considerations must also be addressed, as the tubeside will normally be easier to clean.

[0008] A drawback of the shellside boiling arrangement is considered at partial load or turndown operation, where the shellside velocities may not be sufficient to prevent phase separation and backflow of the liquid fraction back down to the inlet. Such buildup of heavy liquid fraction at high residence time can result in fouling.

[0009] The main drawback of any tubeside boiling arrangement is that the vapor and liquid fractions must be evenly distributed in each of a multiplicity of tube inlets, in order to maintain the expected boiling characteristics in each tube, and an inexpensive and low pressure drop method to achieve this distribution has not been found.

[0010] Accordingly, there exists a need for heat exchanger and baffle designs for effectively processing two-phase inlet flow in vertical units.

SUMMARY OF THE DISCLOSURE

[0010a] According to a first aspect of the present invention, there is provided a heat exchanger comprising: a plurality of longitudinally extending tubes adapted to transport a first fluid flow from a first fluid inlet to a first fluid outlet; a shell encompassing said tubes, the shell having a second fluid inlet and a second fluid outlet: and a plurality of baffles mounted in the shell to guide a second fluid into a helical flow pattern through the shell; wherein a helix angle α of a baffle proximate the inlet is less than a helix angle β of a baffle proximate the outlet; and wherein the heat exchanger does not include a central, axially extending structure to which the baffles are mounted.

[0010b] According to a second aspect of the present invention, there is provided a shell and tube heat exchanger comprising: a tubeside inlet manifold having a first fluid inlet therein; a tubeside outlet manifold having a first fluid outlet therein; a plurality of tubes extending between the manifold and in fluid communication therewith; a shell extending between the manifolds and encompassing said tubes, the shell having a second fluid inlet and a second fluid outlet therein; a plurality of baffles mounted in the shell to guide the second fluid into a helical flow pattern through the shell; wherein a helix angle α of a baffle proximate the second fluid inlet is less than a helix angle β of a baffle proximate the second fluid outlet; and wherein the heat exchanger does not include a central, axially extending structure to which the baffles are mounted.

[0010c] According to a third aspect of the present invention, there is provided a process for exchanging heat with a mixed phase fluid, the process comprising: feeding a mixed phase fluid comprising a vapor and at least one of an entrained liquid and an entrained solid to a heat exchanger, the heat exchanger comprising: a shell having a fluid inlet, and a fluid outlet; a plurality of battles mounted in the shell to guide the fluid into a helical flow pattern through the shell; converting the mixed phase fluid to essentially all vapor; and indirectly exchanging heat between the mixed phase fluid and a heat exchange medium; wherein the helix angle α of a baffle proximate the inlet maintains a velocity of the mixed phase fluid greater than a terminal velocity of the entrained liquid or solid; and wherein a helix angle β of a baffle proximate the outlet is greater than helix angel α of the baffle proximate the inlet.

[0011] There is also disclosed~~In one aspect, embodiments disclosed herein relate to~~ a heat exchanger including: a shell having a fluid inlet and a fluid outlet; a plurality of baffles mounted in the shell to guide the fluid into a helical flow pattern through the shell; wherein a helix angle α of a baffle proximate the inlet is different than a helix angle β of a baffle proximate the outlet.

[0012] There is also disclosed~~In another aspect, embodiments disclosed herein relate to~~ a shell and tube heat exchanger including: a tubeside inlet manifold having a first fluid inlet therein; a tubeside outlet manifold having a first fluid outlet therein; a plurality of tubes extending between the manifolds and in fluid communication therewith; a shell extending between the manifolds and encompassing said tubes, the shell having a second fluid inlet and a second fluid outlet therein; a plurality of baffles mounted in the shell to guide the second fluid into a helical flow pattern through the shell; wherein a helix angle α of a baffle proximate the second fluid inlet is different than a helix angle β of a baffle proximate the second fluid outlet.

[0013] There is also disclosed~~In another aspect, embodiments disclosed herein relate to~~ a process for exchanging heat with a mixed phase fluid, the process including: feeding a mixed phase fluid comprising a vapor and at least one of an entrained liquid and an entrained solid to a heat exchanger, the heat exchanger including: a shell having a fluid inlet, and a fluid outlet; a plurality of baffles mounted in the shell to guide the

CLAIMS

1. A heat exchanger comprising:

a plurality of longitudinally extending tubes adapted to transport a first fluid flow from a first fluid inlet to a first fluid outlet;

a shell encompassing said tubes, the shell having a second fluid inlet and a second fluid outlet: and

a plurality of baffles mounted in the shell to guide a second fluid into a helical flow pattern through the shell;

wherein a helix angle α of a baffle proximate the inlet is less than a helix angle β of a baffle proximate the outlet; and

wherein the heat exchanger does not include a central, axially extending structure to which the baffles are mounted.

2. The heat exchanger of claim 1, wherein the helix angle of the plurality of baffles increases from the fluid inlet to the fluid outlet.

3. The heat exchanger of claim 1, wherein a baffle intermediate the baffle proximate the inlet and the baffle proximate the outlet has a helix angle γ intermediate helix angles α and β.

4. The heat exchanger of claim 1, wherein helix angle α is within the range from about 5° to about 35° and wherein helix angle β is within the range from about 15° to about 45°.

5. The heat exchanger of claim 4, wherein helix angle α is within the range from about 5° to about 25°.

6. A shell and tube heat exchanger comprising:

a tubeside inlet manifold having a first fluid inlet therein;

a tubeside outlet manifold having a first fluid outlet therein;

a plurality of tubes extending between the manifold and in fluid communication therewith;

a shell extending between the manifolds and encompassing said tubes, the shell having a second fluid inlet and a second fluid outlet therein;

a plurality of baffles mounted in the shell to guide the second fluid into a helical flow pattern through the shell;

wherein a helix angle α of a baffle proximate the second fluid inlet is less than a helix angle β of a baffle proximate the second fluid outlet; and

wherein the heat exchanger does not include a central, axially extending structure to which the baffles are mounted.

7. The heat exchanger of claim 6, wherein the helix angle of the plurality of baffles increases from the fluid inlet to the fluid outlet.

8. The heat exchanger of claim 6, wherein a baffle intermediate the baffle proximate the inlet and the baffle proximate the outlet has a helix angle γ intermediate helix angles α and β.

9. The heat exchanger of claim 6, wherein helix angle α is within the range from about 5° to about 35° and wherein helix angle β is within the range from about 15° to about 45°.

10. The heat exchanger of claim 9, wherein helix angle α is within the range from about 5° to about 25°.

11. A process for exchanging heat with a mixed phase fluid, the process comprising:

feeding a mixed phase fluid comprising a vapor and at least one of an entrained liquid and an entrained solid to a heat exchanger, the heat exchanger comprising:

a shell having a fluid inlet, and a fluid outlet;

a plurality of battles mounted in the shell to guide the fluid into a helical flow pattern through the shell;

converting the mixed phase fluid to essentially all vapor; and

indirectly exchanging heat between the mixed phase fluid and a heat exchange medium;

wherein the helix angle α of a baffle proximate the inlet maintains a velocity of the mixed phase fluid greater than a terminal velocity of the entrained liquid or solid; and

wherein a helix angle β of a baffle proximate the outlet is greater than helix angel α of the baffle proximate the inlet.

12. The process of claim 11, wherein the converting comprises evaporating the entrained liquid.

13. The process of claim 11, wherein the converting comprises combusting the entrained solid.

14. The heat exchanger of claim 11, wherein helix angle α is within the range from about 5° to about 35° and wherein helix angle β is within the range from about 15° to about 45°.

Claims

1. A heat exchanger comprising:

a plurality of longitudinally extending tubes adapted to transport a first fluid flow from a first fluid inlet to a first fluid outlet;

a shell encompassing said tubes, the shell having a second fluid inlet and a second fluid outlet: and

a plurality of baffles mounted in the shell to guide a second fluid into a helical flow pattern through the shell;

wherein a helix angle α of a baffle proximate the inlet is less than a helix angle β of a baffle proximate the outlet; and

wherein the heat exchanger does not include a central, axially extending structure to which the baffles are mounted.

2. The heat exchanger of claim 1, wherein the helix angle of the plurality of baffles increases from the fluid inlet to the fluid outlet.

3. The heat exchanger of claim 1 or claim 2, wherein a baffle intermediate the baffle proximate the inlet and the baffle proximate the outlet has a helix angle γ intermediate helix angles α and ß.

4. The heat exchanger of any one of claims 1 to 3, wherein helix angle α is within the range from 5° to 35° and wherein helix angle β is within the range from 15° to 45°.

5. The heat exchanger of claim 4, wherein helix angle α is within the range from 5° to 25°.

6. A shell and tube heat exchanger comprising:

a tubeside inlet manifold having a first fluid inlet therein;

a tubeside outlet manifold having a first fluid outlet therein;

a plurality of tubes extending between the manifold and in fluid communication therewith;

a shell extending between the manifolds and encompassing said tubes, the shell having a second fluid inlet and a second fluid outlet therein;

a plurality of baffles mounted in the shell to guide the second fluid into a helical flow pattern through the shell;

wherein a helix angle α of a baffle proximate the second fluid inlet is less than a helix angle β of a baffle proximate the second fluid outlet; and

wherein the heat exchanger does not include a central, axially extending structure to which the baffles are mounted.

7. The heat exchanger of claim 6, wherein the helix angle of the plurality of baffles increases from the fluid inlet to the fluid outlet.

8. The heat exchanger of claim 6 or claim 7, wherein a baffle intermediate the baffle proximate the inlet and the baffle proximate the outlet has a helix angle γ intermediate helix angles α and β.

9. The heat exchanger of any one of claims 6 to 8, wherein helix angle α is within the range from 5° to 35° and wherein helix angle β is within the range from 15° to 45°.

10. The heat exchanger of claim 9, wherein helix angle α is within the range from 5° to 25°.

11. The heat exchanger of any one of claims 1 to 10, wherein a helix angle of a baffle where two-phase flow is expected is less than a helix angle of a baffle where single phase flow is expected.

12. A process for exchanging heat with a mixed phase fluid, the process comprising:

feeding a mixed phase fluid comprising a vapor and at least one of an entrained liquid and an entrained solid to a heat exchanger, the heat exchanger comprising:

a shell having a fluid inlet, and a fluid outlet;

a plurality of battles mounted in the shell to guide the fluid into a helical flow pattern through the shell;

converting the mixed phase fluid to essentially all vapor; and

indirectly exchanging heat between the mixed phase fluid and a heat exchange medium;

wherein the helix angle α of a baffle proximate the inlet maintains a velocity of the mixed phase fluid greater than a terminal velocity of the entrained liquid or solid; and

wherein a helix angle β of a baffle proximate the outlet is greater than helix angel α of the baffle proximate the inlet.

13. The process of claim 12, wherein the converting comprises evaporating the entrained liquid.

14. The process of claim 12 or claim 13 wherein the converting comprises combusting the entrained solid.

15. The process of any one of claims 12 to 14, wherein helix angle α is within the range from 5° to 35° and wherein helix angle β is within the range from 15° to 45°.

16. The process of any one of claims 12 to 15, wherein a helix angle of a baffle where two-phase flow is expected is less than a helix angle of a baffle where single phase flow is expected.