Plant and Process for Cleaning

The present invention relates to a plant, and to a process, for cleaning tanks or other containers, and for treating the resulting effluents.

A wide variety of different materials are transported in bulk, by road or rail for example, in tankers which are then reused for the transport of the same or different materials. The materials might for example be milk, flour, molasses or other foodstuffs, inorganic acids, latex, petroleum-based products, etc. It is consequently necessary to thoroughly clean such tankers periodically to avoid contamination of subsequent cargoes. Clean-out may be achieved using suitable solvents, hot or cold water, and/or detergents, but the resulting effluents then require treatment. Hitherto such effluents have usually been treated by micro-biological processes similar to those used to treat sewage, but such a process requires a large plant to ensure sufficient treatment time, and may be poisoned by certain chemicals such as phenols, pesticides or herbicides.

According to the present invention there is provided a tank cleaning plant comprising means to wash one or more tanks with water, and so to generate a liquid effluent, means to collect the liquid effluent from the or each tank in a common sump, means to pretreat the liquid effluent to remove gross contaminants, means to add a chemical reagent to the pretreated effluent to promote flocculation, and means to then subject the effluent to ultrafiltration to form a permeate liquid.

The permeate liquid may in many cases be suitable for discharge, for example to a public sewer, without hazard to the environment, as most of the contaminants

have been removed. There may be circumstances however when the concentration of dissolved organic molecules, particularly of molecules of molecular weight below about 300 such as sugar or methanol, is unacceptable (giving too high a biological oxygen demand).

The permeate liquid may then be treated by contacting with an absorber material, such as activated carbon, or highly porous polystyrene particles, and then subjected to a second ultrafiltration process. Spent absorber material may be returned to the sump, and so be removed in the pretreatment. Alternatively the permeate liquid may be treated by nanofiltration, and in this case no absorbent is required.

The resulting permeate from the second ultrafiltration process is consistently clear water despite a wide range of materials which may be present in the tanks, and despite additives such as organic solvents, or detergents, which may be added to the wash water. Furthermore the plant itself can treat effluent liquid with little hold-up, and so does not have to be large. The permeate from the second ultrafiltration process is sufficiently clean to be used as cleaning water at least with tanks which are not for use with foodstuffs. The use of nanofiltration, instead of contact with an absorber along with a second ultrafiltration process, produces an equally clean permeate.

If an organic phase separates from an aqueous phase in the sump, for example if an organic solvent such as paraffin is used in the cleaning process, the organic phase is preferably removed from the effluent liquid so that only the aqueous phase is subjected to the subsequent treatment processes. A skimmer may be used to do this and this may be a part of the pretreatment. The pretreatment may include passing the effluent through a

coarse filter, or may involve passage through one or more interceptors in which solid particulates settle out under gravity to form a sludge, and the organic phase separates from the effluent water. In many cases however the organic phase is in the form of a stable emulsion. In this case the aqueous and organic phases will be separated by the ultrafiltration. The chemical reagent may comprise lime (calcium hydroxide) which raises the pH. Alternative or additional flocculating reagents may be supplied such as ferric chloride or aluminium sulphate.

The plant desirably also includes means to control the temperature of the water used for tank cleaning. It may also include means to wash the outsides of the tanks. And it desirably also includes means to supply air to the tanks to dry them after they have been cleaned; this may be warm or hot air. The air stream may then be passed through a scrubber before being vented to the atmosphere, in order to remove any hazardous or toxic vapours.

The invention also provides a process for cleaning one or more tanks, the process comprising the steps of washing the or each tank with water and so generating a liquid effluent, collecting the liquid effluent from the or each tank in a common sump, pretreating the liquid effluent from the sump to remove gross contaminants, adding a chemical reagent to the pretreated effluent to promote flocculation, and then subjecting the effluent to ultrafiltration to form a permeate liquid.

It should be appreciated that the term tank refers to a wide variety of different containers in which materials may be stored or transported, of which road or rail tankers are just examples.

The invention will now be further and more particularly described, by way of example only, and with reference to the accompanying drawings in which:

Figure 1 shows a diagrammatic plan view of a tank cleaning plant; and

Figure 2 shows a flow diagram of the operation of the plant of Figure 1.

Referring to Figure 1 a tank cleaning plant 10 is shown diagrammatically in plan view. It comprises a central building 12 which houses plant (described later) to supply washing fluids and to treat the effluents. Along each side of the building 12 are roadways providing spaces for four 20 foot ISO containers along each side, or for road tankers; three containers 14 and one tanker 16 are indicated along one side, and four tankers 16 are indicated along the other. Two of the spaces (marked 14A and 16A) are dedicated to cleaning out tanks which have contained foodstuffs, whereas the other spaces may be used for any non-foodstuffs. Such ISO containers 14 contain tanks; they are moved onto the roadway by fork-lift trucks. Along the outside walls of the building 12 are services 18, that is to say pipes providing compressed air, steam, water, and additives such as detergents, alkalis, paraffin etc. as required. Overhead rails 20 extend above the roadways along each side of the building 12. Trucks 22 slide along these rails 20 and carry spinners 24 which are connected by flexible hoses to the services 18 and which can be lowered and raised in or out of tanks by means of a chain block. Other cleaning equipment such as a high pressure water lance 26 (operating with water at 100 atmospheres) and a steam lance 28 are also connected to the services 18.

At one end of the building 12 is a sump 30. Drain pipes from all the tanks being cleaned lead into this sump 30, as do drains which collect liquids from the roadways, for example when the outside of a container 14 or a tanker 16 is washed down. The building 12 encloses the facilities for providing the services 18, and the plant for treating the effluent. These are described in greater detail in relation to Figure 2; some of them are shown diagrammatically in Figure 1 as follows. At the end nearest the sump 30 are filter presses 32 and chemical treatment tanks 34, while in the central part of the building 12 are a waste storage tank 36 and two ultrafiltration units 38 and 40. Near the other end of the building 12 are a boiler 42, various pumps 44, and storage tanks 46 for the additives.

Referring now to Figure 2, when a tanker 16 (or indeed any other reusable tank which is to be cleaned) is positioned on the roadway beside the building 12, a port in its base is first opened to drain any remaining liquid contents into a waste drum, and the port is then connected to a drain pipe 50 leading via a pump 51 to the the sump 30. A spinner 24 (see Figure 1) is moved into position in the tanker 16 through a port in its top, after removal of the lid, and the lid then replaced to trap the hose. Water is supplied to the spinner 24 at between 5 and 12 atmospheres, for example 7 atmospheres, so water jets squirt vigorously in all directions. For cleaning out some materials, such as latex, higher pressure (up to 400atm) cold water jets are desirable. For other materials it is preferable to use warm or hot water, by also supplying steam to the spinner 24; and for some materials it is desirable to add additives such as acid, alkali, detergent, or paraffin to the washing water. Typically the washing process involves two stages: an initial wash with cold or warm water to remove the bulk of the contaminants, during which the dirty

water is pumped straight to the sump 30; and then a thorough wash, usually with hot water and additives, during which the pump 51 is used to recirculate the water back to the spinner 24, and then to the sump 30 when this stage is completed. The recirculation duct desirably includes a coarse filter 52. Recirculating the wash water significantly reduces the volume of water needed and so also reduces the volume of effluent to be treated. The tanker 16 is then rinsed with clean water through the spinner 24, and is then dried by supplying warm air. If there is any chance that the tanker 16 contains toxic vapours, these are removed through an extract duct and passed through a filter 53 before the air is vented to the atmosphere through a scrubber 54.

The sump 30 may include a skimmer (not shown) to remove any floating surface layer of organic liquid. Effluent water from the sump 30 is pumped continuously by a pump 56 through a coarse filter 32, consisting of two filter presses in parallel, to remove the larger solid particles. The filtrate is passed via a control valve 57 to one of two $5m^3$ batch tanks 34. The filter 32 is cleaned periodically and the filtered material disposed of with other wastes in the tank 36. When one of the batch tanks 34 is full the filtrate is then switched to the other batch tank 34. The liquid in the full tank 34 is then dosed by adding chemical reagents to promote flocculation and the liquid mixed by a mixer 58; for example lime might be added to make it alkaline. Many dissolved metals precipitate as hydroxides or hydrated oxides, and many of the organic substances in the liquid adsorb onto these precipitates.

Rather than using the filter 32, the pretreatment might instead be performed by the pump 56 pumping the effluent to a primary interceptor tank (not shown) in

which solid matter settles out as a sludge, and oil collects as a surface layer. The water phase then passes via a weir to a coalescing interceptor tank (not shown) where more of the oil phase collects at the surface. The oil is periodically skimmed from the surfaces of both interceptors and collected in a waste oil container, while the water phase passes via another weir to one or other of the tanks 34.

The liquid from the full tank 34 is then subjected to ultrafiltration in the unit 38 which consists of two ultrafilter modules 59 in series, with a circulating pump 60 to circulate the liquid at about 100 m^3/h. Each module 59 consists of several parallel tubes within a housing, the liquid passing under pressure along the bore of the tubes. The tubes are porous and permeable, being composed of bonded carbon particles and with an essentially continuous coating of metal oxide particles on the inside surface of the tubes. Some of the liquid and low molecular weight dissolved phases pass through the walls of the tubes into the housing, while most of the higher molecular weight dissolved phases and any particulate matter remain in the tubes to form a liquid concentrate or slurry. The oxide coating provides a membrane of pore size less than 0.1 µm. The pressure within the ultrafiltration circuit is maintained, typically at up to 6 atm (600 kPa), by a feed pump 62. The permeate liquid from the modules 59 discharges continuously to a 3m^3 permeate tank 63 and thence to a 5m^3 holding tank 64. When the tank 34 has been emptied the slurry in the ultrafiltration unit 38 is discharged to the waste storage tank 36 via a control valve 66.

In a modification, the two tanks 34 are replaced by a 20m^3 holding tank which acts as a buffer to smooth out

the fluctuations in effluent collection, with a pump to convey effluent to a $1m^3$ feed tank. The feed tank is provided with high and low level gauges, whereby the supply of effluent from the holding tank is controlled. Dosing chemicals (such as lime slurry) are added continuously to the effluent in the feed tank, and the ultrafiltration unit 38 operates continuously. Typically in this case the slurry in the unit 38 will be discharged to the waste storage tank 36 once a day.

The permeate liquid in the tank 63 is clear water, although it may contain dissolved organic molecules. A pump 65 may be provided to return this liquid to the tanker cleaning plant 10, for example for use in the initial washing stage. It may however have too high a biological oxygen demand to be discharged to a sewer, and so need further treatment before it can be discharged.

In the plant of Figure 2 the further treatment is absorption/ultrafiltration. Activated carbon is added as an absorber to the permeate liquid in the holding tank 64. The contents of the tank 64 are kept mixed by a stirrer 68, and are pumped continuously through the second ultrafiltration unit 40, which also consists of two ultrafilter modules 59 in series; the tank 64, a pump 70 and the two modules 59 form a closed loop. The modules 59 of the unit 40 may be more porous than those of the unit 38, and so the liquid pressure in the closed loop does not have to be so high; for example it might be 2 atm (200kPa), with a flow rate of 100 m^3/hr. The carbon absorbs organic contaminants which have passed through the first ultrafiltration unit 38. Either continuously or at periodic intervals some of the circulating liquid is returned, via a control valve 72, to the sump 30, so the spent carbon is removed by the coarse filter 32. The permeate from the second ultrafiltration unit 40 flows to

a $10m^3$ cleaned water holding tank 74. A pump 76 enables the water in the tank 74 to be discharged to a sewer system, or to be fed back to be used for cleaning tankers 16, although it is not used when cleaning foodstuff tankers 16.

A wide range of different absorber materials may be used instead of carbon. Alternatively, as mentioned earlier, the treatment with absorber and the second ultrafiltration treatment can be dispensed with, the permeate from the ultrafiltration unit 38 instead being subjected to nanofiltration. In this case the impurities in the permeate are concentrated in a liquid phase. The ultrafiltration modules 59 in the unit 40 would in this case be replaced by nanofiltration modules; and the concentrate discharge via valve 72 would discharge at intervals to a waste container or possibly a bioreactor, typically once a day.

Preferably the pH of the water in the cleaned water tank 74 is monitored, and if it is too alkaline for discharge, then it is dosed with acid. For example the tank 74 might comprise two chambers separated by a weir, and with an agitator and dosing equipment in the first chamber. Alternatively, the pH may be monitored and the acid dosing performed (e.g. with HCl) in the permeate tank 63, prior to the absorption/ultrafiltration or nanofiltration treatment stage.

The operators of the plant 10 hence have to arrange the tanks which are to be cleaned (e.g. tankers 16) on the roadway, and in each case connect the tank to the drain pipe 50, and insert a spinner 24 into the tank. Depending on what the previous contents of the tank were, the operator can then select which additive should be added to the wash water, if any, and whether steam

heating is required, and then initiate the washing cycle. The washing, rinsing, and drying then occur under automatic control, and last about 15 minutes. The operator can meanwhile wash down external parts of the tank, where necessary, using for example a water lance 26. Operation of the effluent treatment plant can be largely automated. The sump 30, treatment tanks 34, and holding tanks 64 and 74 are all provided with liquid level gauges L. Other instruments (not shown), such as flow meters, sensors to measure pressure differences for example between the ends of a module 59, pH meters, and colorimeters, may also be provided. Periodic cleaning of the ultrafiltration modules 59 may be necessary, and this may be achieved by backflushing using cleaned water from the holding tank 74. The sump 30 acts as an interceptor for dense particles in the effluent, such as stones and grit, and at intervals the collected material from the bottom of the sump 30 must be dug out.

It will be appreciated that the tank cleaning plant 10 may be modified in a variety of ways while remaining within the scope of the invention. For example the size of the plant 10 may be larger or smaller, so as to clean a larger or smaller number of tankers, the capacity of the effluent treatment plant being changed accordingly. The plant 10 may include more spinners 24, water lances 26, or steam lances 28 than shown in Figure 1, and may include other cleaning equipment. The effluent treatment plant may incorporate a range of different types of coarse filter 32 or of interceptor; and the ultrafiltration modules 59 may be replaced by different types of ultrafilter.

Claims

1. A tank cleaning plant comprising means to wash one or more tanks with water and so to generate a liquid effluent, means to collect the liquid effluent from the or each tank in a common sump, means to pretreat the liquid effluent to remove gross contaminants, means to add a chemical reagent to the pretreated effluent to promote flocculation, and means to then subject the effluent to ultrafiltration to form a permeate liquid.

2. A plant as claimed in Claim 1 wherein the washing means incorporated means to recycle liquid effluent to a tank that is being washed, during at least a part of the washing process.

3. A plant as claimed in Claim 1 or Claim 2 wherein the pretreating means comprises at least one filter.

4. A plant as claimed in any one of the preceding Claims wherein the pretreating means comprises at least one interceptor.

5. A plant as claimed in any one of the preceding Claims including means to recycle permeate liquid to the washing means.

6. A plant as claimed in any one of the preceding Claims also comprising means to contact the permeate liquid with a particulate absorber material and means to separate the absorber material from the permeate liquid.

7. A plant as claimed in any one of Claims 1 to 5 also comprising means to subject the permeate liquid to nanofiltration.

8. A tank cleaning plant substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

9. A process for cleaning one or more tanks, the process comprising the steps of washing the or each tank with water and so generating a liquid effluent, collecting the liquid effluent from the or each tank in a common slump, pretreating the liquid effluent from the sump to remove gross contaminants, adding a chemical reagent to the pretreated effluent to promote flocculation, and then subjecting the effluent to ultra-filtration to form a permeate liquid.