FIG. 1 to FIG. 9 shows multiple cross-sectional views of a heat exchanger with the plurality of tubes arranged in various configurations.

FIG. 10A to FIG. ~~12~~ 10F shows different variations of the plurality of projectiles.

FIG. 11A to FIG. 11F shows further variations of the plurality of projectiles.

FIG. 12A to FIG. 12I shows even further variations of the plurality of projectiles.

Detailed Description of the Embodiments

Reference will now be made in detail to an exemplary embodiment of the present invention. While the invention will be described in conjunction with the embodiment, it will be understood that they are not intended to limit the invention to these embodiments. On the contrary, the invention is intended to cover alternatives, modifications and equivalents, which may be included within the spirit and scope of the invention as defined by the appended claims. Furthermore, in the following detailed description of embodiments of the present invention, numerous specific details are set forth in order to provide a thorough understanding of the present invention. However, it will be recognized by one of ordinary skill in the art that the present invention may be practiced without these specific details. In other instances, well-known methods, procedures, components, and circuits have not been described in detail as not to unnecessarily obscure aspects of the embodiments of the present invention.

For purposes of brevity and clarity, descriptions of an embodiment of the present invention are limited hereinafter to a method for cleaning a heat exchanger 10, in accordance with the drawings in FIG. 1 to FIG. 9. This however does not preclude embodiments of the invention where fundamental principles prevalent among the various embodiments of the invention such as operational, functional or performance characteristics are required.

In an exemplary embodiment of the present invention, a method for cleaning a heat exchanger 10 or heat exchange system is described hereafter. The heat exchanger 10 comprises a plurality of tubes 12. The plurality of tubes 12 is, for example, an evaporator or a condenser of heating, ventilation, and air-conditioning (HVAC) systems or the like heat-exchange systems. For such heat exchange systems, heat

transfer occurs at one or more segments containing the plurality of tubes 12. The plurality of tubes 12 are typically clustered as a module with an intake at a first header of the heat exchanger 10, wherethrough a fluid is introduced, and an exhaust at a second header of the heat exchanger 10, wherefrom the fluid passaging through the plurality of tubes 12 is subsequently discharged.

There is a displacement pump for circulating the fluid, which may be in a liquid or gaseous state, or a combination thereof, through the heat exchange system, specifically through the plurality of tubes 12. The displacement pump is used to pump the fluid into the intake at the first header for passaging through the plurality of tubes 12. The method of cleaning the heat exchanger 10 may be used in conjunction with the operation of the heat exchanger 10, i.e. when the displacement pump is circulating the fluid through the plurality of tubes 12.

The heat exchange system comprises an insertion unit, having a plurality of projectiles 20 stored therein. The insertion unit functions to introduce or insert the plurality of projectiles 20 into the heat exchanger 10. In conjunction with the operation of the heat exchanger 10, the plurality of projectiles 20 is inserted into the fluid, such that the projectiles are distributed within the fluid. When the fluid is passaging through the plurality of tubes 12, the projectiles 20 flow together with the fluid through the tubes 12. As the flow progresses, the plurality of projectiles 20 abrade the inner surface of at least one tube 12, thereby encountering and removing particles along the inner surfaces of the tubes 12. The fluid, together with the plurality of projectiles 20, is discharged out the exhaust at the second header. Among the plurality of projectiles 20, at least one projectile 20 has a different specific gravity, relative to the fluid, from at least one of the remaining projectiles 20.

The specific gravity relative to the fluid is defined as the ratio of the density of the projectile 20 to the density of the fluid. For example, a projectile 20 with a higher density than that of the fluid will have a ratio of more than one; and a projectile 20 with a lower density than that of the fluid will have a ratio of less than one. In this embodiment, the plurality of tubes 12 are arranged horizontally such that the plurality of tubes 12 may be separated into three distinct portions – top ~~12~~14, middle ~~14~~16, and bottom ~~16~~18. As the fluid containing the projectiles 20 is pumped into the

plurality of tubes 12 via the intake at the first header, the projectiles 20 will distribute themselves among the top 14, middle 16, and bottom 18 portions of the plurality of tubes 12, depending on the specific gravity of each projectile 20. Projectiles 20 with a specific gravity equal to unity will stay buoyant within the fluid, such that the projectiles 20 suspend in the fluid around a middle portion 16 of the plurality of tubes 12. Projectiles 20 with a specific gravity of less than unity will float in the fluid around a top portion 14 of the plurality of tubes 12. Projectiles 20 with a specific gravity of more than unity will sink in the fluid around a bottom portion 18 of the plurality of tubes 12.

The advantage of having projectiles 20 with different specific gravities is that with such control of the specific gravities, the user is able to determine what portion of the projectiles 20 goes to which portion of the plurality of tubes 12. For example, in some heat exchangers 10, the plurality of tubes 12 may not be evenly distributed in the top 14, middle 16, and bottom 18 portions. Some heat exchangers may have more tubes 12 in the top portion 14 and lesser tubes 12 in the bottom portion 18. Some examples of such arrangements and configurations can be seen in FIG. 1 to FIG. 9. Hence, by way of example and not limitation, by having more projectiles 20 with lower specific gravities and lesser projectiles 20 with higher specific gravities, there will be more projectiles 20 going to the top portion 14 of the plurality of tubes 12 and lesser projectiles 20 going to the bottom portion 18 of the plurality of tubes 12. This leads to a more even distribution of the plurality of projectiles 20 within the plurality of tubes 12. The user thus has the advantage of controlling the portion of projectiles 20 going to whichever portion of the plurality of tubes 12. In contrast, if projectiles 20 of the same specific gravity are used, the projectiles 20 will float or sink to the portion of the plurality of tubes 12 where their buoyancy allows them to be. In some cases, some of the tubes 12 will not receive any projectiles 20, because their buoyancy does not allow them to reach those tubes 12, and those tubes 12 will not be cleaned as there will not be any projectiles 20 passaging therethrough.

The projectiles 20 may also be known as cleaning balls or elastomeric balls. The projectiles 20 may also be made of other types of resilient materials. Unlike large sponge balls used in prior art systems, the elastomeric projectiles are highly resilient and not as compressible as the sponge balls. The elastomeric projectiles are not

designed for compression while they squeeze through the tubes. Instead, the elastomeric projectiles are designed to be smaller than the internal diameter of the tubes for bouncing inside the tubes. The resilient material of the elastomeric projectiles allows them to sustain continued wear and tear as they bounce and move through the tubes for cleaning thereof

As the plurality of projectiles 20 are introduced into the first header, the projectiles 20 travel through the plurality of tubes 12 for cleaning thereof. The projectiles 20 are thus dimensioned to be smaller than the internal diameter of the plurality of tubes 12, i.e. the largest width of each projectile 20 is smaller than the largest internal diameter of each tube 12. For example, each projectile 20 may have a largest width of 11 to 12 millimeters, while the largest internal diameter of each tube 12 is 15 to 16 millimeters. Preferably, the ratio between the largest width of the projectile 20 and the largest internal diameter of the tube 12 is between 0.75 and 0.85. The tolerance of 3 to 5 millimeters between the projectiles 20 and the inner surface of the tube 12 allows the projectiles 20 to have some degree of freedom of movement within the tube 12. Thus, the projectiles 20 can bounce or ricochet off the inner surface of the plurality of tubes 12 while passaging therethrough for dislodging of debris and deposit therefrom and cleaning thereof. In addition, by having the projectiles 20 smaller than the internal diameter of the tube 12, the projectiles 20 will not be trapped while being carried therethrough, as in the case of a prior art system in which the projectile 20 is larger than the internal diameter of the tube 12 and is being forced through the tube 12 to scrape deposits off the inner surface thereof.

Subsequent to the passaging of the plurality of projectiles 20 through the plurality of tubes 12 and the cleaning thereof, the projectiles 20 have to be retrieved for storage and/or future usage. Preferably, the heat exchanger 10 comprises a configuration means, as commonly known in the art, which selectively impedes the passage of the projectiles 20 through the tubes 12. By way of example and not limitation, the heat exchanger 10 may comprise a flow diverting system coupled to the exhaust and a trap disposed proximal thereto. The flow diverting system and the trap is configurable for collecting the projectiles 20 that are discharged out of the tubes 12, thus preventing further transport of the projectiles 20 through the rest of the heat exchange system 10. Alternatively, the flow diverting system and trap may be

configured such that the projectiles 20 are not collected thereby, but instead are transported through the rest of the heat exchanger 10 and back to the intake for another cycle of cleaning of the tubes 12. Other configuration means known to the person having ordinary skill in the art may also be implemented in the heat exchanger 10.

With reference to FIG. 10A to FIG. 10F, FIG. 11A to FIG. 11F, and FIG. 12A to FIG. 12I, each of the projectiles 20 has a centre of mass that may be at any location or point within the body 22 of the projectile 20. Using an example of a single, uniform, spherical projectile 20, its centre of mass is positioned at its geometric centre. The position of the centre of mass in the projectile 20, i.e. the offset of the centre of mass away from the geometric centre, affects the lateral bouncing of the projectile 20 when passaging through a tube 12. The greater the offset is towards the surface 24 of the projectile 20, the greater will be the lateral bouncing of the projectile 20. This leads to increased randomness of the bouncing of the projectiles 20 when passaging through the tubes 12.

The offset and the specific gravity of each projectile 20 may be varied through different means. The following describes some non-limiting examples of such means.

Each projectile 20 has a geometric centre within its body 22 and an outer surface 24, and the centre of mass may be positioned anywhere within the body 22, between the geometric centre and the outer surface 24, inclusive. A projectile 20 with a uniform material composition will have the centre of mass at the geometric centre, while a projectile 20 with non-uniform material composition, such as through a combination of two structural portions 26 and 28 with different material compositions, will have the centre of mass positioned away from the geometric centre.

The projectile 20 may include a hollow portion 30 within the projectile 20, thereby shifting the centre of mass away from the hollow portion 30. Alternatively or additionally, a ball bearing made of metal and/or other material, may be placed in the hollow portion 30. A recess 32 may also be created on the surface 24 of the projectile 20. The recess 32 may be shallow through a small portion under the surface 24, or the recess 32 may be deep through till near or through the opposite

side of the surface 24. The recess 32 may be a straight or tapered bore to provide greater variation to the location of the centre of mass. The projectile 20 may also comprise of multiple structural portions, for example 26 and 28, combined together. Each portion may have a material that is different from the other portions. The non-uniformity of the material composite of the projectile 20 provides varying degrees of the offset of the centre of mass from the geometric centre. Other methods of varying the position of the centre of mass, known to the skilled person, are also possible.

Preferably, at least one projectile 20 comprises bristles 34 extending outwards from the surface 24 of the projectile 20. The bristles 34 may be disposed all around the surface 24 of the projectile 20, or only on a portion of the surface 24. The bristles 34 advantageously assist in the abrading and scraping of deposits from the inner surface of the plurality of tubes 12 when the projectiles 20 are passaging therethrough. Moreover, the inner surface of the tubes 12 may not be entirely smooth and may comprise a rifling grain, such as enhanced tubes. The bristles 34 thus assist in removing deposits from the grooves of the inner surface of the tubes 12. Alternatively or additionally, where the projectile has its surface partially covered with the bristles, the bristled portion will scrub against the grooves of the enhanced tubes, while the non-bristled portion will scrub against the landings of the enhanced tubes, thereby providing a more uniform scrubbing action against the insides of the enhanced tubes.

In cleaning the heat exchanger 10, the fluid is pumped through the plurality of tubes 12, with the plurality of projectiles 20 transported within the fluid. Preferably, the rate of flow of the fluid through the tubes 12 is controllable by a system and/or device implemented in the heat exchange system. By controlling the rate of flow of the fluid through the tubes 12, the speed of the projectiles 20 through the tubes 12 can thus be controlled. For example, a projectile 20 travelling at a higher speed will be subjected to greater bounce and higher frictional forces. Therefore, the projectile 20 will bounce more within the internals of the tube 12, and every contact with the inner surface of the tube 12 has a higher frictional force thereon. The higher frictional force improves the abrading of the inner surface of the tube 12 and thus provides for more efficient cleaning of the tube 12.

In a foregoing manner, a method of cleaning a heat exchanger 10 is described according to an exemplary embodiment of the invention. Although only one embodiment of the invention is disclosed in this document, it will be apparent to one skilled in the art in view of this disclosure that numerous changes and/or modifications can be made to the disclosed embodiment without departing from the scope and spirit of the invention.