"TUBE –W FOR REMOVAL OF FLOCS IN WATER TREATMENT PLANT"

Abstract:

In the process of sedimentation in water treatment, tube settlers are used in the recent times. Some of the most common shapes used are (i) square tube (ii) hexagonal tube and (iii) chevron tube.

The six equal sided standard chevron tube is the modification of first two types of tubes. But there are certain drawbacks in the case of chevron tube which are (i) there is a 90^0 hopper which is single. (ii) the height of the standard chevron tube is fixed which is equal to any other side of the standard chevron tube.

The 90^0 angle of hopper of a chevron tube is rather large which could be narrowed down and the height of the standard chevron tube is fixed and hence cannot be reduced, also the number of hopper is only one.

The above mentioned drawbacks have been eliminated in the present invention 'Tube –W'. The invention is divided in two parts: (i) Single 'Tube –W' and (ii) Multiple 'Tube –W'.

(i) Single 'Tube-W' :

In the case of Single 'Tube-W' it is a ten sided tube having W shaped top and bottom. The W shape consists of four sides with two hoppers each of 45^0 which is a narrow angle compared to 90^0. If 'a' is the side of the standard chevron tube, 'a'being in the range of 40 to 70 mm. then width of the chevron tube is $\sqrt{2}(a)$. In the present invention, Single 'Tube –W' the width of 'Tube - W' is the same i.e. $\sqrt{2}(a)$, the two outer larger sides of W have the same magnitude 'a'. The two W shapes of top and bottom of 'Tube –W', require four sides each i.e. eight in all.

Out of the ten sides of 'Tube – W' the remaining 2 sides are vertical and indicate the height of 'Tube – W' which has normally the magnitude of 'a' but could be reduced as per requirement. The reduced vertical side reduces the height of 'Tube –W' and thus the

vertical distance to be travelled by the flocs before settling on the inclined surface of 'Tube-W'.

Thus the distinct advantages of single 'Tube-W' are (a) there are two hoppers in place of one (b) the angle of each hopper is 45^0 which is much narrow compared to 90^0 hopper of chevron tube (c) the vertical distance the floc has to travel before settling on the inclined sides of the hoppers could be reduced. Thus this invention helps to entrap larger quantity of flocs including the smaller diameter flocs. The narrow 45^0 angle of the two hoppers enable the flocs to concentrate more effectively and thus to slide down the inclined 'Tube –W' more efficiently. The length of single 'Tube-W' is the same as the standard length of other tubes i.e. in the range of 600 to 1000 mm.

(ii) Multiple 'Tube –W' :

In this case, the tube is ten sided similar to single 'Tube-W' as mentioned above but has larger vertical height. The W shaped trays are inserted one below another in the 'Tube –W' at regular vertical spacing 'a' which could be reduced to improve the efficiency. The total height of the multiple 'Tube-W' depends upon the number of W shaped trays inserted in the multiple 'Tube-W' and their spacing. The length of the Multiple 'Tube –W' is same as the standard length of other tubes, i.e. in the range of 600 to 1000 mm. The Multiple 'Tube-W' has the same advantages as single 'Tube –W' but is cheaper than single 'Tube-W'.

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I CLAIM

i) The 'Single 'Tube - W' for removal of flocs in water treatment' the ten sided tube having W shaped top and bottom, with two equal size V shaped hoppers at the top forming W shape and similar W shape at the bottom, the outer sides of both W being same, say 'a' the side of the standard, conventional chevron tube, the two inner sides of W at the top as well as at the bottom being small compared to 'a' the outer sides of W, the angle of all the four V shaped hoppers being 45^0, apart from the 4 sides forming W shape at the top and 4 sides forming W shape at the bottom, the remaining two vertical sides indicating height of single 'Tube-W', the normal height of vertical sides being 'a' but could be smaller than 'a' to improve efficiency, the length of the 'Tube –W' being the standard length in the range of 600 to 1000 mm, and the magnitude of 'a' broadly in the range of 40 mm to 80 mm.

ii) The 'Multiple 'Tube –W' for removal of flocs in water treatment', the ten sided tube similar to Single 'Tube-W' as claimed in claim 1, but having larger vertical height, where in W shaped trays with 45^0 angle as described in Single 'Tube –W' of claim 1 are inserted one below another at equal vertical spacing say 'a' which could be reduced, the total height of Multiple 'Tube –W' depending upon the number of W shaped trays inserted in the Multiple 'Tube –W' and the spacing of the trays, the length of the multiple 'Tube – W' being the standard length in the range of 600 to 1000 mm and the magnitude of 'a' broadly in the range of 40 to 80 mm.

iii) The width of either Single 'Tube – W' as claimed in claim 1, or Multiple 'Tube W' as claimed in Claim 2 being $\sqrt{2}(a)$ where 'a' the

side of the standard conventional chevron tube in the range of 40 to 80 mm.

iv) The Multiple 'Tube-W' as claimed in claim2 and 3 where in a plurality of W-shaped trays inserted, their edges perfectly jointed with the vertical sides of Multiple 'Tube W' leaving no gap in between for water to flow through the gap.

v) The 'Single 'Tube –W' for removal of flocs in water treatment' as claimed in Claim 1 & 3 and substantially as herein described with reference to and as illustrated in Figs. 4,5,6, and 9

vi) The 'Multiple 'Tube – W' for removal of flocs in water treatment' as claimed in Claim 2, 3 & 4 and substantially as herein described with reference to and as illustrated in Figs. 7, 8 and 9.

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Name of the Patent :

'TUBE – W' FOR REMOVAL OF FLOCS IN WATER TREATMENT

1. INTRODUCTION

Surface and ground waters are the two main sources of water for drinking purpose. Both types of waters need treatment to make them fit for drinking purpose. Ground water sources are tube wells, springs, infiltration galleries as well as dug wells. Ground water normally contains dissolved salts of Fe^{++}, Mn^{++}, Ca^{++}, Mg^{++}, F^{-}, Na^{+}, As^{++} etc. These impurities are normally removed by precipitation process except for salts of Na^{+} which are removed by more sophisticated methods such as by resins, electrodialysis, evaporation, reverse osmosis etc.

Surface water sources are rivers, lakes, impounded reservoirs, canals etc. surface water usually contains colloidal impurities such as turbidity due to clay, muck and micro organisms such as virus, bacteria, protozoa, worms, etc. These organisms are responsible for various infections such as jaundice, cholera, typhoid, paratyphoid, worm-infections etc.

2. BACKGROUND

It is necessary to remove above mentioned impurities from the surface water to make it potable. The units in sequence to remove impurities from surface waters in a Water Treatment Plant (W.T.P.) are (i) cascade aerator (ii) flash mixer (iii) flocculator (iv) sedimentation tank (v) filter (vi) chlorination unit (vii) treated water sump.

Sedimentation tank is one of the significant unit in W.T.P. Sedimentation tanks are of two types:

i) Conventional circular clarifier along with scraper

ii) Tube settler or plate setter, which is the modification of conventional clarifier because water detention time in this case is very small and also it does not involve any moving parts or electrical energy for its operation and maintenance, also it does not require any skilled personnel to operate.

3. PRIOR ART

Sedimentation unit is one of the important unit in water treatment. Sedimentation unit is conventionally a circular tank having water depth of 2.5 m to 4.0 m. Tube settler unit is the modification of the conventional circular tank. The detention time in the conventional clarifier is in the range of 2.5 hr. to 4.0 hr. while in case of tube settler it is less than 30 minutes. Chevron shaped tube settler is a modification of square shaped tube. In Patent No. 163038 dated 20.01.1986., the chevron tube is further modified, the details of the same are as follows:

As per the Patent No. 163038, the modified form of the chevron tube 1 is as shown in Fig. 1 and 2. It is a six sided tube, length of each side being 'a'. The V groove makes the hopper bottom of the tube which improved the hydraulic characteristic of the flow compared to a conventional square tube. The chevron tube is modified in the Patent No. 163038 by introducing slightly inclined plates 2 (Fig. 1 and 2) dividing the chevron tube into lower triangular shape and upper pentagon or (M) shape (Fig. 2), the slight inclination of the plates being with respect to the longitudinal plane and axis of the tube, the downward slope being in the opposite direction of the water flow (Fig. 1). The clear spacing between the plates 2 is indicated by 3 (Fig. 1).

The module consisting of a number of rows of modified chevron tubes is installed in the sedimentation tank 5 (Fig. 3), the angle of inclination of the inclined rows being 40^0 to 70^0. The inlet pipe for sedimentation tank is indicated by 6 (Fig. 3) while inlet valve is indicated by 7. The sedimentation tank has V notched troughs 8 at its upper portion (Fig. 3) to collect clarified water from the tube module in the sedimentation tank. The settled sludge at the bottom portion of the sedimentation tank is shown by 11, the sludge outlet pipe is shown by 12, the sludge outlet valve being 13. The clarified water outlet pipe from troughs 8 is shown by 9, the outlet valve being 10.

3.1 Method of Operation of the Modified Chevron Tube in Patent No. 163038:

The preflocculated water enters the sedimentation tank 5 through the inlet pipe 6 from the bottom portion of the tank 5 after the inlet valve 7 is opened, then it rises up the sedimentation tank and travels upwards through the modified chevron tubes 1 where the water slowly travels upwards while the flocs settle in the hopper portion of the chevron tubes as well as on the flat plates 2. The flocs on the plates slide down the plates to join the main stream of the sludge already collected in the hopper shaped chevron bottom, after falling through the openings 3 between the plates 2. The sludge in the hopper bottom together on the flat plates finally slide down to get collected in the bottom of the tank 5. This collected sludge is shown by numerical 11 which is taken out intermittently through the sludge outlet pipe 12 after opening the valve 13. The up travelling clarified water coming out of the tube module is collected in the V-notched collecting through 8 from where it is taken out through the outlet pipe 9 after opening the valve 10. The clarified water then enters the filter unit.

4. DRAWBACKS OF MODIFIED CHEVRON TUBE IN PATENT NO. 163038

1) Modified chevron tube in Patent No. 163038 has only one hopper.
2) The angle of the V shaped hopper of chevron tube is 90^0. This angle is relatively larger compared to 45^0 hopper. Smaller the angle of hopper more efficient is the collection of the flocs and their concentration in the hopper resulting more effective down sliding of the sludge. Thus because of the broader angle of hopper bottom in Patent No. 163038, the collection concentration and sliding down of the sludge is less effective.

5. AIM OF THE INVENTION:

In the present invention, attempt has been made to reduce the above mentioned drawbacks to make the tube performance more effective.

6. BRIEF DESCRIPTION OF THE INVENTION:

The invention is a modification of chevron tube described in Patent No. 163038 dated 20th January 1986.

The angle of the V shaped hopper of the standard conventional chevron tube is 90^0 (Fig. 2). The author of this invention tested four hopper bottoms i.e. 120^0, 90^0, 60^0 and 45^0 for their efficiency and found that narrower the angle of hopper, better is the sliding of the settled flocs along the inclined sides of hopper resulting better concentration of flocs / sludge at the bottom of the hopper. In case of 120^0 hopper, base was almost flat and hence the settled flocs/sludge was almost uniformly spread on the bottom without effectively getting slided down towards the bottom of the hopper but as the angle of

hopper was narrowed down, the settled sludge on the hopper sides slided down to the bottom of the hopper more efficiently because of stiffer slope of the hopper sides resulting better concentration of the flocs/ sludge at the bottom portion of the hopper. In the case of inclined tubes, this well concentrated sludge further slided down along the length of the tube more efficiently.

Thus among the flour angles i.e. 120^0, 90^0, 60^0 and 45^0, the 45^0 V shaped hopper gave the best performance. The settled sludge was in the form of fluid containing about 95% of water hence chocking of the hopper bottom due to sludge / solids did not occur even for this narrow angle of 45^0.

Based on this experience, the author of this invention converted V shaped chevron tube (meaning of chevron as per Oxford Dictionary is V shape) into W shaped tube keeping the width of the standard conventional chevron tube the same i.e. $\sqrt{2}$(a) and adjusting the two 45^0 hopper in the same width. This forms W shape in place of V shape of the Standard Chevron tube. Fig. 2 and 4 compare the c/s of the V shaped chevron tube and the invention i.e. the proposed W shaped tube named as 'Tube –W' while Fig. 5 is the longitudinal section of the invention.

The invention is described by way of example with reference to the accompanying figures as mentioned in Table 1.

Table 1 : Figure Number and Description of the Figure

Figure No.	Description of Figure
1	Longitudinal section of modified chevron tube in Patent No. 163038
2	Cross section at A-A in Fig. 1 of the modified chevron tube in Patent No. 163038

3	Cross section of the sedimentation tank containing chevron tube module of Patent No. 163038
4	Cross section of Single 'Tube-W' along with std. chevron tube in Fig. 2 for comparison.
5	Longitudinal section of single 'Tube –W' inclined at angle between 40^0 to 70^0 to horizontal
6	Cross section of the module consisting of single 'Tube W's jointed longitudinally, c/s being in the perpendicular direction of the lengths of 'Tube W'
7	Cross section of Multiple 'Tube –W's containing N number of trays W in the multiple 'Tube –W'.
8	Cross section of the module consisting of Multiple 'Tube-W's jointed longitudinally and laterally, c/s being perpendicular to the length of the tube module.
9	Cross section of the sedimentation tank where module of Multiple 'Tube W' is installed alongwith inlet, outlet etc.

7. DETAILED DESCRIPTION OF THE INVENTION : (FIG. 4 TO 9)

The invention is described by way of example with the help of Figs 4 to 9. Table 2 mentions various parts of the invention alongwith the corresponding figurewise numericals as mentioned in Fig. 4 to 9.

The invention is divided into two types: (i) Single 'Tube –W' (ii) Multiple 'Tube –W'

7.1 Part I: Single Tube –W (Fig. 4,5 & 6)

The invention, Single 'Tube W' is the ten sided W shaped tube as shown in Fig.4. Out of these 10 sides, two vertical and 4 outer sloping sides are of magnitude 'a' while the inner four sloping sides of 'Tube –W' are of magnitude 0.77a as shown in Fig. 4. Each of the two V shaped hoppers is of 45^0. Forming the W shaped top and bottom of 'Tube –W' as shown in Fig. 4. Lesser the vertical distance 'a', better is the efficiency because vertical distance to be travelled by flocs is less but in this example its magnitude is 'a'.

Table 2: Various Parts of the Invention 'Tube-W' alongwith the Corresponding Numericals

Numerical	Fig. No.	Description of Part
1	4,5	Part 1 of invention : Single 'Tube –W'
5	7	Part 2 of Invention : Multiple 'Tube-W'
1,2,3	6,7,9	No. of W shaped trays in Multiple 'Tube W'
10	9	Cross section of the sedimentation tank where tube-module has been installed
11	9	Cross section of the Multiple 'Tube-W' installed in the tank 10
12	9	Inlet pipe for flocculated water
13	9	Inlet valve on pipe 12
14	9	Clarified water collecting trough with V notches located above the module 11
15	9	Clarified water outlet pipe

16	9	Valve on pipe 15
17	9	Collected sludge at the bottom of tank 10
18	9	Sludge outlet pipe for tank 10
19	9	Valve on sludge outlet pipe 18
⑤	9	Encircled number indicating number of Multiple 'Tube-W' in the tank 10
a	4	i) Vertical sides of single 'Tube-W' ii) Outer larger sides of W at top and bottom
√2 (a)	4 2	Width of single 'Tube-W' Width of Chevron Tube of side 'a'
L	5	Length of single 'Tube-W'
n	6	Number of 'Tube-W' per column in the cross section of the module perpendicular to the length of the tubes
m	6	No. of columns
N	7	No. of W shaped trays inserted in the Multiple 'Tube-W'
2c	8	Two number of Multiple 'Tube-W' per column in the cross-section of the module perpendicular to the length of the Multiple 'Tube-W'
8r	8	Eight number of Rows of 'Tube-W' in the module

The longitudinal section of 'Tube-W' is shown in Fig.5 where 'L' is the length of the tube. Inclination of tubes in the tube-module is in the range of 40^0 to 70^0 although 60^0 is quite common.

The module of such single 'Tube-W' consists of tubes jointed together by a suitable material longitudinally and laterally as shown in Fig. 6 which is a cross-section of the module perpendicular to the length of the tubes. There are n tubes per column and m number of such columns, hence the total number of single 'Tube-W' in the module is m x n.

7.2 Multiple 'Tube-W' (Fig. 7 to 9)

In the case of Multiple 'Tube-W', W shaped trays as described in single 'Tube-W' are inserted one below another at regular vertical spacing which is 'a' in this example (Fig.7) Multiple 'Tube-W' indicated by 5. Total height of the tube depends upon the number of W shaped trays inserted in the tube. If inserted trays are N then height of Multiple 'Tube W' is (N+1) x a where a is the spacing of trays. (Fig.7).

Lesser the vertical spacing 'a', lesser the vertical distance to be travelled by the flocs hence better the efficiency of the Multiple 'Tube-W'. Another advantage is that more number of such trays can be adjusted in the given vertical height of the tube when the spacing is reduced.

The module of such Multiple 'Tube-W' consists of tubes jointed together by a suitable material longitudinally and laterally. A cross section of such a module perpendicular to the length of the tubes is shown in Fig. 8 where there are 2 number of Multiple 'Tube-W' per column shown by 1c,2c each tube containing 3 trays. If there are 8 rows of these tubes as shown by 1r, 2r, ..., 8r in Fig. 8, then total number of Multiple 'Tube-W' is 2 x 8 = 16.

The module either Single 'Tube-W' or Multiple 'Tube-W' is installed in a sedimentation tank. In the present example. Multiple 'Tube-W' module is installed in the tank. Fig.9 indicates the sedimentation tank numerically shown by 10. The cross-section of the module of Multiple 'Tube-W' shown by 11 is installed in the sedimentation tank 10, the module consists of five number of Multiple 'Tube-W' shown by encircled number, each Multiple 'Tube-W' consisting of three W shaped trays. The inlet pipe for flocculated water is shown by 12 while the valve on inlet pipe is shown by 13. The clarified water collecting trough with V notches and located above the tube module 11 is shown by 14. The clarified water outlet pipe 15 alongwith outlet valve 16 is connected to the collecting trough 14. The sludge which gets collected at the bottom portion of the tank is shown by 17 while the sludge outlet pipe is shown by 18 and the sludge outlet valve to regulate the flow is shown by 19.

7.3 Method of Operation of Invention

The flocculated water enters the sedimentation tank 10 through the inlet pipe 12 after opening the inlet valve 13. The water then enters the Multiple 'Tube-W' module shown by 11. The water then travels upwards in the module of Multiple 'Tube-W' at a low velocity. The low velocity enables the flocs to settle down on the plurality of W shaped bottoms in the tubes. Thus the water gets clarified during its upwards travel through the module. The clarified water then gets collected in the collecting trough 14 wherefrom it goes to the next unit through the outlet pipe 15 through the valve 16. The collected sludge 17 at the tank bottom is intermittently taken out through the sludge outlet pipe 18 after operating the sludge outlet valve 19.

8. ADVANTAGES OF THE INVENTION

The 'Tube – W' is a modification of Chevron tube having six equal sides each of magnitude 'a', in Patent No. 163038 dated 20-01-1986. In the case of the Chevron tube, there is a single V shaped bottom the angle of the V being 90^0 and the width $\sqrt{2}(a)$ where in two V shaped bottoms are adjusted forming W shape, the angle of each of the two V shapes is 45^0 i.e. much more steep compared to 90^0 of chevron shape. The 45^0 slope is much more steep compared to 90^0 slope and hence results in more efficient sliding of the flocs which settle on the 45^0 slope. Hence concentration of the flocs at the bottom of the hopper is relatively higher which further helps to more efficient sliding of the sludge along the longitudinal direction of the tube. The two 45^0 hoppers in the W shape tube entrap larger quantity of flocs and allow them to slide down the slope of the hoppers in shorter time. In case of standard conventional chevron tube, the vertical height of the tube is also fixed which can be reduced in the present invention. Smaller the height lesser the time required by the flocs to travel, thus even smaller diameter flocs alongwith large size flocs are removed in the present invention –'Tube-W' making the invention more efficient and effective compared to chevron tube.

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I CLAIM

i) The 'Single 'Tube - W' for removal of flocs in water treatment' the ten sided tube having W shaped top and bottom, with two equal size V shaped hoppers at the top forming W shape and similar W shape at the bottom, the outer sides of both W being same, say 'a' the side of the standard, conventional chevron tube, the two inner sides of W at the top as well as at the bottom being small compared to 'a' the outer sides of W, the angle of all the four V shaped hoppers being 45^0, apart from the 4 sides forming W shape at the top and 4 sides forming W shape at the bottom, the remaining two vertical sides indicating height of single 'Tube-W', the normal height of vertical sides being 'a' but could be smaller than 'a' to improve efficiency, the length of the 'Tube –W' being the standard length in the range of 600 to 1000 mm, and the magnitude of 'a' broadly in the range of 40 mm to 80 mm.

ii) The 'Multiple 'Tube –W' for removal of flocs in water treatment', the ten sided tube similar to Single 'Tube-W' as claimed in claim 1, but having larger vertical height, where in W shaped trays with 45^0 angle as described in Single 'Tube –W' of claim 1 are inserted one below another at equal vertical spacing say 'a' which could be reduced, the total height of Multiple 'Tube –W' depending upon the number of W shaped trays inserted in the Multiple 'Tube –W' and the spacing of the trays, the length of the multiple 'Tube – W' being the standard length in the range of 600 to 1000 mm and the magnitude of 'a' broadly in the range of 40 to 80 mm.

iii) The width of either Single 'Tube – W' as claimed in claim 1, or Multiple 'Tube W' as claimed in Claim 2 being $\sqrt{2}(a)$ where 'a' the

side of the standard conventional chevron tube in the range of 40 to 80 mm.

iv) The Multiple 'Tube-W' as claimed in claim2 and 3 where in a plurality of W-shaped trays inserted, their edges perfectly jointed with the vertical sides of Multiple 'Tube W' leaving no gap in between for water to flow through the gap.

v) The 'Single 'Tube –W' for removal of flocs in water treatment' as claimed in Claim 1 & 3 and substantially as herein described with reference to and as illustrated in Figs. 4,5,6, and 9

vi) The 'Multiple 'Tube – W' for removal of flocs in water treatment' as claimed in Claim 2, 3 & 4 and substantially as herein described with reference to and as illustrated in Figs. 7, 8 and 9.

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