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HEAT EXCHANGER FOR CORROSIVE, EROSIVE AND FAST SETTLING SLURRIES

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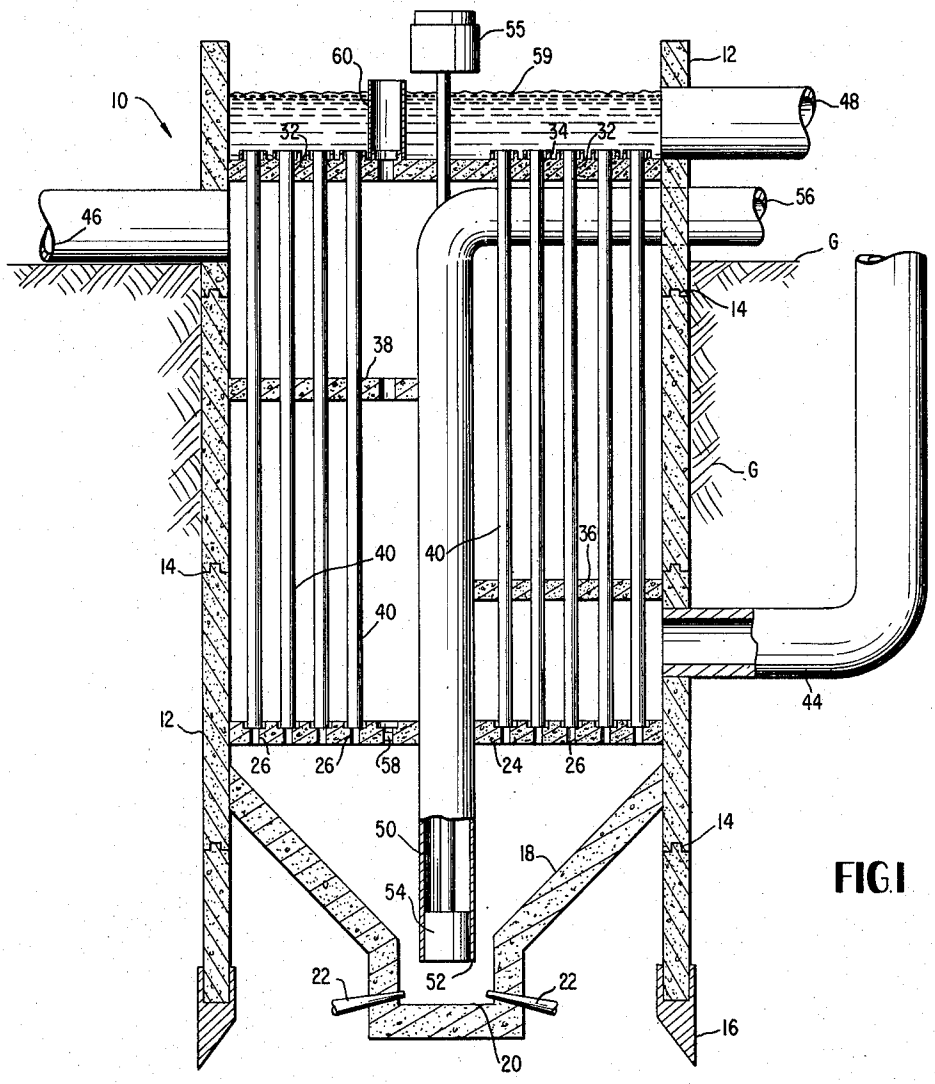
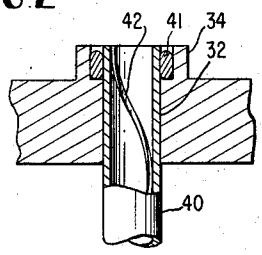


FIG. 1

FIG. 2



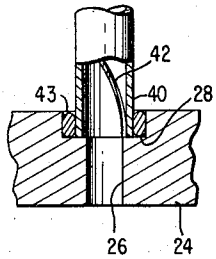


FIG. 3

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HEAT EXCHANGER FOR CORROSIVE, EROSIVE AND FAST SETTLING SLURRIES

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This invention relates to improvements in heat exchangers, and especially to improvements in vertical tubular heat exchangers, especially adapted for heat exchange between fast settling and corrosive slurries.

It is highly desirable that heat exchangers, which are used in a continuous process, be continuously operable. If a heat exchanger is subject to corrosive fluids or other means which cause its gradual deterioration, the desirability of replacing worn out components of the heat exchanger without affecting the continuous operation is evident. Accordingly, it is one object of this invention to provide a heat exchanger structure which is especially adapted for the removal and replacement of defective heat exchanger tubes.

In heat exchangers which are subjected to corrosive heat exchanger liquids, such as salt water, the need for anti-corrosion heat exchanger surfaces is apparent. However, such heat exchanger surfaces are usually quite expensive, therefore causing large heat exchangers to be exorbitantly expensive. It is a further object of this invention to provide a heat exchanger especially adapted for heat exchange of saline solutions and fast settling slurries which is constructed primarily of relatively inexpensive non-corrosive materials.

When handling large volumes of heat exchanger fluid, the energy required for pumping head could be considerable. However, by providing a heat exchanger with the fluid level substantially at ground level, the pumping head can be considerably reduced. This is another object of this invention.

A further object of this invention is to provide a heat exchanger especially adapted for heat exchange between a fast settling slurry and a liquid by constructing the heat exchanger with vertical tubes so that gravity assists in entrainment of fast settling solids, thus also lowering the errosive power of the slurry on the tubes. The friction head is minimized by low velocity flow through the vertical tubes by gravity head.

The heat exchanger of this invention is especially adapted to function as one of the heat exchangers disclosed in general in my copending application Serial No. 258,217, filed February 13, 1963, for Method for the Winning of Fresh Water From Saline Sources by Solvent Extraction as Modified by Surface Adsorption, and Apparatus Therefor. Although especially adapted for this use, it will be obvious to those skilled in the art that the heat exchanger is not to be limited thereto.

Other objects and advantages of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of example, the principles of the invention and the best mode which has been contemplated of applying these principles.

In the drawings:

FIG. 1 is a semi-schematic elevation view partially in section of the heat exchanger of this invention.

FIG. 2 is an enlarged sectional detail view of a tube hole in the top tube sheet.

FIG. 3 is an enlarged sectional detail view of a tube hole in the bottom tube sheet.

Referring now to the drawings, the heat exchanger structure of this invention is indicated generally at 10 and it includes a cylindrical casing 12 which may be made in a plurality of cylindrical sections having joints 14.

The casing is conveniently constructed of concrete similar to a caisson and includes a driving shoe 16 on the lower end thereof. In this manner the casing 12 may be driven into the ground G in the manner of a caisson, while the inside of the casing may be excavated to provide for the bottom of the heat exchanger. The heat exchanger includes a sloping bottom 18 with a sump 20, and this also may be constructed of concrete, on the surface of the excavated ground if desired. If the heat exchanger fluid has a number of solids therein (such as a fast settling slurry) these may be stirred up by suitable mixing means such as stirring jets 22, entering into the lowest portion of the sump 20 for injecting liquid to provide stirring up of the settling material when necessary. In my above referenced copending application the liquid would be the light phase liquid.

The heat exchanger portion inside the casing 12 includes a lower tube sheet 24 which may also be constructed of concrete or the like and this tube sheet has a plurality of tube holes 26 formed therein. At the top of each hole 26 there is a recessed seat 28 as shown in FIG. 3.

An upper tube sheet 30 is also constructed of concrete or the like and has a plurality of tube holes 32 aligned with the tube holes 26 of tube sheet 24. These tube holes 32 are surrounded at the top by a larger diameter upstanding flange 34, see FIG. 2, for a purpose to be described.

Also within the heat exchanger between the two tube sheets there may be a plurality of baffles which extend a portion of the way across the heat exchanger to provide a zigzag path for the heat exchange medium. Two baffles 36 and 38 are shown and these baffles may also be of concrete or other suitable material and may have holes therein aligned with the holes in the tube sheets.

There are a plurality of heat exchange tubes 40, which are straight tubes of a non-corrosive material such as copper or aluminum and may be of large diameter and thin wall. The thin wall of the tube is possible since there would not ordinarily be a large pressure differential between inside and outside of the tube. The tubes may have helical fins 42 having a height of approximately one-fourth the radius of the tube and a pitch of twelve times the radius of the tube for the purpose of insuring that one heat exchanger fluid swirls down in contact with the inside of each tube.

The tubes 40 are positioned in the holes in the tube sheets 24 and 30 and are sealingly received therein. More particularly, the lower end of tube 40 sits on the bottom of recessed seat 28 and a suitable O-ring seal 43 is provided between the outside of the tube and the outside edge of the seat. This allows the tube to be removed vertically. The upper end of each tube 40 is similarly sealed by an O-ring seal 41 compressed between the outside of the upper end of the tube and the inside of upstanding flange 34. Again, however, the tube may be removed vertically upward.

An inlet 44 above the bottom tube sheet 24 is provided for the introduction of a first heat exchanger fluid, for example, water. This heat exchanger fluid passes in zigzag fashion through the inside of the heat exchanger and exits through outlet tube 46 positioned below the top tube sheet 30.

A second heat exchanger fluid, for example, a slurry of adsorbent and light phase liquid, used in the process of my copending application referenced above, may enter through inlet tube 48 positioned above the top of tube sheet 30 and below the top of the casing 12. The second heat exchange fluid will flow vertically downward assisted by gravity through the tubes 40, swirling therein for a longer path and better heat exchange, and will exit below the lower tube sheet 24. A second heat exchanger fluid outlet tube 50 may be positioned in the center of

the heat exchanger and includes an inlet end 52 housing a pump 54 if desired. The pump in turn may be driven from a suitable motor 55. The heat exchanger fluid is then pumped through tube 50 to outlet 56 which is substantially at the level of the ground G.

In order to replace one of the tubes while the heat exchanger is still in service (if, for example, a tube is corroded away, broken, punctured or otherwise damaged), all that is necessary is to first place a sleeve 60 around the upstanding flange 34 at the location of the defective tube. The length of sleeve 60 is such that when sitting on the top of tube sheet 30 it will extend above the level 59 of the slurry as shown in FIG. 1, or, if desired, above the level of the top of the casing 12. Thus, the heat exchanger fluid will not be able to pass downward through the defective tube 40. Next, an expansible plug 58 is inserted through the defective tube and is expanded into the hole 26 of tube sheet 24 below the defective tube to seal the hole in the bottom tube sheet. Then, defective tube 40 may be withdrawn vertically and the first heat exchange medium between the tube sheets will not mix with the second heat exchange medium because of the sleeve 60 and the plug 58. The defective tube may then be replaced by a good tube inserted into recess seat 28 and sealed therein and within upstanding flange 34. Then plug 58 may be withdrawn through the good tube and sleeve 60 may be removed and the heat exchanger will be back in its normal full capacity operation. As can be seen, however, during the change of the tube there was no necessity of shutting down the heat exchanger.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to the preferred embodiment, it will be understood that various omissions and substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

I claim:

1. A heat exchanger especially adapted for handling large volumes of corrosive heat exchange liquids, the heat exchanger comprising;

(*a*) a generally vertical tubular casing,

(*b*) a closed, liquid-tight sloping bottom for the casing,

(*c*) at least two tube sheets each having a plurality of tube holes therein, the sheets being vertically spaced within the casing below the top and above the bottom thereof,

(*d*) a plurality of removable heat exchanger tubes with the ends of the tubes sealingly received in the holes of the tube sheets,

(*e*) the topmost of said tube sheets including means for sealingly receiving the plurality of removable heat exchanger tubes and means for receiving a tube removal shield over each tube hole in the tube sheet,

(*f*) the lowermost of said tube sheets including tube seat means for sealingly receiving a plurality of removable heat exchanger tubes for vertical removal of the tubes therefrom,

(*g*) first heat exchanger fluid inlet and outlet means in the casing between the positions of the tube sheets,

(*h*) second heat exchanger fluid inlet and outlet means above the top tube sheet and below the bottom tube sheet so that the second heat exchanger fluid will flow through said tubes sealingly supported between the tube sheets and the first heat exchanger fluid will flow around the outside of the tubes.

2. A heat exchanger as claimed in claim 1 further comprising baffles between the tube sheet, and wherein the inlets and outlets of the two heat exchanger fluids are arranged so that the two heat exchanger fluids will flow in substantially opposite directions through the heat exchanger.

3. A heat exchanger as claimed in claim 1 wherein the casing is a sectionalized caisson constructed of concrete and wherein the closed, sloping bottom and the tube sheets are also constructed of concrete.

4. A heat exchanger as claimed in claim 1 further comprising stirring means in the lowermost portion of the sloping bottom.

5. A heat exchanger as claimed in claim 1 wherein the heat exchanger casing is embedded in the ground and the second heat exchange fluid inlet is above the top tube sheet but below the top of the casing and the second heat exchange fluid outlet comprises a tube extending below the bottom tube sheet, passing through the casing and terminating in an outlet opening at substantially ground level.

6. A heat exchanger as claimed in claim 5 further comprising pump means in the lower end of the second heat exchange outlet tube.

7. A heat exchanger as claimed in claim 1 wherein said tubes are thin-wall tubes of non-corrosive metal and contain helical fins on their inner surfaces.

8. A heat exchanger as claimed in claim 1 wherein the means for receiving a tube removal shield over each tube hole in the topmost tube sheet comprises an upstanding flange around each tube hole, each said upstanding flange having a larger diameter than each corresponding tube hole; and wherein the means for sealingly receiving a plurality of removable heat exchange tubes comprises an O-ring seal between the outer edge of each tube hole and the inner surface of the upstanding flange around each tube hole.

9. A heat exchanger as claimed in claim 1 wherein the tube seat means in the lowermost of said tube sheets includes a recessed seat at the top of each tube hole, each said recessed seat having a larger diameter than each corresponding tube hole; and wherein an O-ring seal is disposed in each of said recessed seats.

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