METHOD OF CLEANING EQUIPMENT FOR SUPPLYING LIQUID

4 Claims, 15 Drawing Figs.

ABSTRACT: An improved cleaning method for liquid suppling equipment composed of a vertical tank and a liquid transportation means, in which the inside wall surface of the tank is cleaned by cleaning liquid flows covering the whole wall surface to be cleaned, and the cleaning liquid supplied into the tank is discharged at the same flow rate as the supply flow rate. At the same time, the sealing means of the liquid transportation means is cleaned by fresh cleaning liquid.
AN IMPROVED METHOD OF CLEANING EQUIPMENT FOR SUPPLYING LIQUID

The present invention relates to an improved cleaning method for eliminating unnecessary liquid layers remaining on internal wall surfaces of equipment for supplying liquid, and more particularly relates to an improved cleaning method for eliminating unnecessary liquid layers remaining on internal wall surfaces of equipment for supplying liquid, which is composed of a vertical tank and means for transferring the liquid, by positively introducing a cleaning liquid thereinto.

Generally, equipment for supplying liquid, which comprises a vertical tank, a liquid transferring pump, liquid conduits and means for connecting those elements, is preferably used for preparing, mixing, pumping of chemicals and cleaning, reacting, storing and transporting of solutions, emulsions or suspensions of dyes, pigments, sizes, acids, alkanes, salts and surface active agents.

In case this type of equipment is intended for processing multiple kinds of liquids, the following processed liquid has to be eliminated completely from the inside of the equipment prior to the introduction of a liquid to be processed subsequently. This elimination is indispensable in order to prevent an unexpected mixing of both liquids. Generally, this elimination is carried out by introducing a cleaning liquid, more particularly a cleaning water, into the equipment for cleaning of the internal wall surface of the equipment. Despite popular application of this kind of cleaning operation in the industrial process, hardly any proposals have been made concerning a method and apparatus for carrying out the operation in a most efficient manner. For example, in case a relatively foamy liquid such as a surface active agent is left in the liquid supplying equipment, it has been quite a task to completely eliminate the remaining liquid within as short a time as possible using a small quantity of cleaning liquid while effectively preventing formation of liquid foams. Nevertheless, it will be well understood that an efficient cleaning operation is a very important key in carrying out all the processes including the liquid supplying operation in a smooth condition with minimum processing troubles. Particularly, recently developed automatic-control systems using a manner of program control have been introduced into various industrial processes, and then the cleaning operation set in the program must be carried out accurately in conformity to the planned program.

A principal object of the present invention concerns a provision of a novel and excellent method for completely cleaning unnecessary liquid layers remaining on internal wall surfaces of equipment for supplying liquid using a cleaning liquid of the smallest quantity possible within the shortest time possible.

Further features and advantages of the present invention will be more apparent from the ensuing description, reference being made to the accompanying drawings in which:

FIG. 1 is a side view, partly in section, of an embodiment of cleaning apparatus for carrying out the method of the present invention used for vertical tank-type equipment.

FIG. 2 is an explanatory drawing for showing the operational principle of the cleaning method of the present invention used for vertical tank-type equipment.

FIG. 3 is a graphical representation of a relation between a pressure of a cleaning water to be ejected against an inside wall surface of the vertical tank, a width of a liquid flow formed on the wall surface by the ejected cleaning liquid and an included angle between the ejected jet flow of the cleaning liquid and the inside wall surface.

FIG. 4 is a graphical representation of a relation between a cleaning liquid flow rate per one ejection nozzle, the width of the liquid flow on the wall surface and a distance between the ejection nozzle outlet and the wall surface.

FIG. 5A is a plan view of an embodiment of cleaning apparatus for carrying out the method of the invention used for a vertical tank.

FIG. 5B is a front view, partly in section, of the apparatus shown in FIG. 5A.

FIGS. 6 to 9 are partial sectional front views of other embodiments of cleaning apparatus used for a vertical tank, FIG. 10 is a sectional side view of an embodiment of the cleaning apparatus used for a vertical tank.

FIG. 11 is a sectional front view of an embodiment of cleaning apparatus for the method of the invention used for a vertical tank.

FIG. 12 is a section taken along a line A-A in FIG. 11.

FIG. 13 is a partly sectional side view of an embodiment of cleaning apparatus for the method of the invention used for a vertical tank.

FIG. 14 is a partly sectional side view of another embodiment of the cleaning apparatus for the method of the invention used for a vertical tank.

In FIG. 1, a vertical tank 1 is provided with a cleaning liquid ejection pipe 4 and a bottom discharging outlet 5. The cleaning liquid ejection pipe 4 is disposed at the upper opening of the tank 1 and a cleaning liquid 3, for example cleaning water, is ejected therefrom towards an inside wall surface 2 of the tank 1. The liquid contained in the tank 1 is discharged out of the tank 1 through the outlet 5 and a liquid transportation pipe 7 by a liquid transfer pump 6. The ejection pipe 4 is provided with a plurality of ejection nozzles 8 directed towards the inside wall surface 2. The following three requirements should be satisfied for the most effective cleaning results of the inside wall surface 2 by the ejected cleaning liquid.

Firstly, the cleaning liquid 3 ejected towards the wall surface 2 and contacting therewith should not splash thereon. This is because the splashed cleaning liquid does not take part in the cleaning of the wall surface.

Secondly, the wall surface to be cleaned should be completely covered without any rift by a continuous layer of the cleaning liquid flowing down along the wall surface 2. Any rift in the cleaning liquid layer will remain as an incomplete portion of the wall surface 2 and an incomplete and insufficient cleaning effect will result.

Thirdly, the cleaning liquid flowing to the bottom of the tank 1 should be discharged instantly therefrom without remaining there. When the liquid remains at the bottom of the tank 1, a large quantity of float such as foam will develop over the liquid surface and such float is difficult to discharge through the discharging outlet 5.

How the above-described three requirements are satisfied by the method of the present invention will hereinafter be explained. First, a method for satisfying the first requirement will be explained with reference to FIG. 2. Let us define a distance between the ejection nozzles 8 and the wall surface 2 of the tank, 2R is an internal diameter of the ejection pipe 4, 2r is an internal diameter of the nozzles 8, α is an included angle between the wall surface 2 and the nozzle's direction (hereinafter called directing angle), Q is a flow rate in liters/min. of the cleaning liquid ejected through a single nozzle, W is an average width of the liquid flow layer formed on the wall surface in mm. and Pr is a pressure of the cleaning liquid supplied to the ejection pipe 4 in mm. Hg. In this arrangement of the apparatus, l is varied from 5 to 10 mm., 2R from 10 to 40 mm., 2r from 2 to 10 mm. and α from 30 to 80°, water is used for cleaning, the wall surface 2 of the tank 1 and the resulting experimental relationships between α, Pr and W and between Q, W and l are graphically shown in FIGS. 3 and 4 respectively. As is apparent from FIG. 3, the value of W increases with the increase in the value of Pr and with the decrease in the value of α. Further, it was revealed that, provided that the value of 2r is sufficiently smaller than the value of 2R, the value of l has almost nothing to do with the value of W. This is clearly shown in FIG. 4.

The relation between W and α will now be described in more detail. The value of W shows little change when the value of α is smaller than 45°, while it is suddenly decreased when the value of α exceeds 60°, for example when the value of α becomes 85°. This is due to the amount of cleaning liquid splashing on the wall surface increases as the value of α ex-
ceeds 60° and, resultingly, the amount of the cleaning liquid flowing down along the wall surface decreases accordingly.

It has become apparent from the foregoing discussions that the value of the directing angle α should be smaller than 60°. Also, in case the wall surface is not vertical but inclined, the value of the directing angle α is required to be smaller than 60°.

How to satisfy the above-presented second requirement will hereinafter be explained. In case the respective liquid flows ejected from the respective ejecting nozzles form independent flows falling down along the vertical surface, it is necessary that the thus formed mutually adjacent flows combine together at a position not lower than the upper end of the wall surface to be cleaned and form a single successive flow layer covering all the wall surface to be cleaned without any rift, in order to completely clean the wall surface.

An experimentally obtained relation between Q, W and l is graphically illustrated in FIG. 4, whereby it is confirmed that the value of W is substantially constant even when the value of l changes in a range from 17 to 45 mm. and that the value of W increases with the increase in the value of Q. The following relation was confirmed to exist between Q and W:

\[ W = 0.016Q \]  

For the successive combination of the neighboring liquid flows, a distance P between the liquid ejecting points on the wall surface must be related to \( \frac{Q}{W} \) as follows.

\[ P = \frac{Q}{W} \]  

Provided that the value of l was so selected as to be sufficiently smaller than the value of 2R, a distance P between the neighboring ejecting nozzles can be related to the distance P as follows.

\[ p = P \]  

By inserting relations given by the formulas (2) and (3) into the formula (1), the following relation will result.

\[ p = Q/0.016 \]  

From the result shown in the formula (4), it is apparent that the distance p between the ejecting nozzles can be designed by making reference to the value of the cleaning liquid flow rate Q.

Consequently, the above-described second requirement can be well satisfied by forming the ejecting nozzles 8 on the ejection pipe 4 with the distance p calculated from the value of the cleaning liquid flow rate Q using the above-presented formula (4).

Next, how to satisfy the third requirement will be explained. Referring back to FIG. 1 again, let us suppose that the total flow rate of the cleaning liquid ejected into the tank 1 through the ejecting nozzles 8 is \( Q_s \) and the flow rate of the cleaning liquid discharged out of the tank 1 through the discharging outlet 5 is \( Q_d \). Then, the following relation should be satisfied so that no cleaning liquid will be maintained within the tank 1 without discharge.

\[ Q_s = Q_d \]  

Supposing that the discharging rate of the liquid transfer pump 6 is \( Q_c \), the following relation will be induced.

\[ Q_c = Q_d \]  

By inserting the formula (5) into the formula (6), the following relation will result.

\[ Q_c = Q_s \]  

Thus, the above-described third requirement is fully satisfied when the discharging rate of the liquid transfer pump 6 is not smaller than the flow rate of the liquid to be supplied into the tank 1.

Several embodiments of cleaning apparatus for carrying out the method of the present invention used for vertical tank-type equipment are illustrated in FIGS. SA to 10.

In the embodiment shown in FIGS. SA and SB, the cleaning liquid is supplied to the ejection pipe 13 from the main conduit 12 through the branch conduit 12a radially connecting the two. The ejection pipe 13 is annularly disposed in the top opening of the tank 1 with a plurality of ejection nozzles 14 facing the inside wall surface 2 of the tank 1. The nozzles 14 are formed through the ejection pipe 13 in a line at a given constant interval and the cleaning liquid is ejected against the wall surface 2 through the nozzles 14.

Another embodiment of the cleaning apparatus of the invention is shown in FIG. 6, wherein the main conduit 11 is connected to a plurality of spaced superimposed ejection pipes 13a and 13b and the cleaning liquid is simultaneously ejected through the nozzles 14 formed thereon.

In this case, an effective horizontal distance p between neighboring nozzles 14, including nozzles of both pipes 13a and 13b, is defined as shown in the drawing. That is, the distance p is defined as a distance between neighboring nozzles being in a relation that the cleaning liquid ejected from the nozzles forms neighboring flows on the wall surface.

In the modification shown in FIG. 7, the main conduit 11 is connected to a spirally coiled ejection pipe 15 and the distance p is also defined as shown in the drawing in the same manner as mentioned above. The central axis of the spiral coil substantially coincides with that of the tank.

In the embodiment shown in FIG. 8, the main conduit 11 is connected to an ejection pipe 16 of a particular cross-sectional profile. The cross-sectional profile consists of a pair of parallel sides and a pair of arcs connecting the parallel sides and one of the pair of sides 19 facing the wall surface 2 with a parallely spaced relation. The side 19 is provided with a plurality of nozzles 14 formed thereon in two lines and the distance p is defined also as is shown in the drawing in the same manner as mentioned above.

In the embodiment shown in FIG. 9, the ejection pipe 17 is provided with a cross-sectional profile the same as that of the ejection pipe 16 of the preceding embodiment. However, because the wall surface 2 of the tank 1 is inclined as shown in the drawing, one of the pair of parallel sides 20 is accordingly inclined in conformity to the inclination of the wall surface 2.

The ejection pipe 17 is provided with a plurality of nozzles 14 formed thereon on three lines and the distance p is also defined as shown in the drawing in the same manner as mentioned above. Although the geometrical arrangement of the nozzle 14 on the ejection pipe is not limited only to one, two and three lines, the distance p is given by an effective horizontal distance between a pair of virtual lines drawn vertically from a pair of neighboring nozzles, including nozzles formed on different ejection pipes.

There is no particular limitation with respect to the shape of the liquid ejecting nozzles. It can be formed either by piercing the peripheral wall of the ejection pipe or by disposing a beaklike nozzle 18 to the ejection pipe as shown in FIG. 10. The mentioned directing angle of the ejected liquid can be adjusted as desired by changing the shape and internal diameter of the nozzle.

In the cleaning system of the present invention, the cleaning liquid falling down to the bottom portion of the tank 1 is compulsively discharged out of the tank 1 through the liquid transportation pipe 7 by the liquid transfer pump 6. During this discharge, the internal wall surfaces of the pump and the pipe can also be cleaned by the cleaning liquid passing therethrough.

A rotary shaft of the pump is connected to an external driving source and a joint of the shaft with the pump is completely sealed by suitable packings. Further, joints of the transportation pipe with the pump or with the tank are generally sealed by packings of the joint flanges. It is well known that difficulties exist in the complete elimination of the used liquid permeating into such sealing means of the joint parts. For example, when a colored liquid is first processed through the system and another liquid is subsequently processed therethrough, it has been often experienced that the latter is contaminated by the former because the former has already permeated in the sealing means of the joint parts.

Referring to FIGS. 11 and 12, an embodiment of the cleaning apparatus of the present invention used for cleaning of this sealed part of the liquid transfer pump is shown. In the embodiment, a casing 21 of the pump is provided with an opening 22 for accepting a rotary shaft 23 of the pump, which extends
therethrough and is connected to a rotary blade 24. Enclosing the opening 22, a projection 25 is disposed to a sidewall 27 of the casing 21 and an internally threaded cap 26 is inserted over the projection 25. One end of the cap 26 is provided with a partial opening for passing the rotary shaft 23. Inside the cap 26, a packing 28, an annular body 29 and another packing 30 are provided as shown in the drawings, of which the packing 28 is disposed contacting the sidewall 27 of the casing 21 for sealing the clearance between the rotary shaft 23 and the opening 22 of the casing 1 while the packing 30 disposed contacting the partly opened end of the cap 26 for sealing the clearance between the rotary shaft 23 and the partial opening of the cap 26. The annular body 29 is provided with an internal cavity forming the first annular chamber 31 around the rotary shaft 23 passing therethrough. The annular body 29 is further provided with more than one liquid passage 35 formed through a peripheral wall thereof. The cap 26 is also provided with an internal cavity which forms the second annular chamber 33 around the outer periphery of the annular body 29 as shown in the drawing. A water path is provided through the peripheral wall of the cap 26 and is connected with a liquid inlet conduit 34.

The method of cleaning the sealed parts of the system will hereinafter be explained in connection with the above-presented cleaning apparatus.

The cleaning water supplied to the system through the liquid inlet conduit 34 is introduced into the first annular chamber 31 passing through the second annular chamber 33 and the water path 35. Next, the introduced cleaning water further permeates into the clearance formed in between the rotary shaft 23 and the packing 28 and conducted into the liquid transfer pump 6. During this permeation, the cleaning water eliminates previously processed liquid from the sealed portion. Further, although a small quantity of contaminated liquid comes into the first annular chamber 31 through the packing 28 during rotation of the pump, it can be diluted with the cleaning water already in the first annular chamber 31 and has nothing to do with further contamination of the packing 30. Moreover, by successively supplying a small quantity of water into the system throughout the rotation of the pump, the packing 28 can be always kept in a noncontaminated condition.

It has also been extremely difficult to completely eliminate liquid contaminating the sealed portions of a joint flange used in the discharging path of the cleaning liquid. In this connection, Figs. 13 and 14 show embodiments of the apparatus for cleaning the sealed portions of the above-mentioned joint flange.

In the embodiment shown in Fig. 13, respective liquid transportation pipes 41 and 42 are provided with a pair of facing flanges 43 and 44, which are engaged to each other by bolts 46 and nuts 47 with a packing 45 inserted between the two. The surface of the flange 43 facing the flange 44 is provided with an annular groove 48 encircling the liquid transportation pipe 41 and forming an annular chamber between the facing flanges 43 and 44. This annular groove 48 is actually connected to the internal hollow of the pipeline because of the existence of a slight slit formed between the facing termination of the pipes 41 and 42 as shown in the drawings. The bottom of the annular groove 48 is provided with a liquid path 49 connected to a liquid inlet conduit 50.

In the above-presented arrangement of the system, the cleaning water is supplied to the system through the inlet conduit 50, introduced into the annular groove 48 passing through the liquid path 49 and permeates into the internal hollow of the pipe line through the slight slit. By this permeation of the cleaning water, the slit can be well cleaned. The contaminated liquid coming back into the annular groove 48 during this cleaning procedure can be diluted with the cleaning water filling the annular groove 48 and has nothing to do with further contamination of the packing 45. By successively supplying a small quantity of water to the annular groove 48, unfavorable introduction of the contaminated liquid into the annular groove 48 can completely be prevented.

A modification of the embodiment of Fig. 13 is illustrated in Fig. 14. In this modified embodiment, not only the flange 43 but also the flange 44 is formed in a position corresponding to the annular groove 40 of the flange 43. In between both annular grooves 48 and 51, a packing 45 having a plurality of apertures 52 for connecting the two grooves 48 and 51 is inserted for sealing the joint part of the pipes 41 and 42.

The cleaning water supplied through the inlet conduit 50 is introduced into the groove 51 passing through the groove 48 and the apertures 52 as shown with arrows in the drawing and the contamination of the packing 45 is cleaned by the cleaning water in the grooves 48 and 51.

By the employment of the method and apparatus of the present invention, the liquid supply equipment can be cleaned effectively within an extremely short period of time using a necessary minimum quantity of cleaning liquid particularly when the equipment is intended for processing variously colored liquid or various types of chemical liquid in a given succession. The advantage of the present invention will be more appreciated in the case of an automatic liquid transportation indispensable for chemical processes.

What is claimed is:

1. In cleaning of internal walls of equipment for supplying liquid having a vertical-type tank and means for transporting said liquid from said tank, a cleaning method comprising
   a. supplying a cleaning fluid to said tank at a predetermined rate,
   b. ejecting a plurality of liquid flows towards the inside surface of a peripheral inside wall of said tank at a position now lower than an upper extent of a portion of said inside surface of said wall to be cleaned in such a manner that directing angles of said ejected flows are smaller than 60° and that a distance p in mm. between a neighboring pair of said ejected flows is defined by 
   \[ p = Q \times 0.016 \] 
   wherein Q is a flow rate of said one said ejected flow in liters/min,
   c. compulsively discharging said supplied cleaning liquid out from said tank at a discharging flow rate equal to said predetermined rate,
   d. advancing said discharged cleaning liquid through said transporting means and
   e. concurrently introducing fresh cleaning liquid from a supply source thereof into an external portion of a sealing means of said liquid transporting means so as to pass therethrough into said liquid transporting means.

2. A cleaning method according to claim 1, wherein said tank has a peripheral sidewall of circular cross section and wherein said cleaning liquid is directed toward the inside surface of said sidewall of said tank simultaneously throughout the circumference of the tank.

3. A cleaning method according to claim 1, wherein said transporting means comprises a rotary pump having a rotary shaft, and wherein said fresh cleaning liquid is introduced into an annular chamber around said shaft.

4. A cleaning method according to claim 3, wherein said fresh cleaning liquid is introduced radially into said chamber at a plurality of points around its circumference.