ABSTRACT OF THE DISCLOSURE

A rotary, horizontal thin-film type evaporator containing a ring element circumferentially surrounding the rotor shaft located beyond the ends of the rotor blade and adjacent the product outlet to prevent or inhibit viscous product material from moving down the rotor shaft and a scoop element which operates in a material transfer and doctoring relationship with the ring element to remove the accumulated viscous material from the rotor shaft and blades whereby viscous material is efficiently removed and discharged from the evaporator.

Background of the invention

Our invention relates to a rotary, thin-film type fluid processing apparatus for the treatment, reaction or processing of liquids. In particular our invention concerns a wiped or turbulent thin film evaporator which includes a ring element on the rotor shaft to prevent the viscous material that wraps around the rotor shaft from flowing down the rotor shaft and a scoop element to doctor the viscous material that accumulates on the rotor shaft between the ends of the rotor blades and the ring element.

In those horizontal or inclined-axised, thin-film type apparatus such as an evaporator, it is often found during processing of high viscosity materials or materials which become viscous during processing, that such materials tend to wrap around and flow down the rotor shaft. This accumulation of viscous material has many disadvantages some of which are that the material which accumulates on the rotor shaft does not flow out of the product outlet, and generally is thermally degraded and unstable because of the increased residence time of the material in the evaporator. In addition, if the vapor chamber of the evaporator is adjacent to the processing chamber then viscous material may from time to time fall off the rotor shaft and drop into and accumulate in the vapor chamber further during processing, materials which cling or tend to cling to the rotor shaft cause an increase in power consumption, while after a processing operation is completed it is often time consuming and difficult to remove such viscous materials from the rotor shaft. One means suggested to overcome this problem is to secure a ring on the rotor shaft. However, it was found that during processing the material flowed up and around the ring and then continued down the shaft particularly during high flow rates and rotor blade rotation speeds.

Summary of the invention

We have discovered a new and improved means whereby we can control the accumulation and flow of viscous material down the rotor shaft of a thin film evaporator in a simple, economic and efficient manner. Our invention comprises a ring or disk element which is located slightly beyond the ends of the rotating blades, and generally adjacent a product outlet or discharge nozzle. As viscous material tends to wrap around the rotor shaft, it accumulates behind the ring element until the material builds up to a point where it tends to flow over the peripheral edge of the ring element. A scoop element or sharp edged blade, the edge of which is adjacent to the outer diameter of the ring element is secured to the product outlet. The scoop element doctors viscous material as it accumulates beyond the outside radius or dimensions of the ring-retaining element, and directs it toward the product outlet during operation of the evaporator.

Our invention eliminates many of the difficulties associated in the past with processing and/or discharging viscous materials such as preventing or inhibiting the viscous material from flowing down the rotor shaft thereby reducing power consumption and mitigating the difficulty in cleaning the apparatus after processing, minimizing the accumulation of foreign material in the vapor chamber, and reducing the loss of product material because of accumulation on the rotor shaft for long periods of time.

Accordingly, it is an object of our invention to provide an improved thin-film type apparatus such as an evaporator having a means to prevent or inhibit the accumulation of excess viscous material on the rotor shaft, and to discharge the material in an efficient and economical manner.

Another object of our invention is to provide a thin-film type evaporator of a substantially horizontal or horizontally-inclined type containing a ring element and doctor blade element in combination which provides significant advantage over the prior art of using a ring element alone.

A further object of our invention is to provide a thin-film type evaporator having a ring element beyond the ends of the rotor blades to accumulate viscous material and a blade element to remove accumulated viscous material and direct it toward the product outlet.

These and other objects of our invention will be apparent to those persons skilled in the art from the accompanying drawing and the following more detailed description of my invention wherein:

Brief description of the drawing

FIG. 1 is a schematic, longitudinal section through a cylindrical, rotary wiped, thin-film evaporator of our invention employing my ring and scoop arrangement;
FIG. 2 is a cross-sectional view of the evaporator of FIG. 1 along the lines 2--2;
FIG. 3 is a cross-sectional view of another modification of our invention in which the scoop is characterized by a slot therein into which the edge of the ring element fits;
FIG. 4 is a cross-sectional fragmentary view of FIG. 3 taken along lines 4--4.

Description of the preferred embodiment(s)

Briefly, our invention comprises in combination an evaporator which includes a closed chamber as a processing section, the chamber having an interior wall, a rotor within the chamber, means to rotate the rotor, generally radially and axially extending rotor blades on the rotor, which blades extend from the rotor into a close, generally uniform, thin-film association with the interior wall of the processing chamber, a feed inlet to introduce material into the chamber, a product outlet to remove material from the chamber, a vapor chamber adjacent the chamber, a vapor outlet for the withdrawal of vapor from the vapor chamber, a ring element on the rotor shaft to prevent the viscous materials that wrap around the rotor shaft from moving further than desired down the said rotor shaft from the end of the rotor blades, and a blade element to doctor and remove the viscous materials that accumulate behind the ring element. One embodiment includes a ring element located slightly beyond and spaced apart from the ends of the rotor blades the plane of which ring element is generally perpendicular to the plane of the
3,357,479 3 rotor blades. The ring extends radially from the rotor shaft for a short distance. Juxtaposed to the ring element, but not in contact with it is a blade or scoop element one edge of which is generally perpendicular to the plane of the ring. The blade removes the viscous material as it accumulates behind and rises outside of the peripheral edge of the ring, and directs the material as removed toward the product outlet. In another embodiment the blade may also be slotted at the leading edge, into which slot is inserted the outer portion of the ring element whereby viscous material is removed with a minimum of build up, on prior to reaching the external periphery of the ring element.

Our invention will be illustrated in connection with a horizontal-axis, rotary wiped, thin-film evaporator wherein the feed material such as a solvent containing a dissolved or suspended resin, after processing results in a viscous resinous product. My invention may also be employed in those evaporators wherein the flow of the vapor to the liquid feed is countercurrent, as well as in conical or tappered type evaporators such as those disclosed in U.S. Patent No. 2,927,634.

FIG. 1 shows a horizontal-axis, cylindrical type evaporator comprising a closed cylindrical chamber 12 having interior walls and surrounded to all or part of its length by a temperature control jacket 14, which is adapted for the introduction of a heating or cooling heat exchange fluid such as steam, cold water and the like. The chamber 12 is further characterized by a feed inlet 16 for the introduction by pump, gravity or vacuum of a feed material to be processed through the evaporator, a product outlet or discharge nozzle 18 at the opposite end thereof for the removal of the product material, and a vapor outlet 20, which vapor outlet extends into a vapor chamber 22 adjacent the product end of the evaporator 10. Closures 24 and 26 are secured to either end of the chamber 12 and support a horizontally inclined centrallined, tube-like rotor 28, which extends from the end to the other of the chamber 12 through the vapor chamber 22. The rotor 28 is driven by a motor or other means (not shown) and generally extends outwardly from each end of the closing heads. The rotor 28 extends through suitable bearings 30 and 32 and seals or packing material 34 and 36 are disposed at either end of the evaporator 10. Extending axially outward from the rotor shaft are a plurality of generally four or more radial rotor blades 38 by a predetermined amount, so that viscous material illustrated as a resin 44 accumulates behind it. The space may be varied as desired depending upon the material being processed, the speed of rotation and other factors. The ring element extends the proper radius to enable it to be an effective barrier in preventing the flow of viscous material out of the shaft, but not so great as to inhibit the vapor flow path between the closed processing chamber 12 and the vapor chamber 22. An integral part of the product outlet 18 is a scoop or blade or conveying means 42 which projects toward the ring element 40 to "doctor off" or remove any excess viscous product material which during operation accumulates behind the ring element and attempts to move over the ring 40. The scoop 42 projects from the edge of the product outlet 18 within the processing chamber. The base of the scoop element 42 is tube shaped and the outer wall of the tube shaped portion of the scoop element is flush with the inner wall of the product outlet 18 and extends from the bottom of the ring. The bottom of the scoop is flanged which flange is secured to the flanged portion of the product outlet by bolts or other suitable means. The upper portion of the scoop element is characterized by a cover or lid over the tube portion and which lid extends about half way around the circumference of the tube portion. The lid rests from the edge of the tube toward the center of the opening in the tube at an angle of about 15 degrees. From the product outlet 18 the scoop 42 extends at an angle from about 15 degrees or greater toward the ring element 40 until the center of the edge of scoop 42 just reaches, but does not touch the edge of the ring element 40. The edge of the scoop 42 leads into the direction of rotation of the ring element, and as viscous material tends to build up or accumulate behind the ring element 40, it is doctored off or cut away by the leading sharp edge of the scoop 42. The viscous resin material which is cut away from behind the ring then falls or drops into the product outlet or discharge nozzle 18 and is removed. All or a portion of the surface which contacts the viscous material may be treated or coated to prevent material from adhering to the said surface. For example, the surfaces of the ring and blade elements may be coated with a fluorocarbon polymeric coating such as "Teflon" to aid in the removal of the viscous materials.

In the operation of our evaporator 10 referring to Figs. 1 and 2 a material such as a low viscosity liquid to be processed through the evaporator 10 is introduced into the feed port 16 by gravity, under vacuum, or pump with the relatively non-volatile viscous product material is withdrawn through the product outlet 18, and the vaporized material is withdrawn through the vapor outlet 20. Of course, if desired, other or additional vapor product outlets and feed inlets may be used. The rotor shaft 28 and the rotor blades 38 are rotated at high speed during the processing to form a thin film of the feed material against the interior wall of the chamber 12 with a heat exchange fluid such as steam introduced into the temperature control jacket 14, wherein the thin film on the interior wall is placed in heat exchange relationship with the steam in the heating jacket to effect an evaporation of the relatively volatile component of the feed material such as the solvent or such as the resin to be desolvizized processes thereby extending into a small, generally uniform, closely-spaced relationship with respect to the interior walls of the chamber 12, so that upon rotation of the rotor shaft 28 the rotor blades 38 provide a thin, wiped or turbulent film of the processed material on the heated interior wall of the chamber 12.

Affixed to the rotor shaft 28 beyond the ends of the rotor blades 38 and adjacent the product outlet 18 is a ring element 40 which is secured to and circumferentially surrounds and extends radially outward from the rotor shaft 38 to prevent or inhibit the flow of viscous materials further down the rotor shaft. The ring 40 is generally spaced apart from the end of the rotor blades 38 by a predetermined amount, so that viscous material illustrated as a resin 44 accumulates behind it. The spacing may be varied as desired depending upon the material being processed, the speed of rotation and other factors. The ring element extends the proper radius to enable it to be an effective barrier in preventing the flow of viscous material out of the shaft, but not so great as to inhibit the vapor flow path between the closed processing chamber 12 and the vapor chamber 22. An integral part of the product outlet 18 is a scoop or blade or conveying means 42 which projects toward the ring element 40 to "doctor off" or remove any excess viscous product material which during operation accumulates behind the ring element and attempts to move over the ring 40. The scoop 42 projects from the edge of the product outlet 18 within the processing chamber. The base of the scoop element 42 is tube shaped and the outer wall of the tube shaped portion of the scoop element is flush with the inner wall of the product outlet 18 and extends from the bottom of the ring. The bottom of the scoop is flanged which flange is secured to the flanged portion of the product outlet by bolts or other suitable means. The upper portion of the scoop element is characterized by a cover or lid over the tube portion and which lid extends about half way around the circumference of the tube portion. The lid rises from the edge of the tube toward the center of the opening in the tube at an angle of about 15 degrees. From the product outlet 18 the scoop 42 extends at an angle from about 15 degrees or greater toward the ring element 40 until the center of the edge of scoop 42 just reaches, but does not touch the edge of the ring element 40. The edge of the scoop 42 leads into the direction of rotation of the ring element, and as viscous material tends to build up or accumulate behind the ring element 40, it is doctored off or cut away by the leading sharp edge of the scoop 42. The viscous resin material which is cut away from behind the ring then falls or drops into the product outlet or discharge nozzle 18 and is removed. All or a portion of the surface which contacts the viscous material may be treated or coated to prevent material from adhering to the said surface. For example, the surfaces of the ring and blade elements may be coated with a fluorocarbon polymeric coating such as "Teflon" to aid in the removal of the viscous materials.

When the feed material is processed the vapor or more volatile material passes into the vapor chamber 22 and out the vapor outlet 20 and the viscous or product material gravitates toward the bottom and out the product outlet. However, some of the viscous resin material c.g. 50,000 to 80,000 c.p.s. 44 tends to wrap around and flow down the rotor shaft 28, but ring element 40 acts as a barrier to prevent or inhibit this viscous material from flowing down the rotor shaft beyond the point where the ring element is located. However, as material is processed, the viscous materials 44 accumulated behind the ring and tend to flow over the ring and down the rotor shaft. The scoop 42 angled into the direction of rotation doctors off or cuts away the accumulated material from behind the ring element. The center of the edge of the blade is adjacent the outside diameter of the ring element and the blade edge being positioned over the center of the ring element images the cut away viscous materials to the discharge nozzle.

Another embodiment of our invention is shown in Figs. 3 and 4 where an elongated slot 46 is cut in the leading or doctor edge of the blade 42, which slot fits into and intersects with the ring element 40 in a closestitting but not touching relationship. The depth that the blade may intersect the ring element may vary from the outer edge of the ring element to adjacent the rotor shaft. In this manner viscous material can be removed to a predetermined greater depth from behind the ring 42 rather
than permitting the viscous material to overflow the outer edge of the ring. The ring element 40 is free to rotate in slot 46 and the slotted blade leads into the direction of rotation of the rotor shaft.

Our invention has been described, in particular, in terms of a flat ring element used as the retaining means. However, other means such as a conical or hemispherical retaining means may be used. Also other types of doctoring means such as a concave, convex, or a tapered edge may be used in combination with various retaining means and may be secured to the product outlet by a different method, such as welding the blade element to the product outlet.

Our invention as illustrated and described avoids many of the difficulties associated in the past with the processing of viscous material wherein they accumulated and flowed down the rotor shaft.

We have now developed a new and unique apparatus and method for preventing or inhibiting the flow of viscous materials down a rotor shaft in a thin film processing apparatus and, therefore, what we claim is:

1. An improved fluid processing apparatus of a rotary, thin-film type which comprises in combination:
   (a) a closed chamber characterized by an interior wall having a surface of revolution;
   (b) a rotor shaft within the chamber;
   (c) means to rotate the rotor shaft;
   (d) rotor blades secured to the rotor shaft for rotation therewith, the blades generally radially and axially arranged from the rotor shaft and extending into close relationship with the interior wall;
   (e) an inlet in the chamber for the introduction of feed material to be processed;
   (f) an outlet in the chamber axially spaced apart from the inlet for removal of processed material from the chamber;
   (g) process material retaining means extending circumferentially about the rotor shaft and spaced downstream from one end of the rotor blades and having a peripheral edge generally extending outwardly from the axis of the rotor shaft, said retaining means adapted to prevent material clinging to the rotor from moving further down the rotor during rotation of the rotor shaft; and
   (h) a conveying means including a leading edge which is in a material transfer relationship with the retaining means, and adapted to direct material from the retaining means to the outlet, whereby in operation viscous material which tends to cling to the rotor shaft and accumulates on the upstream face of the retaining means is continuously removed and directed to the outlet.

2. The apparatus of claim 1 wherein the leading edge of the conveying means is angled facing into the direction of rotation of the rotor and generally perpendicular to the outer edge of the retaining means.

3. The apparatus of claim 1 wherein the conveying means is characterized by an elongated slot in one edge against which extends at least a portion of the outer edge of the retaining means whereby the leading edge conveys material accumulated on said face of the retaining means to a predetermined depth prior to the material reaching the outer peripheral edge of the retaining means.

4. The apparatus of claim 1 wherein the said surface of the retaining means and the conveying means which contact the material to be processed have a surface coating thereon to prevent viscous material from adhering to these surfaces.

5. The apparatus of claim 1 wherein the retaining means is a ring element sealingly secured to the rotor for rotation therewith.

6. The apparatus of claim 5 wherein the leading edge of the conveying means is placed in a close but not contacting relationship with the outer edge of the ring element and is generally perpendicular to the edge of the ring element.

7. The apparatus of claim 5 wherein the leading edge of the conveying means is characterized by a slot therein and the peripheral edge of the ring element extends in a close relationship therein so that upon operation of the rotor the ring element rotates freely in the slot and the leading edge of the conveying means extends inwardly from the said edge of the ring element.

8. The apparatus of claim 5 wherein the ring element is adjacent the product outlet, and the leading edge of the conveying means extends from the outlet to the peripheral edge of the ring element.

9. The apparatus of claim 5 wherein the retaining means is sealingly comprises a flat ring element the plane of which is generally perpendicular to the axis of the rotor shaft and adjacent the far end of the product outlet and the conveying means is characterized by an elongated slot into which slot extends the peripheral edge of the ring element and the conveying means faces into the direction of rotation of the rotor shaft and is secured to the product outlet whereby viscous material is removed from the upstream face of the ring element and directed into the product outlet.

No references cited.

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