

[Document Name] Specification

[Title of the Invention] DRYING APPARATUS

[Detailed Description of the Invention]

[0001]

[Industrial Field of Utilization]

This invention relates to drying apparatus that rolls up a material to be dried (hereinafter referred to as "to-be-dried material"), presses it to a heating surface thereof, and thereby dries it.

[0002]

[Prior Art]

As is well known, there are various types of drying apparatus for drying a to-be-dried material in the form of a liquid, a fluid, a semifluid, powder, grain, etc.

[0003]

As examples of the drying apparatus, the present applicant proposed previously a few of drying apparatus disclosed in Japanese Utility Model Application Laid-Open No. 19501/1991 and Japanese Utility Model Application Laid-Open No. 64692/1993. That is, it is a drying apparatus comprising: a drying tank having an interior of a cylindrical shape into which a to-be-dried material is inputted; a heating surface that is an inner wall of the drying tank and transfers heat from heating means to the to-be-dried material; the heating means that is disposed around the drying tank and transfers the heat to the heating surface; and a single piece of vertical spiral rotating blade that is set rotatably in the drying tank and whose topside is formed into a planar surface so as to be capable of carrying the to-be-dried material on it and elevating it.

[0004]



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That is, in the drying apparatus, there are set a rotation axis being set along the direction of gravity in the drying apparatus, a single piece of a vertical spiral rotating blade disposed around this rotation shaft, and an arm part for fixing such that one end thereof is fixed to the rotation shaft, the other end is fixed to the vertical spiral rotating blade, and it passes through a to-be-dried material falling space that will be described later. Further, in the apparatus, a to-be-dried material falling space in which the to-be-dried material that reached an upper part of the vertical spiral rotating blade falls is provided as a partition between an inner rim of the vertical spiral rotating blade and the rotation axis, and the apparatus has clearance for allowing the to-be-dried material to contact with the heating surface between an outer rim of the vertical spiral rotating blade and the heating surface.

[0005]

Moreover, when paying attention to a motion of the to-be-dried material when the drying apparatus equipped with the vertical spiral rotating blade is used, the to-be-dried material repeats a cycle as follows: it is carried on the single sheet of the vertical spiral rotating blade to rise from below upward sequentially in a spiral manner, falls downward when it reaches the uppermost part, returns to the initial position, and rises again in a spiral manner. Furthermore, the to-be-dried material is pressed against the heating surface by the centrifugal force in the course of the rising and thereby is dried.

[0006]

In addition, although it is not drying apparatus but is common in a point of removing moisture from a material to be processed, a dehydrator is proposed that is disclosed in the

Japanese Utility Model Application Laid-open No. 78241/1980.
[0007]

This dehydrator is constructed in such a way that, in a cylindrical processing tank (casing) that has an entrance in the lower part thereof and an exit in the upper part thereof, a tubular filter that communicates the entrance and the exit is provided, and, inside this tubular filter, plural pieces of impellers that transfer the material to be processed upward across the whole area of its vertical direction while driving back the material to be processed outward are fixed outwardly facing the tubular filter. The each impeller has such a structural feature that a rotation-direction front rim (this is not an outer edge) thereof is incurvated circularly so as to be located on a further rear side in the rotation direction sequentially as a position on the front rim goes to an outer lateral side.

[0008]

In the case of this dehydrator, the material to be processed is supplied into the processing tank through the entrance, and is moved upward sequentially by receiving a transferring action caused by the impellers of a group of impellers each rotating inside the tubular filter and concurrently repeats collision against the tubular filter by being repelled outward by the impellers universally. Moisture contained in the material to be processed is removed by an impact force at the time of impact against the tubular filter.

[0009]

[Problem to be Solved by the Invention]

In the conventional technology, the drying apparatus equipped with the vertical spiral rotating blade has several points to be solved as described in the following. That is, (1)

the to-be-dried material is carried on a single sheet of vertical spiral rotating blade that continues from the upper part to the lower part to rise upward and concurrently is pressed against the heating surface. However, in the case where the to-be-dried material is a to-be-dried material having strong viscosity etc., if this to-be-dried material once adheres to a certain portion of the single sheet of vertical spiral rotating blade or of the heating surface or undergoes a similar event, jamming of the to-be-dried material occurs at the adhesion portion, expands from that portion in a bunching manner, and a space between the upper blade and the lower blade tends to be filled with the to-be-dried material because there is no transferring path except the single sheet of vertical spiral rotating blade. For this reason, there is a large risk that the rising of the to-be-dried material may be blocked to stop the circulation thereof, and hence drying does not proceed well.

[0010]

Further, (2) there is a fear of a failure that, since the vertical spiral rotating blade is made of a single piece and extends in a spiral form that continues from the bottom to the top side and the clearance between the vertical spiral rotating blade and the heating surface exists from the lower part to the upper part, if a foreign material mixed in the to-be-dried material gets engaged in the clearance, the foreign material cannot escape from the clearance and hence the vertical spiral rotating blade does not rotate smoothly.

[0011]

Moreover, (3) to elevate the to-be-dried material, only one piece of vertical spiral rotating blade is used to do so. Therefore, the amount of the to-be-dried material is small as

compared to the total amount of the to-be-dried material lying on the bottom of the drying tank, and hence it was difficult to bring the to-be-dried material into contact with the heating surface early. In addition to this, a state in which the to-be-dried material remains on the bottom tends to continue and hence it was difficult to improve drying efficiency.

[0012]

Furthermore, (4) although the vertical spiral rotating blade is one that has a spacing between the upper and lower blades according to a pitch of the spiral, in the heating surface between the each upper and lower blades, a part of the heating surface that is not used tends to exist even when the to-be-dried material is pressed against the heating surface by the centrifugal force. For this reason, an area that was not used, namely an area to which the to-be-dried material does not contact is comparatively large as compared to the total area of the heating surface, and hence the whole area of the heating surface was not utilized effectively.

[0013]

Still further, (5) the to-be-dried material is elevated from below upward, is made to fall when it reaches the uppermost part, and is elevated again. During this cycle, heat is given to the to-be-dried material from the heating surface to effect drying. Then, in order to dry the to-be-dried material efficiently, there is a best rotational speed for the vertical spiral rotating blade that is suited to each of various to-be-dried materials. Under this condition, if the vertical spiral rotating blade is rotated at a high speed that exceeds the best rotational speed at which the drying efficiency of the to-be-dried material becomes best, the to-be-dried material would not rise well along

the spiral and consequently the drying efficiency would go worse. That is, when the various to-be-dried material are intended to be dried most efficiently, it is indispensable to adjust the rotational speed of the vertical spiral rotating blade and conversely this adjustment was troublesome.

[0014]

On the other hand, a dehydrator of a structure in which plural pieces of impellers are arranged to face the tubular filter is one where the to-be-dried material is repelled by the impellers toward the tubular filter and impact force at the time of colliding of the to-be-dried material against the filter is utilized; therefore it is difficult to use this in the case where the to-be-dried material is made to contact with the heating surface and thereby is heated and dried.

[0015]

Therefore, what this invention aims at is to provide a technology of efficiently drying a to-be-dried material that features as follows:

(1) Even when a to-be-dried material having strong viscosity is dried, a risk that the to-be-dried material adheres to the blades and the heating surface to cause the to-be-dried material to stagnate is small.

(2) Even if the foreign material mixed in the to-be-dried material gets engaged in clearance between the blades and the heating surface, the technology makes it possible for the foreign material to escape easily.

(3) The amount of the to-be-dried material that rises is increased as compared to the total amount of the to-be-dried material lying on the bottom of the drying tank, and thereby the drying efficiency is improved.

Further, (4) the whole area of the heating surface between the upper and lower blades is utilized effectively.

(5) The troublesome adjustment of the rotational speed of the rotating blades is dispensed with.

[0016]

[Summary of Invention]

To solve the objects, this invention has the following technical means. That is, describing this with reference to numerals in the attached drawings that correspond to embodiments, the invention according to claim 1 is a drying apparatus, comprising: a drying tank 4 having an interior of a cylindrical shape into which a to-be-dried material 3 is inputted; a heating surface 2 that is an inner wall of a cylindrical shape of the drying tank 4 and transfers heat from the heating means to the to-be-dried material 3; the heating means that is disposed around the drying tank 4 and transfers heat to the heating surface 2; and a plurality of base blades 5a that are set rotatably by being linked to a rotation shaft 5b being set along the direction of gravity in the drying tank 4 and each of which is specified to have a length of a circumference of 360 degrees or less when viewed from a horizontal plane, characterized in that

the each base blade 5a has a planar surface 8 formed into the elongated shape extending along the heating surface 2, and an outer rim 10a of the planar surface 8 of the elongated shape extending along this heating surface 2 is formed into an arc-shape extending along the cylindrical shape of the heating surface 2 so that clearance U for allowing each base blade 5a to rotate is formed between the outer rim 10a of the planar surface 8 of the elongated shape extending along the heating surface 2 and the heating surface 2, the planar surface 8 is formed to extend

slantingly upward from one end 18 thereof to the other end 19 facing toward the opposite direction to its rotation direction R, and

during the rotation of the base blades 5a, the to-be-dried material 3 are pressed against the heating surface 2 and dried while being rolled up upward by each of the base blades 5a by the action of moving the to-be-dried material 3 from the one end 18 side to the other end 19 side caused by the planar surfaces 8 of the base blades 5a and by the action of pressing it to the heating surface 2 side by the centrifugal force.

[0017]

The invention of claim 2 is a drying apparatus according to claim 1, characterized in that the clearance is formed to become wider gradually in the opposite direction to the rotation direction R.

[0018]

The invention of claim 3 is a drying apparatus according to claim 1, characterized in that the base blade 5a is such that the one end 18 thereof integrally joins to a scraping plate 20 that extends radially from the rotation shaft 5b, and a protrusion 21 that faces a bottom plate 4c of the drying tank 4 approximately in parallel thereto is provided from an outermost end of this scraping plate 20 in the rotation direction R.

[0019]

The invention of claim 4 is a drying apparatus according to claim 2, characterized in that the base blade 5a is such that the one end 18 thereof integrally joins to the scraping plate 20 that extends radially from the rotation shaft 5b, and a protrusion 21 that faces a bottom plate 4c of the drying tank 4 approximately in parallel thereto is provided from an outermost

end of this scraping plate 20 in the rotation direction R.

[0020]

The invention of claim 5 is a drying apparatus, comprising: a drying tank 4 having an interior of a cylindrical shape into which the to-be-dried material 3 is inputted; a heating surface 2 that is an inner wall of a cylindrical shape of the drying tank 4 and transfers heat from the heating means to the to-be-dried material 3; the heating means that is disposed around the drying tank 4 and transfers heat to the heating surface 2; and plural sheets of base blades 5a that are set rotatably by being linked to a rotation shaft 5b being set along the direction of gravity in the drying tank 4 and each of which is specified to have a length of a circumference of 360 degrees or less when viewed from a plane, characterized in that

the each base blade 5a has a planar surface 8 formed into the elongated shape extending along the heating surface 2, the outer rim 10a of the planar surface 8 of the elongated shape extending along this heating surface 2 is formed into an arc shape extending along the cylindrical shape of the heating surface 2 so that the clearance U for allowing each base blade 5a to rotate is formed between the outer rim 10a of the planar surface 8 of the elongated shape extending along this heating surface 2 and the heating surface 2, and the planar surface 8 is formed to extend slantingly upward from one end 18 thereof to the other end 19 facing toward the opposite direction to its rotation direction R,

the clearance U is made to become wider gradually in the opposite direction to the rotation direction R,

the each base blade 5a is such that the one end 18 integrally joins to a scraping plate 20 extending radially from the rotation

axis 5b, a protrusion 21 that faces a bottom plate 4c of the drying tank 4 approximately in parallel thereto is provided from the outermost end of this scraping plate 20 in the rotation direction R, and

during rotation of the base blades 5a, the to-be-dried material 3 is rolled up upward and concurrently is pressed against the heating surface 2 by each of the base blades 5a and thereby is dried by the action of moving the to-be-dried material 3 from the one end 18 side to the other end 19 side caused by the planar surface 8 of each base blade 5a and by the action of pressing it against the heating surface 2 side exerted by the centrifugal force.

[0021]

The invention of claim 6 is a drying apparatus according to one claim selected from claims 1 to 4, characterized in that, above the plurality of base blades 5a, a plurality of other base blades 50a are set further as at least one-stage impeller with a spacing being set therebetween along the direction of gravity of the rotation shaft 5b.

[0022]

The invention of claim 7 is a drying apparatus according to claim 6, characterized in that the length of a planar surface 58, which is formed into an arc-shape, of the other plural sheets of base blades 50a being set as at least one-stage impeller is formed to be shorter than the length of the planar surface 8, which is formed into an arc-shape, of the plural sheets of base blades 5a being set in the lowest stage.

[0023]

The invention of claim 8 is a drying apparatus according to claim 6, characterized in that the position of the planar surface

58, which is formed into an arc-shape, of the other plural sheets of base blades 50a being set as at least one-stage impeller is arranged being shifted in the rotation direction R with respect to the position of the planar surface 58, which is formed into an arc-shape, of the plural sheets of base blades being set in the lowest stage.

[0024]

The invention of claim 9 is a drying apparatus according to claim 7, characterized in that the position of the planar surface 58, which is formed into an arc-shape, of the other plurality of base blades 50a being set as at least one-stage impeller is arranged being shifted in the rotation direction R with respect to the position of the planar surface 58, which is formed into an arc-shape, of the plurality of base blades being set in the lowest stage.

[0025]

[Function]

According to this invention composed as mentioned above, the following effects can be achieved:

(1) Since by the rotation of the plurality of base blades 5a, the to-be-dried material 3 is rolled up and concurrently is pressed against the heating surface 2 to effect drying by the planar surface 8 of the elongated shape extending along the heating surface 2 of the base blades 5a, by each of the base blade 5a, even if the to-be-dried material 3 is a material having strong viscosity etc., the material does not adhere to the base blade 5a and a heating surface 2 easily. Further, even if the to-be-dried material 3 adheres to these members, it would not remain stagnant because the to-be-dried material 3 is rolled up and elevated upward as a whole across the whole area of the heating surface 2 by the

plurality of base blades 5a.

[0026]

Further, (2) since each of the plurality of base blades 5a has only a length of a circumference of 360 degrees or less when viewed from a plane and is independent, the clearance U between the outer rim 10a of the planar surface 8 of each base blade 5a does not connected to the clearance U of a plurality of base blades 5a, forming non-connected clearance; therefore, even if the foreign material gets engaged in the clearance U, it will escape immediately from there and consequently the engagement does not last.

[0027]

Moreover, (3) since the to-be-dried material 3 lying on the bottom in the drying tank 4 can be rolled up and elevated by each of the plural sheets of base blades 5a, the amount of the to-be-dried material 3 that rises is large as compared to the total amount of the to-be-dried material 3 lying on the bottom in the drying tank 4 and the to-be-dried material 3 is easily brought into contact with the heating surface 2 early.

[0028]

Furthermore, (4) by allowing the each base blade 5a to roll up the to-be-dried material 3 and concurrently press it against the heating surface 2, and by causing the to-be-dried material 3 that is rolled up later to push the to-be-dried material 3 that was rolled up before to effect continuous rising of the to-be-dried material 3, the to-be-dried material 3 can rise across the whole area of the heating surface 2 and can be dried using the whole area of the heating surface 2.

[0029]

Additionally, (5) by rotating the base blades 5a, the

to-be-dried material 3 is rolled up and concurrently is pressed against the heating surface 2, whereby the to-be-dried material 2 can be pressed more firmly against the heating surface 2 by increasing rotational speed of the base blades 5a. By this, a larger amount of the to-be-dried material 3 is rolled up and spreads across the whole area of the heating surface 2 in the form of a thin film, and heat is easily transferred to the to-be-dried material 3.

[0030]

Further additionally, by making the clearance U become wider gradually in the opposite direction to the rotation direction R, it is possible to prevent the foreign material from being engaged in the clearance U, and even if the foreign material gets engaged therein, it is possible to reduce resistance against the rotation of the rotary rolling-up impeller to a small amount.

[0031]

Moreover, (7) by integrally joining one end 18 of the base blade 5a to a scraping plate 20 that extends radially from the rotation axis 5b and providing a protrusion 21 that faces a bottom plate 4c of the drying tank on the outermost end of the scraping plate 20, a function of scooping up the to-be-dried material lying on the bottom in the drying tank 4 on the base blades 5a is improved, so that the amount of the to-be-dried material 3 remaining on the bottom can be lessened.

[Brief Description of the Drawings]

Fig. 1 is a side view with a partial longitudinal cross-section of the drying apparatus according to the first embodiment of this invention.

Fig. 2 is a plan view of the rotary rolling-up impeller according to the first embodiment of this invention.

Fig. 3 is a side view of the rotary rolling-up impeller according to the first embodiment of this invention.

Fig. 4 is a plan view of the base blades according to the first embodiment of this invention.

Fig. 5 is a cross-sectional view taken along line A-A of Fig. 4.

Fig. 6 is a cross-sectional view taken along line B-B of Fig. 4.

Fig. 7 is a view showing a working condition of the drying apparatus according to the first embodiment of this invention.

Fig. 8 is an enlarged view showing a situation of the to-be-dried material when the drying apparatus according to the first embodiment of this invention is used.

Fig. 9 is an enlarged side view of the rotary rolling-up impeller constituting a multi-stage of the drying apparatus according to the second embodiment of this invention.

Fig. 10 is a plan view of the second-stage or third-stage rotary rolling-up impeller according to the second embodiment.

Fig. 11 is an enlarged plan view of the base blades that constitute second-stage or third stage rotary rolling-up impeller according to the second embodiment.

Fig. 12 is an enlarged front view of the base blades that constitute second-stage or third stage rotary rolling-up impeller according to the second embodiment.

[0032]

[Preferred Embodiments]

Next, referring to attached drawings, embodiments of this invention will be explained in detail. Figs. 1 to 10 show drying apparatus 1 according to a first embodiment. In the figures, the numeral 4 represents a cylindrical-shape drying tank, whose

inner wall of a cylindrical shape comprises a heating surface 2 for transferring heat from the heating means to a to-be-dried material 3. The heating means has a jacket 6 formed around the drying tank 4 and a boiler (not shown) that adjoins this jacket 6 and is for sending steam 7 into the jacket 6. The jacket 6 is provided with a steam inflow section 11 for guiding the steam 7 into the jacket 6 and a steam exhaust section 12 for exhausting the steam 7 to the outside of the jacket 6.

[0033]

Further, on a wall of the bottom 4a of the drying tank 4, a tube for supplying to-be-dried material is installed consecutively and supplies the to-be-dried material 3 from a to-be-dried material input tank (not shown) onto the bottom 4a in the drying tank 4 by means of a supplying screw 14. Moreover, on the wall of the upper part 4b, a tube for delivering to-be-dried material is installed consecutively and delivers the to-be-dried material 3 that was dried and concurrently elevated in the drying tank 4 to a tank for reserving dried material (not shown) outside the drying tank 4.

[0034]

Next, on the bottom 4a of the drying tank 4, a plurality of base blades 5a are installed. A whole body of this plurality of base blades 5a is shown here as a rotary rolling-up impeller 5, which is installed consecutively to a motor 17 that was fixed to the outside of the bottom 4a of the drying tank 4 and is made rotatable around the rotation shaft 5b by this motor 17.

[0035]

Next, the attention will be directed to the plurality of base blades 5a shown in detail in Figs. 2 to 8. The plurality of base blades 5a are composed of three sheets of base blades

5a in this example. The base blades 5a are of an identical shape and the each base blade 5a is specified to have a length of a circumference of 360 degrees or less when viewed from a horizontal plane. Further, each of the plurality of base blades 5a has one end 18 and the other end 19 both of which facilitate the movement of the to-be-dried material from one side to the other side. Moreover, each of the plurality of base blades 5a has a planar surface 8 of the elongated shape that is formed between the one end 18 and the other end 19 and extends in the form of an arc along the heating surface 2. Furthermore, the outer rim 10a of the planar surface 8 of the elongated shape extending along the heating surface 2 is formed in the form of an arc that is along the cylindrical shape of the heating surface 2 so that clearance U for allowing each of the base blades 5a to rotate is formed between the outer rim 10a of the planar surface 8 of the elongated shape extending along the heating surface 2 and the heating surface 2.

[0036]

As shown in Figs. 2 and 4, this arc shape is such that the distance L2 from the center of the rotation axis 5b to the outer rim 10a in the other end 19 is specified to be small as compared to the distance L1 from the center of the rotation axis 5b to the outer rim 10a in the one end 18. Therefore, the clearance U is formed to become wider gradually in the opposite direction to the rotation direction R of the base blades 5a.

[0037]

Further, the planar surface 8 is formed so as to extend slantingly upward from the one end 18 thereof to the other end 19 facing toward the opposite direction to its rotation direction R, and during rotation of the base blades 5a, the to-be-dried

material is rolled up to the upper portion of the base blades for each of the base blades 5a and concurrently is pressed against the heating surface 2 by the action of moving the to-be-dried material from the one end 18 to the other end 19 of each of the base blades 5a and by the action of the centrifugal force toward the heating surface 2 side.

[0038]

Further, a specification that the base blade 5a has a length of a circumference of 360 degrees or less when viewed from a horizontal plane means that an angle defined by the one end 18 and the other end 19 centered at a point of center of rotation is equal to 360 degrees or less, but the one end 18 of the base blade integrally joins to the scraping plate 20 fixed to the rotation shaft 5b. That is, the one end section 18 of the base blade 5a is supported by the scraping plate 20.

[0039]

The scraping plate 20 is provided slantingly according to a slope of the planar surface 8 and makes an angle to the bottom plate 4c of the drying tank 4 as shown in Fig. 5. Further, the side edge 20a of this scraping plate 20 facing the rotation direction R is formed into a tapered edge and faces the bottom plate 4c.

[0040]

This scraping plate 20 extends from the rotation shaft 5b to the outer rim 10a of the planar surface 8. That is, an outer end of the scraping plate 20 is functionally a scraping plate 20 and the one end 18 of the planar surface 8. From the outermost end of this scraping plate 20, a protrusion 21 is formed consecutively in the rotation direction R. It faces an extension direction of the planar surface 8 that is formed into an arc-shape.

[0041]

The protrusion 21 has a shape of approximately a right angled triangle, whose slant side 21a is formed to integrally join to the side edge 20a of the scraping plate 20 and is formed into a tapered edge (Fig. 6). This protrusion 21 is protruded being bent from the scraping plate 20 to be approximately in parallel to the bottom plate 4c of the drying tank 4.

[0042]

Incidentally, as another example of the heating means comprising the jacket 6 and the boiler, there can be considered heating means comprising the jacket 6, a heating medium housed in the jacket 6, and an electric heater being set around the jacket 6 in prescribed locations. That is, the heating means is one for transferring heat from the electric heater to the heating surface 2 through the heating medium. Moreover, as further another example, there can be considered heating means comprising an electric heater being set around the drying tank 4, which transfers heat from the electric heater to the heating surface 2.

[0043]

Next, an operation of the drying apparatus 1 will be described. First, by driving a supplying screw 14 inside the tube for supplying to-be-dried material 13, the to-be-dried material 3 is inputted into the drying tank 4 from the to-be-dried material input tank. Then, the motor 17 is driven to make the base blades 5a of the rotating rolling-up blades 5a rotate continuously in a direction of the rotation direction R. The boiler is driven simultaneously, and the steam 7 is guided into the jacket 6 to heat the heating surface 2.

[0044]

By rotation of the base blades 5a of the rotary rolling-up impeller 5 in a R direction, for each base blade 5a, the to-be-dried material 3 is carried on the planar surface 8 of the base blade 5a from the one end 18 and is being moved to the other end 19 side along the base blade 5a. Since each base blade 5a is of the elongated shape along the heating surface 2 and the planar surface 8 extends slantingly upward from the one end 18 to the other end 19, at this time, an action of turning upward exerts on the to-be-dried material 3, and as a result the to-be-dried material 3 is rolled up in a space A inside the drying tank 4 and concurrently is rolled up and pressed against the heating surface 2 by the centrifugal force P (See Figs. 7 and 8).

[0045]

Describing this action in more detail, since the planar surface 8 of each base blade 5a that gives the to-be-dried material 3 a rolling-up action and gives the heating surface 2 a pressing action by the centrifugal force P has the elongated shape along the heating surface 2, and the outer rim 10a of the planar surface 8 is formed into an arc-shape extending along the heating surface 2, the planar surface 8 is one that performs effectively the action of rolling up the to-be-dried material 3 and the action of pressing it against the heating surface 2 rather than simply giving an impulse to the to-be-dried material 3. Further, by each of the plural sheets of base blades 5a, the to-be-dried material 3 is rolled up upward separately and concurrently is pressed against the heating surface 2 rather than being elevated and moved by a single continuous blade in the drying apparatus. Because of this, even the to-be-dried material 3 having strong viscosity 3 etc. does not adhere to the heating surface 2, and the to-be-dried material is not made to pile up at a specific location on the

heating surface 2. Moreover, since each of the plurality of base blades 5a has only a length of a circumference of 360 degrees or less and is independent, the clearance U between the outer rim 10a of the planar surface 8 of the each base blade 5a and the heating surface 2 is not linked with the whole of all the blades; therefore, even if the foreign material in the to-be-dried material 3 gets engaged in the clearance, it escapes therefrom immediately and the engagement does not last.

[0046]

Particularly, in this case, the clearance U is made to become wider gradually in the opposite direction to the rotation direction R of the base blades 5a, it is effective in point of preventing the foreign material from being engaged therein; therefore the clearance U makes it possible for the base blades to perform a smooth operation continuously, avoiding increase in rotational resistance of the base blades 5a caused by the engagement of the foreign material.

[0047]

Further, since the to-be-dried material 3 lying on the bottom in the drying tank 4 can be rolled up and elevated by each of the plural sheets of base blades 5a, the amount of the to-be-dried material 3 that rises is large as compared to the total amount of the to-be-dried material 3 lying on the bottom in the drying tank 4 and the to-be-dried material 3 is easily brought into contact with the heating surface 2 early. The to-be-dried material 3 on the bottom in the drying tank 4 is scooped by the scraping plate and is moved onto the planar surface 8. If the protrusion 21 is provided on the outermost end of the scraping plate 20 is provided, the to-be-dried material 3 lying on the periphery of the bottom can be gathered in a center direction and concurrently

scooped by the scraping plate 20. Therefore, the amount of the to-be-dried material 3 scooped by the scraping plate 20 can be increased further, and the to-be-dried material 3 can be brought into contact with the heating surface 2 earlier. In addition, since the to-be-dried material 3 lying on the periphery of the bottom in the drying tank 4 is gathered successively in the center direction by the protrusion 21, an occasion in which the foreign material gets engaged in the clearance U between the outer rim 10a of the base blade 5a and the heating surface 2 is decreased in number. Thus, the protrusion 21 has double actions.

[0048]

Further, by allowing the each base blade 5a to roll up the to-be-dried material 3 and concurrently press it against the heating surface 2 and by causing the to-be-dried material 3 that is rolled up later to push the to-be-dried material 3 that was rolled up before upward to effect continuous rising of the to-be-dried material 3, the to-be-dried material 3 can rise across the whole area of the heating surface 2 and can be dried with the use of the whole area of the heating surface 2. In addition, by rolling up the to-be-dried material 3 and concurrently pressing it against the heating surface 2 though rotation of the base blades 5a, the to-be-dried material 3 can be pressed more firmly against the heating surface 2 by increasing the rotational speed of the base blades 5a. By this, the to-be-dried material 3 is rolled up along the heating surface further and spreads across the whole area of the heating surface 2 in the form of a thin film, and the heat is easily transferred to the to-be-dried material 3.

[0049]

The to-be-dried material 3 pressed to the heating surface 2 has a surface contacting with the heating surface 2 at the one

side and has an evaporation surface F contacting with air in the space A inside the drying tank 4 at the other side (Fig. 8). Then, in the to-be-dried material 3 contacting the heating surface 2, moisture evaporation takes place to some degree at that side by the heat from the heating surface 2. The to-be-dried material 3 whose moisture content becomes low by moisture evaporation at the time of contacting with the heating surface 2 moves to the evaporation surface F so as to exchange its position with that of the of the to-be-dried material 3 whose moisture content is high. In the to-be-dried material 3 that moved to the evaporation surface F, the moisture evaporation proceeds further by being exposed to air in the space A.

[0050]

The to-be-dried material 3 moves to the evaporation surface F from the heating surface 2 side and at the same time the to-be-dried material 3 rises along the heating surface 2 because the to-be-dried material 3 that is rolled up later pushes the to-be-dried material 3 that was rolled up before intermittently by the rolling up done by the each base blade 5a. That is, the to-be-dried material 3 moves from the heating surface 2 to the evaporation surface F, and concurrently is rolled up along the heating surface 2 to achieve rising.

[0051]

Next, a flow of the to-be-dried material 3 in the vicinity of the each base blade 5a when viewed from a side will be described. When the base blades 5a rotate, the to-be-dried material 3 is rolled up by each of the base blades 5a, and consequently it becomes a situation where the to-be-dried material 3 is rolled up. At this moment, the attention is directed to a motion of the to-be-dried material 3 in the vicinity of two sheets of base blades

5a among the plural sheets of base blades 5a.

[0052]

That is, when the to-be-dried material 3 lying on the topside of the base blade that is located upstream to the rotation direction R among the two sheets of base blades 5a runs out slantingly upward from this upstream-side base blade 5a, it tends to go downward because of its weight. On the other hand, the to-be-dried material 3 lying on the topside of the base blade 5a located downstream is about to run out slantingly upward from this downstream-side base blade 5a. That is, there occurs a portion where the two flows of the to-be-dried material 3 superpose, and in the superposed portion the two flows become a turbulent flow.

[0053]

In this turbulent region, the flow of the to-be-dried material 3 is impetuous and at the same time contact speed to the heating surface 2 becomes faster. Further, as the number of revolution and the rotational speed of the base blades 5a of the rotary rolling-up impeller 5 are increased, a frequency of the turbulent region increases. Moreover, by increasing the number of sheets of the base blades 5a, the number of occurrence locations increases and the contact speed of the to-be-dried material 3 to the heating surface 2 becomes higher.

[0054]

That is, by forming the turbulent flow region, in the to-be-dried material 3, contact having certain contact speed caused by the turbulent flow is exerted on the heating surface 2 as well as contact having certain contact speed caused by the revolution when being rolled up, the to-be-dried material 3 is contacted to the heating surface 2 easily due to a synergistic effect by both contacts and the heat is easily transferred to

the to-be-dried material 3 from the heating surface 2.

[0055]

The to-be-dried material 3 that rises along the heating surface 2 and becomes dry can be guided into a tube for delivering to-be-dried material 15 by driving a delivering screw 16 and transferred to a tank for reserving dried material outside the drying tank 4.

[0056]

In a work where the to-be-dried material 3 is supplied into the drying tank 4 and is dried in the drying tank 4 to obtain the dried material, supply of the to-be-dried material 4 may be paused so that the dried material is obtained intermittently, or the to-be-dried material 3 may be supplied continuously and the dried material is collected continuously so that the dried material is obtained continuously. Further, the base blades 5a constituting the rotary rolling-up impeller 5 are not limited to three sheets as was in the embodiment, but two sheets of or four sheets of base blades may be used to constitute the impeller 5.

[0057]

Next, a second embodiment will be described referring to Figs. 9 to 12. In this embodiment, a rotary rolling-up impeller 5 that is composed of three sheets of base blades, as with the embodiment, is provided in the lower part of the rotation axis 5b, and two stages of rotary rolling-up impellers 50 each of which is composed of three sheets of base blades 50a are provided in the upper part thereof, making a multi-stage construction. A construction of the heating surface 2, the drying tank 4, the jacket 6, etc. is constructed in the as that of the first embodiment, and so only the heating surface 2, the drying tank 4, and the

jacket 6 are shown with dot-dash line in the figure.

[0058]

The base blades 50a of the rotary rolling-up impellers 50 provided in the upper part of the rotation axis 5b to construct two-stage impellers are configured as in Figs. 10 to 12. That is, each base blade 50a has a length of a circumference of 360 degrees or less when viewed from a plane, respectively, and the length is specified to a length shorter than that of the three base blades 5a of the lower-stage impeller.

[0059]

Each base blade 50a has one end 68 and the other end 69 both of which facilitate the movement of the to-be-dried material 3 from one side to the other side, and also has a planar surface 58 that is formed between these ends in the form of an arc and extends along the heating surface 2. An outer rim 60a of this planar surface 58 is also formed in the form of an arc so that clearance U for allowing the base blades 50a to rotate between itself and the heating surface 2. For this base blade 50a, the distance from the center of the rotation shaft 5b to the outer rim 60a of the one end 68 is set equal to the distance from the center of the rotation axis 5b to the outer rim 60a in the other end 69, so that fixed clearance U is formed between itself and the heating surface 2. The one end 68 of the base blade 50a integrally joins to a horizontal arm plate 70 that extends radially from the rotation shaft 5b, and the one end 68 is supported by the horizontal arm plate 70.

[0060]

The planar surface 58 is formed to extend slantingly upward, from the one end 68 to the other end 69, in the opposite direction to the rotation direction. As well, the base blades are constructed

so that the to-be-dried material 3 is rolled up upward by each of the base blades 50a, and concurrently is pressed against the heating surface 2 by the action of moving the to-be-dried material from the one end 68 to the other end 69 side of each base blade 50 and by the action of the centrifugal force toward the heating surface 2 side, also by the rotation of each base blade 50a.

[0061]

The base blades 50a constituting the rotary rolling-up impeller 50 of the upper stage, namely a second stage, are arranged in such a manner that positions thereof are shifted in the rotation direction R with respect to positions of the base blades 5a constituting the rotary rolling-up impeller 5 of the lower-stage, and the base blades 50a constituting the rotary rolling-up impeller 50 of the further upper stage, namely a third stage, are arranged in such a manner that positions thereof are shifted in the rotation direction R with respect to the positions of the base blades 50a constituting the rotary rolling-up impeller 5 of the second stage, both keeping a certain angular relationship. That is, the structure is determined in such a way that the to-be-dried material 3 that is rolled up and rises slantingly upward by the base blades 5a or the base blades 50a of the lower stage is scooped by the one end 68 of the base blades 50a of the upper stage conveniently without being pressed by an underside of the base blades 5a of the lower stage. Since the length of the base blade 50a in the rotation direction R is set shorter than the length of the base blade 5a of the lowest stage, a set-up in which the blades are arranged being shifted with a certain angular relationship mentioned above is easy and the arrangement at proper locations is possible.

[0062]

In the drying apparatus of this second embodiment, the to-be-dried material on the bottom of the drying tank 4 is first rolled up by the rotary rolling-up impeller 5 of the lowest stage, is pressed against the heating surface 2, and rises; and subsequently is rolled up by the rotary rolling-up impellers of the second stage and of the third stage sequentially and concurrently is pressed against the heating surface 2. Since the second and third rotary rolling-up impellers can supplement the rising power and the centrifugal force for the to-be-dried material 3, the height of the drying tank 4 can be raised. That is, since the area of the heating surface 2 becomes larger, processing capability of drying can be augmented.

[0063]

Note that, in the second embodiment, above the rotary rolling-up impeller 5 in the lower part, other rotary rolling-up impellers 50 are provided as two-stage impellers, but a configuration where these other rotary rolling-up impellers 50 are set as a one-stage impeller or three- or more-stage impellers may be adopted.

[0064]

[Advantages of the Invention]

As described in detail in the foregoing, this invention is one that enables the to-be-dried material to be rolled up by each of the plurality of base blades, and concurrently to be pressed against the heating surface, to be moved from the heating surface to the evaporation surface, and to be elevated upward along the heating surface, and thereby moisture content of the to-be-dried material becomes lower as it rises upward and the dried material can be obtained in the upper part of the drying tank. Particularly, since each of the base blades rolls up the to-be-dried material

and presses it against the heating surface to effect drying, even the to-be-dried material having strong viscosity does not adhere to the blades and the heating surface easily, even if the to-be-dried material adheres to these members, the to-be-dried material is elevated as a whole across the whole area of the heating surface, the to-be-dried material would not remain stagnant. Furthermore, since the planar surface of each base blade that gives the to-be-dried material the action of rolling up and the action of pressing it against the heating surface by the centrifugal force is of the elongated shape along the heating surface and extends slantingly upward from the one end to the other end, the planar surface performs effectively the action of rolling up the to-be-dried material and the action of pressing it against the heating surface rather than simply giving an impact to the to-be-dried material.

[0065]

Further, each of the plurality of base blades has only a length of a circumference of 360 degrees or less when viewed from a plane and is independent, and hence the clearance between the outer rim of the planar surface of the each base blade and the heating surface does not continue to the whole of all the blades; therefore the foreign material would not get engaged in the clearance. Particularly, if the clearance is set to become wider gradually in the opposite direction to the rotation direction of the base blades, it is effective for the prevention of this engagement of the foreign material.

[0066]

Further, by the plural sheets of base blades, the to-be-dried material lying on the bottom in the drying tank can be elevated by the plurality of blades, the amount of the

to-be-dried material that rises become large as compared to the total amount of the to-be-dried material lying on the bottom in the drying tank, and it is easy to bring the to-be-dried material into contact with the heating surface, and consequently the drying efficiency is improved easily.

[0067]

The structure of providing the protrusion facing the bottom plate of the drying tank approximately in parallel thereto from the outermost end of the scraping plate, to which the one end of the base blade integrally joins, in the rotation direction is effective to scoop the to-be-dried material lying on the bottom in the drying tank and enables the amount of the to-be-dried material that rises to be increased further, and since the to-be-dried material located at an periphery of the bottom in the drying tank is gathered in the direction of the center at which the rotation shaft exists, it can also contribute to prevent the engagement.

[0068]

Further, by allowing the plurality of base blades to roll up the to-be-dried material, concurrently press it against the heating surface, and by causing the to-be-dried material that is rolled up later to push upward the to-be-dried material that was rolled up before to effect continuous rising of the to-be-dried material, the to-be-dried material can rise across the whole area of heating surface and can be dried with the use of the whole area of the heating surface, so that the whole area of the heating surface can be utilized effectively.

[0069]

In addition, since the to-be-dried material is rolled up and concurrently is pressed against the heating surface and dried

by rotating the plurality of base blades, the to-be-dried material can be pressed more firmly against the heating surface by increasing the rotational speed of the base blades. By this, a larger amount of the to-be-dried material rises along the heating surface and spreads across the whole area of the heating surface in the form of a thin film, the heat is easy to be transferred to the to-be-dried material, and the drying efficiency is improved.

[0070]

Further, by arranging a plurality of base blades so as to form multi-stage impellers, various effects mentioned above can be better demonstrated over the whole regions of the multi stages more excellently and the processing capability of drying can be increased.

[What is claimed is]

[Claim 1] A drying apparatus, comprising:

a drying tank 4 having a cylindrical interior into which a to-be-dried material 3 is inputted;

a heating means that is disposed around said drying tank 4 and transfers the heat to said heating surface 2;

a heating surface 2 that is an inner wall of a cylindrical shape of the drying tank 4 and transfers heat from the heating means to the to-be-dried material 3;

a plurality of base blades 5a that are set rotatably by being linked to a rotation shaft 5b, being set along the direction of gravity in said drying tank 4, and each of which is specified to have a length of a circumference of 360 degrees or less when viewed from a horizontal plane, respectively, wherein

said each base blade 5a has a planar surface 8 formed into an elongated shape extending along said heating surface 2,

the outer rim 10a of the planar surface 8 of the elongated shape extending along said heating surface 2 is formed into an arc-shape extending along a cylindrical shape of said heating surface 2 so that clearance U for allowing each base blade 5a to rotate is formed between the outer rim 10a of the planar surface 8 of an elongated shape extending along this heating surface and said heating surface 2, and

said planar surface 8 is formed to extend slantingly upward from the one side 18 to the other side 19 facing toward the opposite direction to its rotation direction R,

and during rotation of each base blade 5a, the to-be-dried material 3 is rolled up upward by each base blade 5a and is pressed against the heating surface 2 to be dried by the action of moving the to-be-dried material 3 from one end 18 side to the other end

19 side caused by said planar surface 8 of each base blade 5a and by the action of pressing it against the heating surface 2 exerted by centrifugal force.

[Claim 2] A drying apparatus according to claim 1, wherein said clearance U is set to become wider gradually in the opposite direction to said rotation direction R.

[Claim 3] A drying apparatus according to claim 1, wherein said base blade 5a has such a structure that said one end 18 thereof integrally joins to a scraping plate 20 that extends radially from said rotation shaft 5b and,

a protrusion 21 that faces a bottom plate 4c of said drying tank 4 approximately in parallel thereto is provided from an outermost end of this scraping plate 20 in said rotation direction R.

[Claim 4] A drying apparatus according to claim 2, wherein said base blade 5a has such a structure that said one end 18 thereof integrally joins to a scraping plate 20 that extends radially from said rotation shaft 5b and,

a protrusion 21 that faces a bottom plate 4c of said drying tank 4 approximately in parallel thereto is provided from an outermost end of this scraping plate 20 in said rotation direction R.

[Claim 5] A drying apparatus, comprising:

a drying tank 4 having a cylindrical interior into which a to-be-dried material 3 is inputted;

a heating means that is disposed around said drying tank 4 and transfers the heat to said heating surface 2;

a heating surface 2 that is an inner wall of a cylindrical shape of the drying tank 4 and transfers heat from the heating means to the to-be-dried material 3;

a plurality of base blades 5a that are set rotatably by being linked to a rotation shaft 5b being set along the direction of gravity in said drying tank 4 and each of which is specified to have a length of a circumference of 360 degrees or less when viewed from a horizontal plane, wherein

said each base blade 5a has a planar surface 8 formed into an elongated shape extending along said heating surface 2,

an outer rim 10a of the planar surface 8 of the elongated shape extending along this heating surface 2 is formed to an arc-shape along a cylindrical shape of said heating surface 2 so that clearance U for allowing each base blade 5a to rotate is formed between the outer rim 10a of the planar surface 8 of the elongated shape along said heating surface 2, and

said planar surface 8 is formed to extend slantingly upward from one end 18 thereof to the other end 19 facing toward the opposite direction to its rotating direction,

said clearance U becomes wider gradually in the opposite direction to said rotation direction R,

in said each base blade 5a, said one end 18 integrally joins to a scraping plate 20 that extends radially from said rotation shaft 5b,

a protrusion 21 that faces the bottom plate 4c of said drying tank 4 approximately in parallel thereto is provided from an outermost end of this scraping plate 20 in said rotation direction R, and

during rotation of each base blade 5a, the to-be-dried material 3 is rolled up upward by each base blade 5a and is pressed against the heating surface 2 to be dried by the action of moving the to-be-dried material 3 from the one end 18 side to the other end 19 side caused by said planar surface 8 of each base blade

5a and by the action of pressing it to the heating surface 2 side exerted by centrifugal force.

[Claim 6] A drying apparatus according to one of the claims 1 to 4,

wherein said plurality of base blades, other plurality of base blades 50a are further set as at least one-stage impeller along the direction of gravity of said rotation shaft 5b with a spacing being set therebetween.

[Claim 7] A drying apparatus according to claim 6, wherein the length of the planar surface 58, which is formed into an arc-shape, of said different plurality of base blades 50a being set as at least one-stage impeller is formed to be shorter than the length of the planar surface 8, which is formed into an arc-shape, of said plurality of base blades 5a being set in the lowest stage.

[Claim 8] A drying apparatus according to claim 6, wherein the position of the planar surface 58, which is formed into an arc-shape, of said different plurality of base blades 50a being set as at least one-stage impeller is arranged being shifted in the rotation direction R with respect to the position of the planar surface 8, which is formed into an arc-shape, of said plurality of base blades 5a being set in the lowest stage.

[Claim 9] A drying apparatus according to claim 7, wherein the position of the planar surface 58, which is formed into an arc-shape, of said different plural sheets of base blades 50a being set as at least one-stage impeller is arranged being shifted in the rotation direction R with respect to the position of the planar surface 8, which is formed into an arc-shape, of said plurality of base blades 5a being set in the lowest stage.