

DEVICE FOR CLEANING TUBES

Field of the Invention

[0001] The present invention generally relates to devices used for cleaning tubes. In particular, the invention relates to a device that is utilized for cleaning the internal surface of tubes used in heat exchange systems.

Background of the Invention

[0002] Heat exchangers are employed throughout various installations in different industries with the primary purpose of gaining or rejecting heat. Some of the most common applications of heat exchangers are found in condensers and evaporators for air conditioning systems and production plants. They are also used in other industries like power plants, refineries, desalination plants and petrochemical installations.

[0003] Typically, heat exchange systems achieve the purpose of heat transfer by circulating fluid through a bundle of tubes in the system. The nature of fluids flowing within the tubes can result in fouling, for example accumulation of debris, biological growth, build-up of scale and corrosion. As a result, periodic cleaning of the tubes is essential to maintain optimal performance of the heat exchange system. Techniques of tube cleaning are broadly categorized into on-line and off-line methods.

[0004] Off-line cleaning methods, for example rod-and-brush method, chemical cleaning method and high-pressure water jetting method, involve an external cleaning process that requires shutting down the entire heat exchange system before cleaning can be initiated. These off-line cleaning methods are time consuming and labour intensive which make them undesirable for installations requiring short turn-around time. In contrast, on-line cleaning methods utilize cleaning systems that clean heat exchanger tubes while the heat exchange system is in continuous operation. On-line cleaning methods are normally automatic, rendering an extended continuous length run between each regular maintenance shutdown. Hence, they are suitable for implementation into installations that either operates for long hours or sensitive to long system shutdown time.

[0005] One type of on-line cleaning method involves circulating multiple foam balls through the heat exchange system, whereby the foam balls will remove and push out fouling deposits in every tube they travel through. U.S. Pat. No. 5,520,712 disclosed an abrasive cleaning ball made from sponge rubber material and constituted by short lengths of abrasive material. J.P. Pat. No. 58,244,423 discloses another type of cleaning ball with an oval spherical shape containing fibers. In J.P. Pat. No. 58,016,125, fibers are fixed on a hollow cleaning ball having small holes. This type of cleaning ball was claimed to be much better than conventional sponge ball with respect to the displacement of water and air. Although the aforesaid cleaning balls are used in cleaning conventional tubes with smooth internal surfaces, they may not be as effective in cleaning evolutionary heat exchange systems that employ enhanced tubes.

[0006] Traditionally, tubes used in heat exchange systems are manufactured with a smooth internal surface (smooth bore). With the advancement of heat transfer technologies, new features are incorporated onto the tubes to improve the performance and efficiency of heat exchange systems. These new improved tubes are known as enhanced tubes and super enhanced tubes. In contrast with the conventional smooth bore tubes, the enhanced tubes have an internal “rifling” feature, which is basically a spiral groove inside the tube. The spiral groove provides more surface area for heat transfer and creates more turbulence in the fluid passing through the tubes. In addition, the enhanced tubes have thinner tube walls in comparison with conventional tubes so as to provide a more efficient overall heat transfer.

[0007] Efficiency of the heat exchange system is determined by the cleanliness of the heat transfer surfaces of the tubes. In order to maintain the efficiency and life span of the heat exchange system, it is vital to remove any fouling within the tubes. Over the years, the improvement in heat transfer rates by enhancing the tubes has greatly increased the performance and efficiency of heat exchange systems. However, cleaning these enhanced tubes is more difficult and complicated due to its internal spiral groove. The enhanced tubes are more prone to foulings. Their thin tube walls are also more susceptible to localized pitting failure due to microbiologically influenced corrosion (MIC) and under-

deposit corrosion. To prevent these types of corrosion, cleaning of the tubes must be constantly and consistently implemented in order to remove the foulings as they occur.

[0008] Currently, conventional foam balls are not effective in removing the foul deposits formed on the spiral grooves of internal rifling in enhanced tubes. The conventional foam balls merely translate through the tubes and do not provide positive physical contact to the spiral grooves to effectively remove any foul deposits accumulated there. In order to fully harness the advantages of an on-line cleaning method, there is an imperative need to have a device that is capable of cleaning the spiral grooves of enhanced tubes efficiently and effectively. This invention satisfies this need by disclosing a device for cleaning tubes, in particular enhanced tubes. Other advantages of this invention will be apparent with reference to the detailed description.

Summary of the Invention

[0009] The present invention provides a device that is utilized for cleaning tubes, in particular the internal surface of tubes in heat exchange systems.

[0010] Accordingly, in one aspect, the present invention provides the device used for cleaning tubes, comprising a mass with an aperture centrally located thereon; and a plurality of filaments mounted on the mass. The aperture further comprises: a first opening at one extremity of the aperture; a second opening at the other extremity of the aperture, wherein the size of the second opening is relatively larger than the first opening; and a thread internally disposed in the aperture. The plurality of filaments further comprises: a plurality of first filaments, wherein the first filaments are disposed in a fin-like arrangement, wherein the first filaments has a semicircular span, wherein the first opening of the aperture is centrally disposed on the semicircular span of the first filaments; a plurality of second filaments, wherein the second filaments are disposed in a spiral arrangement on the surface of the mass, wherein the central axis of the spiral arrangement of the second filaments corresponds to the central axis of the mass; and wherein the length of the first filaments are relatively shorter than the length of the second filaments.

Brief Description of the Drawings

[0011] Preferred embodiments according to the present invention will now be described with reference to the drawings, in which like reference numerals denote like elements.

[0012] FIG. 1 illustrates a perspective view of the cleaning device.

[0013] FIG. 2 illustrates a cross-sectional side view of the cleaning device.

[0014] FIG. 3 illustrates a side view of the cleaning device.

[0015] FIG. 4 illustrates a longitudinal cross-sectional view of the cleaning device operating inside an enhanced tube.

[0016] FIG. 5 illustrates a fragmentary cross-sectional view of the heat exchange system.

Detailed Description of the Invention

[0017] The present invention may be understood more readily by reference to the following detailed description of certain embodiments of the invention.

[0018] Numerous contraptions have been devised for the purpose of cleaning tubes. In some industries, tubes are used in heat exchange systems for transferring heat. These tubes can be classified into conventional smooth bore tubes, enhanced tubes and super-enhanced tubes, as was discussed hereinabove. The present invention describes a device that can be used for cleaning these types of tubes. For exemplary purposes, the following descriptions will illustrate the device in cleaning enhanced tubes.

[0019] **FIG. 1** illustrates a perspective view of a cleaning device **1** that comprises a mass **2** with a centrally located aperture **10**, wherein the mass has various filaments **20, 21** embedded thereon. **FIG. 3** shows a side view of the cleaning device **1**, wherein the filaments **20** and **21** are disposed in certain patterns that will be discussed subsequently. The mass **2** is preferred to be spherical in shape with a central axis **AA**, and made from incompressible material, for example engineered plastics. These types of engineered plastics can withstand a wide range of temperatures and are resistant to a variety of chemicals. In alternative embodiments, the shape of the mass **2** may be non-spherical, for example oval-shaped.

[0020] FIG. 2 shows a cross-sectional side view of the cleaning device 1, wherein the aperture 10 of the cleaning device 1 is preferably conical in shape to enable fluid to flow into the larger opening 12 and exit from the smaller opening 11. Fluid flowing through the aperture 10 creates a difference in the dynamic fluid pressure between the openings 11 and 12, wherein the dynamic fluid pressure near the region of the larger opening 12 is slightly higher than the dynamic fluid pressure near the smaller opening 11. This differential dynamic fluid pressure facilitates the translation of the cleaning device 1 linearly along the internal of an enhanced tube 30, wherein the translation of the cleaning device 1 is in the same direction as the fluid flow 41 (see FIG. 4). The aperture 10 comprises an internal fin-like thread 14, to manipulate the flow of fluid through the aperture. The thread 14, coupled with the aperture 10 transforms the energy from the fluid flowing through the aperture into a motive force that drives the cleaning device 1 in a spiral motion 40 inside the enhanced tube 30.

[0021] FIG. 3 illustrates one embodiment of the cleaning device 1, wherein a plurality of shorter filaments 20 is mounted on the mass 2 in a fin-like arrangement. This fin-like arrangement has a semicircular span, wherein the smaller opening 11 is centrally disposed thereon. When the cleaning device 1 enters any tube, the fluid that impinges on the shorter filaments 20 orientates the cleaning device into the direction of the fluid flow 41 as shown in FIG. 4. In this orientation, the smaller opening 11 of the cleaning device 1 translates through the enhanced tube 30 first, thereby allowing fluid flow 41 through the aperture 10 to create a differential dynamic fluid pressure on the cleaning device 1. In another embodiment, the shorter filaments may be replaced by a fin component that is preferably made from the same material as the mass 2. Similarly, this fin component has a semicircular span, wherein the smaller opening 11 is centrally disposed thereon. The length of the shorter filaments 20 can be predetermined so that the shorter filaments may not inhibit the movement of the cleaning device 1 into the enhanced tube 30.

[0022] A plurality of longer filaments 21 is mounted on the outer surface of the mass 2, wherein the length of the longer filaments 21 are relatively longer than the length of the shorter filaments 20. Enhanced tubes 30 are manufactured with an internal rifling, as

was discussed hereinabove, wherein the high points and low points of the rifling are known as lands **31** and grooves **32** respectively (see **FIG. 4**). The lengths of the longer filaments **21** are advantageously predetermined so that they can reach and clean the grooves **32** of the enhanced tube **30** effectively. In one preferred embodiment, the longer filaments **21** are mounted in a spiral arrangement on the mass **2** as shown in **FIG. 3**, wherein the central axis of this spiral arrangement corresponds to the central axis **AA**. This spiral arrangement of longer filaments **21** provides an additional mechanism for transforming the energy of fluid flow into a motive force that drives the cleaning device **1** in a spiral motion **40** through the enhanced tube **30**.

[0023] Both types of filaments **20**, **21** can be made from engineered materials with thermal and chemical resistance. The shorter filaments **20** are advantageously preprocessed to be more rigid than the longer filaments **21**. This is to ensure that the fluid flow **41** is able to impinge on the shorter filaments **20** substantially to allow the smaller opening **11** to translate through the enhanced tube **30** first. Furthermore, the flexibility of the longer filaments **21** is engineered to prevent any risks of scratching or damage on the internal surface of the enhanced tubes **30** during cleaning, and to ensure the effective removal of the deposits on the lands **31** and grooves **32**.

[0024] The operation of the cleaning device **1** in a heat exchange system **60** will now be described. **FIG. 5** shows the heat exchange system **60** that comprises an inlet end **52**, a discharge end **53** and a heat exchange unit **50**. The heat exchange unit **50** further consists of a bundle of enhanced tubes **30** and spaces **35** around the enhanced tubes. Typically, fluid flows from the inlet end **52** into the enhanced tubes **30** and out into the discharge end **53** of the heat exchange system **60**, as illustrated by the direction of fluid flow **41**. Heat transfer occurs when the fluid flowing through the enhanced tubes **30** exchanges heat energy with another fluid medium in spaces **35** and the walls of the heat exchange unit **50**. A circulating pump (not shown) is incorporated within the heat exchange system **60** to generate a pressure differential for circulating the fluid in the heat exchange system. This pressure differential is the main motive force for driving the cleaning device **1** in the heat exchange system **60**.

[0025] In one embodiment, the mass **2** used in the present invention may consist of a weighted core **15** (see **FIG. 4**), wherein the weighted core is variable in mass and size. The variation of the weighted core **15** allows the specific gravity of the cleaning device **1** to be advantageously modified. In most configurations of heat exchange systems, the plurality of tubes is bundled together. **FIG. 5** illustrates the heat exchange system **60**, wherein the length of enhanced tubes **30** is laid in a horizontal configuration. The cleaning devices **1** with different specific gravity translate at different levels in the fluid and have a higher tendency to enter various enhanced tubes **30**. This provides an even cleaning distribution of the cleaning devices **1** in the heat exchange system **60** that increases the probability of more tubes being cleansed by the cleaning devices **1**. Hence, the overall efficiency of the cleaning process can be improved. In another embodiment, the mass **2** may comprise plastic materials with different densities for manipulating and modifying the specific gravity and physical properties of the cleaning device **1**.

[0026] When the cleaning device **1** enters a particular enhanced tube **30**, the energy of fluid flow **41** acting on the fin-like pattern of the set of shorter filaments **20** maneuvers the cleaning device **1** into an orientation that enables the smaller opening **11** of the mass to enter the internal of the enhanced tube **30** first. This orientation of the cleaning device **1** allows the fluid in the enhanced tube **30** to flow through the larger opening **12** of the aperture **10** in the mass **2** and exit from the smaller opening **11**, thereby creating a slight localized dynamic fluid pressure difference that facilitates the translation of the cleaning device towards the end of the enhanced tube **30**. **FIG. 4** illustrates one exemplary embodiment of the cleaning device **1** operating in an enhanced tube **30**. When the cleaning device **1** enters an enhanced tube **30**, the circulating pump provides the main motive force for driving the cleaning device through the enhanced tube. In addition, the aperture **10** of the cleaning device **1** in the enhanced tube **30** creates a differential dynamic fluid pressure on the mass **2**, as was discussed hereinabove.

[0027] Simultaneously, the internal fin-like thread **14** of the aperture **10** and the arrangement of the longer filaments **21** serve as mechanisms for transforming the energy of the fluid flow **41** within the enhanced tube **30** into a motive force that drives the cleaning device in a spiral motion **40** inside the enhanced tube. The weighted core **15** is also

asymmetrically positioned in the mass **2** to facilitate the rotation of the cleaning device **1** when the cleaning device translates in a spiral motion **40** along the internal of the enhanced tube **30**. In the other embodiment, the mass **2** that comprises different densities of plastics can also facilitate the rotation of the cleaning device **1** when the cleaning device translates in a spiral motion **40**.

[0028] During the spiral motion **40** of the cleaning device **1**, any foul deposits on the grooves **32** are removed by the longer filaments **21** and carried out of the enhanced tubes **30** by the fluid flow **41**. The methods of extracting the foul deposits that were removed from the grooves are known to those skilled in the art, and will not be discussed herein. The size of the cleaning device **1** and the length of the filaments **20**, **21** can be engineered to suit the sizes of tubes or pipes in other industries, for example pigging applications in oil and gas industries, sewage treatment plants, ship tankers, airlines, cooling water-lines and others.

[0029] While the foregoing descriptions of the present invention presented certain preferred embodiments, it is to be understood that these descriptions are exemplary and are not intended to limit the scope of the present invention. It is expected that those skilled in the art will perceive variations which, while differing from the foregoing, do not depart from the spirit and scope of the invention as herein described and claimed.

CLAIMS

What is claimed is:

1. A device used for cleaning tubes, comprising:
a mass with an aperture centrally located thereon; and
a plurality of filaments mounted on the mass.
2. The device as claimed in claim 1, wherein the mass is spherical in shape.
3. The device as claimed in claim 1, wherein the aperture comprises:
a first opening at one extremity of the aperture;
a second opening at the other extremity of the aperture, wherein the size of the second opening is relatively larger than the first opening; and
a thread internally disposed in the aperture.
4. The device as claimed in claim 3, wherein the aperture is conical in shape.
5. The device as claimed in claim 1, wherein the plurality of filaments comprises:
a plurality of first filaments, wherein the first filaments are disposed in a fin-like arrangement, wherein the first filaments has a semicircular span, wherein the first opening of the aperture is centrally disposed on the semicircular span of the first filaments;
a plurality of second filaments, wherein the second filaments are disposed in a spiral arrangement on the surface of the mass, wherein the central axis of the spiral arrangement of the second filaments corresponds to the central axis of the mass; and
wherein the length of the first filaments is relatively shorter than the length of the second filaments.
6. The device as claimed in claim 1, wherein the mass is made from engineered plastic materials.
7. The device as claimed in claim 1, wherein the mass further comprises:

a weighted core, wherein the weighted core is asymmetrically positioned in the mass.

8. The device as claimed in claim 7, where the weighted core is made of metal.
9. The device as claimed in claim 7, wherein the weighted core have different masses and sizes that provides a variety of relative density of the device.
10. The device as claimed in claim 1, wherein the mass is made from plastics with different densities that provides a variety of relative density of the device.