The present invention relates to dryers wherein a wet dispersible material is introduced into a high velocity stream of gaseous drying medium, for example at 200-800 ft. per second, which creates highly turbulent initial drying conditions to produce very high drying rates.

The invention has particular utility in drying granular, fibrous and like material which can be fed and dispersed in a high velocity gaseous stream to remove external and internal moisture.

A primary object of the present invention is to provide apparatus of the stated character which produces high initial turbulence and dispersion of the wet material so that it dries in a very short retention time, thereby permitting higher initial drying temperatures, but at the same time, minimizing the possibility of product degradation.

Another object of the present invention is to provide a dryer which effects drying of the material while it is dispersed, thereby preventing the formation of clumps in the finished product. Rapid dispersion in the wet state may obviate the need for subsequent size reduction.

More specifically, the invention contemplates a dryer in which the high velocity fluid stream carrying the material is suddenly expanded in the dryer chamber, thereby, effecting a dispersion of the material in the gaseous stream. In the high velocity zone, the gaseous medium may flow either with essentially straight-line motion or if desirable, it may flow with vortex motion thereby imparting a special condition of turbulence as a result of the combined effect of the tangential and axial velocity components.

Another aspect of the present invention is to provide a dryer of simplified construction and operation in which the gaseous drying medium is the sole means for conveying the product in contrast to those dryers which depend on the motion of mechanical parts for conveying the product.

There and other objects of the invention and the various features and details of the construction and operation thereof are more fully set forth hereinafter with reference to the accompanying drawings in which:

Fig. 1 is a vertical sectional view of one embodiment of a dryer made in accordance with the present invention;

Fig. 1a is a fragmentary view of a modified discharge arrangement for the dryer shown in Fig. 1;

Fig. 2 is a horizontal sectional view taken on the line 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 1 showing a modified form of the invention; and,

Fig. 4 is a view similar to Fig. 1 showing a further modified form of the invention.

Referring now to the drawings and more particularly to Figs. 1 and 2 thereof, the dryer chamber comprises a generally cylindrical inlet portion 16 and a generally cylindrical outlet nozzle portion 17 which passes centrally through the top wall 12 of the drying chamber 11 as shown coaxially with the cylindrical chamber 11. The nozzle portion 17 may range from 1/5 to 1/3 of the cross-sectional area of the inlet portion 16 and to this end, the two portions are connected by a tapering mid-portion 18. By reason of the reduced cross-sectional area of the nozzle portion 17, the drying medium introduced into the inlet portion 16 is substantially accelerated as it passes through the nozzle portion, attaining an axial velocity in the range of 150 to 800 feet per second and tangential velocities in the same range. The high axial and tangential velocities of the drying medium in the portion 17 greatly contribute to the high efficiency afforded by the invention, as will be more fully set forth hereinafter.

Air is introduced into the inlet portion 16 of the chamber 15 in a tangential direction. To this end, an inlet conduit 21, as shown in Fig. 2, is disposed tangentially to the inlet portion 16. As shown in Fig. 1, air or other gaseous drying medium is supplied under pressure to the inlet conduit 21 by means of a blower 22 which forces the air through a heater 23, and from the heater into the conduit 21. Of course, the blower acting as an exhauster, may be connected to the discharge conduit 14 to draw the air through the dryer, or a blower and exhauster may be used respectively at the inlet and the discharge end. As shown, the conduit 21 is cylindrical at its intake end 24 and is rectangular at its discharge end 25 where it joins with the inlet portion 16 of the chamber 15, although the intake end may be square or rectangular. The tangential arrangement of the conduit 21 imparts a swirling motion to the air or other drying medium as it is introduced into the chamber 15, as suggested by the arrows in Fig. 1.

In the embodiment shown in Fig. 1, the material to be dried is introduced by suitable means into the air stream prior to its admission into the vortex chamber 15, and the subsequent injection of the air stream into the drying chamber 11. The material as it enters the vortex chamber 15 is picked up by the swirling high velocity air stream and is carried into the body of the drying chamber 11. In the illustrated embodiment, the feed means comprises a screw 28 which feeds the material into the conduit 21 from a hopper 29, but other feeding devices and methods are possible within the scope of the present invention. Further, the location of the feed point can be located at different points prior to the inlet to the vortex chamber, depending on the particular problem involved.

In accordance with the invention, heated gaseous drying medium is injected into the drying chamber 11 from an injector in the form of a high velocity vortex chamber 15. As shown in Fig. 1, the high velocity chamber comprises a generally cylindrical inlet portion 16 and a generally cylindrical outlet nozzle portion 17 which passes centrally through the top wall 12 of the drying chamber 11 as shown coaxially with the cylindrical chamber 11. The nozzle portion 17 may range from 1/5 to 1/3 of the cross-sectional area of the inlet portion 16 and to this end, the two portions are connected by a tapering mid-portion 18. By reason of the reduced cross-sectional area of the nozzle portion 17, the drying medium introduced into the inlet portion 16 is substantially accelerated as it passes through the nozzle portion, attaining an axial velocity in the range of 150 to 800 feet per second and tangential velocities in the same range. The high axial and tangential velocities of the drying medium in the nozzle portion 17 greatly contribute to the high efficiency afforded by the invention, as will be more fully set forth hereinafter.

Air is introduced into the inlet portion 16 of the chamber 15 in a tangential direction. To this end, an inlet conduit 21, as shown in Fig. 2, is disposed tangentially to the inlet portion 16. As shown in Fig. 1, air or other gaseous drying medium is supplied under pressure to the inlet conduit 21 by means of a blower 22 which forces the air through a heater 23, and from the heater into the conduit 21. Of course, the blower acting as an exhauster, may be connected to the discharge conduit 14 to draw the air through the dryer, or a blower and exhauster may be used respectively at the inlet and the discharge end. As shown, the conduit 21 is cylindrical at its intake end 24 and is rectangular at its discharge end 25 where it joins with the inlet portion 16 of the chamber 15, although the intake end may be square or rectangular. The tangential arrangement of the conduit 21 imparts a swirling motion to the air or other drying medium as it is introduced into the chamber 15, as suggested by the arrows in Fig. 1.

In the embodiment shown in Fig. 1, the material to be dried is introduced by suitable means into the air stream prior to its admission into the vortex chamber 15, and the subsequent injection of the air stream into the drying chamber 11. The material as it enters the vortex chamber 15 is picked up by the swirling high velocity air stream and is carried into the body of the drying chamber 11. In the illustrated embodiment, the feed means comprises a screw 28 which feeds the material into the conduit 21 from a hopper 29, but other feeding devices and methods are possible within the scope of the present invention. Further, the location of the feed point can be located at different points prior to the inlet to the vortex chamber, depending on the particular problem involved.
clumps or masses of the material which may be present due to the moist condition thereof. The drying medium, as the drying chamber continues to exert a centrifugal force on the material as well as a dispersing action. The combined effect of these forces insures that the material is continually subjected to intimate contact with the drying medium throughout the drying cycle. The rapid drying occurring in the high velocity vortex chamber 15 permits the use of higher-than-normal drying temperatures, e.g., a material which is dried with a temperature of 200° F. Air in a tray dryer may be dried with a temperature of 350° F. in a dryer of the type described herein.

When the material reaches the bottom of the chamber 11, it is substantially dried. The dried material is then exhausted with the air stream through the discharge conduit 14 to a separating cyclone or the like.

An alternate discharge arrangement is shown in Fig. 1c. This arrangement effects separation of the product from the exhaust air stream within the drying chamber. To this end, the drying chamber 11a is connected to the discharge conduit 14a through the down turned terminal portion of the conduit 14a. This arrangement affords separation of the exhaust air from the product which falls by gravity to the bottom of the chamber 11a where it is conveyed away by a suitable conveyor, such, for example, as shown at 30 in Fig. 1c.

Another embodiment of the present invention is illustrated in Fig. 3. In this embodiment of the invention, the drying chamber comprises a cylindrical body portion 31 which communicates with an exhaust duct 32 by an inverted funnel-shaped upper section 33. The lower portion of the drying chamber may taper inwardly as indicated at 34 and terminate in a funnel-shaped bottom portion 35 which opens to a product conveyor 36, which may be of the screw type shown. In this embodiment of the invention, the gaseous medium carrying the material to be dried is introduced into the drying chamber by an exhaustor in the form of a vortex chamber 41 similar to the chamber 15. In this instance, the injector is injected to direct the stream of drying medium upwardly through the drying chamber. It should be noted that the inlet conduit 42 enters the inlet portion 43 of the vortex chamber tangentially as shown at 44 to effect a swirling motion in the injector. The exhaust nozzle 45 of the chamber is of reduced cross section to accelerate the flow of gases and solids prior to their admission into the drying chamber 31. The material to be dried is introduced into the air stream in advance of the inlet conduit 42, for example, by a screw 46 communicating with a hopper 47.

In this embodiment of the invention, as in the previously described embodiment, the gaseous medium conveying the material to be dried is driven with a swirling movement and is accelerated in the vortex chamber 41. As it is exhausted from the vortex chamber into the drying chamber, the medium is greatly expanded, by reason of the greater cross sectional area of the drying chamber. Thus, the material is acted upon by a violent expansion force resulting from the centrifugal force in the vortex chamber and is carried upwardly toward the exhaust conduit 32. The centrifugal force, in this instance, effects a separation of the heavier particles from the gaseous stream and these particles fall to the bottom of the drying chamber where they are conveyed away by the conveyor 36. These heavier particles are cooled in the conveyor and advanced to a product receiver. The particles not separated through said medium are conveyed through the exhaust duct 32 to the cyclone or other separating unit which collects the product from the gaseous medium.

As in the previously described embodiment, the construction described herein permits the use of a higher temperature drying medium than ordinarily used. In addition, the possibility of clumps forming in the dried product are greatly reduced by the apparatus of the present invention which eliminates the heat of the dried material, which effectively removes both internal and external moisture from the material.

A further embodiment of the present invention is shown in Fig. 4. In this form of the invention, a drying chamber 51 is similar in shape to the chamber 11, the air or other drying medium is introduced into the chamber 51 by an injector in the form of a converging nozzle 52. The material 53 is conveyed through a converging strut 54, a converging portion, and a cylindrical outlet throat portion 56 which passes through the end wall of the drying chamber 51, and through which the drying medium passes at high velocity.

The inlet and outlet portion of the nozzle 52 has relative dimensions in the same range as the chamber 15 described above and operates to accelerate the air stream prior to its admission into the drying chamber. Preferably, the air is supplied to the chamber 52 under heat and pressure, for example, by a heater 55 and fan 56. Since the air is injected centrally of the nozzle 52, the air is not given a swirling motion, but it has been found that the acceleration and turbulence in the throat of the nozzle 54 and the subsequent expansion and deceleration in the drying chamber 51 creates a high degree of dispersion of the material injected into the air stream prior to its admission into the drying chamber 51. If desired, swirling motion may be imparted to the air prior to the nozzle by installing stationary vanes in the duct section 53 of the nozzle 52.

In the present instance, the material is introduced into the air stream in the high velocity or throat section 54 of the nozzle 52. The drying medium in the high velocity side of the nozzle 52 is not given a swirling motion. However, the pressure at 54 will depend on the resistance to flow after the chamber 51. The illustration shows a screw feeder 57 for the material fed from a hopper 58, but any suitable feed means may be employed. As the material from the feeder 57 enters the air stream, the velocity differential between the feed and air creates a high degree of turbulence which breaks up the material and disperses it into the drying chamber. This method permits the use of higher temperatures with a consequent reduction of drying time. From the drying chamber 51, the material is discharged into a separating cyclone or the like, for example, as shown at 59.

While particular embodiments of the present invention have been herein illustrated and described, it is not intended to limit the invention to such disclosure but changes and modifications may be made therein and thereto within the scope of the following claims.

I claim:

1. Apparatus for drying of fibrous, and like material, comprising a generally cylindrical drying chamber, a flow nozzle adjacent one end of said chamber, said nozzle having an enlarged hollow cylindrical inlet portion, a tapering midportion, and a reduced elongated hollow cylindrical outlet throat portion for injecting the gaseous drying medium into said chamber, said elongated throat portion being positioned centrally in said chamber adjacent said one end coaxially with said chamber and being opened toward the opposite end thereof, said outlet throat being smaller in cross sectional area of said cylindrical drying chamber to effect an abrupt expansion of the gaseous medium upon injection into said chamber, a tangential inlet conduit in the enlarged inlet portion of said nozzle, means to introduce heated pressurized drying medium into said nozzle at the said orifice, said conduit being smaller in cross sectional area of said central cylindrical drying chamber to effect an abrupt expansion of the gaseous medium upon injection into said chamber, a tangential inlet conduit in the enlarged inlet portion of said nozzle, means to introduce heated pressurized drying medium into said nozzle at the said orifice, said conduit being smaller in cross sectional area of said central cylindrical drying chamber to effect an abrupt expansion of the gaseous medium upon injection into said chamber.
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and means at the opposite end of said chamber to exhaust the drying medium therefrom.

2. Apparatus for drying of fibrous, and like material, comprising an upright generally cylindrical drying chamber, a tapered flow nozzle adjacent the lower end of said chamber, said nozzle having an enlarged inlet portion and a reduced cylindrical outlet throat portion for injecting the gaseous drying medium into said chamber, said throat portion being positioned centrally in said chamber adjacent said lower end coaxially with said chamber and being opened toward the upper end thereof, said outlet throat being smaller in cross section than the cross sectional area of said cylindrical drying chamber to effect an abrupt expansion of the gaseous medium upon injection into said chamber, a tangential inlet conduit in the inlet portion of said nozzle, means to introduce pressurized drying medium into said nozzle through said inlet conduit, means to heat said drying medium prior to its injection into said chamber, means to introduce said material into said drying medium prior to its injection into said chamber, means at the upper end of said chamber to exhaust said drying medium, and means at the lower end of said chamber to convey material away therefrom.

References Cited in the file of this patent

UNITED STATES PATENTS

<table>
<thead>
<tr>
<th>Patent Number</th>
<th>Inventor</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,478,526</td>
<td>Merrell</td>
<td>Dec. 25, 1923</td>
</tr>
<tr>
<td>1,840,857</td>
<td>Testrup et al.</td>
<td>Jan. 12, 1932</td>
</tr>
<tr>
<td>1,914,895</td>
<td>Peebles</td>
<td>June 20, 1933</td>
</tr>
<tr>
<td>2,368,699</td>
<td>Arnold</td>
<td>Feb. 6, 1945</td>
</tr>
<tr>
<td>2,435,927</td>
<td>Manning et al.</td>
<td>Feb. 10, 1948</td>
</tr>
<tr>
<td>2,460,546</td>
<td>Stephanoff</td>
<td>Feb. 1, 1949</td>
</tr>
<tr>
<td>2,538,833</td>
<td>DeRycke</td>
<td>Jan. 23, 1951</td>
</tr>
<tr>
<td>2,702,949</td>
<td>Parker</td>
<td>Mar. 1, 1955</td>
</tr>
<tr>
<td>2,770,052</td>
<td>Morrison</td>
<td>Nov. 13, 1956</td>
</tr>
</tbody>
</table>