

**DISPLACEABLE BAFFLE FOR A HEAT EXCHANGER
AND METHOD FOR REDUCING VIBRATION OF THE SAME**

FIELD OF THE INVENTION

[0001] This invention relates to tube bundle devices such as heat exchangers, condensers and similar fluid-handling equipment with collections of tubes or rod-like elements, for example, in devices such as nuclear reactors, chemical reactors, electrical heaters, or any collection of parallel cylindrical shapes that has a fluid flow passing over the tubes or other elements. In particular, the present invention relates to a displaceable baffle or support structure for use in connection with the bundle to provide support to the individual tubes within the bundle and reduce vibration. The present invention is also directed to a method for reducing vibration in a tube bundle in a heat exchanger.

BACKGROUND OF THE INVENTION

[0002] Tube bundle equipment such as shell and tube heat exchangers and other similar fluid handling devices such as flow dampers and flow straighteners utilize tubes organized in bundles to conduct the fluids through the equipment. In such tube bundles, there is typically fluid flow both through the inside of the tubes and across the outside of the tubes. The configuration of the tubes in the bundle is set by the tubesheets into which the tubes are set. One common configuration for the tubes is the rectangular or square formation with the tubes set in aligned rows with tube lanes (the straight paths between the tubes) between each pair of rows, aligned orthogonally to one another. In this formation, each tube is adjacent to eight other tubes except at the periphery of the tube bundle and is directly opposite a corresponding tube across the tube lane separating its row from the two adjacent rows. In the triangular tube formation, the tubes in alternate rows are aligned with one another so that each tube is

adjacent to six other tubes (the two adjacent tubes in the same row and four tubes in the two adjacent rows).

[0003] Increases in throughput in existing exchangers are often desired either to reduce capital cost by reducing equipment size or to increase productivity factors. A common limiting factor experienced when evaluating the increase of rates in a heat exchanger is the potential for flow-induced vibration damage of the tubes. Fluid flow patterns around the tubes may give rise to flow-induced vibrations of an organized or random oscillatory nature in the tube bundle and in the case of devices such as heat exchangers in which heat transfer takes place between the tubes and the surrounding fluid, the changes in the velocity, temperature and density of the fluid as it circulates and flows around the tubes may increase the likelihood of vibration. If these vibrations reach certain critical amplitudes, damage to the bundle may result. Tube vibration problems may be exacerbated if the heat exchanger equipment is retubed with tubes of a different material to the original tubes, for example, if relatively stiff materials are replaced with lighter weight tubes. Flow-induced vibration may also occur when equipment is put to more severe operating demands, for example, when other existing equipment is upgraded and a previously satisfactory heat exchanger, under new conditions, becomes subject to flow-induced vibrations. Vibration may even be encountered under certain conditions when a heat exchanger is still in the flow stream but without heat transfer taking place as well as in other bundle devices with collections of rods or rod-like elements in a flow stream with or without heat transfer.

[0004] A number of different equipment designs have evolved to deal with the problem of tube vibration. One example is the rod baffle design. Rod baffle heat exchangers are shell and tube type heat exchangers utilizing rod baffles to support the tubes and secure them against vibrations. The term "baffle" refers to

the cages, placed every 15 cm or so along the length of the tube bundle, in which the ends of a plurality of support rods are connected to form a cage-like tube support structure; hence the term "rod baffle". Rod baffle exchangers, however, tend to be approximately 30 to 40% more expensive than conventional shell-and-tube exchangers and there have been situations where tube bundle devices of this kind have failed owing to flow-induced vibrations. The rod baffles must have very precise dimensions. If the rods in rod baffles are slightly undersized, tube chatter will occur. If the rods are slightly oversized, tube loading will be very difficult and expensive. Rod baffle heat exchangers are described, for example, in U.S. Patents Nos. 4,342,360 to Gentry et al.; 5,388,638 to Gentry; 5,553,665 to Gentry; and 5,642,778 to Gentry.

[0005] As described in U.S. Patent No. 5,553,665, certain applications of the rod baffle design such as gas-compression applications may benefit from longitudinal-flow, with shell-side pressure losses to be minimized. Reduction in shell-side pressure losses may be accomplished by increasing rod baffle spacing, thereby reducing the number of rod baffles, or by decreasing the number of tubes by increasing the tube pitch dimension, i.e., the distance between two adjacent rows of tubes as measured from the center of the tubes. Increasing baffle spacing is usually not an attractive option, since increased baffle spacing increases the likelihood of flow-induced tube vibration occurrence. This rod baffle design represents an attempt to deal with the pressure drop problems of the rod baffle configuration.

[0006] An alternative design is the "Eggcrate" support design. This, however, is even more expensive than the rod baffle design. Like the rod baffle, the eggcrate is also susceptible to tube chatter that could lead to tube failure. Chatter is the motion of a tube hitting the tube supports because of a gap between the support and the tube outside diameter. The gap is required to allow

for inserting the tubes through the eggcrate support when the bundle is being constructed.

[0007] Besides good equipment design, other measures may also be taken to reduce tube vibration. Tube support devices or tube stakes as these support devices are commonly known (and referred to in this specification) may be installed in the tube bundle in order to control flow-induced vibration and to prevent excessive movement of the tubes. A number of tube supports or tube stakes have been proposed and are commercially available. U.S. Patent No. 4,648,442 to Williams, U.S. Patent No. 4,919,199 to Hahn, U.S. Patent No. 5,213,155 to Hahn and U.S. Patent No. 6,401,803 to Hahn, for example, describe different types of tube stake or tube support which can be inserted into the tube bundle to reduce vibration.

[0008] Improved tube stakes are also shown in U.S. Patent No. 7,032,655 to Wannan et al., entitled "Anti-Vibration Tube Support." The use of the tube stakes taught by Wannan et al. have been found to be particularly effective in reducing vibration in tube bundles. These are especially useful in retrofitting existing bundles. Co-pending and commonly assigned US Patent Application No. 11/905,694 to Wannan et al., entitled "Reduced Vibration Tube Bundle Device Having Slotted Baffles," the disclosure of which is incorporated specifically herein by reference, discloses the use of slotted baffles to support the tubes within the tube bundles, as shown in Figs. 1-4. Tube support stakes, like those disclosed in U.S. Patent No. 7,032,655 are used to deflect the individual tubes into contact with the slotted baffles such that the baffles in combination with the stakes support the tubes and reduce vibration, as shown in Fig. 1. There, however, is a need to reduce vibration in tubes bundles without the use of the tube stakes especially for use, for example, in new tube bundles.

SUMMARY OF THE INVENTION

[0009] It is an aspect of the present invention to provide a tube bundle device (e.g., a heat exchanger) having at least one displaceable baffle which supports the tubes in the bundle device. The use of the terminology is used by way of example. It is contemplated that the present invention is not limited to tubes; rather, it is contemplated that the rods and other heat transfer or fluid flow elements may be employed and are considered to be well within the scope of the present invention.

[0010] It is an aspect of the present invention to provide an improved tube bundle device, which provides increased tube support to reduce vibration. The tube bundle device includes a housing, and a tube bundle located within the housing. The tube bundle has a plurality of tubes arranged parallel to one another in tube rows. The tubes may be arranged in a conventional rectangular configuration or a conventional triangular configuration. The tube bundle device includes at least one displaceable support baffle. Each displaceable support baffle has a plurality of apertures formed therein. The apertures are sized to receive at least one tube therethrough. Various aperture configurations are contemplated. The apertures may be sized to receive a single tube therethrough. The apertures may be formed as elongated slots to receive multiple tubes as disclosed, for example, in co-pending US Patent Application No. 11/905,694 filed on October 3, 2007, entitled "Reduced Vibration Tube Bundle Having Slotted Baffles," the disclosure of which is incorporated by reference in their entirety. The apertures may be formed as elongated slots formed from elongated rods or bars secured to a cage, as disclosed, for example, in US Patent No. 7,219,718 and US Patent No. 7,073,575, both entitled "Reduced Vibration Tube Bundle," the disclosures of which are incorporated by reference in their entireties.

[0011] In accordance with the present invention, each displaceable support baffle has at least a first portion and a second portion, whereby the portions are selectively displaceable between a first loading position to facilitate positioning of the displaceable support baffle on the tube bundle and a second installed position causing deflection of the tubes passing through the plurality of apertures. At least one first fastener is provided to secure or maintain the portions in the first loading position. After locating the displaceable support baffle in the desired location along the axis of the tube bundle, the at least one first fastener is either loosened or removed to permit displacement of the portions with respect to each other to the second position. The first fasteners may be clamps, screws, bolts or any other suitable fastener that maintains the portions in the first position while being installed, but can be removed to permit displacement of the portions to the second position. It is contemplated that the portions can be either brought closer together or spread further apart in the second installed position provided that the tubes passing through the displaceable support baffle are deflected. At least one second fastener is provided to secure or maintain the portions in the second installed position. The second fasteners may be clamps, screws, bolts, welds or any other suitable fastener that maintains the portions in the second installed position. The present invention is not intended to be limited to a first portion and a second portion, rather any number of portions greater than two are contemplated provided the portions can be displaced relative to each other in order to provide the necessary deflection of the tubes within the bundle.

[0012] In accordance with another aspect of the present invention, at least one insert is provided between the portions to provide the necessary spacing between the portions such that the tubes are deflected by the portions. The second fasteners are then used to secure the portions and the inserts in their proper orientation.

[0013] In accordance with another aspect of the present invention, the displaceable support baffle is used in conjunction with at least one fixed baffle. Each fixed baffle having a plurality of apertures that are sized to receive at least one of the tubes therethrough. The at least one fixed baffle and the at least one displaceable support baffle are spaced along the longitudinal axis of the tube bundle. Preferably, each displaceable support baffle is spaced from an adjacent fixed baffle. With such an arrangement, when the displaceable support baffles are located in their second installed position, the tubes are deflected a sufficient amount such that the tubes also contact the fixed baffle further stabilizing the tubes within the bundle and reducing vibration.

[0014] In accordance with yet another aspect of the present invention, a displaceable support baffle for use in supporting a plurality of tubes in a tube bundles is disclosed. The displaceable support baffle includes at least a first plate and a second plate. Each plate having a plurality of apertures formed therein. The displaceable support baffle having at least one first fastener assembly for securing the plates together in a first loading position. The displaceable support baffle further includes at least one second fastener assembly for securing the plates together in a second installed position.

[0015] It is another aspect of the present invention to provide a method of supporting a tube bundle having a plurality of tubes arranged parallel to one another in tube rows and longitudinal axis extending in a direction generally parallel to the plurality of tubes. The method includes locating at least one displaceable support baffle on the tube bundle along the longitudinal axis. Each displaceable support baffle having a plurality of apertures formed therein that are sized to receive at least one of the tubes therethrough. Each baffle having two or more portions, wherein each portion of the some of the plurality of apertures

located therein. The method further includes displacing the portions with respect to each other to an installed position and securing the portions in the installed position. The tubes passing through the displaceable baffles are deflected when the portions are displaced with respect to each other.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The invention will now be described in conjunction with the accompanying drawings in which like reference numerals describe like elements and wherein:

Fig. 1 is a schematic view of a tube bundle having at least one displaceable support baffles in accordance with an embodiment of the present invention;

Fig. 2 is a schematic view of a displaceable support baffle in accordance with an embodiment of the present invention;

Fig. 3 is a variation of the displaceable support baffle of Fig. 2;

Fig. 4 is another variation of the displaceable support baffle of Fig. 2;

Fig. 5A is yet another variation of the displaceable support baffle of Fig. 2 having a plurality of horizontally arranged slots in accordance with the present invention;

Fig. 5B is another variation of the displaceable support baffle of Fig. 5A having more than one parallel partition lane;

Fig. 6 is a side view of a tube bundle device in accordance with the present invention having a displaceable support baffle in a loading position;

Fig. 7 is a side view of a tube bundle device of Fig. 6 having the displaceable support baffle in one installed position in accordance with the present invention;

Fig. 8 is a schematic view of a displaceable support baffle having a clamping device in accordance with the present invention;

Fig. 9 is a schematic view of a displaceable support baffle having another clamping device in accordance with the present invention;

Fig. 10 is a side view of a tube bundle device of Fig. 6 having the displaceable support baffle in another installed position in accordance with the present invention;

Fig. 11 is a schematic view of a displaceable support baffle having a plurality of openings sized to receive a tube therein in accordance with the present invention;

Fig. 12 is a schematic view of a displaceable support baffle having a plurality of rods forming a plurality of slots sized to receive tubes therein in accordance with the present invention;

Fig. 13 is a schematic view of fixed support baffle having vertical slots for use in the tube bundle in accordance with the present invention;

Fig. 14 is a schematic view of fixed support baffle having horizontal slots for use in the tube bundle in accordance with the present invention; and

Fig. 15 is a schematic view of blocking baffle for use in the tube bundle in accordance with the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0017] The present invention will now be described in greater detail in connection with the following figures. Applicant notes that the terminology horizontal and vertical when used in connection with the present invention is intended as a point of reference to describe the orientation of the individual components of the baffles with respect to the other components of the baffles. The terminology is not intended to describe the orientation of the baffles or components, which make up the baffles within the heat exchanger. It is contemplated that the tube bundle device 1 can have one of several orientations when in use. Thus the tube bundle device can be in general oriented horizontally, vertically or any angle relative to the horizontal.

[0018] A tube bundle having a plurality of spaced baffles is illustrated in Fig. 1. The tube bundle 10 is part of a tube bundle device 1 (e.g., a heat exchanger or other suitable heat transfer component). The tube bundle 10 includes a plurality of parallel tubes 11, which extend between a pair of tubes sheets 13 and 14. The tube bundle 10 is fitted into the surrounding shell or housing 20 of the tube bundle device 1. Typically fluid flow occurs through both the inside of the tubes 11 and within the shell 20 across the outside of the tubes 11. The tube bundle 10 is provided with baffles to reduce flow-induced vibration within the tube bundle 10 and direct the flow of the fluid towards the tubes 11 away from the shell 20.

[0019] A displaceable support baffle 300 is illustrated in Fig. 2. The displaceable baffle 300 includes a plurality of apertures that are sized to receive the tubes 11 to reduce vibration. The displaceable baffle 300 includes a plurality of slots 36. The slots 36 are arranged to correspond to the rows of the tubes 11 in the bundle 10. A plurality of vertically extending ribs 37 are provided on the baffle 300. Each rib 37 extends vertically between the slots 36. Each rib 37 preferably has a thickness that is slightly smaller than the spacing between adjacent tubes 11 in the tube bundle 10. The present invention is not limited to vertical slots; rather, horizontal slots 46, as illustrated in Figs. 5A and 5B, are considered to be well within the scope of the present invention. With horizontally extending slots 46, a plurality of horizontally extending ribs 47 are provided. Each rib 47 extends horizontally between the slots 46. Each rib 47 preferably has a thickness that is slightly smaller than the spacing between adjacent tubes 11 in the tube bundle 10. The present invention, however, is not intended to be limited to the use of vertical slots 36 or horizontal slots 46, rather, other apertures are contemplated including but not limited to horizontal slots, openings 371 sized to receive a single tube 11, as shown in Fig. 11, and elongated openings 372 formed from elongated bars or rods 373 secured to a

cage 374, as shown in Fig. 12. It is contemplated that the use of openings 371 for receiving individual tubes 11 therethrough may be the preferred aperture configuration.

[0020] A blocking region 34 around the perimeter is configured to redirect any bypass flow from between the outermost tubes 11 and the inside diameter of the shell 20 inwardly towards the tubes 11. Vertical slots 36 receive the tubes 11 therein. The baffle 30 includes a plurality of notches 32 and 33 formed therein. The notches 32 are sized to receive a tie bar 5 therein. The notches 33 are sized to receive a skid bar 6 therein. The skid bar 6 is provided to ensure support during insertion of the tube bundle 10 into the shell 20. The notches 32 and 33 ensure that the baffles 300 are maintained in the proper orientation. The tie bars 5, the skid bars 6, the displaceable baffles 300, the fixed baffles 30, 40 (if utilized) and blocking baffles 60 (if utilized) together form a rigid cage, which facilitates the insertion of the tubes 11 of the bundle 10 into the shell 20.

[0021] Typically, the tube bundle 10 includes at least one partition lane, which separates the tubes 11 within the tube bundle 10 into discrete groups. The partition lanes do not include any tubes 11. The partition lanes may have horizontal and vertical orientations. Fluid flowing through the partition lanes does not contact the heat transfer surfaces of the tubes 11. As such, it is desirable to redirect the flow of fluid within the bundle 10 away from the partition lanes towards the tubes 11 to improve heat transfer. The displaceable baffle 300 includes at least one partition lane blocking area 35 and 310 to redirect the flow of fluid within the shell of the heat exchanger 1 towards the tubes 11 of the tube bundle 10. The plurality of apertures is located on opposing sides of the blocking areas 35 and 310.

[0022] The displaceable baffle 300 in accordance with an aspect of the present invention is divided into at least two separate portions 320 and 330 along partition lane 301 in partition lane blocking area 310. The partition lane 301 is formed by cutting the baffle 300 into two sections. This can be accomplished by laser cutting or other suitable cutting method. The original shape of the baffle 300 (i.e., before cutting the baffle into two or more sections) may be slightly larger than the desired shape such that the baffle 300 after it is cut into two sections and is in an installed position has an outer perimeter that is consistent with the size of the inner perimeter of the shell 20. It is also contemplated that the portions 320 and 330 can be formed as separate sections. The portions 320 and 330 are secured together for loading onto the tube bundle 10 such that the baffle 300 can be properly located at the desired location on the tube bundle 10. A removable clamping assembly 350, as shown in Fig. 8, may be used to secure the portions together for purpose of properly installing the baffle 300. Once the baffle 300 is properly located and the tubes are loaded, the clamping assembly 350 is removed. The baffle 300 has an orientation as illustrated in Fig. 6. The tubes 11 are received within the apertures and a small space 360 exists between the portions 320 and 330.

[0023] Stiffening of the tubes 11 in the bundle 10 to reduce vibration can be accomplished in one of two ways. Once the baffles 300 and other baffles described in greater detail below are properly located on the tube bundle 10 and the clamping assemblies 350 have been removed, the portions 320 and 330 can be moved closer together to a position shown in Fig. 7 or Fig. 9. In such an arrangement, the apertures in the baffle 300 contact the tubes 11 causing an inward deflection of the tubes 11. This deflection of the tubes causes stiffening, which reduces vibration. The portions 320 and 330 can be secured together using an appropriate weld along the partition lane 301, an appropriate clamping device 370, a nut and bolt fastener assembly 380 or any other suitable fastener

provided such fastener maintains the portions 320 and 330 in their proper installed position during operation of the heat exchanger 1.

[0024] Alternatively, once the baffles 300 and other baffles are properly located on the tube bundle 10 and the clamping assemblies 350 have been removed, the portions 320 and 330 can be moved further apart to a position shown in Fig. 10. In such an arrangement, the baffle 300 may have an original shape that is slightly smaller such that when it is in the installed position, the outer perimeter of the baffle 300 substantially corresponds to the inner perimeter of the shell. The slight movement of the two portions 320 and 330 is achieved by slightly moving the two portions away from each other, through the use of cranes, jacks or the like, and placing a properly formed insert 390 (which may be formed from a strip of metal) in the space 391 between the two portions 320 and 330 of the baffle 300. Once the force exerted by the crane or the jacks is removed, the force exerted by the tubes 11 would keep the insert 390 in place; likewise, the same force would create a bending force on the tubes and thereby stiffen them. The two portions can be welded to each other or secured to each other with another set of clamps to provide additional rigidity during bundle handling. In such an arrangement, the apertures in the baffle 300 contact the tubes 11 causing an outward deflection of the tubes 11. The portions 320 and 330 can be maintained in such an orientation using an insert 390. The portions 320 and 330 may be welded to the insert 390. It is also contemplated that a clamping device 370, or any other suitable fastener may be used to secure the portions 320 and 330 provided such fastener maintains the portions 320 and 330 in their proper installed position. It is important to note that the thickness of the insert 390 should be slightly larger than the thickness of the space 391 cut in the baffle 300. For example, if the slot 391 cut is 3 mm wide, the insert 390 may be about 6 or 7 mm thick.

[0025] A displaceable support baffle 400 is illustrated in Fig. 5A. The displaceable baffle 400 includes a plurality of apertures that are sized to receive the tubes 11 to reduce vibration. The displaceable baffle 400 includes a plurality of slots 46. The slots 46 are arranged to correspond to the rows of the tubes 11 in the bundle 10. A plurality of horizontally extending ribs 47 are provided on the baffle 400. Each rib 47 extends horizontally between the slots 46. Each rib 47 preferably has a thickness that is slightly smaller than the spacing between adjacent tubes 11 in the tube bundle 10. The slots 46 can be replaced with openings 361 or elongated openings 372, as described above.

[0026] A blocking region 44 around the perimeter is configured to redirect any bypass flow from between the outermost tubes 11 and the inside diameter of the shell 20 inwardly towards the tubes 11. Horizontal slots 46 receive the tubes 11 therein. The baffle 400 includes a plurality of notches 32 and 33 formed therein. The notches 32 are sized to receive a tie bar 5 therein. The notches 33 are sized to receive a skid bar 6 therein. The skid bar 6 is provided to ensure support during insertion of the tube bundle 10 into the shell 20. The notches 32 and 33 ensure that the baffle 400 is maintained in the proper orientation. The tie bars 5, the skid bars 6, the displaceable baffles 300 and 400, the fixed baffles 30, 40 (if necessary) and blocking baffles 60 (if necessary) together form a rigid cage, which facilitates the insertion of the tubes 11 of the bundle 10 into the shell 20.

[0027] The displaceable baffle 400 includes at least one partition lane blocking area 45 to redirect the flow of fluid within the shell of the heat exchanger 1 towards the tubes 11 of the tube bundle 10. The plurality of apertures is located on opposing sides of the blocking areas 45. The displaceable baffle 400 in accordance with an aspect of the present invention is divided into at least two separate portions 420 and 430 along partition lane 401 in partition lane

blocking area 45. The partition lane 401 is formed by cutting the baffle 400 into two sections. This can be accomplished by laser cutting or other suitable cutting method. Like baffle 300, the original shape of the baffle 400 (i.e., before cutting the baffle into two or more sections) may be slightly larger than the desired shape such that the baffle 400 after it is cut into two sections and is in an installed position has an outer perimeter that is consistent with the size of the inner perimeter of the shell 20 when the portions 420 and 430 are moved closer together. Like baffle 300, the original shape may be slightly smaller when the portions 420 and 430 are moved further apart in the installed position. In some circumstances, the heat exchanger 1 may not have a partition lane. This may occur in a single tube pass heat exchanger. In such an arrangement, it is desirable to include an artificial partition lane on the displaceable baffle (i.e., the width of the tube lane is increased) in order to permit the cutting of the baffle into two or more sections along the partition lane 401. It is desirable to include an artificial partition lane when there are no partition lanes (e.g., an exchanger with a single tube pass) or a partition lane is desired where one does not exist. Fig. 5B illustrates a displaceable baffle 700 having more than one partition lanes 701, 702 and 703, which divide the baffle 700 into portions 710, 720, 730 and 740.

[0028] The portions 420 and 430 are secured together for loading onto the tube bundle 10 such that the baffle 400 can be properly located at the desired location on the tube bundle 10. A removable clamping assembly 350, as shown in Fig. 8, may be used to secure the portions together for purpose of properly installing the baffle 400. The baffle 400 has an orientation as illustrated in Fig. 6. The tubes 11 are received within the apertures and a small space 360 exists between the portions 420 and 430. Once the baffle 400 is properly located and the tubes 11 are loaded, the clamping assembly 350 is removed.

[0029] Stiffening of the tubes 11 in the bundle 10 to reduce vibration can be accomplished in one of two ways. Once the baffles 400 and other baffles described in greater detail below are properly located on the tube bundle 10, tubes 11 are loaded and the clamping assemblies 350 have been removed, the portions 420 and 430 can be moved closer together to a position shown in Fig. 7 or Fig. 9. In such an arrangement, the apertures in the baffle 400 contact the tubes 11 causing an inward deflection of the tubes 11. This stiffens the tubes 11 to reduce vibration. The portions 420 and 430 can be secured together using an appropriate weld along the partition lane 401, an appropriate clamping device 370, a nut-and-bolt fastener assembly 380 or any other suitable fastener provided such fastener maintains the portions 420 and 430 in their proper installed position during operation of the heat exchanger 1.

[0030] Alternatively, once the baffles 400 and other baffles are properly located on the tube bundle 10, tubes 11 are loaded, and the clamping assemblies 350 have been removed, the portions 420 and 430 can be moved further apart to a position shown in Fig. 10. In such an arrangement, the baffle 400 may have an original shape that is slightly smaller such that when it is in the installed position, the outer perimeter of the baffle 400 substantially corresponds to the inner perimeter of the shell. The slight movement of the two portions 420 and 430 is achieved by slightly moving the two portions away from each other, through the use of cranes, jacks or the like, and placing a properly formed insert 390 (which may be formed from a strip of metal) in the space 391 between the two portions 420 and 430 of the baffle 400. Once the force exerted by the crane or the jacks is removed, the force exerted by the tubes 11 would keep the insert 390 in place; likewise, the same force would create a bending force on the tubes and thereby stiffen them. The two portions can be welded to each other or secured to each other with another set of clamps to provide additional rigidity during bundle handling. In such an arrangement, the apertures in the baffle 400 contact the

tubes 11 causing an outward deflection of the tubes 11. The portions 420 and 430 can be maintained in such an orientation using an insert 390. The portions 420 and 430 may be welded to the insert 390. It is also contemplated that a clamping device 370, or any other suitable fastener may be used to secure the portions 420 and 430 provided such fastener maintains the portions 420 and 430 in their proper installed position.

[0031] In accordance with the present invention, the displaceable baffles 300 and 400 are not limited to two displaceable portions 320, 330 and 420, 430; rather, two or more displaceable portions are considered to be well within the scope of the present invention. A baffle 500 having three displaceable portions is illustrated in Fig. 3. Baffle 500 includes an additional partition lane 302. A baffle 600 having four displaceable portions is illustrated in Fig. 4. Baffle 600 further includes an additional partition lane 303. The displaceable portions are displaceable with respect to each other and can be secured in the proper loaded position in the manner described above. Other configurations are considered to be well within the scope of the present invention. Furthermore, various aperture configurations are considered to be suitable for use with the baffles 500 and 600. When the plurality of apertures are slots, the partition lane 401 is generally parallel to the slots such that the slots can displace the tubes 11 when the portions are displaced, as shown in Figs. 2 and 4. When more than one partition lane (e.g., as shown in Figs. 3, 4, 5B) is provided the aperture configuration must permit displacement of the tubes when the portions are displaced relative to each other. In Fig. 5B, the partition lanes 701, 702 and 703 are parallel to each other. With such an arrangement, the apertures may be elongated slots that extend parallel to the partition lanes such that displacement of the portions 710, 720, 730 and 740 will cause the proper deflection of the tubes. Elongated slots extending perpendicular to the partition lanes would not cause the proper deflection of the tubes. In those circumstances, the use of an opening 371 may

be the most appropriate aperture when more than one direction of displacement is contemplated.

[0032] In accordance with the present invention, the displaceable baffles 300 and 400 may be spaced along the length of the tube bundle 10 to reduce vibration. It is also contemplated that the displaceable baffles may be located only at those locations where vibration reduction is needed (e.g., at the end portions of the bundle). The present invention is not intended to be limited to the use of displaceable baffles 300 and 400 alone.

[0033] In accordance with the present invention, the displaceable baffles 300 and 400 may be used in connection with at least one fixed baffle 30 or 40, as shown in Figs. 13 and 14, and at least one blocking baffle 60, as shown in Fig. 15. A fixed baffle 30 having slots is illustrated in Fig. 13. While the fixed baffle 30 is illustrated with vertical slots, the present invention is not intended to be limited to baffles only having slots; rather, other configurations, as described above in connection with the displaceable baffle 300 are considered to be well within the realm of the present invention. The fixed baffle 30 has a plurality of vertical slots 36 that provide support for the tubes 11 to reduce vibration. A blocking region 34 is configured to redirect any bypass flow from between the outermost tubes 11 and the inside diameter of the shell 20 inwardly towards the tubes 11. The vertical slots 36 receive the tubes 11 therein. The baffle 30 includes a plurality of notches 32 and 33 formed therein. The notches 32 are sized to receive a tie bar 5 therein. Generally, tie bars and skid bars are welded to the baffles before loading the tubes. In the case of the present invention, this would not be appropriate for the displaceable baffles. Instead, the tie bars and skid bars would be welded to the displaceable baffles after loading the tubes and after displacing the baffle portions. The fixed baffles and blocking baffles, if used, can be welded to the tie bars and skid bars prior to the loading of the tube

to provide sufficient rigidity to the bundle cage. The present invention is not limited for use with tie bars; rather, the use of conventional tie rods 380, as shown in Fig. 11, may be used. When tie rods 380 are utilized, the tie rods may be allowed to bend together with the tubes 11 when the displaceable baffles are displaced to the loaded portion. On the other hand, the holes in the fixed baffles for the tie rods may be made slightly larger so that bending of the tie rods can be reduced during the displacement of the displaceable baffles. The notches 33 are sized to receive the skid bar 6 therein. The skid bar 6 is provided to ensure support during insertion of the tube bundle 10 into the shell 20. The notches 32 and 33 ensure that the displaceable baffles 300, the fixed baffles 30 and 40 and the blocking baffles 60 (described below) are maintained in the proper orientation. The tie bars 5, the skid bars 6 and the baffles 300, 30, 40 and 60 together form a rigid cage, which facilitates the insertion of the tubes 11 of the bundle 10. The baffle 30 includes at least one partition lane blocking area 35 to redirect the flow of fluid within the shell of the heat exchanger 1 towards the tubes 11 of the tube bundle 10. The slots 36 are arranged to correspond to the rows of the tubes 11 in the bundle 10. A plurality of vertically extending ribs 37 are provided on the baffle 30. Each rib 37 extends vertically between the slots 36. Each rib 37 preferably has a thickness that is slightly smaller than the spacing between adjacent tubes 11 in the tube bundle 10.

[0034] A fixed baffle 40 having horizontal slots 46 that provide support for the tubes 11 in the bundle 10 to reduce vibration is illustrated in Fig. 14. Like baffle 30, the baffle 40 is configured to redirect the flow of fluid away from the gap between the outer tubes 11 of the tube bundle 10 and the inner surface of the shell 20 inwardly towards the tubes 11 in the bundle 10 away from the shell 20 and outwardly away from the partition lanes towards the tubes 11. The baffle 40 has a blocking area 44. The blocking area 44 has a similar construction of the blocking area 34. The baffle 40 may also include at least one partition lane

blocking area 45. The baffle 40 includes a plurality of horizontal slots 46. The slots 46 are located on opposing sides of the partition lane blocking area 35. The slots 46 are sized to receive and support the tubes 11 of the tube bundle 10. A plurality of horizontally extending ribs 47 are provided on the baffle 40. Each rib 47 extends between the slots 46.

[0035] When the displaceable baffles 300, 400 and the fixed baffles 30, 40 contain slots for receiving the tubes therethrough, a blocking baffle 60 may be utilized as is illustrated in Fig. 15. The blocking baffle 60 is configured to direct the flow of fluid inwardly towards the tubes 11 in the bundle 10 away from the shell 20 and outwardly away from the partition lane of the bundle. Each baffle 60 includes a blocking area 64 and a partition lane blocking area 65. The blocking baffle 60 does not provide support to the tubes 11 in the bundle 10.

[0036] The assembly of the tube bundle device 1 will now be described in greater detail. A rigid cage for the tube bundle 10 is constructed using the tie bars 5, skid bars 6, displaceable baffles 300 and 400 and the baffles 30, 40, and 60. The rigid cage is formed by securing the tie bars 5 and skid bars 6 within the respective slots 32 and 33 in the baffles 30, 40, and 60. The tie bars 5 and the skid bars 6 are preferably secured within the slots 32 and 33 by welding or other suitable attachment mechanism. The displaceable baffles 300 and 400 should not be welded to the tie bars and skid bars until after the two portions are displaced and secured in the final position. The displaceable baffles 300 and 400 and the fixed baffles 30 and 40 are spaced at a desired spacing. The baffles may have an alternating pattern with fixed baffles be located adjacent displaceable baffles. Vertically displaceable baffles are preferably located adjacent horizontally displaceable baffles. At least one blocking baffle 60 may be located between the baffles, as shown in Fig. 1.

[0037] Once the rigid cage has been assembled, the tubes 11 of the tube bundle 10 may be inserted into the cage. The tubes 11 are loaded into the bundle 10 by inserting the tubes 11 through the openings in the baffles. After the tubes 11 are located within the cage, the portions of the displaceable baffles are moved into the installed position, as described above. The portions are then secured in the installed position. The tubesheets 13 and 14 may be secured to the ends of the bundle 10. This is accomplished by welding or otherwise securing the end of each tube 11 to a tubesheet. As discussed above, at least one of the tubesheets is stationary. It is contemplated that the ends of the tubes can be secured to a pair of tubesheets 13, one stationary tubesheet 13 and one floating tubesheet 14 or one stationary tubesheet 13 when the U-tubes are used such that both ends of the tubes are secured to the same tubesheet 13. The assembled tube bundle 10 is inserted into the shell 20 by sliding the bundle 10 along skid bars 6 into the shell. Once the bundle 10 is properly oriented within the shell 20, the tubes sheets 13 are secured to the shell 20.

[0038] It will be apparent to those skilled in the art that various modifications and/or variations may be made without departing from the scope of the present invention. Thus, it is intended that the present invention covers the modifications and variations of the apparatus and methods herein, provided they come within the scope of the appended claims and their equivalents.

CLAIMS:

1. A tube bundle device comprising:
a tube bundle having a plurality of tubes arranged parallel to one another in tube rows; and
at least one displaceable support baffle having a plurality of apertures formed therein, wherein the plurality of apertures being sized to receive at least one of the tubes therethrough,
wherein each displaceable support baffle having at least a first portion and a second portion, wherein a portion of the plurality of apertures being located on the first portion and another portion of the plurality of apertures being located on the second portion,
wherein at least the first portion and the second portion being located in a first loading position to facilitate positioning of the displaceable support baffle on the tube bundle on the tube bundle and a second installed position causing deflection of the tubes passing through the plurality of apertures.
2. The tube bundle device according to claim 1, wherein the first portion and second portion are closer together in the second installed position as compared to the first loading position.
3. The tube bundle device according to claim 1, wherein the first portion and second portion are closer together in the first loading position as compared to the second installed position.
4. The tube bundle device according to claim 2 or claim 3, further comprising at least one fastener for securing the first portion to the second portion in the second installed position.

5. The tube bundle device according to claim 4, wherein the at least one fastener is one of a weld, a clamp and a releasable fastener.

6. The tube bundle device according to claim 3, further comprising at least one insert positioned between the first portion and the second portion to maintain the first portion and the second portion in the second installed position.

7. The tube bundle device according to anyone of the preceding claims, further comprising:

at least one fixed baffle having a plurality of apertures formed therein, wherein each of the plurality of apertures being sized to receive at least one of the tubes therethrough.

8. The tube bundle device according to claim 7, further comprising a housing, wherein the tube bundle is received within the housing, wherein each of the fixed baffles having an outer perimeter and a blocking area formed between the outer perimeter and the plurality of apertures, wherein the blocking area being sized to be located within a gap between the housing and outer tubes of the tube bundle.

9. The tube bundle device according to claim 8, wherein the tube bundle having at least one partition lane separating a portion of the tubes of the tube bundle with another portion of the tubes of the tube bundle, wherein each fixed baffle having partition lane blocking area formed therein, wherein each partition lane blocking area being sized to be received within the corresponding partition lane of the tube bundle.

10. The tube bundle device according to claim 9, wherein the tube bundle having a longitudinal axis, wherein the at least one displaceable support baffle and the at least one fixed baffle are spaced along the longitudinal axis.

11. The tube bundle device according to claim 10, wherein each displaceable support baffle is spaced from an adjacent fixed baffle.

12. The tube bundle device according to anyone of the preceding claims, wherein the tube bundle having at least one partition lane separating a portion of the tubes of the tube bundle with another portion of the tubes of the tube bundle, wherein each displaceable support baffle having partition lane blocking area formed therein, wherein each partition lane blocking area being sized to be received within the corresponding partition lane of the tube bundle, wherein the partition lane blocking area having a first part on the first portion and a second part on the second portion.

13. The tube bundle device according to claim 12, wherein the plurality of apertures is a plurality of spaced apart slots.

14. The tube bundle device according to claim 13, wherein the plurality of slots extend generally parallel to the partition lane blocking area.

15. The tube bundle device according to claim 14, wherein each displaceable support baffle further comprising:

a plurality of support ribs, wherein each support rib extends substantially parallel to the plurality of slots.

16. The tube bundle device according to claim 14, wherein each displaceable support baffle further comprising:

at least one reinforcement rib extending in a direction substantially orthogonal to the support ribs and the slots, wherein each rib intersecting at least one rib and at least one slot.

17. A displaceable support baffle for use in supporting a plurality of tubes in a tube bundles, comprising:

a first plate having a plurality of apertures formed therein;

a second plate having a plurality of apertures formed therein;

wherein each of the first plate and the second plate having an outer perimeter and a blocking area formed between the outer perimeter and the plurality of apertures;

a first fastener assembly for securing the first plate to the second plate in a first loading position; and

a second fastener assembly for securing the first plate to the second plate in a second installed position.

18. The displaceable support baffle according to claim 17, wherein each of the first plate and the second plate having partition lane blocking area, wherein the partition lane blocking area being sized to be located in a partition lane in a tube bundle, wherein the partition lane blocking area on the first plate being positioned adjacent the partition lane blocking area on the second plate.

19. The displaceable support baffle according to claim 18, wherein the first fastener assembly being located on the partition lane blocking area of the first plate and the second plate.

20. The displaceable support baffle according to claim 18, wherein the second fastener assembly being located on the partition lane blocking area of the first plate and the second plate.

21. The displaceable support baffle according to claim 18, wherein the plurality of apertures is a plurality of parallel slots, wherein each slot being sized to locate at least one tube therein.

22. The displaceable support baffle according to claim 21, wherein the plurality of slots extend generally parallel to the partition lane blocking area.

23. The displaceable support baffle according to claim 21, wherein the plurality of slots extend generally perpendicular to the partition lane blocking area.

24. A method of supporting a tube bundle having a plurality of tubes arranged parallel to one another in tube rows and longitudinal axis extending in a direction generally parallel to the plurality of tubes, the method comprising:

locating at least one displaceable support baffle on the tube bundle along the longitudinal axis, each displaceable support baffle having a plurality of apertures formed therein, wherein each of the plurality of apertures being sized to receive at least one of the tubes therethrough, wherein each displaceable support baffle having a first portion and a second portion, wherein a portion of the plurality of apertures being located on the first portion and another portion of the plurality of apertures being located on the second portion,

displacing the first portion with respect to the second portion to an installed position; and

securing the first portion to the second portion such that the first portion and the second portion are maintained in the installed position.

25. The method according to claim 24, wherein displacing the first portion with respect to the second portion causing deflection of the tubes passing through the plurality of apertures.

26. The method according to claim 25, wherein displacing the first portion with respect to the second portion comprising inserting an insert between the first portion and the second portion.

27. The method according to claim 24, further comprising:
locating at least one fixed baffle on the tube bundle along the longitudinal axis, wherein each of the at least one fixed baffle having a plurality of apertures formed therein, wherein each of the plurality of apertures being sized to receive at least one of the tubes therethrough.

28. The method according to claim 27, wherein each fixed baffle being spaced from an adjacent displaceable support baffle.