DESCRIPTION

FLUID MIXING CHANNEL STRUCTURE AND MIXING METHOD

Technical Field

[0001]

The present invention relates to a fluid mixing channel structure, for example, for efficiently mixing effluent seawater discharged from a seawater desulfurization apparatus with diluting seawater, and to a mixing method.

Background Art

[0002]

Heretofore, effluent seawater discharged from a desulfurization tower is processed by aeration from the viewpoint of environmental conservation and is then returned to the sea. However, right before the effluent seawater is returned to the sea, in order to adjust the conditions (pH, DO, COD, and the like) of the discharged seawater (effluent seawater), whenever necessary, fresh diluting seawater is mixed therewith in some cases.

As a mixing channel structure for mixing discharged seawater and diluting seawater, a channel merging system has been known, in which a discharge channel through which effluent seawater flows and a fluid conduit or a fluid-

conducting tube through which diluting seawater flows are merged with each other. In the case where effluent seawater discharged from a desulfurization tower is diluted and returned to the sea, since the amount of effluent seawater which is generally processed is large, a mixing channel structure is used in which a small fluid conduit or fluid-conducting tube having a relatively small channel cross-sectional area is merged with a discharge channel having a large channel cross-sectional area.

[0003]

A mixing channel structure according to the above channel merging system will be briefly described with reference to Figs. 19 to 22.

In a mixing channel structure shown in Figs. 19 and 20, a discharge channel 1 through which effluent seawater flows and a fluid conduit 2 through which diluting seawater flows are almost perpendicularly merged with each other, in the form a T shape, at approximately the same water level WL. In addition, as shown in Fig. 22, the discharge channel 1 is provided with a necessary mixing length L from a confluent position 3 with the fluid conduit 2. This mixing length L is a channel length of the discharge channel 1 necessary to mix the effluent seawater and the diluting seawater merged therewith so as to obtain diluted mixed seawater, the conditions of which are each controlled at a predetermined level or lower, and the

concentration of which is controlled to be approximately uniform. Then, after the effluent seawater flowing in the discharge channel 1 is approximately uniformly mixed with the diluting seawater over the mixing length L, the mixed seawater thus obtained is returned to the sea.

[0004]

In addition, a mixing channel structure shown in Fig. 21 employs a fluid-conducting tube 4 instead of the fluid conduit 2. This fluid-conducting tube 4 is merged with the discharge channel 1 at a position lower than the surface of effluent seawater flowing in the discharge channel 1 to form a T shape, and the effluent seawater is approximately uniformly mixed with diluting seawater over a mixing length L provided at the downstream side of the confluent position 3 and is then returned to the sea.

Incidentally, there has been no published technical literature relating to a mixing channel structure which can decrease the mixing length L necessary to obtain approximately uniformly mixed seawater by mixing diluting seawater and effluent seawater which is discharged from a desulfurization tower and then returned to the sea.

Disclosure of Invention

[0005]

However, according to the mixing channel structure

according to the above channel merging system of the related art, the diluting seawater is supplied from the side surface of the discharge channel 1 for mixing, and hence, a long mixing length L is required to obtain approximately uniformly mixed seawater. The reason for this is believed to be that the diluting seawater is merged with the flowing effluent seawater from the side surface, the diluting seawater flowing into the discharge channel 1 is significantly influenced by the flow of the effluent seawater, and therefore, the diluting seawater cannot easily reach (cross to) the sidewall opposite to that from which the diluting seawater is supplied, located in the channel width direction of the discharge channel 1.

[0006]

In addition, when a discharge channel 1 having the long mixing length L described above is installed, besides a large site, a large construction cost is also necessary. Hence, when effluent seawater discharged from a desulfurization tower is returned to the sea, in order to return to the sea mixed seawater that satisfies predetermined environmental standards by mixing, the need to procure a facility site area, the increase in construction cost, and the like are serious obstacles. In addition, the mixing length L described above may vary in accordance with various conditions, such as the flow volume of effluent seawater, the flow volume of diluting seawater, and the channel structure.

The present invention has been conceived in consideration of the above circumstances, and an object of the present invention is to provide a mixing channel structure and a mixing method which can decrease the mixing length L necessary for mixing two types of fluids and which can perform efficient mixing.

[0007]

To this end, the present invention provides the following solutions.

In a fluid mixing channel structure according to a first aspect of the present invention, in which a fluid to be diluted, flowing in a first channel, and a diluting fluid, flowing in a second channel, are merged with each other to form a diluted mixed fluid to be discharged, the second channel, from a channel side surface, is merged with the fluid to be diluted, flowing in the first channel, below a water level, and a weir is provided below the water level at a confluent portion between the first channel and the second channel to regulate the fluid to be diluted, flowing in a bottom surface portion of the first channel.

[0008]

According to the fluid mixing channel structure described above, since the second channel, from the channel side surface, is merged with the fluid to be diluted, flowing in the first channel, below the water level, and the fluid to be

diluted, flowing in the bottom surface portion of the first channel, is regulated by the weir provided below the water level at the confluent portion between the first channel and the second channel, the influence of the flow of the fluid to be diluted on the diluting fluid merged therewith from the channel side surface can be decreased, and hence the diluting fluid flowing into the first channel can easily reach an opposite side wall of the first channel in the channel width direction thereof.

In the case described above, although the weir provided below the water level at the confluent portion between the second channel and the first channel may be provided at least in the vicinity of the downstream side with respect to the width of the second channel, two weirs are preferably provided in the vicinities of the downstream and the upstream sides with respect to the width of the second channel. In addition, the weirs in this case are preferably provided at a level equal to or higher than that of the position where the diluting fluid flowing in the second channel is merged. As a method for merging the diluting fluid with the fluid to be diluted, below the water level, from the channel side surface, a so-called submerged weir or fluid-conducting tube may be used.

[0009]

In a fluid mixing channel structure according to a second

aspect of the present invention, in which a fluid to be diluted, flowing in a first channel, and a diluting fluid, flowing in a second channel, are merged with each other to form a diluted mixed fluid to be discharged, the second channel, from a channel side surface, is merged with the fluid to be diluted, flowing in the first channel, below a water level, and at a confluent portion between the first channel and the second channel, weirs each having a height larger than a channel height of the second channel are provided below the water level at the upstream and the downstream sides with respect to the width of the second channel across the channel width of the first channel.

[0010]

According to the fluid mixing channel structure as described above, since the second channel, from the channel side surface, is merged with the fluid to be diluted, flowing in the first channel, below the water level, and at the confluent portion between the first channel and the second channel, the weirs each having a height larger than the channel height of the second channel are provided below the water level at the upstream and the downstream sides with respect to the width of the second channel across the channel width of the first channel, the influence of the flow of the fluid to be diluted on the diluting fluid merged therewith, below the water level, from the channel side surface of the

first channel, is decreased, and hence the diluting fluid flowing into the first channel can easily reach an opposite side wall thereof in the channel width direction of the first channel. In addition, as a method for merging the diluting fluid with the fluid to be diluted, below the water level, from the channel side surface, a so-called submerged weir or fluid-conducting tube may be used.

[0011]

In the fluid mixing channel structure according to the first and the second aspects described above, a flat portion extending in a channel flow direction is preferably formed at a top portion of the weir disposed at the downstream side, and since the fluid depth is decreased by this flat portion, a region having a decreased channel cross-sectional area can be formed. In this region, since the fluid to be diluted and the diluting fluid are merged with each other, the velocity thereof is increased, and hence the mixing and diffusion of the two types of fluids are improved. In addition, the above flat portion in this case may be provided only at one of the downstream and the upstream sides of the wire or may be provided at both sides.

Irregularities are preferably formed on a fluid flowing surface of the flat portion as described above, and by the above irregularities, turbulence is generated in the flow, so that the mixing is further improved.

[0012]

In one of the fluid mixing channel structures described above, the weir disposed at the upstream side with respect to the width of the second channel is preferably inclined along the flow of the fluid to be diluted from a channel wall-side initial point where the second channel is merged to a channel wall-side end point opposite to the initial point in the channel width direction of the first channel, and by the weir described above, the diluting fluid is uniformly distributed along the channel width direction of the first channel and is then mixed with the fluid to be diluted.

[0013]

A mixing method, in accordance with a third aspect of the present invention, in which a fluid to be diluted, flowing in a first channel, and a diluting fluid, flowing in a second channel, are merged with each other from a channel side surface of the first channel to form a diluted mixed fluid to be discharged, comprises the steps of: merging the diluting fluid with the fluid to be diluted, below a water level; and regulating the fluid to be diluted, flowing in a bottom surface portion of the first channel, at a confluent portion between the diluting fluid and the fluid to be diluted.

[0014]

According to the fluid mixing method as described above, in a fluid mixing method in which the mixed fluid obtained by

merging the diluting fluid, flowing in the second channel, with the fluid to be diluted, flowing in the first channel, from the channel side surface thereof is discharged, since the diluting fluid is merged with the fluid to be diluted, below the water level, and the fluid to be diluted, flowing in the bottom surface portion of the first channel, is regulated at the confluent portion between the diluting fluid and the fluid to be diluted, the influence of the flow of the fluid to be diluted on the diluting fluid merged therewith from the channel side surface can be decreased, and the diluting fluid flowing into the first channel can easily reach the opposite side wall in the channel width direction of the first channel.

[0015]

According to the present invention, for example, as is the case in which mixed seawater obtained by mixing effluent seawater discharged from a desulfurization tower and diluting seawater is returned to the sea, the mixing length L necessary for mixing two types of fluids can be decreased, and as a result, a fluid mixing channel structure and a mixing method which can perform efficient mixing can be provided. Accordingly, by the fluid mixing channel structure and the mixing method, according to the present invention, in which the mixing length L can be decreased, the size of the site and the construction cost necessary for construction of a plant including a fluid mixing channel structure can be reduced, and

as a result, a significant increase in design freedom can be obtained.

Brief Description of Drawings

[0016]

[FIG. 1] Fig. 1 is a perspective view of a fluid mixing channel structure of a first embodiment according to the present invention.

[FIG. 2] Fig. 2 is a sectional view taken along line A-A in Fig. 1.

[FIG. 3] Fig. 3 is a plan view of the fluid mixing channel structure shown in Fig. 1.

[FIG. 4] Fig. 4 is a plan view of a fluid mixing channel structure of a second embodiment according to the present invention.

[FIG. 5] Fig. 5 is a sectional view taken along line B-B in Fig. 4.

[FIG. 6] Fig. 6 is a longitudinal sectional view of a first Modified Example of a flat portion shown in Fig. 4.

[FIG. 7] Fig. 7 is a longitudinal sectional view of a second Modified Example of the flat portion shown in Fig. 4.

[FIG. 8] Fig. 8 is a longitudinal sectional view of a third Modified Example of the flat portion shown in Fig. 4.

[FIG. 9] Fig. 9 is a plan view of a fluid mixing channel structure of a third embodiment according to the present

invention.

[FIG. 10] Fig. 10 is a plan view of a fluid mixing channel structure of a fourth embodiment according to the present invention.

[FIG. 11] Fig. 11 is a perspective view of a fluid mixing channel structure of a fifth embodiment according to the present invention.

[FIG. 12] Fig. 12 is a sectional view taken along line C-C in Fig. 11.

[FIG. 13] Fig. 13 is a perspective view of a flat portion, provided with irregularities, of a sixth embodiment according to the present invention.

[FIG. 14] Fig. 14 is a sectional view taken along line D-D in Fig. 13.

[FIG. 15] Fig. 15 is a plan view showing a first Modified Example of the irregularities shown in Fig. 13.

[FIG. 16] Fig. 16 is a plan view showing a second Modified Example of the irregularities shown in Fig. 13.

[FIG. 17] Fig. 17 is a sectional view taken along line E-E in Fig. 16.

[FIG. 18] Figs. 18 (a) and (b) are plan views of scale-shaped irregularities in different directions, as a third Modified Example of the irregularities shown in Fig. 13.

[FIG. 19] Fig. 19 is a perspective view showing a fluid mixing channel structure having an open-type fluid conduit, as

an example of the related art.

[FIG. 20] Fig. 20 is a side view of the fluid mixing channel structure shown in Fig. 19.

[FIG. 21] Fig. 21 is a perspective view showing a fluid mixing channel structure having a fluid-conducting tube, as another example of the related art.

[FIG. 22] Fig. 22 is a plan view showing the fluid mixing channel structure shown in Figs. 19 and 21.

Explanation of Reference Signs:

[0017]

10, 10A~10D: mixing channel

11: discharge channel (first channel)

12: fluid conduit (second channel)

12A: fluid-conducting tube (second channel)

13: confluent position

14, 14A: first weir

15, 15A: second weir

16: third weir

17, 17A: cross channel

20, 20A, 20B, 20C: flat portion

30, 31, 32, 33A, 33B: irregularities

Best Mode for Carrying Out the Invention

[0018]

Hereinafter, a fluid mixing channel structure and a mixing method of embodiments according to the present invention will be described with reference to the drawings.

First Embodiment

A mixing channel 10 shown in Figs. 1 to 3 is used, for example, in the case in which a large amount of discharged seawater (effluent seawater) discharged from a desulfurization tower of a flue-gas desulfurization facility is diluted with diluting seawater to form mixed seawater which satisfies environmental standards and the like and is then returned to the sea. Specifically, the mixing channel 10 shown in the figures has a discharge channel (first channel) 11 through which the effluent seawater (fluid to be diluted) flows and a fluid conduit (second channel) 12 through which the diluting seawater (diluting fluid) flows, and the fluid conduit 12 is merged perpendicularly with the discharge channel 11 at one side surface 11a thereof to form a T shape. In other words, the mixing channel 10 has a structure in which the discharge channel 11, having a large channel cross-sectional area through which a large amount of effluent seawater flows, and the fluid conduit 12, having a small cross-sectional area through which a relatively small amount of diluting seawater flows, are merged with each other to form a T-shape.

In this embodiment, the discharge channel 11 and the

fluid conduit 12 are both open-type channels whose cross-sectional shapes are rectangular, and a water level WL of the effluent seawater is the same as that of the diluting seawater.

[0019]

At a confluent portion 19 where the discharge channel 11 and the fluid conduit 12 are merged, a first weir 14 and a second weir 15 are provided below the water level WL, in that order from the upstream side of the effluent seawater, in order to regulate the effluent seawater flowing in a bottom surface portion of the discharge channel 11 in the channel flow direction (indicated by an open arrow F in the figure).

The first weir 14 and the second weir 15 in this case are disposed in parallel with each other with a distance therebetween approximately equal to a channel width Wd of the fluid conduit 12 and are provided across a channel width Wh of the discharge channel 11 so as to be perpendicular to the flow of the effluent seawater. That is, the first weir 14 and the second weir 15 are formed approximately perpendicular to a bottom surface 11b of the discharge channel 11 at positions extending from left and right side walls 12a of the fluid conduit 12 so as to regulate the flow in a bottom surface portion, which is from the channel bottom surface 11b to a height H.

[0020]

The first weir 14 and the second weir 15 described above may be formed of walls having a strength that can sufficiently withstand the water pressure, and hence, in this embodiment, for example, concrete walls having a relatively small thickness may be used. However, the first weir 14 and the second weir 15 are not limited to concrete walls, and for example, steel structural members and/or steel plates may also be used.

[0021]

In addition, in order to merge the diluting seawater with the effluent seawater in the discharge channel 11, that is, in order to merge the diluting seawater with the effluent seawater flowing in the discharge channel 11, below a water level, from the channel side surface 11a, a third weir 16 is provided at an outlet port 12b of the fluid conduit 12. This third weir 16, which is generally called a submerged weir, regulates an upper part of the flow in the fluid conduit 12 and also has an opening provided at a bottom surface side of the fluid conduit 12, which functions as a channel for the diluting seawater. The third weir 16 in this embodiment is a submerged weir having an opening from the channel bottom surface to a height h which functions as a channel for the diluting seawater, and hence the height h from the channel bottom surface 11b is set lower than the water level WL. In this embodiment, an open arrow f in the figure indicates the

flow direction of the diluting seawater.

[0022]

In addition, a diluting seawater channel height h formed by the third weir 16 is set equal to or lower than the height H of the first weir 14 and the second weir 15 ($h \leq H$). Hence, since the height H of the first weir 14 and the second weir 15 is lower than the water level WL, the diluting seawater flowing in the fluid conduit 12 is reliably merged with the effluent seawater below the water level through the opening portion having a height h.

[0023]

The above mixing channel 10 has a structure in which the diluting seawater flowing in the fluid conduit 12, which has an outlet opening having the restricted height h and which is provided in the channel side surface 11a of the discharge channel 11, is merged with the effluent seawater flowing in the discharge channel 11, below the water level, and also in which the first weir 14 and the second weir 15 are provided at the confluent portion 13 where the diluting seawater is merged with the discharge channel 11 in order to regulate the effluent seawater flowing in a bottom surface portion, that is, the portion up to a height H. Hence, the diluting seawater merged with the discharge channel 11 flows through a cross channel 17 formed between the first weir 14 and the second weir 15 so as to cross the discharge channel 11 having

the channel width Wh and to reach an opposite side wall 11c while the influence of the flow of the effluent seawater is decreased.

That is, since the cross channel 17 formed by the first weir 14 and the second weir 15 having the height H is provided over the channel width Wh of the discharge channel 11, the diluting seawater merged with the effluent seawater (below the water level), flowing in the discharge channel 11, from the fluid conduit 12 through the outlet opening having the height h, which is restricted by the third weir 16, primarily flows through the cross channel 17 in which the flow is regulated by the first weir 14 and the second weir 15 and can easily reach the opposite channel side surface (side wall) 11c.

[0024]

In addition, since the portion flowing at a channel bottom surface 11b side is regulated by the first weir 14 and the second weir 15, the diluting seawater flowing through the cross channel 17 is gradually mixed with the effluent seawater flowing at the top with increased velocity due to a decrease in channel cross-sectional area, so as to overflow upwards while flowing in the channel width Wh direction. Therefore, turbulence is generated in the flow, and as a result, mixing can be efficiently performed. Accordingly, in the channel width direction Wh of the discharge channel 11, the diluting seawater is approximately uniformly merged and mixed with the

effluent seawater flowing in the discharge channel 11, and hence the mixing length L necessary to obtain approximately uniform properties of the total flow formed from the effluent seawater and the diluting seawater merged therewith can be decreased.

[0025]

As for the relationship between the height H of the first weir 14 and the second weir 15 and the height h of the outlet opening described above, it is preferable that the diluting seawater be merged with the effluent seawater below a water level which is lower than the height H of the cross channel 17, that is, that the height h of the outlet opening be set smaller than the height H of the weir, since the influence of the flow of the effluent seawater is decreased. However, even if the height h at which the diluting seawater is merged is larger than the height H of the cross channel 17, although the mixing length L is increased to a certain extent, as long as the cross channel 17 is formed by the first weir 14 and the second weir 15, the effluent seawater flowing in the bottom portion can be regulated, and hence the mixing length L can be decreased as compared to the case in which the cross channel 17 is not provided at all.

Second Embodiment

[0026]

Next, a fluid mixing channel structure of a second embodiment according to the present invention will be described with reference to Figs. 4 and 5. In this embodiment, constituent elements and the like similar to those in the above embodiment are designated by the same reference numerals as described above, and a detailed description thereof is omitted.

In the above embodiment, although the first weir 14 and the second weir 15 are formed of the concrete walls having a relatively small thickness, in a mixing channel 10A of this embodiment, a second weir 15A having a flat portion 20, extending in the flow direction F, at a top portion is used as the weir disposed at the downstream side of the flow of the effluent seawater. That is, the second weir 15A is a pillar-shaped member having the flat portion 20 with a length α in the flow direction of the effluent seawater which is sufficiently large as compared to the width (thickness) required in terms of strength. In this embodiment, for this second weir 15A, for example, a concrete or steel structural member may be used.

[0027]

When the second weir 15A described above is used, at the downstream side of the cross channel 17, the discharge channel 11 is formed to have a small channel cross-sectional area over the length α of the flat portion 20. Accordingly, since the

diluting seawater is merged with the effluent seawater from the cross channel 17 to form the mixed seawater having a larger volume, the velocity of the mixed seawater flowing along the flat portion 20 is further increased, so that the degree of turbulence of the flow is also increased. Hence, in the region corresponding to the flat portion 20, since the effluent seawater flowing in the discharge channel 11 and the diluting seawater from the cross channel 17, which are merged with each other, are mixed and diffused, the mixing is efficiently and reliably performed, and as a result, approximately uniform properties of the merged total flow can be obtained, even with a smaller mixing length L.

[0028]

Next, Modified Examples of the above flat portion 20 will be described with reference to Figs. 6 to 8. In the Modified Examples, constituent elements and the like similar to those in the above embodiment are designated by the same reference numerals as described above, and a detailed description thereof is omitted.

A flat portion 20A of a first Modified Example shown in Fig. 6 is formed from an upper surface of a plate member 21 provided at the top of the second weir 15 shown in the first embodiment. Since the plate member 21 in this case is provided from the top of the second weir 15 to the downstream side in the channel flow direction F to form an L shape,

substantially the same effect as that of the second weir 15A of the above-described second embodiment can be obtained. That is, the second weir of this Modified Example is a weir obtained by removing a part having no effect on the flow from the pillar-shaped second weir 15A shown in the second embodiment.

[0029]

A flat portion 20B of a second Modified Example shown in Fig. 7 is different from the plate member 21 of the first Modified Example provided at the downstream side and is formed of a plate member 22 provided at the top of the second weir 15 in the direction of the upstream side. With the structure described above, since the width of the channel merged with the effluent seawater from the cross channel 17 is decreased to β, the diluting seawater merged with the effluent seawater is more uniformly mixed therewith in the channel width Wh direction of the discharge channel 11. In addition, as with the second embodiment and the first Modified Example described above, in the region corresponding to the flat portion 20B, since the effluent seawater flowing in the discharge channel 11 and the diluting seawater from the cross channel 17, which are merged with each other, are mixed and diffused, the mixing is efficiently and reliably performed, and as a result, approximately uniform properties of the merged total flow can be obtained, even with a smaller mixing length L.

[0030]

A flat portion 20C of a third Modified Example shown in Fig. 8 is a combination of the above first and second Modified Examples and is formed from the plate member 21 provided at the downstream side and the plate member 22 provided at the upstream side. In this case, the plate members 21 and 22 may be separately or integrally formed.

With the structure described above, since the channel width through which the diluting seawater from the cross channel 17 is merged with the effluent seawater is decreased to β, the diluting seawater merged with the effluent seawater is more uniformly mixed therewith in the channel width Wh of the discharge channel 11. In addition, in the region corresponding to the flat portion 20C, since the effluent seawater flowing in the discharge channel 11 and the diluting seawater from the cross channel 17, which are merged with each other, are mixed and diffused, the mixing is efficiently and reliably performed, and as a result, approximately uniform properties of the merged total flow can be obtained, even with a smaller mixing length L.

Third Embodiment

[0031]

Next, a fluid mixing channel structure of a third embodiment according to the present invention will be

described with reference to Fig. 9. In this embodiment, constituent elements and the like similar to those in the above embodiment are designated by the same reference numerals as described above, and a detailed description thereof is omitted.

In the above embodiment, although the first weir 14 and the second weir 15 are disposed in parallel with each other, in a mixing channel 10B of this embodiment, a first weir 14A provided at the upstream side is inclined in the channel flow direction F of the discharge channel 11. In particular, the first weir 14A, which extends from a channel wall-side initial point S where the fluid conduit 12 is merged to a channel wall-side end point E opposite to the initial point S in the channel width Wh direction of the discharge channel 11 and which is provided at the upstream side of the fluid conduit 12 having a channel width Wd, is inclined toward the downstream side of the flow of the effluent seawater.

[0032]

That is, since the first weir 14A is inclined so that the channel wall-side initial point S connected to the channel side surface 11a where the fluid conduit 12 is merged is disposed at the upstream side as compared to the channel wall-side end point E connected to the channel side surface 11c, the channel cross-sectional area of the cross channel 17A formed at a confluent portion 13A is gradually decreased from

the side wall surface where the fluid conduit 12 is merged toward the opposite side wall surface in the channel direction Wh.

By forming the cross channel 17A as described above, the distribution of the diluting seawater flowing in the cross channel 17A is made uniform in the channel width Wh direction. In other words, because a channel width Wf of the cross channel 17A in plan view is decreased toward the channel end point E where the volume of the diluting seawater is decreased by merging it with the effluent seawater while flowing, the height (depth) of the diluting seawater flowing in the cross channel 17 is made uniform in the channel width Wh direction. Accordingly, since the volume of the diluting seawater merged with the effluent seawater from the cross channel 17A is made uniform in the channel width Wh direction, even when the mixing length L is decreased, mixing can be efficiently performed, and hence the total mixed flow can be made to have approximately uniform properties. In addition, although not shown in the figure, the second weir 15 may have a structure formed with a combination of the second embodiment and the Modified Examples thereof.

Fourth Embodiment

[0033]

Next, a fluid mixing channel structure of a fourth

embodiment according to the present invention will be described with reference to Fig. 10. In this embodiment, constituent elements and the like similar to those in the above embodiment are designated by the same reference numerals as described above, and a detailed description thereof is omitted.

A mixing channel 10C of this embodiment is provided with only the second weir 15, and the first weir 14 is not used. That is, the effluent seawater flowing in the bottom surface portion of the discharge channel 11 is regulated by the second weir 15. With this structure, the construction cost can be decreased since the number of weirs is decreased, and in addition, the mixing length L can also be decreased. Although not shown in the figure, the second weir 15 may have a structure formed with a combination of the second embodiment and the Modified Examples thereof.

Fifth Embodiment

[0034]

Next, a fluid mixing channel structure of a fifth embodiment according to the present invention will be described with reference to Figs. 11 and 12. In this embodiment, constituent elements and the like similar to those in the above embodiment are designated by the same reference numerals as described above, and a detailed description

thereof is omitted.

A mixing channel 10D of this embodiment employs a fluid-conducting tube 12A instead of the above fluid conduit 12 of the first embodiment. That is, the open-type fluid conduit 12 is changed to the fluid-conducting tube 12A formed by a tube.

[0035]

According to the structure as described above, from the positional relationship between the discharge channel 11 and the fluid-conducting tube 12A merged with the side surface thereof, the diluting seawater can be easily merged with the effluent seawater below a water level without providing a submerged weir, such as the third weir 16. That is, since the fluid-conducting tube 12A through which a small amount of diluting seawater flows can be formed from a tube having a relatively small diameter, the fluid-conducting tube 12A may be connected to and merged with the channel side surface 11a of the discharge channel 11 so that the bottom portion is set at approximately the same level of the bottom surface 11b of the discharge channel 11 and the top portion of the fluid-conducting tube 12A is set at a level lower than the water level WL.

In addition, the effect of the cross channel 17 formed by the first weir 14 and the second weir 15 is the same as that in the case in which the fluid conduit 12 described above is used.

[0036]

In addition, in order to obtain high mixing efficiency, the relationship between a height h of the opening of the fluid-conducting tube 12A and the height H of the first weir 14 and the second weir 15 is preferably set so that $h \leq H$ holds, as in the above embodiment.

In addition, although not shown in the figures, the mixing channel using the fluid-conducting tube 12A described above may be formed with a combination of the above embodiments, and the same effects can also be obtained.

Sixth Embodiment

[0037]

Next, a fluid mixing channel structure of a sixth embodiment according to the present invention will be described with reference to Figs. 13 and 14. In this embodiment, constituent elements and the like similar to those in the above embodiment are designated by the same reference numerals as described above, and a detailed description thereof is omitted.

In this embodiment, irregularities 30 are formed on a fluid flowing surface of the above flat portion 20. The irregularities 30 shown in Figs. 13 and 14 are formed of linear thin plates protruding from the surface at regular intervals so as to cross approximately perpendicularly to the

flow of the effluent seawater and that of the mixed seawater.

[0038]

The flat portion 20 provided with the irregularities 30 as described above generates, for example, whirlpools in the flow of the effluent seawater and/or the mixed seawater to cause turbulence, and hence the mixing between the effluent seawater and the diluting seawater is further improved. Hence, with the irregularities 30 provided on the flat portion 20, the mixing length L can be effectively decreased. In addition, when the irregularities 30 are formed on the flat portion 20A, 20B, or 20C described as the Modified Examples of the flat portion 20, of course, an effect similar to that described above can also be obtained, and furthermore, when the irregularities 30 are formed on the top surface of the first weir 14 and that of the second weir 15, which are formed from concrete having a relatively small thickness, turbulence is generated in the flow, and hence the mixing efficiency can also be improved.

[0039]

In addition, various Modified Examples of the irregularities 30 described above can be made; some of the Modified Examples, shown in Figs. 15 to 17, will be described here.

In a first Modified Example shown in Fig. 15, irregularities 31 are intermittently provided on straight

lines disposed with a predetermined pitch in the flow direction. As the irregularities 31 in this case, thin plates are provided perpendicular to the flat portion in a staggered manner.

[0040]

In a second Modified Example shown in Figs. 16 and 17, irregularities 32 are provided along zigzag lines disposed with a predetermined pitch in the flow direction. As the irregularities 32 in this case, for example, thin plates each folded as shown in a cross-sectional view of Fig. 17 are fixed on the surface of the flat portion 20. In addition, instead of the irregularities 32 described above, for example, irregularities 33A or 33B formed by repeatedly folding thin plates to form scale shapes may be provided on the flat portion 20 as a third Modified Example shown in Fig. 18A or 18B, respectively.

Also when the irregularities 31, 32, 33A, and 33B of the first to third Modified Examples are employed, for example, whirlpools are generated in the flow of the effluent seawater and that of the mixed seawater, and turbulence is generated in the flow; hence, the mixing between the effluent seawater and the diluting seawater is further improved.

[0041]

According to the mixing channel structures of the above

embodiments, when the mixed seawater obtained by diluting the effluent seawater flowing in the discharge channel 11 with the diluting seawater, which flows in the fluid conduit 12 or the fluid-conducting tube 12A and which is merged with the effluent seawater from the channel side surface, is returned to the sea, since the diluting seawater is merged with the effluent seawater below the water level, and the effluent seawater flowing in the channel bottom surface portion of the discharge channel 11 in the channel direction F is regulated at the confluent portion between the diluting seawater and the effluent seawater, a fluid mixing method can be realized in which the influence of the flow of the effluent seawater on the diluting seawater merged therewith from the channel side surface is decreased, and hence the diluting seawater flowing into the discharge channel 11 can easily reach the side wall at the opposite side in the channel width Wh direction.

[0042]

In addition, according to the fluid mixing channel structure and the mixing method of the present invention, for example, as in the case in which mixed seawater obtained by mixing effluent seawater discharged from a desulfurization tower and diluting seawater is returned to the sea, the mixing length L necessary for mixing two types of fluids can be decreased, and as a result, efficient mixing can be performed. When the mixing length L can be decreased as described above,

in plant construction which needs a fluid mixing channel structure, such as the discharge channel 11 and/or the fluid conduit 12, the size of the site and the construction cost can be reduced, and in particular, since the length of the discharge channel 11 located at the downstream side of the confluent portion 13 can be decreased, the degree of design freedom can be increased.

[0043]

In the embodiments described above, the mixing channel structure in which a large amount of discharged seawater (effluent seawater) discharged from a desulfurization tower of a flue-gas desulfurization facility is mixed with fresh diluting seawater for dilution is described; however, the present invention is not limited thereto. Of course, the present invention can also be applied to a mixing channel structure and a mixing method in which two other types of fluids are efficiency mixed together to form a mixed fluid having approximately uniform properties and concentration.

In addition, the present invention is not limited to the above embodiments and can be freely modified without departing from the spirit and the scope of the present invention.

CLAIMS

1. A fluid mixing channel structure in which a fluid to be diluted, flowing in a first channel, and a diluting fluid, flowing in a second channel, are merged with each other to form a diluted mixed fluid to be discharged,

wherein the second channel, from a channel side surface, is merged with the fluid to be diluted, flowing in the first channel, below a water level, and

a weir is provided below the water level at a confluent portion between the first channel and the second channel to regulate the fluid to be diluted, flowing in a bottom surface portion of the first channel.

2. A fluid mixing channel structure in which a fluid to be diluted, flowing in a first channel, and a diluting fluid, flowing in a second channel, are merged with each other to form a diluted mixed fluid to be discharged,

wherein the second channel, from a channel side surface, is merged with the fluid to be diluted, flowing in the first channel, below a water level, and

at a confluent portion between the first channel and the second channel, weirs each having a height larger than a channel height of the second channel are provided below the water level at the upstream and the downstream sides with

respect to the width of the second channel across the channel width of the first channel.

3. The fluid mixing channel structure according to Claim 1 or 2, wherein at a top portion of the weir located at the downstream side, a flat portion extending in the channel flow direction is formed.

4. The fluid mixing channel structure according to Claim 3, wherein irregularities are formed on a fluid flowing surface of the flat portion.

5. The fluid mixing channel structure according to one of Claims 1 to 4,

wherein the weir disposed at the upstream side with respect to the width of the second channel is inclined along the flow of the fluid to be diluted from an initial point at a channel wall where the second channel is merged to an end point at an opposite channel wall side.

6. A mixing method in which a fluid to be diluted, flowing in a first channel, and a diluting fluid, flowing in a second channel, are merged with each other to form a diluted mixed fluid to be discharged, comprising the steps of:

merging the diluting fluid with the fluid to be diluted,

below a water level, from a channel side surface of the first channel; and

regulating the fluid to be diluted, flowing in a bottom surface portion of the first channel, at a confluent portion between the diluting fluid and the fluid to be diluted.