

CYCLONE MIST ELIMINATOR AND METHOD

RELATED APPLICATION

[0001] The present application claims priority to United States Provisional Application No. 63/453,629 filed on March 21, 2023, which is incorporated by reference in its entirety.

BACKGROUND

[0002] The present disclosure relates generally to devices for the separation of liquid entrained with gas in a flowing vapor stream and, more particularly, to cyclone mist eliminators and methods of using the same to separate the liquid from the gas in the flowing vapor stream.

[0003] Cyclone mist eliminators within columns or vessels are used to remove liquid, typically in the form of liquid droplets, from a vapor stream to improve process efficiencies, reduce product loss, and prevent equipment damage in various types of processes. In one type of axial flow cyclone mist eliminator, a number of cyclone boxes that each contain multiple cyclone cans are arranged in side-by-side relationship in multiple stacked rows.

[0004] Each cyclone can comprises a cylindrical wall that forms an open-ended flow chamber oriented in a direction of flow of the vapor stream so that the vapor stream enters the flow chamber at an inlet end, flows along the length of the flow chamber, and then exits at an outlet end. An activator or swirler is positioned within the flow chamber to impart a swirling motion to the vapor stream as it flows within the flow chamber. The swirling motion of the vapor stream creates centrifugal forces that cause the liquid droplets to separate from the vapor stream by impinging upon and coalescing on an inner surface of the cylindrical wall. The coalesced liquid then flows to openings provided in the cylindrical wall near the outlet end of the flow chamber and exits the flow chamber through the openings and enters the open volume of the box outside of the cylindrical wall.

[0005] In one embodiment, the liquid drains from the cyclone boxes through a series of individual drain pipes connected to an outlet end of each cyclone box and then into a sump from which it is removed by additional drain pipes. In another embodiment, the drain pipes from the cyclone boxes are eliminated by placing the cyclone cans in each row into two cyclone boxes that are slightly spaced apart from each other to form a single central vertical flow channel in the spacing between the cyclone boxes. The roof of each cyclone box slopes toward

the central vertical flow channel so that liquid is able to drain from each cyclone box onto the sloped roof of an underlying cyclone box and then into the central vertical flow channel. The size of the cyclone boxes must be individually tailored for each application to accommodate the number of cyclone cans needed to obtain the desired separation capacity.

[0006] Further improvements in the design of these cyclone mist eliminators are desired to provide improved operation under high gas and liquid loads and in applications where the column or vessel may be subjected to rocking motion from wind or waves that may adversely impact separation performance.

BRIEF DESCRIPTION

[0007] This brief description is provided to introduce a selection of concepts in a simplified form that are further described in the detailed description below. This brief description is not intended to identify key features or essential features of the claimed subject matter, nor is it intended to be used to limit the scope of the claimed subject matter. Other aspects and advantages of the present disclosure will be apparent from the following detailed description of the embodiments and the accompanying figures.

[0008] In one aspect, the present disclosure is directed to a cyclone box for removing liquid from a flowing vapor stream. The cyclone box comprises a box structure having a front end and a spaced apart back end, first and second spaced apart side walls extending in a direction between the front end and the back end, and a roof having first and second sloping sides, wherein the first sloping side of the roof slopes in a direction of the first side wall to allow liquid when on the first sloping side of the roof to drain toward and into a first drainage channel running downwardly along the first side wall and the second sloping side of the roof slopes in a direction of the second side wall to allow liquid when on the second sloping side of the roof to drain toward and into a second drainage channel running downwardly along the second side wall. The cyclone box also comprises at least one cyclone can mounted within the box structure and comprising: a cylindrical wall that forms a flow chamber having an inlet end at the front end of the box structure and an opposite outlet end at the back end of the box structure; a swirler positioned within the cylindrical wall to impart a swirling motion to a vapor stream when flowing through the flow chamber from the inlet end to the outlet end that creates centrifugal forces to cause liquid in the vapor stream to coalesce on an inner surface of the cylindrical wall; and one or more outlets to allow the liquid coalesced on the inner surface of the cylindrical wall to drain into a volume of the box structure outside of the cylindrical can.

[0009] In another aspect, the present disclosure is directed to a cyclone mist eliminator comprising a plurality of cyclone boxes arranged in side-by-side relationship in vertically stacked rows within a separation vessel. Each cyclone box comprises a box structure having a front end and a spaced apart back end, first and second spaced apart side walls extending in a direction between the front end and the back end, and a roof having first and second sloping sides, wherein the first sloping side of the roof slopes in a direction of the first side wall to allow liquid when on the first sloping side of the roof to drain toward and into a drainage channel running downwardly along the first side wall and the second sloping side of the roof slopes in a direction of the second side wall to allow liquid when on the second sloping side of the roof to drain toward and into another one of the drainage channels running downwardly along the second side wall. The drainage channels are formed by the first side wall and a facing second wall of an adjacent one of the cyclone boxes within the same row and by the second side wall and a facing first wall of another adjacent one of the cyclone boxes within the same row. The cyclone box further comprises at least one cyclone can mounted within the box structure and comprising: a cylindrical wall that forms a flow chamber having an inlet end at the front end of the box structure and an opposite outlet end at the back end of the box structure; a fixed swirler positioned within the cylindrical wall to impart a swirling motion to a vapor stream when flowing through the flow chamber from the inlet end to the outlet end that creates centrifugal forces to cause liquid in the vapor stream to coalesce on an inner surface of the cylindrical wall; and one or more outlets to allow the liquid coalesced on the inner surface of the cylindrical wall to drain into a volume of the box structure outside of the cylindrical can.

[0010] In a further aspect, the present disclosure is directed to a method of separating liquid from a flowing vapor stream using the cyclone mist eliminator described above. The method comprises the steps of: flowing the vapor stream through the flow chambers of the cyclone cans and imparting a swirling motion to the vapor stream when passing through the swirlers to cause liquid in the vapor stream to impact against and coalesce on an inner surface of the cylindrical walls; directing the coalesced liquid from the inner surface of the cylindrical walls through the outlets to drain into the volume of the box structure outside of the cylindrical can; and flowing the drained liquid onto and along the first and second sloping slides of the roof and into the drainage channels.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The present disclosure is described in detail below with reference to the attached drawing figures, wherein:

[0012] Fig. 1 is a schematic side elevation view, taken in vertical section, of a vessel in which liquid is intended to be separated from a vapor stream using an array of cyclone boxes arranged in side-by-side relationship in a plurality of stacked rows;

[0013] Fig. 2 is a fragmentary perspective view of the vessel of Fig. 1 and showing a front or upstream side of the array of cyclone boxes;

[0014] Fig. 3 is a fragmentary perspective view of the vessel of Fig. 1 and showing a rear or downstream side of the array of cyclone boxes;

[0015] Fig. 4 is a rear elevation view taken in vertical section of the array of cyclone boxes;

[0016] Fig. 5 is a fragmentary rear side perspective view of one of the cyclone boxes with portions removed to show internal details; and

[0017] Fig. 6 is a fragmentary rear side perspective view of a portion of the array of cyclone boxes.

DETAILED DESCRIPTION

[0018] The subject matter of the present disclosure is described with specificity herein to meet statutory requirements. However, the description itself is not intended to limit the scope of this patent. Rather, the inventors have contemplated that the claimed subject matter might also be embodied in other ways, to include different components, combinations of components, steps, or combinations of steps similar to the ones described in this document, in conjunction with other present or future technologies.

[0019] Turning now to the drawings in greater detail and initially to Fig. 1, an embodiment of a vessel in which liquid is separated from a flowing vapor stream is represented generally by the numeral 10. The vessel 10 may be solely dedicated to the separation of the liquid, typically in the form of liquid droplets, from the flowing vapor stream, or additional processes may be performed within the vessel 10 along with the liquid separation. The vessel 10 may be positioned on land or it may be positioned offshore, such as on a floating platform, barge or ship. In some embodiments, the vapor stream may result from upstream, midstream, or downstream processing of oil and gas. As examples, the vapor stream in some embodiments may be a process stream involved in scrubbing absorption, stripping, distillation, evaporation, compression, or other processes.

[0020] The vessel 10 includes a horizontally extending external shell 12 that is generally cylindrical in configuration, although other configurations, including polygonal, are possible and are within the scope of the present invention. The shell 12 is of any suitable diameter and length and is constructed from one or more rigid materials that are desirably inert to or are otherwise compatible with the fluids and conditions present during operation of the vessel 10.

[0021] The shell 12 of the vessel 10 defines an open internal region 14 in which the desired liquid separation from the vapor stream and, optionally, other processes occur. The flow path of the vapor stream as it enters, travels within, and then exits the vessel 10 is represented schematically by the arrows 16.

[0022] In the illustrated embodiment, the vapor stream 16 enters the vessel 10 through a feed nozzle 18 that turns the radial inlet flow direction of the vapor stream 16 toward a hemispheric end of the vessel 10 where it reverses its flow direction and then flows in a direction toward an opposite end of the vessel 10. The vapor stream 16 then encounters an optional agglomerator 20 that may be of a mesh and/or vane type and operates to increase the size of the liquid droplets entrained within the vapor stream 16 and to remove some of the liquid from the vapor stream 16.

[0023] After exiting the agglomerator 20, the vapor stream 16 passes through a cyclone mist eliminator 22 where liquid droplets are separated from the vapor stream 16. The vapor stream then enters a chamber 24 before exiting the vessel 10 through an outlet nozzle 26. The separated liquid descends within the vessel 10 and may be removed through a bottom takeoff nozzle 28.

[0024] Turning now to Figs. 2-6, the cyclone mist eliminator 22 extends within the open internal region 14 of the vessel 10 in a chordal fashion across a cross section of the shell 12 at a location closer to the outlet nozzle 26 than the feed nozzle 18. The cyclone mist eliminator 22 comprises a plurality of cyclone boxes 30 that may be arranged and secured together in side-by-side relationship in a plurality of vertically stacked rows, with the cyclone boxes 30 being in horizontal and vertical alignment. In one embodiment, most or all of the cyclone boxes 30 are of a uniform standard size and construction that allows the cyclone boxes 30 to be readily fabricated and assembled to form a cyclone mist eliminator in vessels 10 have a wide range of diameters or chordal lengths.

[0025] Each cyclone box 30 comprises a box structure 32 within which at least one, and in other embodiments, multiple cyclone cans 34 are mounted and extend in parallel and spaced apart relationship to each other. In one example, the cyclone boxes 30 may have two rows of cyclone cans 34, with the same number of cyclone cans 34 in each row and the cyclone cans 34 in one row in vertical alignment with the cyclone cans 34 in the other row. In another

example, the cyclone boxes 30 may have two rows of cyclone cans 34 with a different number of cyclone cans 34 in each row and the cyclone cans 34 in one row staggered in relation to the cyclone cans 34 in the other row. In the illustrated embodiment, most of the cyclone boxes 30 have four cyclone cans 34 arranged in a square pitch. The number of cyclone cans 34 within each box structure 32 may be the same throughout the cyclone mist eliminator 22 or more cyclone cans 34 may be positioned within certain portions of the cyclone mist eliminator 22 than in other portions. For example, smaller cyclone boxes 30 with fewer cyclone cans 34 may be positioned at the ends of one or more rows to allow the cyclone mist eliminator 22 to more closely conform to the curved shell 12 of the vessel 10.

[0026] Each box structure 32 has an upstream or front end 36 and an opposite downstream or back end 38 that is spaced a preselected distance from the front end 36. The box structure 32 also includes first and second spaced apart side walls 40 and 42 that extend in a direction between the front and back ends 36 and 38 and a roof 44 that has first and second sloping sides 46 and 48 that slope downwardly from a peak 50. In one embodiment, the first and second spaced apart side walls 40 and 42 and the roof 44 may be formed by bending a sheet of material. In those cyclone boxes 30 that are positioned about the perimeter of the cyclone mist eliminator 22 and do not receive liquid draining from above, the roof 44 only serves to cover the box structure 32 and may be flat rather than sloping.

[0027] The first sloping side 46 of the roof 44 slopes in a direction of the first side wall 40 to allow liquid when it is on the first sloping side 46 to drain toward and into a drainage channel 52 that runs vertically downwardly along the first side wall 40. The drainage channel 52 is formed in a spacing between the first side wall 40 of the box structure 32 of one cyclone box 30 and a facing second wall 42 of the box structure 32 of an adjacent one of the cyclone boxes 30. In the embodiment in which the cyclone boxes 30 are in vertical alignment with the cyclone boxes 30 in the adjacent rows of cyclone boxes 30, the drainage channel 52 extends vertically downward in a continuous manner from row to row.

[0028] Similarly, the second sloping side 48 of the roof 44 slopes in a direction of the second side wall 42 to allow liquid when it is on the second sloping side 48 to drain toward and into another drainage channel 52 that runs vertically downwardly along the second side wall 42 and is formed in a spacing between the second side wall 42 of the box structure 32 of one cyclone box 30 and a facing first wall 40 of the box structure 32 of an adjacent one of the cyclone boxes 30.

[0029] Again, in the embodiment in which the cyclone boxes 30 are in vertical alignment with the cyclone boxes 30 in the adjacent rows of cyclone boxes 30, each of the drainage channels

52 extends vertically downward in a continuous manner from row to row. Advantageously, the number of drainage channels 52 in each row of cyclone boxes 30 is determined by the number of cyclone boxes 30 in that row. For example, when ten cyclone boxes 30 are in a row, such as shown in the lower row in Fig. 4, nine drainage channels 52 may be formed by the spacing between the first and second side walls 40 and 42 of the box structures 32 of the cyclone boxes 30 in that row, thereby greatly increasing the liquid removal capacity in comparison to a prior art cyclone mist eliminator in which only two cyclone boxes are used and the liquid drains in only one direction from the roof into a single center drain channel. By providing the bi-directional drainage of the liquid on the roof 44 of the box structure 32 of the cyclone boxes 30 disclosed herein and providing a greater number of cyclone boxes 30, more liquid is able to enter the drainage channels 50 even in situations where the vessel 10 is subjected to a rocking motion under wind or wave loads.

[0030] In one embodiment, the first and second sloping sides 46 and 48 have the same or approximately the same surface area so that equal amounts of liquid are directed to the drainage channels 52 at the first and second side walls 40 and 42 of the box structure 32 of each cyclone box 30. In other embodiments, the areas of the first and second sloping sides 46 and 48 may be different in at least some of the cyclone boxes 30 to cause a greater quantity of liquid to flow in one direction than the other. For example, the roofs 44 in the cyclone boxes 30 at or near the outer perimeter of the cyclone mist eliminator 22 may be constructed to direct more liquid toward the shell 12 than in a radially inward direction to achieve a more uniform distribution of the liquid across the cyclone mist eliminator 22.

[0031] Each of the cyclone cans 34 in the cyclone boxes 30 may comprise a cylindrical wall 54 that forms a flow chamber 56 for the vapor stream 16. The flow chamber 56 has an inlet end 60 at the front end 36 of the box structure 32 and an opposite outlet end 62 at the back end 38 of the box structure 32. An activator or swirler 58 that may be fixed against movement is positioned within the cylindrical wall 54 to impart a swirling motion to the vapor stream 16 as it flows through the flow chamber 56 from the inlet end 60 to the outlet end 62. The swirling motion creates centrifugal forces that cause liquid in the vapor stream 16 to be flung against and coalesce on an inner surface of the cylindrical wall 54.

[0032] The coalesced liquid moves along the inner surface of the cylindrical wall 54 in a direction toward the outlet end as a result of the flowing vapor stream 16 and is able to exit the flow chamber 56 through one or more outlets that may be in the form of elongated slots 64 provided in the cylindrical wall 54 downstream from the swirler 58. The exiting liquid drains into a volume of the box structure 32 outside of the cylindrical can 34 and is delivered onto the

roof 44 of the underlying cyclone box 30. The liquid then flows on the first sloping side 46 and the second sloping side 48 of the roof 44 and enters the drainage channels 52. In one embodiment, the first and second side walls 40 and 42 of each cyclone box 30, other than those in the lowermost row, may rest directly on the roof 44 of the box structure 32 of the underlying cyclone box 30. In order to allow the liquid on the roof 44 to pass through the first and second side walls 40 and 42, drain openings 66 (Fig. 6) may be formed in a lower portion of the first and second side walls 40 and 42 to allow liquid on the roof 44 to drain through the drain openings 62 and into the drainage channels 52.

[0033] Each of the cyclone cans 34 may additionally include a recycle tube 68 having an inlet end 70 that is open to the volume of the box structure 32 outside of the cylindrical can 34 and an outlet end 72 that is open to the flow chamber 56 within the cylindrical wall 54. The recycle tube 68 allows a portion of the vapor stream 16 that has exited the flow chamber 56 through the elongated slots 64 to reenter the flow chamber 56 for separation of liquid that may remain in the reentering vapor stream 16. The bulk of the vapor stream 16 flowing through the flow chamber 56 exits through the open outlet end 62 of the flow chamber 56.

[0034] Each cyclone box 30 may include a front plate 74 that is positioned at the front end 36 of the box structure 32 and is joined with the first and second side walls 40 and 42, the roof 44 and the cylindrical wall 54 at the inlet end 60 of the flow chamber 56 and a back plate 76 that is positioned at the back end 38 of the box structure 32 and is joined with the first and second side walls 40 and 42, the roof 44 and the cylindrical wall 54 at the outlet end 62 of the flow chamber 56. The front plate 74 and the back plate 76 respectively including openings 78 and 80 that are aligned with the flow chamber 56 to allow the vapor stream to pass through the front plate 74 to enter the flow chamber 56 and to allow the vapor stream to pass through the back plate 76 when exiting the flow chamber 56. In one embodiment, the front plate 74 and/or the back plate 76 may extend sideways beyond the first and second side walls 40 and 42 a preselected distance and include flanges 82 that allow adjacent cyclone boxes 30 to be connected together with the drainage channels 52 formed in the spacing between the facing first and second side walls 40 and 42 of the adjacent cyclone boxes 30.

[0035] As can best be seen in Figs. 4 and 6, partial dividing walls 84 may be positioned vertically between sideways or horizontally adjacent cyclone cans 34 within the box structure 32 of each cyclone box 30 to shield against the liquid exiting the flow chamber 56 through the slots 64 in the cylindrical wall 54 of one of the cyclone cans 34 impeding the liquid from exiting the flow chamber 56 of the adjacent cyclone can 34. Deflector hats 86 may be positioned between vertically adjacent cyclone cans 34 within the box structure 32 to prevent the liquid

that exits the flow chamber 56 of the overlying cyclone cans 34 from descending into the flow chambers 56 of the underlying cyclone cans 34 through the slots 64 or interfering with liquid exiting through the slots 64 in the underlying cyclone cans 34. In one embodiment, each of the deflector hats 86 slopes downwardly in two opposite directions toward the first and second side walls 40 and 42 of the box structure 32.

[0036] A sump 88 may be positioned below the rows of cyclone boxes 30 to receive and collect the liquid as it is discharged from the drainage channels 52. Drain pipes 90 that extend downwardly from the sump 88 may be used to deliver the liquid collected in the sump 88 to a location near the bottom takeoff nozzle 28 for subsequent removal from the vessel 10. Sloping shields 92 (Figs. 4 and 6) may be positioned between the sump 88 and the lower row of cyclone boxes 30 to direct liquid descending from the open bottom of those cyclone boxes 30 toward the liquid descending from the drainage channels 52.

[0037] A series of plates 94 may be secured around the perimeter of the cyclone mist eliminator 22 between the perimeter cyclone boxes 30 and the shell 12 of the vessel 10 to block the vapor from bypassing the cyclone mist eliminator 22 in the otherwise open spaces between the perimeter cyclone boxes 30 and the shell 12.

[0038] The cyclone mist eliminator 22 may be operated to remove liquid from the vapor stream 16 by flowing the vapor stream 16 through the flow chambers 56 of the cyclone cans 34 and imparting a swirling motion to the vapor stream 16 as it passes through the swirlers 58 to create centrifugal forces that cause liquid in the vapor stream 16 to impact against and coalesce on an inner surface of the cylindrical walls 54 that define the flow chambers 56. The coalesced liquid on the inner surface of the cylindrical walls 54 is directed through the slots 64 and drains into the volume of the box structure 32 outside of the cylindrical cans 34. The drained liquid then flows onto and descends along the first and second sloping sides 46 and 48 of the underling roof 44 and enters the drainage channels 52 after passing through the drain openings 66 in the lower portions of the first and second side walls 40 and 42. The liquid then descends through the drainage channels 52 and exits into the sump 88 for subsequent flow through the drain pipes 90 toward the bottom takeoff nozzle 28 where it may be removed from the vessel 10. The multiple drainage channels 52 may accommodate a greater flow volume of liquid than if only a single center drainage channel were used and the first and sloping sides 46 and 48 of the roof 44 allow the liquid flow into the drainage channels 52 to be less impacted by any swaying motion of the vessel 10 as a result of wind or wave loads.

ADDITIONAL CONSIDERATIONS

[0039] In this description, references to “one embodiment,” “an embodiment,” or “embodiments” mean that the feature or features being referred to are included in at least one embodiment of the technology. Separate references to “one embodiment,” “an embodiment,” or “embodiments” in this description do not necessarily refer to the same embodiment and are also not mutually exclusive unless so stated and/or except as will be readily apparent to those skilled in the art from the description. For example, a feature, structure, act, etc. described in one embodiment may also be included in other embodiments but is not necessarily included. Thus, the current technology can include a variety of combinations and/or integrations of the embodiments described herein.

[0040] In the specification and claims, reference will be made to several terms, which shall be defined to have the following meanings. The singular forms “a,” “an,” and “the” include plural references unless the context clearly dictates otherwise.

[0041] Approximating language, as used herein throughout the specification and the claim, may be applied to modify any quantitative representation that could permissibly vary without resulting in a change in the basic function to which it is related. Accordingly, a value modified by a term or terms, such as “about” and “substantially” are not to be limited to the precise value specified. In at least some instances, the approximating language may correspond to the precision of an instrument for measuring the value.

[0042] As used herein, the terms “radial” and “radially” refer to directions and orientations extending substantially perpendicular to a longitudinal axis. Moreover, directional references, such as “side” and similar terms are used herein solely for convenience and should be understood only in relation to each other.

[0043] The terms “coupled,” “attached to,” and the like refer to both direct coupling, fixing, or attaching, as well as indirect coupling, fixing, or attaching through one or more intermediate components or features, unless otherwise specified herein.

[0044] Although the present application sets forth a detailed description of different embodiments, it should be understood that the legal scope of the description is defined by the words of the claims and equivalent language. The detailed description is to be construed as exemplary only and does not describe every possible embodiment because describing every possible embodiment would be impractical. Numerous alternative embodiments may be implemented, using either current technology or technology developed after the filing date of this patent, which would still fall within the scope of the claims.

[0045] Throughout this specification, plural instances may implement components, operations, or structures described as a single instance. Structures and functionality presented as separate components in example configurations may be implemented as a combined structure or component. Similarly, structures and functionality presented as a single component may be implemented as separate components. These and other variations, modifications, additions, and improvements fall within the scope of the subject matter herein. The foregoing statements in this paragraph shall apply unless so stated in the description and/or except as will be readily apparent to those skilled in the art from the description.

[0046] As used herein, the terms “comprises,” “comprising,” “includes,” “including,” “has,” “having” or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus.

[0047] Although the disclosure has been described with reference to the embodiments illustrated in the attached figures, it is noted that equivalents may be employed, and substitutions made herein, without departing from the scope of the disclosure as recited in the claims.

CLAIMS

What is claimed is:

1. A cyclone box for removing liquid from a flowing vapor stream, said cyclone box comprising:

a box structure having a front end and a spaced apart back end, first and second spaced apart side walls extending in a direction between the front end and the back end, and a roof having first and second sloping sides,

wherein the first sloping side of the roof slopes in a direction of the first side wall to allow liquid when on the first sloping side of the roof to drain toward and into a first drainage channel running downwardly along the first side wall and the second sloping side of the roof slopes in a direction of the second side wall to allow liquid when on the second sloping side of the roof to drain toward and into a second drainage channel running downwardly along the second side wall; and

at least one cyclone can mounted within the box structure and comprising:

a cylindrical wall that forms a flow chamber having an inlet end at the front end of the box structure and an opposite outlet end at the back end of the box structure;

a swirler positioned within the cylindrical wall to impart a swirling motion to a vapor stream when flowing through the flow chamber from the inlet end to the outlet end that creates centrifugal forces to cause liquid in the vapor stream to coalesce on an inner surface of the cylindrical wall; and

one or more outlets to allow the liquid coalesced on the inner surface of the cylindrical wall to drain into a volume of the box structure outside of the cylindrical can.

2. The cyclone box of claim 1, wherein the one or more outlets are formed in the cylindrical wall downstream from the swirler.

3. The cyclone box of claim 1, wherein the swirler is fixed against movement.

4. The cyclone box of claim 1, including drain openings formed in a lower portion of the first and second side walls to allow liquid within the box structure to drain through the drain openings in the first side wall into the first drainage channel and through the drain openings in the second side wall into the second drainage channel when the cyclone box is stacked on top of the roof of another cyclone box.

5. The cyclone box of claim 1, including a recycle tube having an inlet end that is open to the volume of the box structure outside of the cylindrical can and an outlet end that is open to the flow chamber within the cylindrical wall.
6. The cyclone box of claim 1, including multiple ones of the cyclone cans positioned in spaced apart and parallel extending relationship to each other within the box structure.
7. The cyclone box of claim 6, including dividing walls positioned between horizontally adjacent ones of the cyclone cans.
8. The cyclone box of claim 7, including deflector hats positioned above the cylindrical wall to shield the one or more outlets from liquid descending into the one or more openings from above.
9. The cyclone box of claim 1, including a front plate positioned at the front end of the box structure and joined with the first and second side walls, the roof and the cylindrical wall at the inlet end of the flow chamber and a back plate positioned at the back end of the box structure and joined with the first and second side walls, the roof and the cylindrical wall at the outlet end of the flow chamber, the front plate and back plate including openings aligned with the flow chamber.
10. A cyclone mist eliminator comprising:
 - a plurality of cyclone boxes arranged in side-by-side relationship in vertically stacked rows within a separation vessel, each cyclone box comprising:
 - a box structure having a front end and a spaced apart back end, first and second spaced apart side walls extending in a direction between the front end and the back end, and a roof having first and second sloping sides,
 - wherein the first sloping side of the roof slopes in a direction of the first side wall to allow liquid when on the first sloping side of the roof to drain toward and into a drainage channel running downwardly along the first side wall and the second sloping side of the roof slopes in a direction of the second side wall to allow liquid when on the second sloping side of the roof to drain toward and into another one of the drainage channels running downwardly along the second side wall,

wherein the drainage channels are formed by the first side wall and a facing second wall of an adjacent one of the cyclone boxes within the same row and by the second side wall and a facing first wall of another adjacent one of the cyclone boxes within the same row; and
at least one cyclone can mounted within the box structure and comprising:
a cylindrical wall that forms a flow chamber having an inlet end at the front end of the box structure and an opposite outlet end at the back end of the box structure;
a fixed swirler positioned within the cylindrical wall to impart a swirling motion to a vapor stream when flowing through the flow chamber from the inlet end to the outlet end that creates centrifugal forces to cause liquid in the vapor stream to coalesce on an inner surface of the cylindrical wall; and
one or more outlets to allow the liquid coalesced on the inner surface of the cylindrical wall to drain into a volume of the box structure outside of the cylindrical can.

11. The cyclone mist eliminator of claim 10, wherein in each cyclone box the one or more outlets are formed in the cylindrical wall downstream from the swirler.

12. The cyclone mist eliminator of claim 10, wherein the first and second side walls of each cyclone box rest on the roof of the box structure of an underlying cyclone box and include drain openings formed in a lower portion of the first and second side walls to allow liquid within the box structure to drain through the drain openings in the first side wall into the first drainage channel and through the drain openings in the second side wall into the second drainage channel.

13. The cyclone mist eliminator of claim 12, each cyclone can includes a recycle tube having an inlet end that is open to the volume of the box structure outside of the cylindrical can and an outlet end that is open to the flow chamber within the cylindrical wall.

14. The cyclone mist eliminator of claim 12, including multiple ones of the cyclone cans positioned in spaced apart and parallel extending relationship to each other within the box structure of each cyclone box.

15. The cyclone mist eliminator of claim 14, including dividing walls positioned between horizontally adjacent ones of the cyclone cans within each box structure.

16. The cyclone mist eliminator of claim 15, including deflector hats positioned above the cylindrical wall in each cyclone can to shield the one or more outlets from liquid descending into the one or more openings from above.

17. The cyclone mist eliminator of claim 10, wherein in each cyclone box a front plate is positioned at the front end of the box structure and is joined with the first and second side walls, the roof and the cylindrical wall at the inlet end of the flow chamber and a back plate is positioned at the back end of the box structure and is joined with the first and second side walls, the roof and the cylindrical wall at the outlet end of the flow chamber, the front plate and back plate including openings aligned with the flow chamber.

18. The cyclone mist eliminator of claim 10, wherein the drainage channels within each row of cyclone boxes are vertically aligned with the drainage channels in adjacent rows of cyclone boxes.

19. The cyclone mist eliminator of claim 18, including a sump positioned below the rows cyclone boxes to receive liquid discharged from the drainage channels.

20. A method of separating liquid from a flowing vapor stream using a cyclone mist eliminator of claim 10, comprising the steps of:

flowing the vapor stream through the flow chambers of the cyclone cans and imparting a swirling motion to the vapor stream when passing through the swirlers to cause liquid in the vapor stream to impact against and coalesce on an inner surface of the cylindrical walls;

directing the coalesced liquid from the inner surface of the cylindrical walls through the outlets to drain into the volume of the box structure outside of the cylindrical can; and

flowing the drained liquid onto and along the first and second sloping slides of the roof and into the drainage channels.