

【DESCRIPTION】**【Invention Title】**

SQUARE PRESSURE TANK

【Technical Field】

[0001] The present invention relates to a square pressure tank, and more particularly, to a square pressure tank capable of enhancing efficiency of space, as well as maintaining internal high pressure.

【Background Art】

[0002] Natural gas is generally supplied as a pipe natural gas (PNG) from a production region to a consuming region through a pipeline, or, if the consuming region is far away from the production region, natural gas is supplied as a liquefied natural gas (LNG) by a ship. Here, the LNG is directly used as fuel for a transportation means such as a ship, as well as a place where general LNG is used, and, to this end, LNG is generally stored in a cylindrical pressure tank and used.

[0003] A cylindrical pressure tank has good pressure resistance and a small volume so that it may be conveniently used in an automobile, or the like. However, when a large amount of LNG is required such as in a ship, a plurality of cylindrical pressure tank must be installed. In particular, in case where LNG is used as fuel of a ship, a large number of cylindrical pressure tank are required to be installed in the ship, and here, arrangement of a

plurality of cylindrical pressure tank occupies a very large space in the ship due to intervals between the pressure tank.

[0004] In order to solve the problem, a non-cylindrical membrane type or a spherical type tank system has been developed, and the inventor of this application has also proposed, in WO2012-148154, a grid type pressure tank improving shortcomings of the membrane type or spherical type tank system.

[0005] The related art grid type pressure tank is manufactured as a box type tank which has enhanced strength through a plurality of grid structures formed inside thereof. However, if the grid type pressure tank is manufactured to be small in size so that it may be used in a small to medium-sized ships, as well as large-sized ships, a work space for an operator (or a worker) to get in to perform maintenance work of the tank is so narrow that manufacturing and maintenance of the tank are difficult.

[0006] Also, in the case of cylinder pressure vessels, formulas for estimating a thickness of each member have been proposed or defined (e.g., ASME Boiler and Pressure Vessel Code), but design formulas applicable to the design for square pressure tank have not been proposed or defined.

[0007] Further, an outer shape of pressure tank may not be changed according to shapes of spaces in which the

pressure tank are accommodated.

【Disclosure】

【Technical Problem】

[0008] An object of the present invention is to provide a square pressure tank having enhanced space efficiency through a grid structure, an outer plate, and a coupling form of the grid structure and the outer plate, as well as maintaining high pressure inside thereof.

[0009] Another object of the present invention is to specify design variables required for designing and manufacturing a square pressure tank and provide design formulas of a pressure tank having an internal grid structure satisfying space efficiency and pressure resistance.

[0010] Still another object of the present invention is to allow an external shape of a pressure tank to be changed according to a shape of accommodated space and to provide design variables and design formulas required here.

【Technical Solution】

[0011] In one general aspect, a square pressure tank includes: an internal grid part including a plurality of grids spaced apart from each other in a length direction, a width direction, and a height direction and an internal through portion formed in the length direction; and a tank outer plate (i.e., an outer plate of a tank) covering an outer surface of the internal grid part, wherein at least

one surface of the tank outer plate is gently curved.

[0012] In particular, the internal grid part may include: length-directional auxiliary members spaced apart from each other in the length direction, height-directional auxiliary members spaced apart from each other in the height direction, and width-directional auxiliary members spaced apart from each other in the width direction, wherein corners of any one of the length-directional auxiliary members, the height-directional auxiliary members, and the width-directional auxiliary members may have a shape corresponding to the tank outer plate having the gently curved surface to support a pressure load acting on the tank outer plate.

[0013] Also, the internal grid part may include a grid cut part formed by cutting length-directional, width-directional, and height-directional corners in a straight line or curved line.

[0014] Also, the tank outer plate may include: a planar outer plate part covering a plane of the internal grid part and a cut outer plate part covering the grid cut part, wherein a predetermined space is formed between corners of the grid cut part and the cut outer plate part.

[0015] Also, the length-directional auxiliary member may have a circular or elliptical length-directional opening, and an area of the length-directional opening may be 90% or less of an area of the length-directional

auxiliary member.

[0016] Also, the width-directional auxiliary member may have a width-directional opening, the height-directional auxiliary member may have a height-directional opening, a width of a width-directional neck on one side obtained by subtracting the width-directional opening from the width-directional auxiliary member may range from 50 mm to 3000 mm, and a width of a height-directional neck on one side obtained by subtracting the height-directional opening from the height-directional auxiliary member may range from 50 mm to 3000 mm.

[0017] Also, the length-directional auxiliary members may be arranged at an interval of 1000 mm to 5000 mm, and the width-directional auxiliary members and the height-directional auxiliary members may be arranged at an interval of 400 mm to 1000 mm.

[0018] Also, a plurality of length-directional unit openings having a unit space may be arranged to form a length-directional opening in the length-directional auxiliary members.

[0019] Also, the number of the length-directional unit openings provided in the length-directional auxiliary members may be determined by Equation below.

[0020]
$$\frac{N \times A_0}{A_1} \leq 0.9$$

[0021] (Here, N is the number of length-directional

unit openings, A0 is an area of the length-directional unit opening, and A1 is an area of the length-directional auxiliary member).

[0022] Also, a width-directional length or a height-directional length of the length-directional unit opening may be 300 mm or greater.

[Advantageous Effects]

[0023] The square pressure tank according to the present invention has an advantage that internal high pressure may be maintained and space efficiency may be improved.

[BRIEF DESCRIPTION OF THE DRAWINGS]

[0024] FIGS. 1 to 6 illustrate a square pressure tank according to a first exemplary embodiment of the present invention.

[0025] FIGS. 7 to 9 are diagrams showing a square pressure tank according to a first modification of the first exemplary embodiment of the present invention.

[0026] FIGS. 10 to 12 are diagrams showing a square pressure tank according to a second modification of the first exemplary embodiment of the present invention.

[0027] FIGS. 13 to 16 are diagrams showing a square pressure tank according to a second exemplary embodiment of the present invention.

[0028] FIGS. 17 to 19 are diagrams showing a square pressure tank according to a first modification of the

second exemplary embodiment of the present invention.

[0029] FIGS. 20 to 24 are diagrams showing a square pressure tank according to a third exemplary embodiment of the present invention.

[0030] FIGS. 25 to 29 are diagrams showing a square pressure tank according to a fourth exemplary embodiment of the present invention.

[0031] FIGS. 30 to 35 are diagrams showing a square pressure tank according to a first modification of the fourth exemplary embodiment of the present invention.

[0032] FIGS. 36 and 37 are diagrams showing a square pressure tank according to a second modification of the fourth exemplary embodiment of the present invention.

[0033] FIGS. 38 to 45 are diagrams showing a square pressure tank according to a fifth exemplary embodiment of the present invention.

[0034] FIGS. 46 to 48 are diagrams showing a square pressure tank according to a first modification of the fifth exemplary embodiment of the present invention.

[0035] FIGS. 49 to 51 are diagrams showing a square pressure tank according to a second modification of the fifth exemplary embodiment of the present invention.

[0036] FIGS. 52 and 53 are diagrams showing a square pressure tank according to a third modification of the fifth exemplary embodiment of the present invention.

[Best Mode]

[0037] Hereinafter, a square pressure tank having the above-described characteristics will be described in detail with reference to the accompanying drawings.

[0038] <Square pressure tank according to first exemplary embodiment of present invention>

[0039] FIGS. 1 to 6 are diagrams showing a square pressure tank according to a first exemplary embodiment of the present invention.

[0040] As illustrated in FIGS. 1 to 3, a square pressure tank 100 according to the first exemplary embodiment of the present invention includes an internal grid part 110 including a plurality of grids 111 spaced apart from each other in a length direction, a width direction, and a height direction and including an internal through part 113 formed in the length direction and a tank outer plate 120 covering an outer surface of the internal grid part 110.

[0041] Here, the internal grid part 110 includes a grid cut part 112 formed by cutting the corners in the length direction, the width direction, and the height direction in a straight line or a curved line.

[0042] The grid cut part 112 is a point where welding of the tank outer plate 120 is finished and a space between the grid cut part 112 and the tank outer plate 120 serves as a movement passage of a fluid during an operation.

[0043] The tank outer plate 120 formed to cover an outer surface of the internal grid part 110 includes a planar outer plate part 121 formed to cover a planar surface of the internal grid part 110 and a cut outer plate part 122 connecting the planar outer plate parts 121 and covering the grid cut part 112.

[0044] The structure of the internal grid part and the tank outer plate of the square pressure tank according to the first exemplary embodiment of the present invention will be described in more detail.

[0045] In FIG. 1, when a height-directional length of the tank outer plate 120 is H , a width-directional length W of the tank outer plate 120 may be within a range of $0.5 \cdot H$ to $1.5 \cdot H$ and a length-directional length L of the tank outer plate 120 may be $1.5 \cdot H$ or greater.

[0046] Also, the cut outer plate part 122 connecting the planar outer plate part 121 and covering the grid cut part 112 has a predetermined curvature R , and here, the cut outer plate part 122 may have a curvature of $0.3 \cdot H$ or less and a curvature of at least 250 mm or greater.

[0047] Further, as described above, the space between the grid cut part 112 and the cut outer plate part 122 is a movement passage of a fluid during an operation.

[0048] In addition, a design pressure P for determining a thickness of the tank outer plate 120 is determined based on gauge pressure of an internal stored

fluid and may generally be 1.0 bar to 50.0 bar.

[0049] Referring to a thickness t_p of the planar outer plate part 121 and a thickness t_c of the cut outer plate part 122 of the tank outer plate 120, allowable stress may be calculated by considering a tensile strength and a yield strength of each material with a safety coefficient, and the thickness t_p of the planar outer plate part 121 and the thickness t_c of the cut outer plate part 122 may be determined such that a stress value generated in the tank outer plate 120 does not exceed the allowable stress. Preferably the thickness t_p of the planar outer plate part 121 is 50 mm or less and the thickness t_c of the cut outer plate part 122 is equal to or smaller than the thickness t_p of the planar outer plate part 121, and here, a thickness difference is limited on the basis of a welding limit criteria.

[0050] An allowable standard for membrane stress, as well as bending stress, must be satisfied. Generally, bending stress acting on a plate is relatively larger than membrane stress, and thus, if the standard for bending stress is satisfied, the standard for membrane stress is also satisfied.

[0051] As illustrated in FIG. 3, the internal grid part 110 is formed such that the plurality of grids 111 are spaced apart from each other in the height direction, the length direction, and the width direction. More

specifically, the grids 111 constituting the internal grid part 110 includes length-directional auxiliary members 111a arranged to be spaced apart from each other in the length direction, height-directional auxiliary members 111b arranged to be spaced apart from each other in the height direction, and width-directional auxiliary members 111c spaced apart from each other in the width direction.

[0052] The length-directional length, the width-directional length, and the height-directional length of the entire internal grid part 110 are equal to the length-directional length L , the width-directional length W , and the height-directional length H of the tank outer plate 120, and an end of the internal grid part 110 is bonded to an inner surface of the tank outer plate 120.

[0053] As illustrated in FIG. 4, each of the length-directional auxiliary members 111a spaced apart from each other in the length direction has a length-directional opening 111a-1 forming an internal through part 113 for providing a minimum work space required for operators at the time of internal manufacturing, and the length-directional opening 111a-1 may have a circular or elliptical shape to uniformly distribute internal pressure.

[0054] Here, when a width-directional length of the length-directional opening 111a-1 is WL and a height-directional length of the length-directional opening 111a-1 is HL , the length WL and the length HL may be 1200 mm or

greater to provide a work space for operators in case of internal manufacturing.

[0055] Also, it is preferable that a minimum width $(W-WL)/2$ or $(H-HL)/2$ of the length-directional auxiliary member 111a has dimensions between a minimum of 50 mm and a maximum of 300 mm.

[0056] In addition, the plurality of length-directional auxiliary members 111a are arranged in the length direction at a predetermined gap GL . Here, if the predetermined gap GL between the length-directional auxiliary members 111a is too narrow, welding is impossible, and thus, the predetermined gap may be provided to secure a space of 250 mm or greater.

[0057] Here, since the length-directional auxiliary member 111a must withstand internal pressure by connecting the bottom and the ceiling of the tank outer plate 120, a value obtained by multiplying allowable stress to a smallest sectional area of the length-directional auxiliary member 111a must be greater than pressure applied to the bottom and the ceiling of the tank outer plate 120.

[0058] That is, balance of a force by the length in the length direction in which the length-directional auxiliary members 111a are spaced apart from each other may be calculated and must satisfy Equation 1 below.

[0059] [Equation 1]

[0060] $(GL * P / tO) * (W / (W - WL)) < \sigma_a$

[0061] (P: design pressure, σ_a : allowable stress)

[0062] In addition, since the length-directional auxiliary members 111a are required to withstand internal pressure by connecting both wall surfaces of the tank outer plate 120, Equation 2 below must be satisfied for the both wall surfaces in the same manner.

[0063] [Equation 2]

[0064] $(GL * P / tO) * (H / (H - HL)) < \sigma_a$

[0065] Therefore, the thickness of the length-directional auxiliary member 111a must have minimum rigidity to prevent buckling of the grid 111 satisfying the aforementioned two equations. Preferably, the thickness is 5 mm or greater except for a margin of a portion in which the thickness is corroded after formation and does not exceed 50 mm as a maximum value of the thickness t_p of the planar outer plate part 121 and the thickness t_c of the cut outer plate part 122.

[0066] Meanwhile, as illustrated in FIG. 5, the plurality of length-directional auxiliary members 111a are arranged in the length direction. A gap GL_E between the length-directional auxiliary member 111a disposed at the end on which internal pressure concentrates and the planar outer plate part 121 is determined by the curvature R of the both corner grid cut part 112 at the end of the tank outer plate 120 in the length direction is determined from

a value obtained by subtracting a length obtained according to the number N of the grids 111 and the predetermined gap GL from a length obtained by subtracting a curvature R of the both corner grid cut part 112 from the length L of the tank outer plate 120 in the length direction.

[0067] [Equation 3]

[0068]
$$GL_E = (L - 2 * R - (N - 1) * GL) / 2$$

[0069] The gap GL_E between the length-directional auxiliary member 111a disposed at the end of the tank outer plate 120 and the planar outer plate part 121 at the end of the tank outer plate 120 in the length direction is preferably 3/4 of the predetermined gap GL between other length-directional auxiliary members 111a and is preferably 100 mm or greater in consideration of welding work of an operator.

[0070] A shape of the internal opening 111a-1 is ideally a circular shape, but the internal opening 111a-1 may have any shape within a range that satisfies a reference of allowable stress, such as an elliptical shape or a rectangular shape in which the corners are rounded.

[0071] As illustrated in FIG. 5, the length in the length direction and the length in the width direction of the height-directional auxiliary members 111b spaced apart from each other in the height direction are equal to the length-directional length L and the width-directional

length W of the tank external plate 120, and a rectangular height-directional opening part 111b-1 having rounded corners is formed therein.

[0072] When the length-directional length of the height-directional opening 111b-1 is LH and the width-directional length of the height-directional opening 111b-1 is WH , the length-directional length LH and the width-directional length WH of the height-directional opening 111b-1 must guarantee a minimum size for providing a work space for operators during internal manufacturing, which may be 1000 mm or greater.

[0073] Meanwhile, it is preferable that a minimum width $(L-LH)/2$ or $(W-WH)/2$ of the height-directional auxiliary member 111b has dimensions between a minimum of 50 mm and a maximum of 300 mm.

[0074] The thickness of the height-directional auxiliary member 111b must be a thickness having a minimum rigidity to prevent buckling and preferably 5 mm or greater, except for a margin of a portion where the thickness is corroded after formation. The minimum thickness may be determined in a manner similar to that of Equation 1 and Equation 2.

[0075] The plurality of height-directional auxiliary members 111b are arranged in the height direction at a predetermined gap GH like the length-directional auxiliary members, and here, if the predetermined gap GH is too

narrow, welding is impossible, and thus, space of 250 mm or greater is preferably secured.

[0076] Meanwhile, a gap GH_E between the height-directional auxiliary member 111b disposed at the end on which inner pressure concentrates and the planar outer plate part 121 at the height-directional end of the tank outer plate 120 may be determined in a manner similar to that of Equation 3.

[0077] The gap GH_E between the height-directional auxiliary member 111b disposed at the end and the planar outer plate part 121 at the height-directional end of the tank outer plate 120 is preferably $3/4$ or less of the gap GH between other height-directional auxiliary members 111b and is preferably 100 mm or greater in consideration of welding work of the operator.

[0078] It is preferable that the shape of both length-directional ends of the height-directional opening 111b-1 is circular in order to uniformly distribute force.

[0079] FIG. 6 illustrates the width-directional auxiliary members 111c arranged to be spaced apart from each other in the width direction, and the width-directional auxiliary members 111c are configured to have the same shape as that of the height-directional auxiliary member 111b described above.

[0080] When the length-directional length of the width-directional opening 111c-1 is LW and the height-

directional length of the width-directional opening 111c-1 is HW, the length-directional length LW of the width-directional opening 111c-1 and the height-directional length HW of the width-directional opening 111c-1 must guarantee a minimum size for providing a work space for operators during internal manufacturing, which may be 1000 mm or greater.

[0081] Meanwhile, it is preferable that the minimum width $(L-LW)/2$ or $(H-HW)/2$ of the width-directional auxiliary member 111c has dimensions between a minimum of 50 mm and a maximum of 300 mm.

[0082] The thickness of the width-directional auxiliary member 111b must be a thickness having a minimum rigidity to prevent buckling and preferably 5 mm or greater, except for a margin of a portion where the thickness is corroded after formation. The minimum thickness may be determined in a manner similar to that of Equation 1 and Equation 2.

[0083] The plurality of width-directional auxiliary members 111c are arranged in the height direction at a predetermined gap GH like the length-directional auxiliary members and the height-directional auxiliary members, and here, if the predetermined gap GW is too narrow, welding is impossible, and thus, space of 250 mm or greater is preferably secured.

[0084] Meanwhile, a gap GW_E between the width-

directional auxiliary member 111c disposed at the end on which inner pressure concentrates and the planar outer plate part 121 at the end of the tank outer plate 120 in the height direction may be determined in a manner similar to that of Equation 3.

[0085] The gap GW_E between the width-directional auxiliary member 111c disposed at the end and the planar outer plate part 121 at the width-directional end of the tank outer plate 120 is preferably $\frac{3}{4}$ or less of the gap GW between other width-directional auxiliary members 111c and is preferably 100 mm or greater in consideration of welding work of the operator.

[0086] It is preferable that the shape of both length-directional ends of the width-directional opening 111c-1 is circular in order to uniformly distribute force.

[0087] Meanwhile, the above-described internal grid part 110 may have a gas passing part (not shown) formed to allow a gas to flow therethrough and a liquid passing part (not shown) formed to allow a liquid to move therethrough.

[0088]

[0089] <Square Pressure Tank According to First Modification of First Exemplary Embodiment of Present Invention>

[0090] FIGS. 7 to 9 are diagrams showing a square pressure tank according to a first modification of the first exemplary embodiment of the present invention.

[0091] The square pressure tank 100 according to the first modification of the first exemplary embodiment of the present invention is configured such that internal through parts 113 are spaced apart from each other in a width direction as illustrated in FIG. 8 to provide a minimum work space required for the operators at the time of manufacturing the internal grid part 110.

[0092] That is, as illustrated in FIG. 9, the square pressure tank 100 according to the first modification of the first exemplary embodiment of the present invention includes two length-directional openings 111a-1 to form the two internal through parts 113 in the length-directional auxiliary member 111a to enhance pressure resistance of the square pressure tank 100.

[0093] In addition, it is preferable that a width-directional distance M between the length-directional openings 111a-1 is at least 300 mm or greater.

[0094] Here, in the square pressure tank 100 according to the first modification of the first exemplary embodiment of the present invention, when the height-directional length of the tank outer plate 120 is H, preferably, the width-directional length W ranges from $1.5 \cdot H$ to $3.0 \cdot H$ and the length-directional length L is $1.5 \cdot H$ or greater.

[0095]

[0096] <Square Pressure Tank According to Second

Modification of First Exemplary embodiment of Present Invention>

[0097] FIGS. 10 to 12 are diagrams showing a square pressure tank according to a second modification of the first exemplary embodiment of the present invention.

[0098] The square pressure tank 100 according to the second modification of the first exemplary embodiment of the present invention is configured such that internal through parts 113 are spaced apart from each other in width direction and height direction as illustrated in FIG. 11 to provide a minimum work space required for the operators at the time of manufacturing the internal grid part 110.

[0099] In addition, it is preferable that, as for the distance M between the length-directional openings 111a-1, a distance M1 spaced in the width direction and a distance M2 spaced in the height direction are at least 300 mm or more.

[00100] Here, as illustrated in FIG. 12, the square pressure tank 100 according to the second modification of the first exemplary embodiment of the present invention includes four length-directional openings 111a-1 to form four internal through parts 113 inside the length-directional auxiliary member 111a, and thus, pressure resistance may be maintained although size of the tank is increased, and in case where a height-directional length H

of the square pressure tank is 10000 mm or greater, preferably, the square pressure tank is configured to have the form according to the second modification of the first exemplary embodiment.

[00101] Here, in the square pressure tank 100 according to the second modification of the first exemplary embodiment of the present invention, when the height-directional length of the tank outer plate 120 is H , preferably, the width-directional length W ranges from $0.5 \cdot H$ to $1.5 \cdot H$ and the length-directional length L is $1.5 \cdot H$ or greater.

[00102]

[00103] <Square Pressure Tank According to Second Exemplary embodiment of the Present Invention>

[00104] FIGS. 13 to 16 are diagrams showing a square pressure tank according to a second exemplary embodiment of the present invention.

[00105] A square pressure tank 200 according to the second exemplary embodiment of the present invention includes an internal grid part 210 including a plurality of grids 211 spaced apart from each other in the length direction and including an internal through part 213 formed in the length direction and reinforcing grid parts 205 disposed at both ends in the length direction such that the plurality of grids 211 are spaced apart from each other in the width direction and the height direction and

a tank outer plate 220 covering an outer surface of the internal grid part 210.

[00106] Here, like the square pressure tank 100 according to the first exemplary embodiment described above, the internal grid part 210 includes a grid cut part 212 formed by cutting the corners in the length direction, the width direction, and the height direction in a straight line or a curved line.

[00107] The tank outer plate 220 includes a planar outer plate part 221 formed to cover a planar surface of the internal grid part 210 and a cut outer plate part 222 covering the grid cut part 212.

[00108] The structure of the internal grid part 210 and the tank outer plate 220 of the square pressure tank according to the second exemplary embodiment of the present invention will be described in more detail.

[00109] When a height-directional length of the tank outer plate 220 is H , a width-directional length W of the tank outer plate 220 may be $1.2 \cdot H$ or less and a length-directional length L of the tank outer plate 220 may be $1.5 \cdot H$ or greater.

[00110] The cut outer plate part 222 connecting the planar outer plate part 221 and covering the grid cut part 212 has a predetermined curvature R , and here, the cut outer plate part 222 may have a curvature of $0.3 \cdot H$ or less and a curvature of at least 250 mm or greater.

[00111] Also, the design pressure P is determined based on gauge pressure of an internal stored fluid and may generally be 1.0 bar to 50.0 bar.

[00112] Referring to a thickness t_p of the planar outer plate part 221 and a thickness t_c of the cut outer plate part 222 of the tank outer plate 220, allowable stress may be calculated by considering a tensile strength and a yield strength of each material with a safety coefficient, and the thickness t_p of the planar outer plate part 221 and the thickness t_c of the cut outer plate part 222 may be determined such that a stress value generated in the tank outer plate 220 does not exceed the allowable stress. Preferably the thickness t_p of the planar outer plate part 221 is 50 mm or less and the thickness t_c of the cut outer plate part 222 is equal to or smaller than the thickness t_p of the planar outer plate part 221, and here, a thickness difference is limited on the basis of a welding limit criteria.

[00113] Also, an allowable standard for membrane stress, as well as bending stress, must be satisfied. Generally, bending stress acting on a plate is relatively larger than membrane stress, and thus, if the standard for bending stress is satisfied, the standard for membrane stress is also automatically satisfied.

[00114] As described above, the internal grid part 210 of the square pressure tank 200 according to the second

exemplary embodiment of the present invention includes a plurality of grids 211 spaced apart from each other in the length direction and reinforcing grid parts 205 spaced apart from each other at both ends of the internal grid part 210 such that the plurality of grids 211 are spaced apart from each other in the height direction and width direction. In detail, the internal grid part 210 includes length-directional auxiliary members 211a disposed to be spaced apart from each other in the length direction and the reinforcing grid part 205 includes height-directional auxiliary members 211b spaced apart from each other in the height direction and width-directional auxiliary members 211c spaced apart from each other in the width direction.

[00115] The length-directional length, the width-directional length, and the height-directional length of the internal grid part 210 are equal to the length-directional length L , the width-directional length W , and the height-directional length H of the tank outer plate 220, and an end of the internal grid part 210 is bonded to an inner surface of the tank outer plate 220.

[00116] As illustrated in FIG. 15, each of the length-directional auxiliary members 211a spaced apart from each other in the length direction has a length-directional opening 211a-1 forming an internal through part 213 for providing a minimum work space required for operators at the time of internal manufacturing, and the length-

directional opening 211a-1 may have a circular or elliptical shape to uniformly distribute internal pressure.

[00117] Here, when a width-directional length of the length-directional opening 211a-1 is WL and a height-directional length of the length-directional opening 211a-1 is HL, the length WL and the length HL may be 1200 mm or greater to provide a work space for operators in case of internal manufacturing.

[00118] Also, it is preferable that a minimum width $(W-WL)/2$ or $(H-HL)/2$ of the length-directional auxiliary member 211a has dimensions between a minimum of 50 mm and a maximum of 300 mm.

[00119] In addition, the plurality of length-directional auxiliary members 211a are arranged in the length direction at a predetermined gap GL. Here, if the predetermined gap GL between the length-directional auxiliary members 211a is too narrow, welding is impossible, and thus, the predetermined gap may be provided to secure a space of 250 mm or greater.

[00120] Here, since the length-directional auxiliary member 211a must withstand internal pressure by connecting the bottom and the ceiling of the tank outer plate 220, a value obtained by multiplying allowable stress to a smallest sectional area of the length-directional auxiliary member 211a must be greater than pressure applied to the bottom and the ceiling of the tank outer

plate 220.

[00121] That is, balance of a force by a width-directional distance in which the length-directional auxiliary members 211a are spaced apart from each other may be calculated and must satisfy Equation 1 above.

[00122] Further, since the length-directional auxiliary member 211a has to withstand the internal pressure by connecting both wall surfaces of the tank outer plate 220 of the tank, Equation 2 may be derived in the same manner for both wall surfaces.

[00123] Therefore, the thickness of the length-directional auxiliary member 211a must have minimum rigidity to prevent buckling of the grid 211 satisfying the aforementioned two equations. Preferably, the thickness is 5 mm or greater except for a margin of a portion in which the thickness is corroded after formation and does not exceed 50 mm as a maximum value of the thickness t_p of the planar outer plate part 221 and the thickness t_c of the cut outer plate part 222.

[00124] A shape of the length-directional opening 211a-1 is ideally a circular shape, but the length-directional opening 211a-1 may have any shape within a range that satisfies a reference of allowable stress, such as an elliptical shape or a rectangular shape in which the corners are rounded.

[00125] As illustrated in FIG. 16, the reinforcing grid

part 205 is formed, and a width-directional length of the height-directional auxiliary members 211b, spaced apart from each other in the height direction is equal to the width-directional length of the tank outer plate 220.

[00126] Here, it is preferable that a length-directional minimum length LH_S or a width-directional minimum length WH_S of the height-directional auxiliary member 211b has dimensions between a minimum of 50 mm and a maximum of 300 mm.

[00127] The thickness of the height-directional auxiliary member 211b must be a thickness having a minimum rigidity to prevent buckling and preferably 5 mm or greater, except for a margin of a portion where the thickness is corroded after formation. The minimum thickness may be determined in a manner similar to that of Equation 1 and Equation 2.

[00128] The plurality of height-directional auxiliary members 211b are arranged in the height direction at a predetermined gap GH , and here, if the predetermined gap GH is too narrow, welding is impossible, and thus, space of 250 mm or greater is preferably secured.

[00129] In addition, a gap GH_E between the height-directional auxiliary member 211b disposed at the end on which inner pressure concentrates and the planar outer plate part 221 at the height-directional end of the tank outer plate 220 may be determined in a manner similar to

that of Equation 3.

[00130] The gap GH_E between the height-directional auxiliary member 211b disposed at the end and the planar outer plate part 221 at the end of the tank outer plate 220 in the height direction is preferably $3/4$ or less of the gap GH between other height-directional auxiliary members 211b and is preferably 100 mm or greater in consideration of welding work of the operator.

[00131] As illustrated in FIG. 16, the reinforcing grid part 205 is formed and a height-directional length of the width-directional auxiliary members 211c spaced apart from each other in the width direction is equal to the height-directional length H of the tank outer plate 220.

[00132] Here, it is preferable that a height-directional minimum length HW_S or length-directional minimum length LW_S of the width-directional auxiliary member 211c has dimensions between a minimum of 50 mm and a maximum of 300 mm.

[00133] The thickness of the width-directional auxiliary member 211b must be a thickness having a minimum rigidity to prevent buckling and preferably 5 mm or greater, except for a margin of a portion where the thickness is corroded after formation. The minimum thickness may be determined in a manner similar to that of Equation 1 and Equation 2.

[00134] The plurality of width-directional auxiliary

members 211c are arranged in the width direction at a predetermined gap GW, and here, if the predetermined gap GW is too narrow, welding is impossible, and thus, space of 250 mm or greater is preferably secured.

[00135] Also, the gap GW_E between the width-directional auxiliary member 211c disposed at the end on which inner pressure concentrates and the planar outer plate part 221 at the width-directional end of the tank outer plate 220 may be determined in a manner similar to that of Equation 3.

[00136] The gap GW_E between the width-directional auxiliary member 111c disposed at the end and the planar outer plate part 221 at the width-directional end of the tank outer plate 220 is preferably 3/4 or less of the gap GW between other width-directional auxiliary members 211c and is preferably 100 mm or greater in consideration of welding work of the operator.

[00137]

[00138] <Square Pressure Tank According to First Modification of Second Exemplary embodiment of the Present Invention>

[00139] FIGS. 17 to 19 are diagrams showing a square pressure tank according to a first modification of the second exemplary embodiment of the present invention.

[00140] The square pressure tank 200 according to the first modification of the second exemplary embodiment of

the present invention is configured such that internal through parts 213 are spaced apart from each other in a width direction to provide a minimum work space required for the operators at the time of manufacturing the internal grid part 210.

[00141] That is, as illustrated in FIG. 19, the square pressure tank 200 according to the first modification of the second exemplary embodiment of the present invention includes two length-directional openings 211a-1 to form the two internal through parts 213 in the length-directional auxiliary member 211a to enhance pressure resistance of the square pressure tank 200.

[00142] In addition, it is preferable that the width-directional distance M between the length-directional openings 211a-1 is at least 300 mm or greater.

[00143] Here, in the square pressure tank 200 according to the first modification of the second exemplary embodiment of the present invention, when the height-directional length of the tank outer plate 220 is H, preferably, the width-directional length W ranges from $1.5 \cdot H$ to $3.0 \cdot H$ and the length-directional length L is $1.5 \cdot H$ or greater.

[00144]

[00145] <Square Pressure Tank According to Third Exemplary embodiment of Present Invention>

[00146] FIGS. 20 to 24 are diagrams showing a square

pressure tank according to a third exemplary embodiment of the present invention.

[00147] A square pressure tank 300 according to the third exemplary embodiment of the present invention includes an internal grid part 310 including a plurality of grids 311 spaced apart from each other in a length direction and a height direction and including internal through parts 313 formed in the length direction and a tank outer plate 320 covering an outer surface of the internal grid part 310, and the internal through parts 313 are spaced apart from each other in the width direction.

[00148] It is preferable that a width-directional distance of the internal through parts 313 is 300 mm or greater.

[00149] Here, the internal grid part 310 includes a grid cut part 312 formed by cutting the corners in the length direction, the width direction, and the height direction in a straight line or a curved line.

[00150] Also, the tank outer plate 320 formed to cover an outer surface of the internal grid part 310 includes a planar outer plate part 321 formed to cover a planar surface of the internal grid part 310 and a cut outer plate part 322 connecting the planar outer plate parts 321 and covering the grid cut part 312.

[00151] The square pressure tank 300 according to the third exemplary embodiment of the present invention will

be described in more detail.

[00152] When a height-directional length of the tank outer plate 320 is H , a width-directional length W may be within a range of $1.5 \cdot H$ to $3.0 \cdot H$ and a length-directional length L may be $1.5 \cdot H$ or greater.

[00153] Also, the cut outer plate part 322 connecting the planar outer plate part 321 and covering the grid cut part 312 has a predetermined curvature R , and here, the cut outer plate part 322 may have a curvature of $0.3 \cdot H$ or less and a curvature of at least 250 mm or greater.

[00154] In addition, a design pressure P for determining a thickness of the tank outer plate 320 is determined based on gauge pressure of an internal stored fluid and may generally be 1.0 bar to 50.0 bar.

[00155] Referring to a thickness t_p of the planar outer plate part 321 and a thickness t_c of the cut outer plate part 322 of the tank outer plate 320, allowable stress may be calculated by considering a tensile strength and a yield strength of each material with a safety coefficient, and the thickness t_p of the planar outer plate part 321 and the thickness t_c of the cut outer plate part 322 may be determined such that a stress value generated in the tank outer plate 320 does not exceed the allowable stress. Preferably the thickness t_p of the planar outer plate part 321 is 50 mm or less and the thickness t_c of the cut outer plate part 322 is equal to or smaller than the thickness

tp of the planar outer plate part 321, and here, a thickness difference is limited on the basis of a welding limit criteria.

[00156] An allowable standard for membrane stress, as well as bending stress, must be satisfied. Generally, bending stress acting on a plate is relatively larger than membrane stress, and thus, if the standard for bending stress is satisfied, the standard for membrane stress is also satisfied.

[00157] As illustrated above, the internal grid part 310 is formed such that the plurality of grids 311 are spaced apart from each other in the length direction and the height direction. More specifically, the grids 311 constituting the internal grid part 310 includes length-directional auxiliary members 311a arranged to be spaced apart from each other in the length direction and height-directional auxiliary members 311b arranged to be spaced apart from each other in the height direction.

[00158] The length-directional length and the height-directional length of the entire internal grid part 310 are equal to the length-directional length L and the height-directional length H of the tank outer plate 320, and an end of the internal grid part 310 is bonded to an inner surface of the tank outer plate 320.

[00159] As illustrated in FIG. 22, each of the length-directional auxiliary members 311a spaced apart from each

other in the length direction has a length-directional opening 311a-1 forming an internal through part 313 for providing a minimum work space required for operators at the time of internal manufacturing, and the length-directional opening 311a-1 may have a circular or elliptical shape to uniformly distribute internal pressure.

[00160] Here, when a width-directional length of the length-directional opening 311a-1 is WL and a height-directional length of the length-directional opening 311a-1 is HL, the length WL and the length HL may be 1200 mm or greater to provide a work space for operators in case of internal manufacturing.

[00161] Also, it is preferable that the minimum width $(W-WL)/2$ or $(H-HL)/2$ of the length-directional auxiliary member 311a-1 has a dimension between a minimum of 50 mm and a maximum of 300 mm.

[00162] Here, the square pressure tank 300 according to the third exemplary embodiment of the present invention is preferably configured such that a width-directional distance between the internal through parts 313 is 300 mm or greater, the width-directional distance M between the length-directional openings 311a-1 is preferably at least 300 mm or greater.

[00163] In addition, the plurality of length-directional auxiliary members 311a are arranged in the length direction at a predetermined gap GL. Here, if the

predetermined gap GL between the length-directional auxiliary members 311a is too narrow, welding is impossible, and thus, the predetermined gap may be provided to secure a space of 250 mm or greater.

[00164] Meanwhile, the gap GL_E between the length-directional auxiliary member 311a disposed at the end on which internal pressure concentrates and the planar outer plate part 321 at the height-directional end of the tank outer plate 320 may be determined in a manner similar to that of Equation 3.

[00165] The gap GL_E between the length-directional auxiliary member 311a disposed at the end and the planar outer plate part 321 at the width-directional end of the tank outer plate 320 is preferably $3/4$ or less the gap GL between the other length-directional auxiliary members 311a and is preferably 100 mm or greater in consideration of welding work of the operator.

[00166] Here, since the length-directional auxiliary member 311a must withstand internal pressure by connecting the bottom and the ceiling of the tank outer plate 320, a value obtained by multiplying allowable stress to a smallest sectional area of the length-directional auxiliary member 311a must be greater than pressure applied to the bottom and the ceiling of the tank outer plate 320.

[00167] That is, balance of a force by the length in

the length direction in which the length-directional auxiliary members 311a are spaced apart from each other may be calculated and must satisfy Equation 1 above.

[00168] In addition, since the length-directional auxiliary members 311a are required to withstand internal pressure by connecting both wall surfaces of the tank outer plate 320, Equation 2 above may be derived for the both wall surfaces in the same manner.

[00169] Therefore, the thickness of the length-directional auxiliary member 311a must have minimum rigidity to prevent buckling of the grid 311 satisfying the aforementioned Equation 1 and Equation 2. Preferably, the thickness is 5 mm or greater except for a margin of a portion in which the thickness is corroded after formation and does not exceed 50 mm as a maximum value of the thickness t_p of the planar outer plate part 321 and the thickness t_c of the cut outer plate part 322.

[00170] A shape of the length-directional opening 311-a is ideally a circular shape, but the internal opening 111a-1 may have any shape within a range that satisfies a reference of allowable stress, such as an elliptical shape or a rectangular shape in which the corners are rounded.

[00171] As illustrated in FIG. 23, the length in the length direction and the length in the width direction of the height-directional auxiliary members 311b spaced apart from each other in the height direction are equal to the

length-directional length L and the width-directional length W of the tank external plate 320, and a rectangular height-directional opening part 311b-1 having rounded corners is formed therein.

[00172] When the length-directional length of the height-directional opening 311b-1 is LH and the width-directional length of the height--directional opening 311b-1 is WH , the length-directional length LH and the width-directional length WH of the height--directional opening 311b-1 must guarantee a minimum size for providing a work space for operators during internal manufacturing, which may be 1000 mm or greater.

[00173] Meanwhile, it is preferable that a minimum width $(L-LH)/2$ or $(W-WH)/2$ of the height-directional auxiliary member 311b has dimensions between a minimum of 50 mm and a maximum of 300 mm.

[00174] The thickness of the height-directional auxiliary member 311b must be a thickness having a minimum rigidity to prevent buckling and preferably 5 mm or greater, except for a margin of a portion where the thickness is corroded after formation. The minimum thickness may be determined in a manner similar to that of Equation 1 and Equation 2.

[00175] The plurality of height-directional auxiliary members 311b are arranged in the height direction at a predetermined gap GH , and here, if the predetermined gap

GH is too narrow, welding is impossible, and thus, space of 250 mm or greater is preferably secured.

[00176] Meanwhile, a gap GH_E between the height-directional auxiliary member 311b disposed at the end on which inner pressure concentrates and the planar outer plate part 321 at the height-directional end of the tank outer plate 320 may be determined in a manner similar to that of Equation 3.

[00177] The gap GH_E between the height-directional auxiliary member 311b disposed at the end and the planar outer plate part 321 at the height-directional end of the tank outer plate 320 is preferably $3/4$ or less of the gap GH between other height-directional auxiliary members 311b and is preferably 100 mm or greater in consideration of welding work of the operator.

[00178] It is preferable that the shape of both length-directional ends of the height-directional opening 311b-1 is circular in order to uniformly distribute force.

[00179]

[00180] <Square Pressure Tank According to Fourth Exemplary embodiment of Present Invention>

[00181] FIGS. 25 to 29 are diagrams showing a square pressure tank according to a fourth exemplary embodiment of the present invention.

[00182] A square pressure tank 400 according to a fourth exemplary embodiment of the present invention

includes an internal grid part 410 including a plurality of grids 411 including internal openings 411-1 spaced apart from each other in a length direction, a height direction, and a width direction and connected to each other to form surface grids and a tank outer plate 420 covering an outer surface of the internal grid part 410.

[00183] Here, at least one surface of the internal grid part 410 is curved and formed as a curved surface.

[00184] As described above, since one surface of the internal grid part 410 is a curved surface, the tank outer plate 420 formed of a curved surface may be reinforced to distribute a load to membrane stress, while minimizing bending stress of the tank outer plate for supporting a pressure load acting on the tank outer plate.

[00185] Also, the internal grid part 410 includes a grid cut part 412 formed by cutting the corners in the length direction, the width direction, and the height direction in a straight line or a curved line.

[00186] In addition, the tank outer plate 420 includes a planar outer plate part 421 covering a plane of the internal grid part 410 and a curved outer plate part 422 including a gently curved outer plate part 422-2 covering the curved surface of the tank outer plate 420 and a cut outer plate part 422-1 covering the grid cut part 412.

[00187] The square pressure tank 400 according to the fourth exemplary embodiment of the present invention will

be described in more detail.

[00188] When a height-directional length of the tank outer plate 420 is H , the width-directional length W is $1.5 \cdot H$ or greater, the length-directional length L is $1.5 \cdot H$ or greater or $2 \cdot W$ or greater.

[00189] Here, the curved outer plate part 422 has a predetermined curvature. Preferably, the cut outer plate part 422-1 covering the grid cut part 412 has a curvature ranging from $0.1 \cdot H$ to $0.5 \cdot H$ and the gently curved outer plate part 422-2 has a curvature of $1 \cdot H$ or less and has a curvature greater than at least $0.1 \cdot H$.

[00190] In addition, a design pressure P for determining a thickness of the tank outer plate 420 is determined based on gauge pressure of an internal stored fluid and may generally be 1.0 bar to 50.0 bar.

[00191] Referring to a thickness t_p of the planar outer plate part 421 and a thickness t_c of the curved outer plate part 422 of the tank outer plate 420, allowable stress may be calculated by considering a tensile strength and a yield strength of each material with a safety coefficient, and the thickness t_p of the planar outer plate part 421 and the thickness t_c of the curved outer plate part 422 may be determined such that a stress value generated in the tank outer plate 420 does not exceed the allowable stress. Preferably the thickness t_p of the planar outer plate part 421 is 50 mm or less and the

thickness t_c of the curved outer plate part 422 is equal to or smaller than the thickness of the planar outer plate part 421, and here, a thickness difference is limited on the basis of a welding limit criteria.

[00192] An allowable standard for membrane stress, as well as bending stress, must be satisfied. Generally, bending stress acting on a plate is relatively larger than membrane stress, and thus, if the standard for bending stress is satisfied, the standard for membrane stress is also satisfied.

[00193] As described above, the internal grid part 410 is formed such that the plurality of grids 411 including the internal opening 411-1 are spaced apart from each other in the height direction, the length direction, and the width direction. More specifically, the internal grid part 410 includes length-directional auxiliary members 411a arranged to be spaced apart from each other in the length direction, height-directional auxiliary members 411b arranged to be spaced apart from each other in the height direction, and width-directional auxiliary members 411c spaced apart from each other in the width direction.

[00194] The length-directional length, the width-directional length, and the height-directional length of the entire internal grid part 410 are equal to the length-directional length L , the width-directional length W , and the height-directional length H of the tank outer plate

420, and an end of the internal grid part 410 is bonded to an inner surface of the tank outer plate 420.

[00195] As illustrated in FIG. 27, each of the length-directional auxiliary members 411a spaced apart from each other in the length direction has a length-directional opening 411a-1 forming an internal opening 411-1 for providing a minimum work space required for operators at the time of internal manufacturing, and the length-directional opening 411a-1 may have a circular or elliptical shape to uniformly distribute internal pressure.

[00196] In some cases, the length-directional opening 411a-1 may be formed as a plurality of openings having a predetermined width WL and a predetermined height HL as illustrated in (b) of FIG. 27.

[00197] The length-directional auxiliary members 411a are arranged in plurality in the length direction, and here, a predetermined gap GL between the length-directional auxiliary members 411a preferably ranges from 1m to 5m.

[00198] In addition, the thickness of the length-directional auxiliary member 411a must have minimum rigidity to prevent buckling of the grid 411 satisfying the aforementioned Equation 1 and Equation 2. Preferably, the thickness is 5 mm or greater except for a margin of a portion in which the thickness is corroded after formation and does not exceed 50 mm as a maximum value of the

thickness t_p of the planar outer plate part 421 and the thickness t_c of the curved outer plate part 422.

[00199] When a height-directional length of the length-directional opening 411a-1 is HL and a width-directional length of the length-directional opening 411a-1 is WL , the height-directional length HL of the length-directional opening 411a-1 may be $0.9 \cdot HP$ or less, or at least 300 mm or greater.

[00200] The width-directional length WL of the length-directional opening 411a-1 is preferably $0.9 \cdot WP$ or less and is preferably at least 300 mm or greater.

[00201] Here, HP refers to a height-directional length of the planar outer plate part 421, and WP refers to a width-directional length of the planar outer plate part 421.

[00202] Further, the radius RL of a length-directional fillet part having rounded corners of the length-directional opening 411a-1 is preferably 0.5 times or less a minimum value of the height-directional length and the width-directional length of the length-directional opening 411a-1 and is preferably at least 1 mm or greater.

[00203] The number of the length-directional openings 411a-1 formed in the length-directional auxiliary member 411a may be calculated by the Equation 4 below.

[00204] [Equation 4]

[00205]
$$\frac{N \times A_0}{A_1} \leq 0.9$$

[00206] In Equation 4, N is the number of the length-directional openings 411a-1, A₀ is the area of the length-directional opening 411a-1, and A₁ is the area of the length-directional auxiliary member 411a.

[00207] In other words, it is preferable that a total area of the length-directional openings 411a-1 having the number of N does not exceed 90% of a maximum area of the length-directional auxiliary member 411a.

[00208] As illustrated in FIG. 28, a length-directional length of the height-directional auxiliary member 411b spaced apart from each other in the height direction is equal to the length-directional length LP of the planar outer plate part 421, a width-directional length of the height-directional auxiliary member 411b is equal to the width-directional length WP of the planar outer plate part, and a rectangular height opening 411b-1 having rounded corners is formed therein.

[00209] Here, a height-directional neck b₁ of the height-directional auxiliary member 411b for forming a surface grid with the length-directional auxiliary member 411a and the width-directional auxiliary member 411c preferably ranges from 50 mm to 3000 mm.

[00210] In addition, it is preferable that the radius R_H of the height-directional fillet part of the height-

directional auxiliary member 411b has a curvature of at least 1 mm or greater.

[00211] Also, the thickness of the length-directional auxiliary member 411b must have minimum rigidity to prevent buckling and is preferably 5 mm or greater except for a margin of a portion in which the thickness is corroded after formation.

[00212] The plurality of height-directional auxiliary members 411b are arranged in the height direction at the predetermined gap GH. Here, if the gap GH is too narrow, welding is not possible, and thus, space ranging from 400 mm to 1000 mm is preferably secured.

[00213] As illustrated in FIG. 29, the length-directional length of the width-directional auxiliary members 411c spaced apart from each other is equal to the length-directional length LP of the planar outer plate part 421, and the height-directional length of the width-directional auxiliary member 411c is equal to the height-directional height H of the tank outer plate 420 and the width-directional opening 411c-1 having rounded corners is formed therein.

[00214] Here, the width-directional neck b2 of the width-directional auxiliary member 411c for forming a surface grid with the length-directional auxiliary member 411a and the height-directional auxiliary member 411b preferably ranges from 50 mm to and 3000 mm.

[00215] In addition, it is preferable that the radius RW of the with-directional fillet part of the width-directional auxiliary member 411c has a curvature of at least 1 mm or greater.

[00216] Also, the thickness of the width-directional auxiliary member 411c must have minimum rigidity to prevent buckling and preferably ranges from 5 mm to 50 mm, except for a margin of a portion in which the thickness is corroded after formation.

[00217] In addition, the plurality of width-directional auxiliary members 411c are arranged in the width direction at the predetermined gap GW. Here, if the gap GW is too narrow, welding is not possible, and thus, space ranging from 400 mm to 1000 mm is preferably secured.

[00218]

[00219] <Square Pressure Tank According to Modification 1 of Fourth Exemplary embodiment of Present Invention>

[00220] FIGS. 30 to 34 are diagrams showing a square pressure tank according to a first modification of the fourth exemplary embodiment of the present invention.

[00221] A square pressure tank 400 according to the first modification of the fourth exemplary embodiment of the present invention includes an internal grid part 410 having a curved upper surface in the width direction.

[00222] When a height-directional length of the length-directional auxiliary member 411a is HL, a width-

directional length WL of the length-directional auxiliary member 411a preferably ranges from $1 \cdot HL$ or $0.5 \cdot HL$ to $2 \cdot HL$.

[00223] Also, as illustrated in (b) of FIG. 32, the length-directional auxiliary member 411a has a first radius R1 having a predetermined curvature at both width-directional lower ends, a second radius R2 having a predetermined curvature at both width-directional upper ends of the length-directional auxiliary member 411a, and a third radius R3 connecting the second radii and having a predetermined curvature.

[00224] It is preferable that the curvature of the first radius R1 is equal to or smaller than a and b when a height-directional unit of the length-directional auxiliary member 411a is a and a width-directional unit length is b.

[00225] (The height-directional unit length a is $1/N$ of a length excluding a length longer than an upper reference line in the height direction length HL of the length-directional auxiliary member 411a. Here, N is the number of a, the width-directional unit length b is $1/M$ of the width-directional length WL of the length-directional auxiliary member 411a, where M is the number of b).

[00226] If the curvature of the first radius R 1 is smaller than a or b, the curvature of the first radius R 1 is preferably 100 mm or greater.

[00227] The curvature of the second radius R2 may be

equal to or smaller than the curvature of the first radius R_1 , and the curvature of the third radius R_3 may be expressed as a multiple of rational number of a .

[00228] Also, it is preferable that the predetermined gap GL of the length-directional auxiliary member 411a is equal to a or b , but does not exceed 5 m.

[00229] It is preferable that the thickness of the length-directional auxiliary member ranges from 5 mm to 50 mm, except for a margin of corrosion after formation.

[00230] Further, in the square pressure tank 400 according to the first modification of the fourth exemplary embodiment of the present invention, when the height-directional length of the length-directional opening 411a-1 is HL and the width-directional length of the length-directional opening 411a-1 is WL , the height-directional length HL of the length-directional opening 411a-1 is $0.9 \cdot H$ or less and is preferably 300 mm or greater.

[00231] The width-directional length WL of the length-directional opening 411a-1 is preferably $0.9 \cdot W$ or less and is preferably at least 300 mm or greater.

[00232] Here, the radius RL of the length-directional fillet part having rounded corners of the length-directional opening 411a-1 is 0.5 times or less a minimum value of the height-directional length and the width-directional length of the length-directional opening 411a-

1 and is preferably at least 1 mm or greater.

[00233] In addition, the number of the length-directional openings 411a-1 formed in the length-directional auxiliary member 411a may be calculated by the Equation 4 above.

[00234] That is, it is preferable that a total area of the length-directional opening 411a-1 having the number of N does not exceed 90% of a maximum area of the length-directional auxiliary member 411a.

[00235] Also, a length h_1 from a height-directional lower end of the length-directional auxiliary member 411a to a height-directional lower end of the length-directional opening 411a-1 is at least 300 mm or greater, and a length w_1 from a width-directional side end of the length-directional auxiliary member 411a to a width-directional side end of the length-directional opening 411a-1 is 300 mm or greater.

[00236] As illustrated in FIG. 33, the square pressure tank 400 according to the first modification of the fourth exemplary embodiment of the present invention includes an end part 406 including at least one grid 411 in contact with an inner surface of the tank outer plate 420 at both length-directional ends of the internal grid part 410.

[00237] A unit length a of the length-directional auxiliary member 411a of the grid 411 forming the end part 406, a unit length b of the width-directional auxiliary

member 411c, and a unit length c of the height-directional auxiliary member 411b are preferably 5 m or less.

[00238] Also, thicknesses of the length-directional auxiliary member 411a, the width-directional auxiliary member 411c, and the height-directional auxiliary member 411b of the grid 411 forming the end part 406 range of 5 mm to 50 mm.

[00239] A first width $E1$ of an end opening 406-1 formed in the length-directional auxiliary member 411a, the width-directional auxiliary member 411c, and the height-directional auxiliary member 411b forming the end part 406 is preferably 600 mm or greater and $0.9*b$ or less, and a second width $E2$ of the end opening 406-1 is preferably 600 mm or greater and $0.9*a$ or less.

[00240] Also, the radius RE of the end fillet part, which is a fillet part formed in the end opening 406-1 of the end part 406, preferably has a curvature of 1 mm or greater.

[00241] As illustrated in FIG. 34, the square pressure tank 400 according to the first modification of the fourth exemplary embodiment of the present invention includes an arch part 407 formed along the gently curved outer plate part 422-2 of the curved outer plate part 422.

[00242] The height-directional length HA of the arch part 407 may be calculated using Equation 5 below.

[00243] [Equation 5]

[00244] $HA = h + 2(Ra + k)$

[00245] Here, h is a length between central points of an arc of the arch part 407, Ra is the radius of the arc, and k is a side end width of the arch part 407.

[00246] Further, a width-directional length WA of the arch part 407 may be calculated using Equation 6 below.

[00247] [Equation 6]

[00248] $WA = 2(Ra + k)$

[00249] Also, a thickness of the arch part 407 preferably ranges from 5 mm to 50 mm.

[00250] As illustrated in FIG. 35, the arch part 407 adjacent to the end part 406 may have a shape of a semi-arch part.

[00251] A height-directional length HS of the semi-arch part 407-1 is equal to the height-directional length of the arch part 407 and may be obtained using $H=2l+n$. Here, l is an upper end length of the semi-arch part 407-1 and n is a middle length of the semi-arch part 407-1.

[00252] It is needless to say that the width-directional length WS of the semi-arch part 407-1 is equal to the width-directional length of the arch part 407, but the semi-arch part 407-1 may have any other width-directional length depending on the shape.

[00253] The diagonal length m of the semi-arch part 407-1 is a length excluding the arch fillet part having the radius RS , and the radius RS of the arch fillet part

is at least 1 mm or greater.

[00254] The side end width j of the semi-arch part 407-1 is smaller than the width-directional length WS of the semi-arch part 407-1, and a thickness of the semi-arch part 407-1 ranges from 5 mm to 50 mm.

[00255] The angle θ at which the diagonal line is formed has a value of 1 to 45 degrees, and a distance q between the arch fillet parts is preferably determined in consideration of the radius RS of the arch fillet part.

[00256]

[00257] <Square Pressure Tank According to Second Modification of Fourth Exemplary embodiment of Present Invention>

[00258] FIGS. 36 to 37 are diagrams showing a square pressure tank according to a second modification of the fourth exemplary embodiment of the present invention.

[00259] The tank outer plate 420 of the square pressure tank 400 according to the second modification of the fourth exemplary embodiment of the present invention includes the curved outer plate part 422 including the gently curved outer plate part 422-2 formed such that a width-directional upper surface and both ends are curved.

[00260]

[00261] <Square Pressure Tank According to Fifth Exemplary embodiment of Present Invention>

[00262] FIGS. 38 to 45 are diagrams showing a square

pressure tank according to a fifth exemplary embodiment of the present invention.

[00263] A square pressure tank 500 according to a fifth exemplary embodiment of the present invention includes an internal grid part 510 including a plurality of grids 511 including internal openings 511-1 spaced apart from each other in a length direction, a width direction, and a height direction and connected to each other to form surface grids and a tank outer plate 520 covering an outer surface of the internal grid part 510, and here, the internal grid part 510 is formed such that one length-directional side thereof is tapered in at least one of the width direction and the height direction.

[00264] Here, the internal grid part 510 includes a grid cut part 512 formed by cutting the corners in the length direction, the width direction, and the height direction in a straight line or a curved line.

[00265] Also, the tank outer plate 520 includes a planar outer plate part 521 covering a plane of the internal grid part 510 and a cut outer plate part 522 covering the grid cut part 512.

[00266] Here, the planar outer plate part 521 includes a first planar outer plate part 521-1 covering the plane of the internal grid part 510 and a second planar outer plate part 521-2 covering the internal grid part 510 tapered in any one of the height direction and the width

direction with the first planar outer plate part 521-1.

[00267] The square pressure tank according to the fifth exemplary embodiment of the present invention will be described in more detail.

[00268] When a total height-directional length of the tank outer plate 520 is H , the width-directional length $W1$ of the first planar outer plate part 521-1 is $1.5 \cdot H$ or greater and the width-directional length $W2$ of the second planar outer plate part 521-2 covering the internal grid part 510 may be equal to $W1$ or smaller when tapered.

[00269] The total length-directional length L of the tank outer plate 520 is $1.5 \cdot H$ or greater, and in the total length-directional length L of the tank outer plate 520, the length-directional length $L1$ of the first planar outer plate part 521-1 is preferably $0.1 \cdot L$ or greater and the length-directional length $L2$ of the second planar outer plate part 521-2 is preferably $0.1 \cdot L$ or greater.

[00270] Here, the angle θ formed by the first planar outer plate part 521-1 and the second planar outer plate part 521-2 preferably ranges from 135 degrees to 180 degrees.

[00271] A design pressure P for determining a thickness of the tank outer plate 120 is determined based on gauge pressure of an internal stored fluid and may generally be 1.0 bar to 50.0 bar.

[00272] Referring to a thickness t_p of the planar outer

plate part 521 and a thickness t_c of the cut outer plate part 522 of the tank outer plate 520, allowable stress may be calculated by considering a tensile strength and a yield strength of each material with a safety coefficient, and the thickness t_p of the planar outer plate part 521 and the thickness t_c of the cut outer plate part 522 may be determined such that a stress value generated in the tank outer plate 520 does not exceed the allowable stress. Preferably the thickness t_p of the planar outer plate part 521 is 50 mm or less and the thickness t_c of the cut outer plate part 522 is equal to or smaller than the thickness of the planar outer plate part 521, and here, a thickness difference is limited on the basis of a welding limit criteria.

[00273] An allowable standard for membrane stress, as well as bending stress, must be satisfied. Generally, bending stress acting on a plate is relatively larger than membrane stress, and thus, if the standard for bending stress is satisfied, the standard for membrane stress is also satisfied.

[00274] The grid 511 of the internal grid part 510 includes length-directional auxiliary members 511a arranged to be spaced apart from each other in the length direction, height-directional auxiliary members 511b arranged to be spaced apart from each other in the height direction, and width-directional auxiliary members 511c

spaced apart from each other in the width direction.

[00275] The length-directional length, the width-directional length, and the height-directional length of the entire internal grid part 510 are equal to the length-directional length L , the width-directional length W , and the height-directional length H of the tank outer plate 520, and an end of the internal grid part 510 is bonded to an inner surface of the tank outer plate 520.

[00276] That is, the height-directional length of the length-directional auxiliary member 511a spaced apart from each other in the length direction is equal to the height-directional length of the tank outer plate 520, and the width-directional length of the length-directional auxiliary member 511a is equal to the width-directional length of the tank outer plate 520.

[00277] As illustrated in FIG. 40, each of the length-directional auxiliary members 511a spaced apart from each other in the length direction has a length-directional opening 511a-1 forming an internal opening 513 for providing a minimum work space required for operators at the time of internal manufacturing, and the length-directional opening 511a-1 may have a circular or elliptical shape to uniformly distribute internal pressure.

[00278] Here, when the width-directional length of the length-directional opening 511a-1 is WL and the height-directional length is HL , the width-directional length WL

and the height-directional length HL of the length-directional opening 511a-1 are preferably 1200 mm or greater to provide a work space for the operators at the time of internal manufacturing.

[00279] A minimum width $(W-WL)/2$ or $(H-HL)/2$ of the length-directional auxiliary member 511a-1 preferably has a dimension between a minimum of 50 mm and a maximum of 300 mm.

[00280] Here, since the square pressure tank 500 according to the fifth exemplary embodiment of the present invention is formed such that the width-directional distance between the inner openings 513 is 300 mm or greater, the width-directional distance M between the length-directional openings 511a-1 is preferably at least 300 mm or greater.

[00281] The plurality of length-directional auxiliary members 511a are arranged in a length direction at a predetermined gap GL. Here, if the predetermined gap GL between the length-directional auxiliary members 511a is too narrow, welding is impossible, and thus, the predetermined gap may be provided to secure a space of 250 mm or greater.

[00282] Here, since the length-directional auxiliary member 511a must withstand internal pressure by connecting the bottom and the ceiling of the tank outer plate 520, a value obtained by multiplying allowable stress to a

smallest sectional area of the length-directional auxiliary member 511a must be greater than pressure applied to the bottom and the ceiling of the tank outer plate 520.

[00283] That is, balance of a force by the length in the length direction in which the length-directional auxiliary members 511a are spaced apart from each other may be calculated and must satisfy Equation 1 above.

[00284] In addition, since the length-directional auxiliary members 511a are required to withstand internal pressure by connecting both wall surfaces of the tank outer plate 520, Equation 2 above must be derived for the both wall surfaces in the same manner.

[00285] Therefore, the thickness of the length-directional auxiliary member 511a must have minimum rigidity to prevent buckling of the grid 511 satisfying the aforementioned Equation 1 and Equation 2. Preferably, the thickness is 5 mm or greater except for a margin of a portion in which the thickness is corroded after formation and does not exceed 50 mm as a maximum value of the thickness t_p of the planar outer plate part 521 and the thickness t_c of the cut outer plate part 522.

[00286] A shape of the internal opening 511a-1 is ideally a circular shape, but the internal opening 511a-1 may have any shape within a range that satisfies a reference of allowable stress, such as an elliptical shape

or a rectangular shape in which the corners are rounded.

[00287] As illustrated in FIG. 41, the height-directional auxiliary members 511b spaced apart from each other in the height direction is equal to the length-directional length of the plane outer plate part 521, the width-directional length of the height-directional auxiliary member 511b is equal to the width-directional length of the tank outer plate 520, and the height-directional opening 511b-1 is formed to face the shape of the internal grid part 510 formed to be tapered therein.

[00288] Here, the height-directional neck b1 of the height-directional auxiliary member 511b for forming a surface grid with the length-directional auxiliary member 511a and the width-directional auxiliary member 511c is ranges from 50 mm to 300 mm.

[00289] Further, the thickness of the height-directional auxiliary member 511b must be a thickness having a minimum rigidity to prevent buckling and preferably ranges from 5 mm to 50 mm, except for a margin of a portion where the thickness is corroded after formation.

[00290] The plurality of height-directional auxiliary members 511b are arranged in the height direction at a predetermined gap GH, and here, if the predetermined gap GH is too narrow, welding is impossible, and thus, the gap GH preferably ranges from 400 mm to 1000 mm.

[00291] As illustrated in FIG. 42, the length-directional length of the width-directional auxiliary members 511c spaced apart from each other in the width direction is equal to the length of the plane outer plate part 521, the height-directional length of the width-directional auxiliary member 511c has a height-directional length facing a tapered shape, and the width-directional opening 511c-1 is formed to face the shape of the internal grid part formed to be tapered therein.

[00292] Here, it is preferable that a chamfering angle $\theta 1$ of the width-directional auxiliary member 511c ranges from a minimum of 0 degree to a maximum of 45 degrees.

[00293] As illustrated in FIG. 43, the square pressure tank 500 according to the fifth exemplary embodiment of the present invention includes the end part 506 including at least one grid 511 in contact with an inner surface of the tank outer plate 520 at both length-directional ends of the internal grid part 510.

[00294] A unit length a of the length-directional auxiliary member 511a of the grid 511 forming the end part 506, a unit length b of the width-directional auxiliary member 511c, and a unit length c of the height-directional auxiliary member 511b are preferably 5 m or less.

[00295] Also, thicknesses of the length-directional auxiliary member 511a, the width-directional auxiliary member 511c, and the height-directional auxiliary member

511b of the grid forming the end part 506 ranges from 5 mm to 50 mm.

[00296] A first width E1 of an end opening 506-1 formed in the length-directional auxiliary member 511a, the width-directional auxiliary member 511c, and the height-directional auxiliary member 511b forming the end part 506 is preferably 600 mm or greater and $0.9 \cdot b$ or less, and a second width E2 of the end opening 506-1 is preferably 600 mm or greater and $0.9 \cdot a$ or less.

[00297] Also, the radius RE of the end fillet part, which is a fillet part formed in the end opening 406-1 of the end part 506, preferably has a curvature of 1 mm or greater.

[00298] As illustrated in FIG. 44, the square pressure tank 500 according to the fifth exemplary embodiment of the present invention includes an arch part 507 formed along the cut outer plate part 522.

[00299] The height-directional length HA of the arch part 507 may be calculated using Equation 5 above.

[00300] Further, a width-directional length WA of the arch part 507 may be calculated using Equation 6 above.

[00301] Also, a thickness of the arch part 507 preferably ranges from 5 mm to 50 mm.

[00302] As illustrated in FIG. 45, in the square pressure tank 500 according to the fifth exemplary embodiment of the present invention, the arch part 507

adjacent to the end part 506 may have a shape of a semi-arch part 507-1.

[00303] A height-directional length H_S of the semi-arch part 507-1 is equal to the height-directional length of the arch part 507 and may be obtained using $H=2l+n$. Here, l is an upper end length of the semi-arch part 507-1 and n is a middle length of the semi-arch part 507-1.

[00304] It is needless to say that the width-directional length W_S of the semi-arch part 507-1 is equal to the width-directional length of the arch part 507, but the semi-arch part 507-1 may have any other width-directional length depending on the shape.

[00305] The diagonal length m of the semi-arch part 507-1 is a length excluding the arch fillet part having the radius R_S , and the radius R_S of the arch fillet part is at least 1 mm or greater.

[00306] The side end width j of the semi-arch part 507-1 is smaller than the width-directional length W_S of the semi-arch part 507-1, and a thickness of the semi-arch part 507-1 ranges from 5 mm to 50 mm.

[00307] The angle θ at which the diagonal line is formed has a value of 1 to 45 degrees, and a distance q between the arch fillet parts is preferably determined in consideration of the radius R_S of the arch fillet part.

[00308]

[00309] <Square Pressure Tank According to First

Modification of Fifth Exemplary embodiment of Present Invention>

[00310] FIGS. 46 to 48 are diagrams showing a square pressure tank according to a first modification of the fifth exemplary embodiment of the present invention.

[00311] The square pressure tank 500 according to the first modification of the fifth exemplary embodiment of the present invention is configured such that one length-directional side of the internal grid part 510 is tapered in the width direction and one side of the internal grid part 510 is curved.

[00312] Here, as illustrated in FIG. 48, when the front of the tank outer plate 520 is adopted as a curved surface, a radius R_F of the front arc may be introduced and applied to the height-directional auxiliary member 511b.

[00313]

[00314] <Square Pressure Tank According to Second Modification of Fifth Exemplary embodiment of Present Invention>

[00315] FIGS. 49 to 51 are diagrams showing a square pressure tank according to a second modification of the fifth exemplary embodiment of the present invention.

[00316] As illustrated in FIGS. 49 and 50, the square pressure tank 500 according to the second modification of the fifth exemplary embodiment of the present invention is configured such that one length-directional side of the

internal grid part 510 is tapered in the width direction and the height direction.

[00317] Here, as illustrated in FIG. 51, a diagonal length L3 of the width-directional auxiliary members 511c arranged to be spaced apart from each other at a predetermined distance in the width direction is preferably smaller than L2, and a length L4 of a lower end of the width-directional auxiliary member 511c is preferably smaller than L2.

[00318] In addition, it is preferable that a height-directional length HF of the width-directional auxiliary member 511c formed to be tapered is equal to or smaller than a total height-directional length of the width-directional auxiliary member 511c.

[00319] Here, the angle θ at which the width-directional auxiliary member 511c is tapered preferably ranges from 0 degree to 45 degrees.

[00320]

[00321] <Square Pressure Tank According to Third Modification of Fifth Exemplary embodiment of Present Invention>

[00322] FIGS. 52 and 53 are diagrams showing a square pressure tank according to a third modification of the fifth exemplary embodiment of the present invention.

[00323] As illustrated in FIGS. 52 and 53, a square pressure tank 500 according to the third modification of

the fifth exemplary embodiment of the present invention is configured such that one length-directional side of the internal grid part 510 is tapered in the width direction and the height direction and one side of the internal grid part 510 is curved.

【CLAIMS】**【Claim 1】**

A square pressure tank comprising:

an internal grid part including a plurality of grids spaced apart from each other in a length direction, a width direction, and a height direction and an internal through portion formed in the length direction; and

a tank outer plate covering an outer surface of the internal grid part, wherein at least one surface of the tank outer plate is gently curved.

【Claim 2】

The square pressure tank of claim 1, wherein

the internal grid part includes length-directional auxiliary members spaced apart from each other in the length direction, height-directional auxiliary members spaced apart from each other in the height direction, and width-directional auxiliary members spaced apart from each other in the width direction,

wherein corners of any one of the length-directional auxiliary members, the height-directional auxiliary members, and the width-directional auxiliary members have a shape corresponding to the tank outer plate having the gently curved surface to support a pressure load acting on the tank outer plate.

【Claim 3】

The square pressure tank of claim 2, wherein
the internal grid part includes a grid cut part
formed by cutting length-directional, width-directional,
and height-directional corners in a straight line or
curved line.

【Claim 4】

The square pressure tank of claim 3, wherein
the tank outer plate includes:
a planar outer plate part covering a plane of the
intern grid part; and
a cut outer plate part covering the grid cut part,
wherein a predetermined space is formed between
corners of the grid cut part and the cut outer plate part.

【Claim 5】

The square pressure tank of claim 2, wherein
the length-directional auxiliary member has a
circular or elliptical length-directional opening, and an
area of the length-directional opening is 90% or less of
an area of the length-directional auxiliary member.

【Claim 6】

The square pressure tank of claim 5, wherein
the width-directional auxiliary member has a width-

directional opening,

the height-directional auxiliary member has a height-directional opening,

a width of a width-directional neck on one side obtained by subtracting the width-directional opening from the width-directional auxiliary member ranges from 50 mm to 3000 mm, and

a width of a height-directional neck on one side obtained by subtracting the height-directional opening from the height-directional auxiliary member ranges from 50 mm to 3000 mm.

【Claim 7】

The square pressure tank of claim 6, wherein

the length-directional auxiliary members are arranged at an interval of 1000 mm to 5000 mm, and

the width-directional auxiliary members and the height-directional auxiliary members are arranged at an interval of 400 mm to 1000 mm.

【Claim 8】

The square pressure tank of claim 2, wherein

a plurality of length-directional unit openings having a unit space are arranged to form a length-directional opening in the length-directional auxiliary members.

【Claim 9】

The square pressure tank of claim 8, wherein
the number of the length-directional unit openings
provided in the length-directional auxiliary members is
determined by Equation below:

$$\frac{N \times A_0}{A_1} \leq 0.9$$

(Here, N is the number of length-directional unit
openings, A0 is an area of the length-directional unit
opening, and A1 is an area of the length-directional
auxiliary member).

【Claim 10】

The square pressure tank of claim 8, wherein
a width-directional length or a height-directional
length of the length-directional unit opening is 300 mm or
greater.