duct 31 is condensed to form drainage water W. Since an odor is dissolved into the drainage water W, the odor can be removed.

If necessary, a deodorizing filter 73 packed with activated carbon may be added for further removal of the odor in the gas. The gas passing through the deodorizing filter 73 has been robbed of vapor by the condenser 72. Thus, the life of the activated carbon is prolonged.

To prevent leakage of the microwave, grid panels 80, 81 are provided at the duct inlet portion 31b and

the duct outlet portion 31a. This ensures increased safety.

The actions of the microwave rotary dryer 1 constituted as described above will be explained in accordance with the procedure for treating the food processing residue.

The drive motor 14 is driven to rotate the rotating drum 11. When the charging hatch 60 comes to the upper peripheral surface, the rotation of the rotating drum 11 is stopped. In this state, the charging hatch 60 is opened, and a food processing residue of a good quality, which has occurred at a food processing plant or the like, is charged en masse into the rotating drum 11. Then, the charging hatch 60 is closed. At this time, the slide hatch 61 is also shut. The water content of the food processing residue charged is 80 to 60 wt. %.

The drive motor 14 is driven again to rotate the rotating drum 11 normally. Simultaneously, the hot air feeder 30 is actuated to feed hot air into the rotating drum 11 in a circulating manner. In accordance with rotations of the rotating drum 11, the food processing residue accumulating in a lower portion of the rotating drum 11 is scooped upward along the circumferential direction by the lifter blades 15. As the food processing residue approaches the top in the circumferential direction, it falls downwards. Thus,

the food processing residue is heated in the rotating drum 11 upon efficient contact with hot air while being agitated.

Since the food processing residue is thus heated with hot air, water contained therein evaporates to dry the food processing residue. Heating with hot air is performed by heat conduction from the surface of the food processing residue to its interior. Hence, the food processing residue becomes dry sequentially, starting at its surface. To prevent carbonization of the food processing residue, the temperature of the hot air is restricted to about 120 to 150°C.

When a predetermined time has passed after starting heating with hot air, the microwave feeder 50 is actuated, with heating with the hot air feeder 30 continued, to project a microwave into the rotating drum 11. Thus, the food processing residue is also heated with the microwave (microwave induction heating).

The front end opening face of the wave guide 52 is open obliquely downwardly. Hence, the microwave is projected toward a lower space of the rotating drum 11, namely, a portion in which the food processing residue is present. Furthermore, the metallic lifter blades 15 rotate circumferentially, so that the field strength in the rotating drum 11 changes as the lifter blades 15 move. That is, the microwave does not become

a standing wave in the rotating drum 11, but the radio wave distribution intensity changes, meaning that the microwave (radio wave) is agitated in the rotating drum 11. As a result, the projected microwave is absorbed to the food processing residue efficiently and reliably. Consequently, the food processing residue in the rotating drum 11 can be dried uniformly and satisfactorily by microwave heating.

This microwave heating is so-called internal heating, a type of heating in which the microwave penetrating inside the food processing residue (dielectric) turns into heat because of a dielectric loss, thereby heating the food processing residue from its interior. This type of heating enables rapid heating, and has the action of pushing the inside water to the outside. On the other hand, heating with hot air is so-called external heating, a type of heating in which the food processing residue is heated from its surface side. As noted from this, the food processing residue is heated by both methods, external heating with hot air and internal heating with the microwave. Thus, the inside and outside of the food processing residue are heated uniformly, and so become dry in a short time without drying unevennesses.

In short, when the water content of the food processing residue lowers, hot air drying alone slows the drying speed, and lengthens the drying time. Thus,

microwave heating is combined with hot air drying to heat the food processing residue from its inside as well, thereby pushing the inside water out to the surface. By this combination, the drying speed is quickened to shorten the drying time. Besides, a microwave is selectively absorbed to portions with a large water content, generating heat. Thus, uneven drying minimally occurs, and uniform drying can be promoted.

The food processing residue is heated and dried, and changed into a dry product. This dry product has been sterilized by a temperature rise and microwave irradiation.

The dry product obtained by drying the food processing residue is agitated by the lifter blades 15, whereby it is ground, made fine, and granulated. Since the rotating drum 11 is disposed in an inclined state, each time the dry product is scooped up by the lifter blades 15 and fallen down, it is gradually moved toward the right end of the rotating drum 11 (the lower site of the inclination). The dry product moving rightward in the rotating drum 11 and building up in the right-hand portion is pushed up by the spiral blade 16 toward the left end of the rotating drum (the upper site of the inclination).

When the dry product obtained by drying the food processing residue has reached a targeted water content (e.g., 10 wt.%), heating by the hot air feeder 30 and

the microwave feeder 50 is terminated, and the rotation of the rotating drum 11 is stopped.

Then, the clamp 62 is released, and the slide hatch 61 is slid and separated from the right end face of the rotating drum 11. By this measure, the right end face of the rotating drum 11 can be opened widely. With the entire right end face as a broad withdrawal port, the dry product can be discharged and expelled smoothly. Since the withdrawal port can be opened wide in this manner, the microwave rotary dryer 1 is preferred, if it is marketed as a big dryer capable of batch treating a large amount of food processing residue.

At the time of discharge and expelling of the dry product, the drive motor 14 may be controlled to rotate the rotating drum 11 reversely. By so doing, the dry product can be aggressively pushed downward by the spiral blade 16 to enable its movement and expelling. Thus, the withdrawal of the dry product can be completed easily in a short time.

The volume of the dry product reaching the target water content (e.g., 10 wt.%) has decreased to about 1/5 of the initial volume of the food processing residue (water content 80-60 wt.%). Hence, the transportation and storage of the dry product can be performed easily. Moreover, microwave irradiation in combination with heating suppresses the proliferation of microorganisms in the dry product, ensuring high safety. Accordingly,

the dry product can be utilized effectively as raw materials for dry foods and feed compositions.

Besides, the microwave feeder 50 is actuated midway in drying, so that power consumption can be decreased. Also, a saving in energy is achieved by optimally adjusting the temperature of hot air generated by the hot air feeder 30, the timing of initiating microwave heating, or the drying time, depending on the amount of the food processing residue charged or its water content.

In addition, upon completion of the drying treatment, the charging hatch 60 and the slide hatch 61 are opened, and the interior of the rotating drum 11 can be cleaned. Thus, the dryer can be used hygienically.

<Second Embodiment>

Next, a microwave rotary dryer 101 according to a second embodiment of the invention will be described with reference to FIG. 3. With the microwave rotary dryer 101 of the second embodiment, the basic concept of using hot air drying and microwave drying in combination is the same as in the microwave rotary dryer 1 of the first embodiment shown in FIGS. 1 and 2, but the arrangement, etc. are partially different. Thus, portions different from the microwave rotary dryer 1 of the first embodiment will be mainly explained, and portions performing the same functions will be assigned

the same numerals, with overlapping descriptions being omitted.

In the microwave rotary dryer 101 of the second embodiment, a rotating drum 11 of a rotating drum device 10 is rotatably supported by rotation support rollers 13a, 13b, with a rotation axis thereof being in a horizontal state. On an inner peripheral surface of the rotating drum 11, only lifter blades 15 are provided, and no spiral blade is provided.

A rotating bearing 19 is interposed between a fixed chamber 17 and the rotating drum 11, and a rotating bearing 21 is similarly interposed between a fixed chamber 18 and the rotating drum 11.

A wave guide 52 of a microwave feeder 50 is disposed in an inclined state relative to a horizontal plane, and a front end opening face of the wave guide 52 is perpendicular to a wave guide axis direction. Hence, a microwave guided from a microwave oscillator 51 and projected from the front end opening face of the wave guide 52 moves along the axial direction of the wave guide 52. As a result, the microwave is projected toward a lower space of the rotating drum 11, and is efficiently incident on a food processing residue charged into the rotating drum 11. Since the rotating drum 11 is positioned horizontally, while the wave guide 52 is positioned obliquely, the microwave is obliquely incident on the surface of the food

processing residue, and is efficiently absorbed.

On a peripheral surface of the rotating drum 11, a charging/withdrawing hatch 63 as a charging port and a withdrawal port is attached in an openable and closable manner. The charging/withdrawing hatch 63 is an elongated member extending along the axial direction of the rotating drum 11. The aforementioned first embodiment has the charging hatch 60 as a charging port, and the slide hatch 61 as a withdrawal port. Whereas the present embodiment has the single charging/withdrawing hatch 63 which concurrently serves as a charging port and a withdrawal port.

To charge a food processing residue into the rotating drum 11, the charging/withdrawing hatch 63 is positioned on an upper peripheral surface, and opened in this state. Then, the food processing residue is charged.

To expel a dry product from the rotating drum 11 after completion of drying of the food processing residue, the charging/withdrawing hatch 63 is positioned on a lower peripheral surface, and opened in this state. Then, the dry product is discharged and expelled. Since the charging/withdrawing hatch 63 is an axially elongated member, the dry product is mostly borne on the charging/withdrawing hatch 63 before it is opened. Thus, mere opening of the charging/withdrawing hatch 63 results in a spontaneous

fall of the dry product under its own weight, making it easy to discharge and expel the dry product to the outside.

The second embodiment has a structure in which the rotating drum 11 is positioned horizontally, and the charging/withdrawing hatch 63 concurrently serving as a charging port and a withdrawal port is provided; and has a constitution in which the dry product is withdrawn by its spontaneous fall without using a spiral blade. Thus, the mechanism for discharging and expelling the dry product can be simplified. The microwave rotary dryer 101 is preferred, particularly if it is marketed as a small dryer capable of batch treating a food processing residue.

Besides, upon completion of the drying treatment, the charging/withdrawing hatch 63 is opened, and the interior of the rotating drum 11 can be cleaned. Thus, the dryer can be used hygienically.

The configurations and actions of the other portions are the same as in the first embodiment.

In the above-described two embodiments, examples of drying a food processing residue by the invention have been mentioned. However, it goes without saying that the invention can be applied when drying various foods (food materials) to produce dry foods eaten by humans.

Industrial Applicability

As described above, the microwave rotary dryer of the invention is preferred for use in industrial fields in which food processing residues or various foods are dried to produce materials for dry foods, livestock feeds, or dry foods.

Claims



1. A microwave rotary dryer characterized by comprising:
a rotating drum device having a rotating drum;
a hot air feeder for generating hot air and flowing the hot air into the rotating drum; and
a microwave feeder for feeding a microwave into the rotating drum.

2. A microwave rotary dryer characterized by comprising:
a rotating drum device comprising a rotating drum having axially parallel lifter blades provided at a plurality of locations along a circumferential direction of an inner peripheral surface of the rotating drum, and a drum support/drive device for rotating the rotating drum along the circumferential direction while supporting the rotating drum;

a hot air feeder comprising a duct having a duct inlet portion communicating with an end face of the rotating drum, and a duct outlet portion communicating with the other end face of the rotating drum, a hot air generator interposed in the duct for blowing a combustion gas, which has been obtained by combustion of a fuel, into the duct, and a circulating blower interposed in the duct for sending air in the duct from



the duct inlet portion toward the duct outlet portion;
and

a microwave feeder comprising a microwave oscillator for generating a microwave, and a wave guide inserted into the rotating drum from the end face of the rotating drum and adapted to guide the generated microwave and project the microwave into the rotating drum.

3. A microwave rotary dryer characterized by comprising:

a rotating drum device comprising a rotating drum disposed with an axis of rotation thereof in a horizontal state and having axially parallel lifter blades provided at a plurality of locations along a circumferential direction of an inner peripheral surface of the rotating drum, and a drum support/drive device for rotating the rotating drum along the circumferential direction while supporting the rotating drum;

a hot air feeder comprising a duct having a duct inlet portion communicating with an end face of the rotating drum, and a duct outlet portion communicating with the other end face of the rotating drum, a hot air generator interposed in the duct for blowing a combustion gas, which has been obtained by combustion of a fuel, into the duct, and a circulating blower



interposed in the duct for sending air in the duct from the duct inlet portion toward the duct outlet portion; and

a microwave feeder comprising a microwave oscillator for generating a microwave, and a wave guide inserted into the rotating drum from the end face of the rotating drum, adapted to guide the generated microwave, and obliquely disposed so as to project the microwave obliquely toward a lower space in the rotating drum.

4. A microwave rotary dryer characterized by comprising:

a rotating drum device comprising a rotating drum disposed with an axis of rotation thereof in an inclined state relative to a horizontal plane, having axially parallel lifter blades provided at a plurality of locations along a circumferential direction of an inner peripheral surface of the rotating drum, and also having a spiral blade provided in an inner peripheral surface portion located at an inclined lower site of the inner peripheral surface of the rotating drum, and a drum support/drive device for rotating the rotating drum along the circumferential direction while supporting the rotating drum;

a hot air feeder comprising a duct having a duct inlet portion communicating with an end face of the



rotating drum, and a duct outlet portion communicating with the other end face of the rotating drum, a hot air generator interposed in the duct for blowing a combustion gas, which has been obtained by combustion of a fuel, into the duct, and a circulating blower interposed in the duct for sending air in the duct from the duct inlet portion toward the duct outlet portion; and

a microwave feeder comprising a microwave oscillator for generating a microwave, and a wave guide inserted into the rotating drum from the end face of the rotating drum, adapted to guide the generated microwave, and having a front end opening which is obliquely downwardly open so as to project the microwave obliquely toward a lower space in the rotating drum.

5. The microwave rotary dryer of claim 2, 3 or 4, characterized by including a deodorization device having a condenser which withdraws a partial gas from inside the duct, and cools the withdrawn gas with cooling water for cooling the microwave oscillator to condense a vapor contained in the gas, discharges the condensate outside as drainage water, and also discharges the vapor-deprived gas outside.

6. The microwave rotary dryer of claim 5, characterized in that the deodorization device is



equipped with a deodorizing filter for passing the gas discharged from the condenser, and then discharging the filtered gas outside.

7. The microwave rotary dryer of claim 2, 3 or 4, characterized in that grid panels for preventing leakage of the microwave are provided in the duct inlet portion and the duct outlet portion.