(i.e., some 8 to 10 feet above the ground) on a platform **41** by a structural skeleton of supporting shores **42** and cross braces **43**.

Carried on the platform **41** is the heat-treating chamber comprising a first section **45** in which a heated air medium is directed at high velocity against the surfaces of the veneer material to evaporate moisture therefrom, and a second section **55** in which ambient air is circulated to cool the veneer and also carry away remaining moisture. As best shown in FIGS. 4 and 4A, a pair of centrifugal fans **46** in the heating section **45** pressurizes air which is also heated to high temperature (typically, above 350° F.) by a gas burner (not shown). The pressurized heated air is then forced into a respective first plenum chamber **47** and thence into an associated hollow air box **48** disposed laterally on either side of the veneer material which is transported through the central core area. As indicated in FIG. 4A, the veneer **18** is carried through the center of the chamber by means of a sandwiching conveyor web **35***a* and **35***b* supported and driven by a roller mechanism **49**.

The heated air emerges from the respective air boxes **48** at high velocity, typically 2,500 —10,000 linear feet per minute, through a plurality of jet nozzles **52** spaced in a staggered arrangement to direct the heated air medium perpendicularly to the horizontal surfaces of the moving veneer material **18**. The high-velocity, high-temperature jet action produces an efficient and rapid drying of the partially dried veneer material and, because of the disruption of the interface boundary layer which occurs due to the sharp right-angle impingement of the jet streams on the flat surface of the sheet material, the drying action is extremely thorough. The high air temperatures used, which are considerably above those conventionally employed in veneer dryers, are not injurious because the moisture is rapidly drawn from the interior of the veneer material and quickly evaporated from the surface, thereby producing a cooling effect which protects the board from injury or discoloration. A more detailed explanation of the drying phenomena associated with this type of high-temperature, high-velocity impingement jet action is set forth in U.S. Pat. No. 3,199,213 whose disclosure is herein incorporated by reference.

After impingement on the veneer material, the air flow is swept laterally across the surface thereof and exhausted from the central core area and into the respective second plenum passages **51**, and thereafter drawn toward the inlet side of the opposing centrifugal fan **46** to complete the circulation path. The moisture carried away from the veneer material in the drying process and collected in the gaseous medium is then exhausted to the atmosphere through the vent stack **53**.

After passage through the heating section **45**, the veneer material then passes into the adjacent cooling section **55** of similar design in which unheated ambient air is directed in high velocity jet streams perpendicularly against the respective faces of the veneer sheet so as to draw off remaining moisture. In this cooling section the air is circulated in a fashion similar to that in the heating section by means of a single centrifugal fan **56**, and the moisture-laden air is exhausted to the atmosphere by a separate stack **58** provided in the cooling section.

The conveyor mechanism **35** which transports the veneer material **18** in a closed loop configuration through the secondary dryer **30** is of generally conventional design utilizing powered and idler rollers driven by suitable mechanisms known to the art. In order to secure the veneer material **18** during its passage through the heat-treating chamber where high-velocity jet air flows are encountered, the veneer is preferably constrained in sandwichlike fashion by the conveyor web **35** which, as shown in FIG. 4A, overlies the top and bottom of the material during this portion of its travel. In its arcuate vertical passage from the overhead-mounted drying chamber to the ground level moisture detection and grading stations, and then back again, the veneer material is supported, as shown in FIG. 3A, by an overlying conveyor belt portion **35***c* which presses the veneer material **18** against a plurality of closely spaced idler rollers **35** disposed along the arcuate path. It will be noted from the nature of the conveyor mechanism **35** shown in FIG. 3 that the veneer sheets **18** will continue to recirculate in the closed path between the drying chamber and the grading station until the steel material is physically taken off the conveyor belt.

While the described embodiment of the present invention has been directed to a system for handling veneer in sheet form, it will be apparent that the system is readily adaptable for the handling of veneer in ribbon form by the alignment of the primary and secondary dryers in a colinear arrangement and, in such modification, some lengthening of the elliptical path traveled by the conveyor belt of the secondary dryer system might be required in order to deal with the longer ribbon lengths involved.

ILLUSTRATIVE EXAMPLE

In an exemplary operation of the primary-secondary dryer system disclosed herein, samples of intermixed sapwood and heartwood green veneer, having a range of initial moisture content varying from 35 percent to 158 percent (based, as is the conventional industry practice, on the bone dry weight of the veneer) were entered into the infeed of the primary dryer unit. The operating parameters of the primary dryer were set so that only the material having the lowest initial moisture content was fully dried in this unit; thus, the material of originally 35 percent moisture level was reduced to a satisfactory moisture level of 4 percent in its passage through the primary unit, and this material was then removed from the system. However, the veneer material of initially 158 percent moisture content was reduced to only a partially dry 22 percent moisture level after passage through the primary dryer, and this wet material was thereafter continued on to the secondary dryer where it was finally reduced to a satisfactory 3½ percent moisture level in two passes through the secondary dryer unit. Material of moisture content intermediate these two extremes required but a single pass through the secondary dryer to reach the desired moisture level. In this manner all of the material was dried to a satisfactory moisture level within a narrow range centering around 2 —4 percent moisture content, with none of the material being underdried and none of it requiring further handling or reprocessing as "redry " material.

What we claim is:

1. Apparatus, for continuous heat treating of planar material, of the type comprising a drying chamber having a horizontal core opening extending longitudinally through the center thereof, a conveyor for carrying said material through said chamber core, and a plurality of nozzles arranged in a spaced array throughout said chamber and coupled to a source of pressurized heated air for directing jets of high temperature air at high velocity and substantially perpendicularly to the major surfaces of said material advancing through said chamber core, characterized in that said chamber is supported overhead and above ground level by a skeletal framework so as to form an exposed open area underneath said chamber and that said conveyor is arranged in a vertically disposed closed loop so that said material, after passage through said chamber core, is transported downward, then through said open area directly underneath said chamber, and finally upward to return to the input of said chamber, whereby material will be repetitively cycled through said drying chamber until removed from said conveyor.

2. The apparatus of claim 1 further characterized in that a moisture detector means for discriminating fully dried from partially dried material is positioned to examine material on said conveyor after its passage through said chamber core, and a grading station is provided underneath said chamber in said open area at which personnel may remove fully dried material from said conveyor as marked by said moisture detector.

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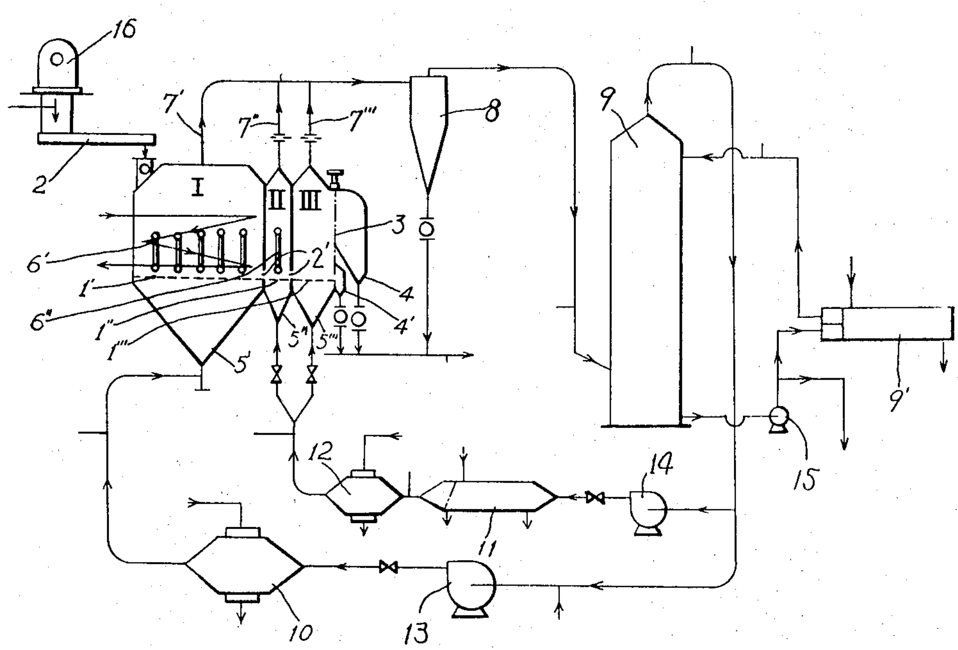

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CONTINUOUS FLUIDIZATION-TYPE POWDER DRYING PLANT AND METHOD OF USE

SUMMARY OF THE INVENTION

This invention relates to a continuous fluidization-type powder drying plant having a plurality of drying chambers transversely parallelly connected thereto.

This invention has for its object the provision of a plant for drying powder, said plant being of the structure in which, in a plant used for drying polyethylene of high density, polypropylene and other synthetic resins or organic and inorganic chemicals containing singly or in conjugate state hydrocarbon-based, alcohol-based, water and other solvents by a continuous fluidization system in a gas which is in a single or azeotropic state of said organic solvents and in a nitrogen carrier gas, an object of drying is attained by separating heated drying gas into a gas of high humidity and a gas of low humidity and treating the gases through individual circuits and circulating a greater part of said heated gas in the form of the gas treated at relatively high temperatures and which needs no special cooling, and an object of efficient finished drying is attained by cooling and drying a small quantity of circulating gas alone to low temperatures.

According to this invention, a cleansing column for finished drying for use in the whole quantity of heated drying gas can be dispensed with, a refrigeration load can be decreased to a very small degree, and a desired quantity of steam is not only decreased but there is little or no need of nitrogen spent, with the result that cost of operation can be reduced.

Another object of this invention is to provide a continuous fluidization-type powder drying plant having a plurality of drying columns transversely parallelly connected thereto, said plant being of the structure in which a plurality of fluidization-type powder drying columns are connected and disposed parallelly at the same height, said columns have porous plates respectively on the same horizontal level, the neighboring columns of said columns communicate with each other only through the gaps between the upper sides of said porous plates and the lower ends of the sidewalls partitioning two drying columns, a first drying column is provided on one side of the upper portion thereof with a moist powder feeder, a last drying column is provided on dried powder outlets any of said drying columns is selectively provided therein with heat exchangers, fine powder mixed gas outlet pipes are respectively connected to the upper portions of the drying columns, said pipes are led in one pipe to a cyclone collector and further to a gas cleansing and dehumidifying column, the gas discharged from said cleansing and dehumidifying column is separately led into a plurality of pipes, the heated gas communication chamber of said first column is supplied under pressure with a gas of relatively high humidity, and the other drying columns are provided with a means for feeding a gas of relatively low humidity.

Next, a description will be taken of the invention with reference to the accompanying drawing illustrating an embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a diagrammatic view showing by way of example a continuous fluidization-type powder drying plant having a plurality of drying chambers transversely parallelly connected thereto.

DETAIL OF THE INVENTION

Referring now to the drawing, continuous fluidization powder drying columns I, II, III ... are disposed and connected in series at the same height, and provided with porous plates **1′**, **1″** and **1‴** ... each placed on the same horizontal level, neighboring columns I, II and II, III .... communicate with each other only through the gaps between the upper side of the porous plates **1′**, **1″ 1‴** .... and the lower ends of the sidewalls partitioning both columns. A first continuous fluidization drying column I is provided on one side of the upper portion thereof with a moist powder feeder **2**, and a last fluidization powder-drying column III is provided on the side thereof with a fence **3**, said fence **3** being provided on the upper and lower edges with dried powder outlets **4** and **4′**, respectively. Any of the fluidization powder-drying columns I, II, III ... are selectively provided therein with heat exchange devices **6′**, **6″** ... and the columns are respectively provided on the undersides thereof with heated drying gas communication chamber **5′**, **5″**, **5‴** .... The drying columns are respectively provided on the upper portions with fine powder mixed gas outlet pipes **7′**, **7″**, **7‴** ... which are connected and led in one pipe to a cyclone collector **8** and the gas discharged from the cyclone **8** is fed to a cleansing and dehumidifying column **9**. The discharged gas from the dehumidifying column is separately fed to a plurality of pipes and the heated gas communication chamber **5′** of said first drying column I is supplied under pressure by pump **13**, with a gas of relatively high humidity which has been heated by a steam heater **10** and the heated gas communication chamber **5′** of the other drying columns II and III are provided with a means for selectively supplying under pressure a gas of low humidity i.e. a gas of high degree of drying through a gas cooler **11** and a gas heater **12**. The apparatus of the invention comprises a plurality of the drying columns connected and disposed transversely parallelly to each other in the manner described above.

The cleansing and dehumidifying column **9** is designed to collect heptane from the spent liquid discharged from the column **9** and to feed the heptane at about 30° C. back thereto through a heptane cooler **9′** by mean of the pump **15**. The numeral **16** in the drawing designates a dehumidifier.

Next, a description will be made of the action of this invention with reference to the case in which polyethylene of high density is used as a material to be dried.

Polyethylene granules to be dried are fed in a hexane content of 25 percent WB to a continuous fluidization powder-drying column I through a humidifier **16**, and are dried on a porous plate **1′** in a circulating nitrogen gas containing hexane C_6H_{14} of high humidity (45° C. dew point) to the first order balance moisture content of 1.5 to 20 percent WB in the presence of a heat exchange device **6′**. Thereafter, the granules are moved to a porous plate **1″** on the same horizontal level with the plate **1′** and to a fluidization powder-drying column II, into which a nitrogen gas containing hexane C_6H_{14} of low humidity (a dew point of −10° to −20° C.) is fed under pressure through a heated gas feed passageway different from that through which the heated gas was fed to said drying column I, the granules are dried to a higher degree of drying. The granules thus dried to a higher degree in the drying column II are then moved to the succeeding drying columns III—and dried to higher and higher degrees until finally they are dried to a degree of less than 0.1 percent moisture content in the final drying column III in the case of the plant shown.

Drying in the drying column II is reduced to be shortest necessary period of time and the quantity of gas also is smallest in view of a separator being disposed. The drying column III depends upon its object as a purger and upon the property of material to be dried for its dimensions, a period of staying time allowed to the materials and the quantity of gas used.

The heated gas discharged from each partitioned drying columns is fed through each regulating valve or orifices to a cyclone collector **8** for purging and collecting powder, and the gas is introduced into a cleansing and dehumidifying column **9**. By spraying a colling hexane liquid from the top of the inside of the column are effected purge of dust and dehumidifying to bring about saturation at about 40° C., and a greater part of gas is increased in pressure and elevated by a steam heater **10** to a temperature of 105° C. and circulated to the drying column I. Part of the gas discharged from the cleansing and dehumidifying column **9**, after the increase in pressure, flows to a circuit different from said gas circulation passageway and is circulated to the drying column II by mean of the pump **14**. This circulating gas is dehumidified by a gas cooler **11** (indirect heat exchange by the medium of brine from refrigerator) to a dew point of −10° C into a gas of low humidity and elevated by a steam heater **12** to a temperature of 105° C and circulated to the drying columns II or III.

That is to say, a large quantity of gas of high humidity and 105° C is circulated to the drying column I and a small quantity of gas of low humidity and 105° C is circulated to the drying columns II and III.

In the plant of a conventional type in which one drying column was mounted, it was necessary to cool a large quantity of circulating gas to low temperatures or to spend pure nitrogen gas for purging in large quantities. In contrast thereto, the plant of the invention which is constructed as described above is free from such a disadvantage and functions in the manner described, and therefore makes it easy to dry a material to a final desired moisture content by use of a small quantity of circulating nitrogen gas during a relatively short period of gas staying. That is to say, as a greater part of the circulating gas is circulated as a high dew point, there is no necessity of effecting particular drying. A greater part of the gas can be collected by cooling by use of general inexpensive industrial water, and a small quantity of circulating gas alone needs being cooled to low temperatures, but as percentage of the quantity of such a gas to the whole quantity of gas is very small, both the quantity of steam for heating and the quantity of nitrogen spent are very small.

I claim:

1. A continuous fluidization-type powder drying plant for drying high density chemical powders comprising in combination:

a. at least first and second adjacent vertical drying columns (I, II) disposed in series at substantially the same height and the same horizontal level separated by a common wall, porous plates (**1**, **1**′) towards the bottom of said columns with gaps above said plates providing communication between said columns, the first drying column being substantially larger than the second drying column;

b. a moist powder feeder (**2**) on the upper portion of said first drying column and at least one dried powder outlet (**4**) on the lower portion of the last column, at least one heat exchange device (**6**) in one of said columns, heated drying communication chambers (**5**′, **5**″) at the undersides of said columns, fine powder mixed gas outlet pipes (**7**′, **7**″) coupled to a cyclone collector (**8**) leading from the upper portion of said columns, including a throttle valve in said second drying column outlet pipe (**7**″), a separate gas discharge line from said cyclone collector;

c. a gas cleaning and dehumidifying column (**9**) fed by said gas discharge line towards the bottom of said dehumidifying column, a hexane cooling liquid spray means at the top of said dehumidifying column, a hexane cooler (**9**′) next to said column including pump means (**15**) to circulate the hexane from the bottom of said dehumidifying column (**9**) through said cooler (**9**′) to the spray means at the top of said dehumidifying column, an outlet line from the top of said dehumidifying column over said spray means; and,

d. first and second branch lines from said outlet line, said first branch line going to said first drying column communication chamber (**5**′), said second branch line going to said second drying column communication chamber (**5**″), a first pump (**14**), a gas cooler (**11**) and heater (**12**) in said first branch line, a second pump (**13**) and steam heater (**10**) in said second branch line, whereby said first drying column is supplied under pressure with a gas of relatively high humidity and said second drying column with a gas of relatively low humidity.

2. A plant as claimed in claim **1**, including at least a third drying column after said second drying column, said third drying column including an outlet pipe (**7**‴) with a throttle valve therein.

3. The method of fluidized drying of chemical powder material so that heated drying gas is separated into a gas of high humidity and a gas of low humidity and treating said gases in individual circuits, circulating a greater part of the heated gas at a relatively high temperature and finish drying the material by cooling and drying a small quantity of circulating gas at a low temperature, comprising the steps of:

a. passing the powder raw material through a dehumidifier towards the top of a first larger vertical elongated treating zone communicating with a parallel second similar smaller treating zone;

b. withdrawing said treated material from the top of said zones into a cyclone collector, while withdrawing material from powder outlets in the bottom of said second treating zone;

c. leading out drying gas from the top of said cyclone collector to the bottom of a circulating cleaning and dehumidifying zone, removing the drying gas from the top of said cleaning and dehumidifying zone; and

d. separately feeding said cleaned and dehumidifying drying gas through first and second branch lines to the bottom of said first and second vertical treating zones while subjecting said treating gas in said branch lines to selected cooling, heating and steam heat applications so as to selectively supply said first and second vertical treating zones at the bottom thereof with drying gas of high humidity in said first treating zone and of low humidity in said second zone.