

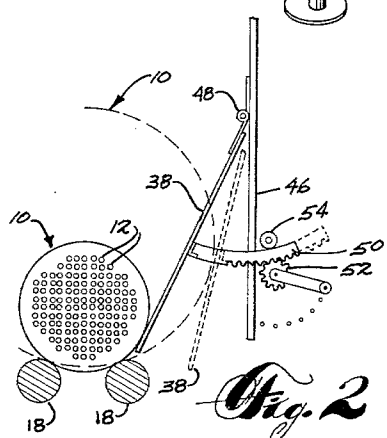
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APPARATUS FOR CLEANING HEAT EXCHANGER TUBES

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APPARATUS FOR CLEANING HEAT EXCHANGER TUBES

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2 Claims. (Cl. 51-14)

This application relates to an improved method and apparatus for cleaning foreign deposits, such as grease, scale, and the like, from the difficultly accessible interior surfaces of tubular heat exchanger reaction equipment.

Shell and tube heat exchangers are well known in the art and are extensively used as preheaters, superheaters, condensers, coolers, etc., in a myriad number of processes. The exchangers usually comprise an outer shell enclosing an assembled tubular bundle. Illustrations of such equipment are shown, for example, in chapter 28 of the book, "Unit Operation," by George Granger Brown & Associates, John Wiley & Sons, Inc., New York, 1950. The tubular bundle comprises a multiplicity of individual tubes retained in position in the tubular bundle by means of a plurality of stationary tube support sheets. Deposits of grease, carbon, scale or other foreign matter form both on the inside and outside surfaces of the tubes which constitute the difficultly accessible interior surfaces of the exchangers. These deposits impair the efficiency of the exchanger by reducing the heat transfer coefficients and restricting the fluid flow of material both through the inside and around the outside of the tubes. These deposits must, therefore, be periodically removed.

According to the improved method and apparatus of this invention the tubular bundle to be cleaned is contacted with a moving cleaning mixture comprising a liquid and an abrasive material in such a way that the lines of force of the moving cleaning mixture are continuously cut by the outside surfaces of the tubular bundle. This relative movement of the cleaning mixture and the outside surfaces of the tubular handle can be achieved by any suitable means. For example, one preferred means involves mechanically rotating the tubular bundle with its axis in a horizontal or inclined plane while continuously passing said cleaning mixture downwardly in a vertical plane through the tubular bundle. In one preferred embodiment, the inside surfaces of the individual tubes in the tubular bundle are cleaned by passage of a portion of said cleaning mixture through the inside of the tubes.

The method and apparatus of this invention will be further described with reference to the attached drawings which illustrate a preferred embodiment thereof and of which:

FIGURE 1 is a schematic drawing of the proposed apparatus; and

FIGURE 2 is a schematic drawing of a proposed means of adjusting and holding the position of the inclined side baffles of the trough-like cleaning assembly shown in FIGURE 1.

Referring to FIGURE 1, numeral 2 defines an outer housing of the cleaning apparatus. Numeral 4 defines the legs which support the outer housing 2 of the cleaning apparatus.

Numeral 10 refers to a tubular bundle to be cleaned. The tubular bundle 10 comprises a multiplicity of individual tubes 12 spaced from each other and generally held fixedly in the form of a circular bundle by two stationary tube support sheets 14 and 16 positioned at either end of the tubular bundle 10. Additional guide or support sheets can be spaced along the length of the tubular bundle 10 if desired. The tubular support sheets 14 and 16 rest on sets of rollers 18 and 20, respectively.

Additional sets of rollers or other means can be used to support the tubular bundle 10 if desired.

The set of rollers 20 can be powered by any suitable means. In FIGURE 1, rollers 20 are powered by a shaft 22 which is in turn connected to a motor 24. The set of rollers 20 is also fixedly attached by any suitable means, such as welding, to a plate 26 which is held in a fixed spacial position by any suitable support means, such as one or more angle irons 28, which are in turn fixedly attached to the side wall 29 of the outer housing 2 of the cleaning apparatus.

The set of rollers 18 is not powered and is fixedly attached to a plate 30 which is movably attached by any suitable means, such as by a set of wheels 32 to rails 34. The rails 34 are held in a fixed position by any suitable support means attached to the outer housing 2 of the cleaning apparatus. Conventional wheel lock means can be provided to lock the wheels 32 to the rails 34 when the rollers 18 are in the desired position.

Numeral 36 defines a trough-like assembly which consists of side baffles 38 and removable end plate baffles 40 and 42.

At least the lower edge and preferably the lower portion of each of the side baffles 38 are positioned almost tangent to the outer surface and below the center line of the tubular bundle 10 to keep the cleaning mixture in close proximity to the tubular bundle 10. Any suitable means can be provided to vary the distance of the side baffles 38 from the walls 44 and 46. One such means, as shown in FIGURE 1, is to attach the side baffles 38 to the walls 44 and 46 by means of a plurality of hinges 48. By hinging the side baffles 38, tubular bundles 10 of varying diameter can be accommodated for cleaning in the trough-like assembly 36.

The hinged side baffles 38 can be held in any fixed inclined position by any desired means. One such means, as shown in FIGURE 2, includes the use of a geared rack 50 which is attached to the side baffle 38 by any suitable means and passes through an appropriate opening in the walls 44 or 46 in the cleaning apparatus. The rack 50 is operated by a pinion gear 52 which in turn is operated in the usual manner. A follower wheel 54 is positioned on the upper side of the rack 50 to insure proper meshing of the rack and pinion gears.

The side baffles 38 are provided with a plurality of baffle guides 56 positioned near the movable end plate baffle 40. Above each of the baffle guides 56 and attached to the walls 44 and 46 of the outer housing 2 is a corresponding baffle guide 58. By the use of the baffle guides 56 and 58, the end plate baffle 40 can be placed in a number of positions and tubular bundles 10 of varying lengths can be accommodated for cleaning in the trough-like assembly 36.

End plate baffle 40 has a semi-circular opening 60 which has a radius slightly larger than the radius of the tubular bundle 10 to be cleaned so as to permit the passage of the tubular bundle 10 therethrough. The purpose of the end plate baffle 40 is to act as a loose seal and to keep the cleaning mixture in close contact with the tubular bundle 10 to be cleaned. The height of the end plate baffle 40 is preferably at least as high as the top of the side baffle 38. The sides of the end plate baffle 40 are truncated so as to permit the end plate baffle 40 to be positioned in the proper baffle guide 56 when the side baffles 38 are in their usual inclined position. A number of end plate baffles 40 are provided to accommodate the varying diameter tubular bundles 10 to be cleaned.

End plate baffle 42 is also provided with a semi-circular opening 62 which has a radius slightly larger than the radius of the tubular bundle 10 to be cleaned so as to permit the passage of the tubular bundle 10 therethrough. A number of baffles 42 are provided to accommodate the

various diameter tubular bundles. End plate baffle 42 is held in position by baffle guides 64 which are attached to the walls 44 and 46 and along the edge of a floor member designated by numeral 66. The floor member 66 is mounted permanently in a horizontal plane and is attached to walls 29, 44 and 46 at a point above the rollers 20. The top of end plate baffle 42 is lower than the top of end plate baffle 40 so as to act as a weir over which the cleaning mixture can flow into the compartment bounded by walls 29, 44 and 46, the floor member 66 and the end plate 42. This permits the cleaning mixture to enter the open ends of the tubes in the tubular bundle and clean the inside surfaces of the tubes while passing therethrough.

In order to aid the passage of the cleaning mixture through the inside of the tubes, the tubular bundle 10 can be inclined by any suitable means. Thus, the axis of the tubular bundle will rotate in an inclined plane, that is, in a plane which makes an oblique angle with the horizon. For example, the rollers 18 can be positioned at a lower elevation than the rollers 20 or means can be provided to elevate the entire cleaning apparatus on the side where the motor 24 is positioned. Means such as a variable length compression shaft attached to the forward wall 68 can be provided to hold the inclined tubular bundle 10 in position.

A number of vertical lift pumps 70 are provided to circulate the cleaning mixture from a point below the trough-like assembly 36 to a point in elevation above the trough-like assembly. Each of the vertical pumps 70 is provided with means for individual control so that fewer pumps can be used when shorter tubular bundles are cleaned.

In the apparatus as shown and discussed above, the set of rollers 20 and the rails 34 on which the set of rollers 18 rest are in a fixed position relative to vertical movement. As a result of this fixed roller level, the center of the tubular bundles to be cleaned is raised as the diameter of the tubular bundle increases. If desired, means can be provided to raise or lower the set of rollers 18 and 20 (along with rails 34, shaft 22 and motor 24) so as to maintain the center of the tubular bundles of the various diameters in the same vertical plane.

The assembly and operation of this cleaning apparatus are as follows. The side baffles 38 of the trough-like assembly 36 are adjusted to their widest opening. The set of rollers 18 is positioned on the rails 34 so that the distance between the midpoint of the rollers 18 and midpoint of the rollers 20 is adjusted to accommodate the length of the tubular bundle 10 to be cleaned. The tubular bundle 10 is lifted into the trough-like assembly 36 by any suitable means so that the tube support sheets 14 and 16 rest on the rollers 18 and 20, respectively. The side baffles 38 of the trough-like assembly 36 are adjusted to provide a rough fit with the tubular bundle 10. The proper end plate baffles 40 and 42 are inserted into the proper guide baffles 56-58 and 64, respectively. The motor 24 is started which rotates the tubular bundle 10 by means of shaft 22 and rollers 20. The appropriate number of pumps 70 are started to lift the cleaning mixture and discharge it on the tubular bundle 10 from a point in elevation above the tubular bundle. By virtue of the rotation as caused by the action of the motor 24, the shaft 22 and the sets of rollers 20 and 18, the outside surfaces of the tubular bundle 10 will continuously cut the lines of force of the descending cleaning mixture. As the volume of cleaning mixture increases, some cleaning mixture will overflow weir 42 and enter the compartment bounded by walls 29, 44 and 46, floor member 66, and the end plate 42 for passage through the inside of the tubes. A separate vertical lift pump can be inserted to provide cleaning mixture for this compartment if desired.

The cleaning mixture comprises a liquid and an abrasive material, and is circulated by any suitable means, for example, by vertical lift pumps, to a point in elevation above the tubular bundle to be cleaned. The cleaning mixture is then permitted to cascade between, around and

ture is then permitted to cascade between, around and through the tubular bundle by force of gravity. By "through" the tubular bundle, is meant not only through the spaces formed by the outside surfaces of the tubes, but also the spaces formed by the inside surfaces of the tubes. As a result thereof, grease, scale and other foreign material, are removed from the surfaces of the tubes both by the liquid and abrasive admixed therewith. The cleaning mixture itself is preferably periodically treated for removal of these foreign substances by any suitable means, for example, by flotation, distillation, etc.

The cleaning mixture as indicated above comprises a liquid and an abrasive material. The liquid portion of the cleaning mixture is preferably a solvent for the foreign substances to be removed from the surfaces of the tubes. The liquid can be, for example, water, naphthas, chlorinated hydrocarbons, such as chloroform, carbon tetrachloride, ethylene dichloride or ethylene perchloride; aromatics, such as benzene, toluene or xylenes, reagents, such as various acid or alkaline solutions, for example, acetic acid or sodium hydroxide solutions; and materials which will decrease the surface tension and increase wetability of the cleaning fluid. Also, materials which function to chelate, sequester or otherwise modify the solubility of deposits can be used.

The abrasive material is a solid and comprises metals or alloys, such as iron or steel, or naturally-occurring mineral substances, such as sand, gravel, or the like. The abrasive material should be hard enough to remove the foreign substances from the surfaces of the tubes while at the same time being soft enough so that the actual surface of the tube itself remains substantially undamaged. If the inside of any of the tubes in the bundle are plugged solid with foreign substances, they must, before becoming subject to the cleaning method of this invention, be unplugged by a suitable remaining procedure.

It is within the concept of this invention to employ several particle sizes of abrasive materials either concurrently or successively. That is, a small particle size abrasive material might be more advantageously employed initially when the spaces formed by the outside and inside surfaces of the tubes in the tubular bundle are the smallest. The abrasive particles can be spherical or irregularly shaped, but the particles will tend to the spherical form due to erosion of their own surfaces while performing the cleaning function. The particle size of the abrasive material can vary from about 74 microns to about 2,000 microns in diameter. The preferred dimensions of the abrasive material will depend as noted above upon the dimensions of the spaces formed by the outside and inside surfaces of the tubes.

In general, the greater the quantity of abrasive material which is used per unit volume of liquid, the more efficient the cleaning operation. However, if too much abrasive material is employed, it will tend to plug, especially inside the tubes instead of being washed away with entrained foreign substances.

The bulk of the cleaning mixture after passage through and between the tubes in the tubular bundle is recirculated by a vertical pump or pumps to a point in elevation above the tubular bundle where it again is permitted to cascade down, over, between and through the tubes. The force with which the cleaning mixture contacts the tubular bundle is equal to the mass of the cleaning mixture times its acceleration. By the term "lines of force" is meant the direction in which the force of the cleaning mixture acts. Thus, the cleaning mixture which is permitted to cascade down on the tubular bundle has lines of force acting in a generally vertical plane, which lines of force are cut by the outside surfaces of the tubular bundle which is caused to rotate with its axis in a horizontal or inclined plane. The discharge openings of the vertical lift pumps can be directed against appropriate baffles or can be placed at such a distance above the tubular bundle to be

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cleaned that the force of the impinging cleaning mixture will cause essentially no damage to the tubular bundle. The distance between the point of discharge on the vertical lift pump and the top of the tubular bundle can vary, for example, from several inches to ten feet or more. A portion of a cleaning mixture is continuously removed for a cleanup and portions of fresh liquid and abrasive materials are continuously added.

Any suitable means can be provided to agitate the cleaning mixture. For example, air jets can be provided in the bottom of the cleaning apparatus to maintain the abrasive materials in suspension in the liquid.

Any suitable means can be provided to heat the cleaning mixture to any desired temperature. For example, steam coils can be provided in the bottom of the cleaning apparatus. Increased temperatures promote solvent action of the cleaning mixture, but temperatures must be controlled to maintain the cleaning mixture substantially in the liquid phase.

In accordance with the invention, the lines of force of the moving cleaning mixture are continuously cut by the outside surfaces of the tubular bundle. As noted above, one preferred means for achieving this relative movement is to rotate the tubular bundle with its axis in a horizontal or inclined plane while continuously passing the cleaning mixture downwardly in a vertical plane through the tubular bundle. By rotating the tubular bundle there will be a more even distribution of the cleaning mixture over the outside surfaces of the tubular bundle. The speed of rotation can be between 0.1 to 10 or more revolutions per minute, but is preferably about 0.5 to 2 revolutions per minute in order to avoid excessive wear of the tubes or tube sheets by contact with portions of the cleaning apparatus.

Resort may be had to such variations and modifications as fall within the spirit and scope of the invention and the appended claims.

I claim:

1. Apparatus for cleaning simultaneously the inside and outside surfaces of a tubular bundle of a shell and tube heat exchanger comprising:

a partial enclosure open at the top and bottom;
means for supporting and rotating said tubular bundle longitudinally within said partial enclosure with the

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open ends of said tubular bundle exterior to said partial enclosure;

means for discharging a cleaning mixture comprising a liquid and an abrasive material on the outside surfaces of the tubular bundle, said partial enclosure maintaining the cleaning mixture in close contact with said tubular bundle;

an overflow compartment adjacent said partial enclosure and in communication with an open end of said tubular bundle;

one side of said partial enclosure defining an overflow weir mounted between the partial enclosure and said overflow compartment to thereby permit the cleaning mixture to overflow from the partial enclosure to the overflow compartment and thereby flow through the interior of the tubes and thereby clean the same.

2. Apparatus as defined in claim 1 in which the means for supporting and rotating said tubular bundle comprises a plurality of rollers, at least one set of which is powered.

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