

DESCRIPTION

HEAT INSULATION STRUCTURE FOR CYLINDRICAL TUBE

5 **Technical Field**

[0001]

10 The present invention relates to a heat insulation structure for a cylindrical tube configured such that on an outer circumferential portion of a cylindrical tube in which cold fluid flows, there are provided semi-circular heat insulating members halved in a circumferential direction of the cylindrical tube with an adjacent pair of heat insulating member end portions thereof being coupled to each other via a connecting member elongate in an axial direction of the cylindrical tube, at each one of two opposed positions located in the circumferential direction of the cylindrical tube with end faces thereof being placed in
15 abutment against each other.

Background Art

[0002]

20 Such heat insulation structure for a cylindrical tube is provided for heat insulation of the cylindrical tube by covering an outer circumference portion of the cylindrical tube in which cold fluid such as LNG, LPG, etc. flows, with an heat insulating member. Normally, the outer circumference portion of the cylindrical tube is covered with
25 multiple layers (e.g. two layers or three layers) of heat insulating members.

Incidentally, when the cylindrical tube is covered with such multiple layers, heat insulating members having different diameters will be provided under a coaxially superposed state thereof.

30 [0003]

According to one exemplary conventional heat insulation structure for a cylindrical tube, in each one of a pair of heat insulating member end portions connected via a connecting member, as a groove-like engagement portion to which the connecting member is
35 engaged, a receded groove portion receded from the end face of the heat insulating member end portion along the circumferential direction of the

cylindrical tube includes, at a radially outer portion of this receded groove portion in the radial direction of the cylindrical tube, a retaining groove portion which is receded toward the radially outer side of the cylindrical tube and the connecting member includes a main body
5 connecting part having a cross sectional shape engageable with the receded groove portion of each one of the pair of heat insulating member end portions and a pair of retaining connecting parts engageable with the retaining groove portion (see e.g. Patent Document 1).

10 **Prior Art Document**
[0004]

Patent Document 1: Japanese Unexamined Patent Application Publication No. 2016-194368.

15 **Disclosure of the Invention**
Problem to be Solved by Invention
[0005]

The cylindrical tube generally has a shape provided with coupling flange parts at its opposed ends. By flange-connecting a
20 plurality of such cylindrical tubes with each other, a flow passage for flowing cold fluid therein is formed. Further, the coupling flange part of the cylindrical tube may be coupled also to a valve such as an opening/closing valve.

And, when the heat insulating members are to be attached to the
25 outer circumference portion of the cylindrical tube, such heat insulating members having a predetermined length in the axial direction of the cylindrical tube will be attached one after another from one end portion to the other end portion of the cylindrical tube.

[0006]
30 More particularly, at a position adjacent one end portion of the cylindrical tube, semi-circular heat insulating members halved along the circumferential direction of the cylindrical tube are disposed side by side along the circumferential direction of the cylindrical tube with the end faces of the heat insulating members being placed in abutment against
35 each other. Then, an elongate connecting member, while being moved in the longitudinal direction, will be engaged (inserted) into the receded

groove portions formed in the pair of heat insulating member end portions respectively, thus attaching the heat insulating members. Next, at the position adjacent the attached heat insulating members, further semi-circular heat insulating members halved in the circumferential direction of the cylindrical tube will be disposed side by side in the circumferential direction of the cylindrical tube with the end faces thereof being placed in abutment against each other and under this state, the elongate connecting member will be moved in the longitudinal direction to be engaged (inserted) into the receded groove portions formed in the pair of heat insulating member end portions respectively for completing the attachment of the heat insulating members. This procedure will be carried out in repetition one after another from the one end portion to the other end portion of the cylindrical tube.

[0007]

However, in the case of the above-described arrangement where the heat insulating members are attached one after another from end portion toward the other end portion of the cylindrical tube and lastly, the heat insulating members are attached at the position adjacent the other end portion of the cylindrical tube, the flange of the other end portion of the cylindrical tube will block the receded groove portions formed respectively in the pair of heat insulating member end portions. Thus, due to the presence of this flange portion, the above-described operation of engaging (inserting) the elongate connecting member into the respective receded groove portions of the pair of heat insulating member end portions in association with the moving of the elongate connecting member in the longitudinal direction is not possible.

[0008]

Namely, in order to allow for the above-described operation of engaging (inserting) the elongate connecting member into the respective receded groove portions of the pair of heat insulating member end portions in association with the moving of the elongate connecting member in the longitudinal direction, a space corresponding to the length of the connecting member is required on one side of the heat insulating members in the axial direction of the cylindrical tube. However, in case the heat insulating members are to attached to the position adjacent the other end portion of the cylindrical tube, the

presence of the flange there does not allow securing of such space corresponding to the length of the connecting member.

[0009]

Incidentally, according to one conceivable arrangement, a gap can be provided between the flange of the other end portion of the cylindrical tube and the heat insulating members so that the pair of heat insulating member end portions may be engaged (inserted) into the receded groove portions formed respectively in the pair of heat insulating member end portions in association with flexion of the elongate connecting member. In this case, however, the elongate connecting member can be damaged by the flexion, thus becoming unable to be engaged (inserted) into the receded groove portions.

[0010]

For this reason, as shown in Fig. 17 and Fig. 18, it is conceivable to form stepped engagement portions Z in the form of steps along the radial direction of the cylindrical tube 1, at positions in the respective pair of heating insulating member end portions where the end faces of the semi-circular heat insulating members P halved in the circumferential direction of the cylindrical tube 1 are opposed to each other. Incidentally, Fig. 17 and Fig. 18 illustrate an exemplary case in which three-layers of heat insulating members are to be attached.

[0011]

However, in this case, the provision of such stepped engagement portions Z leads to disadvantageous increase in the number of kinds of the heat insulating members P, so the production and management thereof will become troublesome. Moreover, even when the stepped-engagement portions Z of the pair of heat insulating member end portions are engaged with each other, this arrangement suffers inconvenience of weak engagement and difficulty in attaching operation of the heat insulating members P.

Namely, the stepped engagement portions Z of the pair of heat insulating member end portions relies basically on a force of friction for maintenance of their engaged state, so this engagement is vulnerable to inadvertent detachment.

[0012]

The present invention has been made in view of the

above-described state of the art and its principal object is to provide an improved heat insulation structure for a cylindrical tube that allows non-easily detachable secure engagement between the connecting member and the heat insulating member despite absence of space corresponding to the length of the connecting member at the one side portion of the heat insulating member in the axial direction of the cylindrical tube.

Solution

[0013]

According to the present invention, there is provided a heat insulation structure for a cylindrical tube configured such that on an outer circumferential portion of a cylindrical tube in which cold fluid flows, there are provided semi-circular heat insulating members halved in a circumferential direction of the cylindrical tube with an adjacent pair of heat insulating member end portions thereof being coupled to each other via a connecting member elongate in an axial direction of the cylindrical tube, at each one of two opposed positions located in the circumferential direction of the cylindrical tube with end faces thereof being placed in abutment against each other, according to an inventive characterizing feature of the arrangement:

at each one of the pair of heat insulating member end portions at one of the two opposed positions, as a groove-like engagement portion to which the connecting member is to be engaged, there is provided a cutaway portion formed by cutting away an inner portion of the heat insulating member end portion in the radial direction of the cylindrical tube along the circumferential direction of the cylindrical tube, the cutaway portion being provided, on the radially outer side of the cylindrical tube, with a retaining receded portion that is receded outwards in the radial direction of the cylindrical tube;

the connecting member at one of the two opposed positions includes a main body portion having a cross sectional shape engageable with the cutaway portion respectively of the pair of heat insulating member end portions and a pair of retaining protruding portions engageable with the retaining receded portion;

at each one of the pair of heat insulating member end portions at

the other of the two opposed positions, as a groove-like engagement portion to which the connecting member is to be engaged, there is provided a receded portion that is receded from the end face along a tangential direction of the cylindrical tube is provided in the form of a flat face with an inner surface and an outer surface thereof disposed side by side along the radial direction of the cylindrical tube extending along the tangential direction of the cylindrical tube; and

the connecting member at the other of the two opposed positions has a cross-sectional shape provided in the form of a flat face along the inner surface and the outer surface of the receded portion of each of the pair of heat insulating member end portions.

[0014]

Incidentally, the "tangential direction of the cylindrical tube" mentioned above means the tangential direction of the cylindrical tube at an opposed position where the end faces of the pair of heat insulating members are disposed in abutment against each other.

[0015]

Namely, at each one of the pair of opposed positions located in the circumferential direction of the cylindrical tube with the end faces of the halved heat insulating members being placed in abutment against each other, in order to realize a state of the adjacent pair of heat insulating member end portions being coupled to each other via the connecting member, this can be done by a following procedure for example.

Firstly, to each one of the engagement portions formed at the opposed ends of one heat insulating member of the pair of the halved semi-circular heat insulating members, the connecting member having the main body portion and the retaining protruding portions and the connecting member in the shape of a flat face will be engaged respectively. In this, the connecting member having the main body portion and the retaining protruding portions will be engaged to the engagement portion formed as a cutaway portion having the retaining receded portion, whereas the connecting member in the form of a flat face will be engaged to the engagement portion formed as a receded portion receded from the end face in the tangential direction of the cylindrical tube.

[0016]

Thereafter, the one heat insulating member to which the connecting member having the main body portion and the retaining protruding portions and the connecting member in the form of a flat face have been engaged will be attached on the outer circumference portion of the cylindrical tube.

In succession to the above, firstly, to the connecting member having the main body portion and the retaining protruding portions, the engagement portion formed at one end of the other heat insulating member, namely, the engagement portion formed as the cutaway portion provided with the retaining receded portion will be engaged while being moved from the position corresponding to the outer side of the cylindrical tube in the direction closer to the cylindrical tube.

[0017]

Next, to the connecting member in the form of a flat face, the engagement portion formed on the other end of the other heat insulating member will be engaged. More particularly, the engagement portion formed as the receded portion receded from the end face in the tangential direction of the cylindrical tube will be engaged while being moved in the tangential direction of the cylindrical tube at the opposed position where the end faces of the pair of heat insulating members are disposed in abutment against each other.

[0018]

With the above-described procedure, at each one of the two opposed positions located in the circumferential direction of the cylindrical tube where the end faces of the halved heat insulating members are placed in abutment against each other, the pair of heat insulating member end portions adjacent each other will be coupled to each other via the connecting members. With this, the connecting members can be attached even when no space corresponding to the length of the connecting member is present at one side portion of the heat insulating members in the axial direction of the cylindrical tube.

[0019]

Moreover, when the engagement portion formed as the cutaway portion provided with the retaining receded portion is engaged to the connecting member having the main body portion and the retaining protruding portions, as the retaining protruding portions retain the

retaining receded portion, the engagement between the connecting member having the main body portion and the retaining protruding portions and the engagement portion can effectively resist inadvertent detachment.

5 Further, when the engagement portion formed as the receded portion receded from the end face in the tangential direction of the cylindrical tube is engaged to the connecting member in the form of a flat face, e.g. even if the heat insulating member tends to rotate about the portion engaged with the connecting member having the main body
10 portion and the retaining protruding portions, as the inner surface and the outer surface of this receded portion disposed side by side along the radial direction of the cylindrical tube and formed in the flat face along the tangential direction of the cylindrical tube come into abutment against the inner surface and the outer surface of this receded portion of
15 the connecting member having the shape of a flat face, such rotational motion will be prevented, so that the engagement between the connecting member in the form of the flat face and the engagement portion can effectively resist inadvertent detachment.

[0020]

20 In short, with the heat insulation structure for a cylindrical tube according to the present invention, even when no space corresponding to the length of the connecting member is present at one side portion of the heat insulating member in the axial direction of the cylindrical tube, the connecting member can be attached with less possibility of detachment
25 of its engagement with the heat insulating members.

[0021]

According to the present invention, there is also provided a heat insulation structure for a cylindrical tube configured such that on an outer circumferential portion of a cylindrical tube in which cold fluid
30 flows, there are provided semi-circular heat insulating members halved in a circumferential direction of the cylindrical tube with an adjacent pair of heat insulating member end portions thereof being coupled to each other via a connecting member elongate in an axial direction of the cylindrical tube, at each one of two opposed positions located in the
35 circumferential direction of the cylindrical tube with end faces thereof being placed in abutment against each other, according to an inventive

characterizing feature of the arrangement:

at each one of the pair of heat insulating member end portions at the two opposed positions, as a groove-like engagement portion to which the connecting member is to be engaged, there is provided a cutaway portion formed by cutting away an inner portion of the heat insulating member end portion in the radial direction of the cylindrical tube along the circumferential direction of the cylindrical tube, the cutaway portion being provided, on the radially outer side of the cylindrical tube, with a retaining receded portion that is receded outwards in the radial direction of the cylindrical tube; and

the connecting member at each one of the two opposed positions includes a main body portion having a cross sectional shape engageable with the cutaway portion respectively of the pair of heat insulating member end portions and a pair of retaining protruding portions engageable with the retaining receded portion.

[0022]

Namely, at the respective one of the two opposed positions located in the circumferential direction of the cylindrical tube where the end faces of the halved heat insulating members are placed in abutment against each other, in order to realize a state of the adjacent pair of heat insulating member end portions being coupled to each other via the connecting member, this can be done by a following procedure for example.

Firstly, to the respective engagement portions formed at the opposed ends of one heat insulating member of the pair of halved semi-circular heat insulating members, the connecting member having the main body portion and the retaining protruding portions will be engaged.

[0023]

Thereafter, the one heat insulating member having the connecting members having the main body portion and the retaining protruding portions engaged to the opposed ends thereof will be attached to the outer circumferential portion of the cylindrical tube.

In succession to the above, firstly, to the one heat insulating member having the main body portion and the retaining protruding portions of the pair of heat insulating members, the engagement portion

formed at one end of the other heat insulating member, namely, the engagement portion formed as the cutaway portion provided with the retaining receded portion will be engaged while being moved from the position corresponding to the outer side of the cylindrical tube in the direction closer to the cylindrical tube.

[0024]

Next, to the other of the pair of connecting members having the main body portion and the retaining protruding portions, the engagement portion formed at the other end of the other heat insulating member, namely, the engaging portion formed as a cutaway portion having the retaining receded portion, will be brought into engagement, while being from the portion corresponding to the outer side of the cylindrical tube in the direction closer to the cylindrical tube.

[0025]

Incidentally, when the engagement portion formed in the other end of the other heat insulating member is to be moved from the portion corresponding to the outer side of the cylindrical tube in the direction closer to the cylindrical tube, the other heat insulating member will be elastically deformed to be expanded/compressed along the radial direction of the cylindrical tube, so it will be advantageous if the insulating member has a diameter greater than the height of the retaining protruding portion.

[0026]

With the above-described procedure, at each one of the two opposed positions located in the circumferential direction of the cylindrical tube where the end faces of the halved heat insulating members are placed in abutment against each other, the pair of heat insulating member end portions adjacent each other will be coupled to each other via the connecting members. With this, the connecting members can be attached even when no space corresponding to the length of the connecting member is present at one side portion of the heat insulating members in the axial direction of the cylindrical tube.

[0027]

Moreover, when the engagement portion formed as a cutaway portion having the retaining receded portion is engaged to the connecting member having the main body portion and the retaining protruding

portions, as the retaining protruding portions retain the retaining receded portion, the engagement between the connecting member having the main body portion and the retaining protruding portions and the engagement portion can effectively resist inadvertent detachment.

5 [0028]

In short, with the heat insulation structure for a cylindrical tube according to the present invention, even when no space corresponding to the length of the connecting member is present at one side portion of the heat insulating member in the axial direction of the cylindrical tube, the connecting member can be attached with less possibility of detachment of its engagement with the heat insulating members.

10 [0029]

According to the present invention, there is also provided a heat insulation structure for a cylindrical tube configured such that on an outer circumferential portion of a cylindrical tube in which cold fluid flows, there are provided semi-circular heat insulating members halved in a circumferential direction of the cylindrical tube with an adjacent pair of heat insulating member end portions thereof being coupled to each other via a connecting member elongate in an axial direction of the cylindrical tube, at each one of two opposed positions located in the circumferential direction of the cylindrical tube with end faces thereof being placed in abutment against each other, according to an inventive characterizing feature of the arrangement:

at each one of the pair of heat insulating member end portions at the two opposed positions, as a groove-like engagement portion to which the connecting member is to be engaged, there is provided a receded portion that is receded from the end face along a tangential direction of the cylindrical tube is provided in the form of a flat face with an inner surface and an outer surface thereof disposed side by side along the radial direction of the cylindrical tube extending along the tangential direction of the cylindrical tube; and

the connecting member at the respective two opposed positions has a cross-sectional shape provided in the form of a flat face along the inner surface and the outer surface of the receded portion of the respective one of the pair of heat insulating member end portions.

35 [0030]

Incidentally, the "tangential direction of the cylindrical tube" mentioned above means the tangential direction of the cylindrical tube at an opposed position where the end faces of the pair of heat insulating members are disposed in abutment against each other.

5 [0031]

Namely, at each one of the opposed positions located in the circumferential direction of the cylindrical tube where the end faces of the halved heat insulating members are placed in abutment against each other, in order to realize a state of the adjacent pair of heat insulating member end portions being coupled to each other via the connecting member, this can be done by a following procedure for example.

Firstly, to the respective engagement portions formed at the opposed ends of one heat insulating member of the pair of halved semi-circular heat insulating members.

15 [0032]

Thereafter, the one heat insulating member having the connecting members in the form of a flat face engaged to the opposed ends thereof will be attached to the outer circumferential portion of the cylindrical tube.

20 In succession to the above, firstly, with moving the other heat insulating member closer to the cylindrical tube, to the connecting member in the form of a flat face engaged with the opposed ends of one heat insulating member, the engagement portions formed at the opposed ends of the other heat insulating member, namely, the engagement portions formed as the receded portions receded from the end face in the tangential direction of the cylindrical tube will be engaged at the opposing portion where the end faces of the pair of heat insulating members are placed in abutment against each other.

25 [0033]

30 With the above-described procedure, at each one of the two opposed positions located in the circumferential direction of the cylindrical tube where the end faces of the halved heat insulating members are placed in abutment against each other, the pair of heat insulating member end portions adjacent each other will be coupled to each other via the connecting members. With this, the connecting members can be attached even when no space corresponding to the

length of the connecting member is present at one side portion of the heat insulating members in the axial direction of the cylindrical tube.

[0034]

Further, when the engagement portion formed as a receded portion receded from the end face in the tangential direction of the cylindrical tube is engaged to the connecting member in the form of a flat face, e.g. even if the heat insulating member tends to rotate about the portion engaged with one connecting member, as the inner surface and the outer surface of the receded portion disposed side by side along the radial direction of the cylindrical tube and formed in the flat face along the tangential direction of the cylindrical tube come into abutment against the inner surface and the outer surface of this receded portion of the connecting member having the shape of a flat face, such rotational motion will be prevented, so that the engagement between the connecting member in the form of the flat face and the engagement portion can effectively resist inadvertent detachment.

[0035]

In short, with the heat insulation structure for a cylindrical tube according to the present invention, even when no space corresponding to the length of the connecting member at one side portion of the heat insulating member in the axial direction of the cylindrical tube, the connecting member can be attached with less possibility of detachment of its engagement with the heat insulating members.

[0036]

According to a further characterizing feature of the heat insulation structure for a cylindrical tube of the present invention:

the connecting member in the form having a flat face is formed of a material capable of elastic deformation; and

at one engaging portion of a pair of engaging portions of the connecting member to be engaged to the receded portion adjacent thereto, there is formed a slit which separates this engaging portion in the radial direction of the cylindrical tube.

[0037]

Namely, at one engaging portion of a pair of engaging portions of the connecting member in the form having a flat face to be engaged to the receded portion adjacent thereto, there is formed a slit which

separates this engaging portion in the radial direction of the cylindrical tube. Therefore, for example, if the engaging portion having no slit formed therein of the pair of the engaging portions of the connecting member is engaged with the engagement portion of the heat insulating member to be attached firstly of the pair of heat insulating members and the engagement portion of the heat insulating member to be attached later of the pair of heat insulating members is engaged with the engaging portion having the slit formed therein, the engaging operation of engaging the engagement portion to the engaging portion can be carried out advantageously with elastic deformation of the engaging portion having the slit formed therein.

[0038]

Namely, the engaging portion having the slit formed therein, when being pressed to be clamped in the radial direction, can reduce its width along the radial direction of the cylindrical tube with the formation of the slit therein. Therefore, the operation of engaging the engagement portion of the heat insulating member to the engaging portion having the slit formed therein can be carried out advantageously with the elastic deformation of the slit-formed engaging portion with reduction in its width along the radial direction of the cylindrical tube.

[0039]

Incidentally, if the width of the slit-formed engaging portion along the radial direction of the cylindrical tube is formed slightly greater than the width between the inner surface and the outer surface of the receded portion forming the engaging portion, at the time of the engagement of the engagement portion of the heat insulating member to the slit-formed engaging portion, a contact pressure between the inner surface and the outer surface of the receded portion forming the engagement portion and the slit-formed engaging portion is increased for resisting inadvertent detachment even more effectively.

[0040]

In short, with the above-described further characterizing feature of the inventive heat insulation structure for a cylindrical tube, it is possible to carry out advantageously the operation of bringing the engagement portion of the heat insulating member to be attached later of the pair of heat insulating members to the slit-formed engaging

portion of the pair of engaging portions of the connecting member.

[0041]

According to a further characterizing feature of the heat insulation structure for a cylindrical tube of the present invention:

5 the connecting member in the form having a flat face is formed of a material capable of elastic deformation; and

at each one of a pair of engaging portions of the connecting member to be engaged to the receded portion adjacent thereto, there is formed a slit which separates this engaging portion in the radial
10 direction of the cylindrical tube.

[0042]

Namely, at each one of a pair of engaging portions of the connecting member in the form having a flat face to be engaged to the receded portion adjacent thereto, there is formed a slit which separates
15 this engaging portion in the radial direction of the cylindrical tube. Therefore, the operation of engaging one of the pair of engaging portions of the connecting member to the engagement portion of the heat insulating member to be attached first of the pair of heat insulating members as well as the operation of engaging the engagement portion of
20 the heat insulating member to be attached later of the pair of heat insulating members to the other (remaining) engaging portion of the pair of engaging portions of the connecting member can be carried out advantageously.

[0043]

25 Namely, the engaging portion having the slit formed therein, when being pressed to be clamped in the radial direction, can reduce its width along the radial direction of the cylindrical tube with the formation of the slit therein. Therefore, the operation of engaging the engagement portion of the heat insulating member to the engaging
30 portion having the slit formed therein can be carried out advantageously with the elastic deformation of the slit-formed engaging portion with reduction in its width along the radial direction of the cylindrical tube.

[0044]

Incidentally, if the width of the slit-formed engaging portion
35 along the radial direction of the cylindrical tube is formed slightly greater than the width between the inner surface and the outer surface

of the receded portion forming the engaging portion, at the time of the engagement of the engagement portion of the heat insulating member to the slit-formed engaging portion, a contact pressure between the inner surface and the outer surface of the receded portion forming the engagement portion and the slit-formed engaging portion is increased for resisting inadvertent detachment even more effectively.

[0045]

In short, with the above-described further characterizing feature of the inventive heat insulation structure for a cylindrical tube, it is possible to carry out advantageously the operation of bringing the engagement portion of the heat insulating members into engagement with the pair of engaging portions of the connecting member.

[0046]

According to a still further characterizing feature of the heat insulation structure for a cylindrical tube of the present invention:

on the outer circumferential portion of the cylindrical tube, a plurality of heat insulating walls provided in a cylindrical shape and having different diameters of the halved semi-circular heat insulating members are provided to form a plurality of layers.

[0047]

Namely, as the outer circumferential portion of the cylindrical tube is covered by a plurality of heat insulating walls forming multiple layers, the cylindrical tube can be heat-insulated appropriately.

[0048]

In short, with the above-described further characterizing feature of the inventive heat insulation structure for a cylindrical tube, the cylindrical tube can be heat-insulated appropriately.

[0049]

According to a still further characterizing feature of the heat insulation structure for a cylindrical tube of the present invention:

at a position adjacent in the axial direction of the cylindrical tube to a disposing position of the semi-circular heat insulating members coupled to each other via the connecting member on the outer circumferential portion of the cylindrical tube, arc-shaped heat insulating members divided into plurality in the circumferential direction of the cylindrical tube are provided, at each one of a plurality of

opposed positions in the circumferential direction of the cylindrical tube with end faces thereof being placed in abutment against each other, such that a pair of heat insulating member end portions adjacent each other are coupled to each other via a coupling member which is formed
5 elongate along the axial direction of the cylindrical tube;

at each one of the pair of heat insulating member end portion coupled via the coupling member, as an engaging groove portion for the coupling member, a receded groove portion receded from the end face in the circumferential direction of the cylindrical tube is formed, at an outer
10 portion of this receded groove portion in the radial direction of the cylindrical tube, with a retaining groove portion receded to the outer side in the radial direction of the cylindrical tube; and

the coupling member includes a main body coupling portion having a cross sectional shape engageable with the receded groove
15 portion of each one of the pair of heat insulating member end portions and a pair of retaining coupling portions engageable with the retaining groove portion.

[0050]

Namely, when the heat insulating members having a
20 predetermined length in the axial direction of the cylindrical tube are to be attached one after another from one end portion toward the other end portion of the cylindrical tube, at a portion adjacent one end portion of the cylindrical tube or a portion away from the other end portion of the cylindrical tube, the arc-shaped heat insulating members coupled to each
25 other via the coupling member will be attached and lastly at the portion adjacent the other end portion of the cylindrical tube, the semi-circular heat insulating members coupled to each other via the connecting member will be attached, whereby the heat insulating members can be appropriately attached along the entire length of the cylindrical tube.

[0051]

Incidentally, when the arc-shaped heat insulating members coupled to each other via the elongate coupling member are to be attached to the outer circumferential portion of the cylindrical tube, these arc-shaped heat insulating members divided into plurality in the
35 circumferential direction of the cylindrical tube will be arranged side by side in the circumferential direction of the cylindrical tube with the end

faces thereof being placed in abutment against each other. Then, under this state, the elongate coupling member will be moved in the longitudinal direction to come into engagement (insertion) with the engaging groove portion formed in the respective adjacent heat insulating member end portion, whereby the heat insulating members will be attached.

[0052]

And, as the engaging groove portion formed in the respective heat insulating member end portions coupled to each other via the coupling member, a receded groove portion receded from the end face of the heat insulating member in the circumferential direction of the cylindrical tube is formed, at an outer portion of this receded groove portion in the radial direction of the cylindrical tube, with a retaining groove portion receded to the outer side in the radial direction of the cylindrical tube; and in correspondence therewith, the coupling member includes a main body coupling portion having a cross sectional shape engageable with the receded groove portion of the respective heat insulating member end portion and a pair of retaining coupling portion engageable with the retaining groove portion. Thus, by retaining the retaining groove portion to the retaining coupling portions, adjacent heat insulating members can be appropriately coupled with each other. Therefore, when the heat insulating members are cooled by the cold fluid flowing inside the cylindrical tube, thanks to heat shrinkage of the heat insulating members, it is possible to suppress formation of a large gap between the end faces of adjacent heat insulating members, so that the cylindrical tube can be heat-insulated in an appropriate manner.

[0053]

In short, with the above-described further characterizing feature of the inventive heat insulation structure for a cylindrical tube, with ensuring appropriate heat insulation of the cylindrical tube, the heat insulating members can be appropriately attached along the entire length of the cylindrical tube.

[0054]

According to a still further characterizing feature of the heat insulation structure for a cylindrical tube of the present invention:

on the outer circumferential portion of the cylindrical tube, a

plurality of heat insulating walls provided in a cylindrical shape and having different diameters of a plurality of arc-shaped heat insulating members coupled to each other via the coupling member are provided to form a plurality of layers.

5 [0055]

Namely, as on the outer circumferential portion of the cylindrical tube, a plurality of heat insulating walls provided in a cylindrical shape and having different diameters of a plurality of arc-shaped heat insulating members coupled to each other via the coupling member are provided to form a plurality of layers, the cylindrical tube can be heat-insulated even more appropriately.

[0056]

In short, with the above-described further characterizing feature of the inventive heat insulation structure for a cylindrical tube, the cylindrical tube can be heat-insulated even more appropriately.

BRIEF DESCRIPTION OF THE DRAWINGS

[0057]

Fig. 1 is a side view in vertical section showing attached states of heat insulating members,

Fig. 2 is a cutaway perspective view showing attached states of the heat insulating members and semi-circular heat insulating members,

Fig.3 is a section view taken along III-III line in Fig. 1,

25 Fig.4 is a section view taken along IV-IV line in Fig. 1,

Fig. 5 is an exploded perspective view showing relation between a coupling member and a heat insulating member,

Fig. 6 is a front view showing relation between a connecting member and semi-circular heat insulating members,

30 Fig. 7 is a perspective view of the connecting member,

Fig. 8 is a perspective view showing a mode of attachment of a coupling body,

Fig. 9 is an enlarged perspective view of the coupling body,

Fig. 10 is a front view showing an attachment mode of a semi-circular heat insulating member according to a second embodiment,

Fig. 11 is a perspective view showing a connecting member in the

second embodiment,

Fig. 12 is a front view showing an attachment mode of a heat insulating member in a third embodiment,

Fig. 13 is a front view showing relation between semi-circular heat insulating members and a connecting member in the third embodiment,

Fig. 14 is a front view showing an attachment mode of the semi-circular heat insulating member in the third embodiment,

Fig. 15 is a perspective view showing a connecting member in the third embodiment,

Fig. 16 is a front view showing an attachment mode of semi-circular heat insulating member in a fourth embodiment,

Fig. 17 is a front view showing an attachment mode of a heat insulating member in a comparison example, and

Fig. 18 is an exploded perspective view showing an attachment mode of the heat insulating member in the comparison example.

MODES OF EMBODYING THE INVENTION

[0058]

[First Embodiment]

Next, a first embodiment of the present invention will be explained with reference to the accompanying drawings.

(General Configuration of Heat insulation structure)

As shown in Fig. 1 and Fig. 2, there is provided a cylindrical tube 1 in which cold fluid such as LNG, LPG, etc. is caused to flow. On the outer circumferential portion of this cylindrical tube 1, a plurality of heat insulating members P formed of urethane foam made by foaming urethane resin are attached in juxtaposition along the circumferential direction and the axial direction of the cylindrical tube 1.

[0059]

Each one of the plurality of heat insulating members P extends in an arcuate form (semi-circular form in this embodiment) along the circumferential direction of the cylindrical tube 1 with a predetermined thickness along the radial direction of the cylindrical tube 1 and is made by cutting a base material elongate in the axial direction of the

cylindrical tube 1 to a predetermined length in the axial direction of the cylindrical tube 1.

Incidentally, as shown in Fig. 5, in the following discussion, the radially outer side face of the heat insulating member P is defined as an outer face 3 and a radially inner side face thereof is defined as an inner face 4, opposed faces in the circumferential direction are defined as end faces 5 and opposed faces in the axial direction are defined as side faces 6, respectively.

[0060]

In this embodiment, the heat insulating members P are attached to form three layers of heat insulating walls.

Namely, as the heat insulating members P, there are provided a large-diameter heat insulating member PL having the greatest diameter, an intermediate-diameter heat insulating member PM having an intermediate diameter and a small-diameter heat insulating member PS having the smallest diameter (see Fig. 3 and Fig. 4).

Incidentally, under the superposed or stacked state of the heat insulating members P, the outer face 3 of the large-diameter heat insulating member PL is located on the outermost side, the inner face 4 of the large-diameter heat insulating member PL and the outer face 3 of the intermediate-diameter heat insulating member PM are disposed side by side with a same diameter, the inner face 4 of the intermediate-diameter heat insulating member PM and the outer face 3 of the small-diameter heat insulating member PS are disposed side by side with a same diameter, and the inner face 4 of the small-diameter heat insulating member PS is disposed side by side with the outer circumferential face of the cylindrical tube 1 with a same diameter.

[0061]

At opposed end portions of the cylindrical tube 1, flanges F are provided. As these flanges F are coupled with flanges of adjacent cylindrical tubes 1, there is formed a flow passage through which the cold fluid is caused to flow.

The plurality of heat insulating members P will be attached one after another from the one end portion to the other end portion of the cylindrical tube 1, thus being attached at the portion adjacent one end portion of the cylindrical tube 1, at the portion adjacent the other end

portion of the cylindrical tube 1 and the portion(s) present therebetween.
[0062]

Referring to the mode of disposing the heat insulating members P side by side in the axial direction of the cylindrical tube 1, the mode of disposing the small-diameter heat insulating members PS and the mode of disposing the large-diameter heat insulating members PL having the largest diameter are same; whereas, the mode of disposing the intermediate-diameter heat insulating members PM is different.

Namely, the small-diameter heat insulating member PS, the intermediate-diameter heat insulating member PM and the large-diameter heat insulating member PL are formed to have a basic length (e.g. 1 m) along the axial direction of the cylindrical tube 1.

[0063]

And, respecting the small-diameter heat insulating members PS and the large-diameter heat insulating members PL, these will be arranged such that the heat insulating members P having the basic length are disposed side by side from one end portion toward the other end portion of the cylindrical tube 1. Whereas, respecting the intermediate-diameter heat insulating members PM, these will be arranged such that after heat insulating members P having a half the basic length (e.g. 0.5 m) are arranged at the one end portion of the cylindrical tube 1, the heat insulating members P having the basic length will be arranged one after another toward the other end portion of the cylindrical tube 1.

[0064]

At the portion adjacent the other end portion of the cylindrical tube 1, the axial lengths of the small-diameter heat insulating members PS, the intermediate-diameter heat insulating members PM and the large-diameter heat insulating members PL will be determined appropriately in correspondence with the axial length of the cylindrical tube 1.

However, the axial lengths of the small-diameter heat insulating member PS, the intermediate-diameter heat insulating member PM and the large-diameter heat insulating member PL adjacent the other end portion of the cylindrical tube 1 are configured to exceed 1 m, in order to form a space for attachment of a coupling member 7 which will be

described later.

[0065]

Further, respecting the intermediate-diameter heat insulating member PM, as the intermediate-diameter heat insulating member PM having the half the basic length (e.g. 0.5 m) is to be disposed at the portion adjacent the one end portion of the cylindrical tube 1, the portion adjacent the other end portion of the cylindrical tube, the axial length of the small-diameter heat insulating member PS, the axial length of the large-diameter heat insulating member PL and the axial length of the intermediate-diameter heat insulating member PM will be different.

In the instant embodiment, the axial length of the intermediate-diameter heat insulating member PM is set to a length which is a sum of the axial length of the small-diameter heat insulating member PS and the large-diameter heat insulating member PL and the half of the basic length (e.g. 0.5 m).

[0066]

Moreover, at the intermediate portions excluding the portion adjacent the one end portion of the cylindrical tube 1 and the portion adjacent the other end portion of the cylindrical tube 1, the arrangement (to be referred to simply as "basic attachment arrangement" hereinafter) for attaching the heat insulating members P in juxtaposition along the circumferential direction of the cylindrical tube 1 remains the same, but the attachment arrangement (to be referred to simply as "end portion attachment arrangement" hereinafter) of attaching the heat insulating members P in juxtaposition along the circumferential direction of the cylindrical tube 1 at the portion adjacent the other end portion of the cylindrical tube 1 differs from the above-described basic attachment arrangement. Next, the basic attachment arrangement and the end portion attachment arrangement will be described one after the other.

[0067]

Incidentally, at the portion between the flange F of the cylindrical tube 1 and the heat insulating member P, there is charged heat insulating material D such as glass wool. And, at the portion corresponding to the upper portion of the flange F of the cylindrical tube 1, with an arrangement similar to the basic attachment arrangement, arc-shaped flange heat insulating members Q are disposed in two layers.

[0068]

(Basic Attachment Arrangement)

In this basic attachment arrangement, as shown in Fig. 3, the plurality of arc-shaped (semi-circular shape in the instant embodiment) heat insulating members P divided along the circumferential direction of the cylindrical tube 1 are provided on the outer circumferential portion of the cylindrical tube 1 with end faces thereof being placed in abutment against each other, at a plurality of opposed positions located along the circumferential direction of the cylindrical tube 1 respectively, with these heat insulating members P being coupled to each other through mutual coupling of an adjacent pair of heat insulating member end portions thereof via coupling members 7 (see Fig. 5) formed elongate along the axial direction of the cylindrical tube.

Incidentally, the length of the coupling members 7 is set equal to the axial length of the heat insulating member P and also the coupling members 7 are formed of urethane resin, like the heat insulating members P.

[0069]

As shown in Fig. 3 and Fig. 5, at the respective pair of heat insulating member end portions coupled via the coupling member 7, as an engaging groove portion U for the coupling member 7, a receded groove portion 8 receded from the end face in the circumferential direction of the cylindrical tube is provided with a retaining groove portion 8a which is receded to the radially outer side of the cylindrical tube 1 at the portion of this receded groove portion 8 on the radially outer side of the cylindrical tube 1.

[0070]

And, the coupling member 7 has a cross sectional shape that includes a main body coupling portion 7A to be engaged in the receded groove portion of each one of the pair of heat insulating member end portions and a pair of retaining coupling portions 7a engageable with the retaining groove portion 8a.

[0071]

Therefore, in this basic attachment arrangement, with the semi-circular heat insulating members P being arranged side by side in the circumferential direction of the cylindrical tube 1 on the outer

circumferential portion of this cylindrical tube 1, the coupling member 7 will be moved along the longitudinal direction (the axial direction of the cylindrical tube 1) to be engaged with the receded groove portion 8 of each one of the pair of heat insulating member end portions, whereby the heat insulating members P will be attached to the outer circumferential portion of the cylindrical tube 1 (see Fig. 5).

[0072]

More particularly, firstly, the small-diameter heat insulating members PS will be attached to the outer circumferential face of the cylindrical tube 1. Next, the intermediate-diameter heat insulating members PM will be attached to the outer circumferential faces of the small-diameter heat insulating members PS. Lastly, the large-diameter heat insulating members PL will be attached to the outer circumferential faces of the intermediate-diameter heat insulating members PM.

Under the above-described state in which the small-diameter heat insulating members PS, the intermediate-diameter heat insulating members PM and the large-diameter heat insulating members PL have been attached, on the outer circumferential portion of the cylindrical tube 1, a plurality (three) of heat insulating wall portions provided in the cylindrical form and with the different diameters by the plurality of arc-shaped (two semi-circular) heat insulating members P coupled with each other via the coupling members 7 are provided to form multiple layers.

[0073]

Also, the small-diameter heat insulating members PS, the intermediate-diameter heat insulating members PM and the large-diameter heat insulating members PL are attached in such a manner that the opposed position where the end faces of the small-diameter heat insulating members PS are placed in abutment against each other and the opposed position where the end faces of the intermediate-diameter heat insulating members PM are placed in abutment against each other have their phases 90 degrees different from each other in the circumferential direction of the cylindrical tube 1 and similarly the opposed position where the end faces of the intermediate-diameter heat insulating members PM are placed in abutment against each other and the opposed position where the end

faces of the large-diameter heat insulating members PL are placed in abutment against each other have their phases 90 degrees different from each other in the circumferential direction of the cylindrical tube 1.

[0074]

5 **(End portion Attachment Arrangement)**

10 In the end face attachment arrangement, as shown in Fig. 4, the above-described semi-circular heat insulating members P halved in the circumferential direction of the cylindrical tube 1 are used as the semi-circular heat insulating members PA halved in the circumferential direction of the cylindrical tube 1.

15 And, the heat insulating members P are provided on the outer circumference portion of the cylindrical tube 1 in such a manner that at the respective two opposed positions in the circumferential direction of the cylindrical tube 1 where the end faces thereof are placed in abutment against each other, the adjacent pair of heat insulating member end portions are coupled with each other via the elongate connecting members B along the axial direction of the cylindrical tube 1.

20 Incidentally, the length of the connecting member B is set equal to the axial length of the heat insulating member P and also the connecting member B is formed of urethan resin, like the heat insulating member P.

[0075]

25 At each one of the pair of heat insulating member end portions at the above-described two portions, as a groove-like engaging portion V in which the connecting member B is to be engaged, a receded portion 10 which is receded from the end face 5 in the tangential direction of the cylindrical tube 1 is formed with an inner surface 10u and an outer surface 10g disposed side by side along the radial direction of the cylindrical tube 1, both surfaces being formed as flat surfaces extending along the tangential direction of the cylindrical tube 1.

30 Incidentally, the "tangential direction of the cylindrical tube 1" in the above discussion means the tangential direction of the cylindrical tube 1 at the opposed positions where the end faces 5 of the pair of heat insulating members P are placed in abutment against each other.

35 [0076]

Further, the receded portion 10, as indicated by virtual lines in

the Fig. 6 illustration, is formed by cutting away a side portion 8b positioned aside a retaining groove portion 8a of the receded groove portion 8 provided in the basic attachment arrangement.

Namely, in the instant embodiment, the heat insulating member P is configured to have the receded groove portion 8. And, in the basic attachment arrangement, this heat insulating member P is used as it is. Whereas, in the end portion attachment arrangement, the side portion 8b positioned aside the retaining groove portion 8a of the receded groove portion 8 is cut away to form a square-shaped receded portion 10 and the heat insulating member P with such receded portion 10 formed therein is used as the semi-circular heat insulating member PA.

[0077]

And, the connecting member B at the two opposed positions is configured as an elongate square-shaped body 11 having a cross section in the form of a square having flat faces along the inner surface 10u and the outer surface 10g of the receded portion 10 of each one of the pair of heat insulating member end portions.

Incidentally, as the corner portions of the square-shaped receded portion 10 are formed arcuate, the cross sectional shape of the elongate square-shaped member 11 is a "roundish-cornered square shape".

[0078]

Moreover, in the instant embodiment, the elongate square-shaped body 11 having the square-shaped cross section is formed of an elastically deformable material (urethane resin) and each one of a pair of engaging portions 11A of this elongate square-shaped body 11 engageable with the receded portion adjacent thereto s 10 defines a slit 12 which separates the engaging portion 11A in the radial direction of the cylindrical tube, as shown in Fig. 7.

Incidentally, the thickness of the elongate square-shaped body 11 is set to about 15 mm, whereas the width of the slit 12 is set to about 2 mm.

[0079]

Therefore, in the case of this end face attachment arrangement, the heat insulating members P will be attached to the outer circumferential portion of the cylindrical tube 1 by the following procedure.

Firstly, to the receded portions 10 formed at the opposed end portions of one heat insulating member P of the halved semi-circular heat insulating members P (semi-circular heat insulating members PA), the elongate square-shaped body 11 will be engaged.

5 Incidentally, in order to engage the elongate square-shaped body 11 into the receded portion 10, the elongate square-shaped body 11 will be engaged (inserted) in the receded portion 10 in association with moving of this elongate square-shaped body 11 in the longitudinal direction. Alternatively, the elongate square-shaped body 11 will be
10 engaged in the receded portion 10 in association with moving of this elongate square-shaped body 11 in the receding direction of the receded portion 10.

[0080]

 Thereafter, the one heat insulating member P (semi-circular heat
15 insulating member PA) having the elongate square-shaped body 11 engaged therein will be attached in abutment against the outer circumferential portion of the cylindrical tube 1.

 In succession, as the other heat insulating member P is moved closer to the cylindrical tube 1, to the elongate square-shaped body 11
20 engaged with the opposed end portions of the one heat insulating member P, the receded portions 10 formed at the opposed end portions of the other heat insulating member P will be brought into engagement while being moved in the tangential direction of the cylindrical tube 1 at the opposed portions where the end faces 5 of the pair of heat insulating
25 members P are placed in abutment against each other.

[0081]

 More particularly, firstly, the small-diameter heat insulating members PS will be attached to the outer circumferential face of the cylindrical tube 1. Next, the intermediate-diameter heat insulating
30 members PM will be attached to the outer circumferential faces of the small-diameter heat insulating members PS. Lastly, the large-diameter heat insulating members PL will be attached to the outer circumferential faces of the intermediate-diameter heat insulating members PM.

 Under the above-described state in which the small-diameter
35 heat insulating members PS, the intermediate-diameter heat insulating members PM and the large-diameter heat insulating members PL have

been attached, on the outer circumferential portion of the cylindrical tube 1, a plurality (three) of heat insulating walls provided in the cylindrical form and with the different diameters by the halved semi-circular (two semi-circular) heat insulating members P are provided to form multiple (three) layers.

[0082]

Also, like the basic attachment arrangement, the small-diameter heat insulating members PS, the intermediate-diameter heat insulating members PM and the large-diameter heat insulating members PL are attached in such a manner that the opposed position where the end faces of the small-diameter heat insulating members PS are placed in abutment against each other and the opposed position where the end faces of the intermediate-diameter heat insulating members PM are placed in abutment against each other have their phases 90 degrees different from each other in the circumferential direction of the cylindrical tube 1 and similarly the opposed position where the end faces of the intermediate-diameter heat insulating members PM are placed in abutment against each other and the opposed position where the end faces of the large-diameter heat insulating members PL are placed in abutment against each other have their phases 90 degrees different from each other in the circumferential direction of the cylindrical tube 1.

[0083]

(Heat Insulation Enhancement Arrangement)

In the instant embodiment, for enhancing the heat insulation between the plurality of heat insulating members P attached to the outer circumferential face of the cylindrical tube 1, namely, the heat insulation between the adjacent heat insulating members P, a heat insulation enhancement arrangement is provided.

Namely, the plurality of heat insulating members P attached to the outer circumferential face of the cylindrical tube 1 are shrunk when being cooled by the cold fluid flowing inside the cylindrical tube 1. As a result, gaps will be formed between the respective adjacent heat insulating members P, thus tending to cause reduction in the heat insulation performance. For this reason, the heat insulation enhancement arrangement is provided for enhancing the heat insulation performance.

[0084]

Such heat insulation enhancement arrangement includes an inner side reinforcement arrangement provided for the heat insulating walls formed by the small-diameter heat insulating members PS and the intermediate heat insulating members PM and an outer side reinforcement arrangement provided for the heat insulating walls formed by the large-diameter heat insulating members PL. Next, the inner side reinforcement arrangement and the outer side reinforcement arrangement will be explained one after another. It is noted that in the Figs. 1-6 illustrations, the description of the heat insulation reinforcement arrangement is omitted.

[0085]

(Inner Side Reinforcement Arrangement)

In the inner side reinforcement arrangement, as shown in Fig. 8, for a portion where the end faces 5 of the pair of heat insulating members P disposed side by side in the circumferential direction of the cylindrical tube 1 are placed in abutment against each other, an adhesive tape (moisture proof butyl tape) 13 having gas-tightness is affixed and also for the heat insulating members P adjacent at the portion where the side faces 6 of the heat insulating members P disposed side by side in the axial direction of the cylindrical tube 1 are placed in abutment against each other, a coupling body W having a pair of retaining portions Wa is attached.

[0086]

Referring more particular to the arrangement of attaching the coupling body W to the adjacent heat insulating members P, the coupling body W having the pair of retaining portions Wa is inserted respectively to the radially inner side of the cylindrical tube 1 for the outer surface portions of the pair of small-diameter heat insulating members PS adjacent each other in the axial direction of the cylindrical tube 1 and the pair of the intermediate-diameter heat insulating members PM adjacent each other.

Incidentally, the pair of small-diameter heat insulating members PS adjacently juxtaposed in the axial direction of the cylindrical tube 1 and the pair of intermediate-diameter heat insulating members PM adjacently juxtaposed correspond to a pair of heat insulating members P

which form the inner side heat insulating walls in the radial direction of the cylindrical tube 1 of the plurality of layers (three layers) of heat insulating walls formed on the outer circumferential portion of the cylindrical tube 1 and which are adjacently juxtaposed in the axial direction of the cylindrical tube 1.

[0087]

In the instant embodiment, as shown in Fig. 9, the coupling body W is configured to have the retaining portions Wa on the width-wise opposed end sides of a bendably deformable band-like member 14 and the coupling body W is attached as being wound about the outer surface portions of the pair of heat insulating members P.

More particularly, the band-like member 14 is made of Tarpaulin which comprises a polyester fiber fabric sandwiched by soft synthetic resin films. And, to this band-like member 14, the retaining portions Wa formed by sharpening treatment with synthetic resin are added.

[0088]

Therefore, as the band-like member 14 has no adhesiveness, after this band-like member 14 is wound about the outer surface portions of the pair of heat insulating members P, on this wound band-like member 14, a narrow tape 15 having adhesiveness is wound to suppress detachment of the band-like member 14.

[0089]

(Outer Side Reinforcement Arrangement)

In the outer side reinforcement arrangement, as shown in Fig. 8, astride a pair of large-diameter heat insulating members PL adjacently juxtaposed in the axial direction of the cylindrical tube 1, a band-like first leak-proof body 16 having adhesiveness is affixed. And, at each of the plurality of (two) opposed positions where the end faces 5 of the large-diameter heat insulating members PL disposed adjacently juxtaposed in the circumferential direction of the cylindrical tube 1 are placed in abutment against each other, astride the pair of large-diameter heat insulating members PL disposed adjacent in the circumferential direction of the cylindrical tube 1, a band-like second leak-proof body 17 having adhesiveness is affixed.

[0090]

Incidentally, as may be apparent from the above explanation, the

heat insulating wall formed by the large-diameter heat insulating members PL corresponds to the heat insulating wall which is located on the outermost side in the radial direction of the cylindrical tube 1 of the plurality of (three) heat insulating walls.

5 [0091]

Moreover, in the instant embodiment, on the entire outer circumferential faces of the large-diameter heat insulating members PL, a square-shaped third leak-proof body 18 having adhesiveness is affixed for further enhancement of the heat insulation performance.

10 Incidentally, the first leak-proof body 16, the second leak-proof body 17 and the third leak-proof body 18 are formed respectively by using e.g. a tape (ALGC tape) produced by applying a rubber-based adhesive agent having good bonding force to a substrate formed of an aluminum foil and a glass cloth affixed to each other.

15 [0092]

Incidentally, as the order of affixing the first leak-proof body 16, the second leak-proof body 17 and the third leak-proof body 18 respectively, advantageously, the third leak-proof body 18 will be affixed first and then the second leak-proof body 17 will be affixed and lastly the first leak-proof body 16 will be affixed.

20

[0093]

[Second Embodiment]

Next, a second embodiment will be explained. In this, it is noted that this second embodiment differs from the first embodiment in the mode of forming the slit 12 in the elongate square-shaped body 11. The rest of its arrangement is identical to that of the first embodiment. As such, only differences thereof from the first embodiment will be discussed below and discussion on the identical arrangement to that of the first embodiment will be omitted.

30

[0094]

As shown in Fig. 10 and Fig. 11, in this second embodiment, of the pair of engaging portions 11A in the elongate square-shaped body 11, only in one engaging portion 11A, the slit 12 for separating this engaging portion in the radial direction of the cylindrical tube 1 is formed.

35

Namely, in the first embodiment, the slits 12 are formed in the

respective one of the pair of the engaging portions 11A of the elongate square-shaped body 11. This second embodiment differs from the first embodiment in that the slit 12 is formed in only one engaging portion 11A of the pair of engaging portions 11A.

5 **[0095]**

 In this second embodiment, firstly, when the elongate square-shaped body 11 is to be engaged to each one of the receded portions 10 formed at the opposed end portions of the one heat insulating member P of the pair of halved semi-circular heat insulating members P (semi-circular heat insulating members PA), the engaging portion 11A having no slit 12 formed therein is engaged.

 Incidentally, when the elongate square-shaped body 11 is to be engaged to the receded portions 10, the elongate square-shaped body 11 will be brought into engagement (insertion) with the receded portions 10 in association of movement of the elongate square-shaped body 11 in the longitudinal direction. Or, conversely, the elongate square-shaped body 11 will be brought into engagement with the receded portions 10 in association with a movement of the elongate square-shaped body 11 in the direction of recession of the receded portions 10.

20 **[0096]**

 Thereafter, one heat insulating member P to which the elongate square-shaped body 11 has been engaged will be attached into abutment against the outer circumferential portion of the cylindrical tube 1.

 In succession, as the other heat insulating member P is moved closer to the cylindrical tube 1, to the engaging portion 11A with the slit 12 formed therein of the elongate square-shaped body 11 engaged to the opposed end portions of the one heat insulating member P, the receded portions 10 formed at the opposed end portions of the other heat insulating member P will be engaged while being moved in the tangential direction of the cylindrical tube 1 at the opposed positions where the end faces 5 of the pair of heat insulating members P are placed in abutment against each other.

[0097]

35 **[Third Embodiment]**

 Next, a third embodiment will be explained. In this, it is noted

that this third embodiment differs from the first embodiment in the arrangement of the connecting member B used in the end portion attachment arrangement. The rest of its arrangement is identical to that of the first embodiment. As such, only differences thereof from the first embodiment will be discussed below and discussion on the identical arrangement to that of the first embodiment will be omitted.

[0098]

In the first embodiment described above, the outside diameter of the cylindrical tube 1 ranges around 30 mm. Whereas, in this third embodiment, the outside diameter of the cylindrical tube 1 is as large as 300 mm approximately, so the heat insulating member P is formed like an arc of 90 degrees.

[0099]

In the basic attachment arrangement of this third embodiment, as shown in Fig. 12, like the first embodiment, the heat insulating members P are coupled to each other via the coupling members 7 to form a plurality of (three) heat insulating wall portions.

[0100]

Further, in the end face attachment arrangement, as show in Fig. 13 and Fig. 14, the semi-circular heat insulating members PA halved in the circumferential direction of the cylindrical tube 1 comprise two 90-degree arc-shaped heat insulating members P coupled to each other via the coupling members 7 used in the basic attachment arrangement.

[0101]

Namely, at each one of the pair of opposed positions where the semi-circular heat insulating members PA halved in the circumferential direction of the cylindrical tube are disposed in the circumferential direction of the cylindrical tube 1 with the end faces thereof being placed in abutment against each other, the pair of heat insulating member end portions adjacent each other are coupled vial the elongate connecting members B along the axial direction of the cylindrical tube 1.

[0102]

At each one of the pair of heat insulating member end portions of at one of the two opposed positions described above, as a groove-like engaging portion V engageable with the connecting member B, a square-shaped cutaway portion 20 formed by cutting away an inner

portion of the heat insulating member end portion in the radial direction of the cylindrical tube 1 along the circumferential direction of the cylindrical tube 1 is formed, at a portion of this cutaway portion 20 on the radially outer side of the cylindrical tube 1, with a retaining receded portion 20a which is receded radially outwards of the cylindrical tube 1.

[0103]

Further, at each one of the pair of heat insulating member end portions of the other portion of the two opposed positions, as a groove-like engaging portion V engageable with the connecting member B, like the first embodiment described above, a receded portion 10 receded from the end face 5 along the tangential direction of the cylindrical tube 1 is formed with an inner surface 10u and an outer surface 10g thereof disposed side by side along the radial direction of the cylindrical tube 1 being formed as flat faces along the tangential direction of the cylindrical tube 1.

Incidentally, the "tangential direction of the cylindrical tube 1" mentioned above means the tangential direction of the cylindrical tube 1 at an opposed position where the end faces 5 of the pair of heat insulating members P are disposed in abutment against each other.

[0104]

The square-shaped cutaway portion 20, as indicated by virtual lines in Fig. 13, is formed such that by cutting away a lower portion 8c located downwards (inner side in the radial direction of the cylindrical tube 1) of the receded groove portion 8 in the basic attachment arrangement, the retaining groove portion 8a may be used as the retaining receded portion 20a.

Further, like the first embodiment, the receded portion 10, as indicated by the virtual lines in Fig. 13, is formed by cutting away the side portion 8b located on the lateral side of the retaining groove portion 8a of the receded groove portion 8 used in the basic attachment arrangement.

[0105]

Namely, in the instant embodiment, the heat insulating member P is formed with the receded groove portion 8. And, in the basic attachment arrangement, this heat insulating member P is used as it is.

Whereas, in the end portion attachment arrangement, the

cutaway portion 20 is formed by cutting away the lower portion 8c positioned downwards of the receded groove portion 8 located at the end portion of one heat insulating member P of the pair of heat insulating members P coupled to each other via the coupling members 7. Also, the square-shaped receded portion 10 is formed by cutting away the side portion 8b located laterally of the retaining groove portion 8a of the receded groove portion 8 located at the end portion of the other heat insulating member P. Then, a pair of heat insulating members P with the cutaway portions 20 and the receded portions 10 formed therein in the above-described manner are used as the semi-circular heat insulating members PA.

[0106]

And, the connecting member B at one of the two opposed positions, as shown in Fig. 15, is formed as an elongate M-shaped member 21 having an M-shaped cross section having a square-shaped main body portion 21A having a cross-sectional shape engageable with the square-shaped cutaway portion 20 of each one of the pair of heat insulating member end portions and a pair of retaining protruding portions 21a engageable with the retaining receded portion 20a.

[0107]

Also, like the first embodiment, the connecting member B at the other one of the two opposed position is provided as the elongate square-shaped body 11 having a square-shaped cross section including flat faces extending along the inner surface 10u and the outer surface 10g of the receded portion 10 of each one of the pair of heat insulating member end portion.

[0108]

Further, in third embodiment, in order to realize the state in which the pair of heat insulating member end portions adjacent are coupled to each other via the connecting members B at each one of the two opposed positions located in the circumferential direction of the cylindrical tube 1 where the end faces of the halved semi-circular heat insulating members PA are placed in abutment against each other, this is done by the following procedure.

Firstly, to each one of the engaging portions V formed at the opposed ends of the one semi-circular heat insulating member PA of the

pair of halved semi-circular heat insulating members PA, the elongate M-shaped member 21 and the elongate square-shaped body 11 will be engaged.

More particularly, the elongate M-shaped member 21 will be engaged with the engaging portion V formed as the square-shaped cutaway portion 20 having the retaining receded portion 20a, and the elongate square-shaped body 11 will be engaged with the engaging portion V formed as the receded portion 10 which is receded from the end face in the tangential direction of the cylindrical tube.

[0109]

Thereafter, the one semi-circular heat insulating member PA to which the elongate M-shaped member 21 and the elongate square-shaped member body 11 have been engaged will be attached to and in abutment against the outer circumferential portion of the cylindrical tube 1.

Next, firstly, to the elongate M-shaped member 21, the engaging portion V formed at one end of the other semi-circular heat insulating member PA, namely, the engaging portion V formed as the cutaway portion 20 having the retaining receded portion 20a, will be moved from the portion corresponding to the outer side of the cylindrical tube 1 in the direction closer to the cylindrical tube 1 to be brought into engagement.

[0110]

Next, to the elongate square-shaped body 11, the engaging portion V formed at the other end of the other semi-circular heat insulating member PA, namely, the engaging portion V formed as the receded portion 10 receded from the end face 5 in the tangential direction of the cylindrical tube 1 will be engaged while being moved in the tangential direction of the cylindrical tube 1 at the opposed positions where the end faces of the pair of semi-circular heat insulating members PA are placed in abutment against each other.

[0111]

With the above-described procedure, at each one of the two opposed positions located in the circumferential direction of the cylindrical tube 1 where the end faces of the halved semi-circular heat insulating members PA are placed in abutment against each other, as the adjacent pair of heat insulating member end portions are coupled to each

other via the connecting members B, the connecting members B can be attached even when no space corresponding to the length of the connecting member B is present at one portion of the semi-circular heat insulating member PA in the axial direction of the cylindrical tube 1.

[0112]

Incidentally, in the basic attachment arrangement, when the heat insulating members P are disassembled with removal of the coupling members 7 for the purpose of inspection of the cylindrical tube 1 for instance, there is the risk of the receded groove 8 formed portion of the heat insulating member P being damaged. In such case, advantageously, the lower portion 8c located downwardly of the receded groove portion 8 may be cutaway to form the cutaway portion 20, and the heat insulating members P may be coupled to each other by the elongate M-shaped members 21, in place of the coupling members 7.

[0113]

[Fourth Embodiment]

Next, a fourth embodiment will be explained. It is noted that this fourth embodiment differs from the third embodiment only in the arrangement of the connecting member B in the end portion attachment arrangement. The rest of its arrangement is identical to that of the third embodiment. As such, only differences thereof from the third embodiment will be discussed below and discussion on the identical arrangement to that of the third embodiment will be omitted.

[0114]

Namely, the semi-circular heat insulating members PA halved in the circumferential direction of the cylindrical tube 1 is constituted by coupling two heat insulating members P formed as 90-degree arcs via the coupling members 7 used in the basic attachment arrangement.

More particularly, the semi-circular heat insulating members PA halved in the circumferential direction of the cylindrical tube are provided such that the adjacent pair of heat insulating members P are coupled to each other via the connecting members B elongate along the axial direction of the cylindrical tube 1 at each one of the two opposed positions located in the circumferential direction of the cylindrical tube 1 where the end faces thereof are placed in abutment against each other.

[0115]

At each one of the pair of heat insulating member end portions at the above-described two opposed positions, as the groove-shaped engaging portion V engageable with the connecting member B, the square-shaped cutaway portion 20 formed by cutting away the inner portion of the heat insulating member end portion relative to the radial direction of the cylindrical tube 1 along the circumferential direction of the cylindrical tube 1 is formed, at the portion of this cutaway portion 20 in the radially outer side of the cylindrical tube 1, with the retaining receded portion 20a which is receded to the radially outer side of the cylindrical tube 1.

[0116]

Namely, in the instant embodiment, there is formed the heat insulating member P having the receded groove portion 8. And, in the basic attachment arrangement, this heat insulating member P is used as it is.

Whereas, in the end face attachment arrangement, the cutaway portion 20 is formed by cutting away the lower portion 8c located downwardly of the receded groove portion 8 located at the opposed end portions of the pair of heat insulating members P coupled to each other via the coupling members 7 and a pair of heat insulating members P having such cutaway portions 20 formed therein as above will be used as the semi-circular heat insulating members PA (see Fig. 13).

[0117]

And, the connecting member B at the two opposed positions is formed as the elongate M-shaped member 21 having the M-shaped cross section including the square-shaped main body portion 21A with a cross section engageable with the square-shaped cutaway portion 20 of each one of the pair of heat insulating member end portions and a pair of retaining protruding portions 21a engageable with the retaining receded portion 20a (see Fig. 15).

[0118]

In this fourth embodiment, at each one of the two opposed positions located in the circumferential direction of the cylindrical tube 1 where the end faces of the halved semi-circular heat insulating members PA are placed in abutment against each other, coupling of the adjacent

pair of heat insulating member end portions via the connecting member B is carried out by the following procedure.

Firstly, the elongate M-shaped member 21 will be brought into engagement with the respective engaging portion V formed at the opposed ends of one semi-circular heat insulating member PA of the halved pair of heat insulating members PA.

More particularly, the elongate M-shaped member 21 will be engaged to the engaging portion V formed as the square-shaped cutaway portion 20 having the retaining groove portion 20a.

[0119]

Thereafter, one semi-circular heat insulating member PA to which the elongate M-shaped member 21 has been engaged will be attached in abutment against the outer circumferential portion of the cylindrical tube 1.

In succession, firstly, to one of the pair of elongate M-shaped members 21, the engaging portion V formed at one end of the other semi-circular heat insulating member PA, i.e. the engaging portion V formed as the square-shaped cutaway portion 20 having the retaining groove portion 20a will be brought into engagement in association with moving thereof from the portion corresponding to the outer side of the cylindrical tube 1 in the direction closer to the cylindrical tube 1.

[0120]

Next, to the other elongate M-shaped member 21, the engaging portion V formed at the other end portion of the other semi-circular heat insulating member PA, i.e. the engaging portion V formed as the square-shaped cutaway portion 20 having the retaining groove portion 20a will be brought into engagement in association with moving thereof from the portion corresponding to the outer side of the cylindrical tube 1 in the direction closer to the cylindrical tube 1.

[0121]

Incidentally, in the course of the movement of the engaging portion V formed at the other end of the other semi-circular heat insulating member PA from the portion corresponding to the outer side of the cylindrical tube 1 in the direction closer to the cylindrical tube 1, the other semi-circular heat insulating member PA will be elastically deformed for expansion/contraction along the radial direction of the

cylindrical tube 1.

[0122]

With the above-described procedure, at each one of the two opposed positions located in the circumferential direction of the cylindrical tube 1 where the end faces of the halved semi-circular heat insulating members PA are placed in abutment against each other, by coupling the adjacent pair of heat insulating member end faces via the connecting members B to each other, the connecting members B can be attached even when no space corresponding to the length of the connecting member B is present at one side portion of the semi-circular heat insulating member PA in the axial direction of the cylindrical tube 1 (see Fig. 16).

[0123]

[Other Embodiments]

Next, other embodiments will be explained one after another.

(1) In the foregoing embodiments, there were disclosed the case in which the heat insulating member P is split into two semi-circular shape or four arcuate parts along the circumferential direction of the cylindrical tube 1. However, the invention is not limited thereto. In the basic attachment arrangement, the heat insulating member P may be split into three parts or five or more parts along the circumferential direction of the cylindrical tube 1. Also, in the end face attachment arrangement, the heat insulating member P may be split into an even number of parts of six or more along the circumferential direction of the cylindrical tube 1 and the semi-circular heat insulating member P may be formed by interconnecting these.

[0124]

(2) In the foregoing embodiments, there was disclosed the case in which the heat insulating members P are attached to the outer circumferential portion of the cylindrical tube 1 in the basic attachment arrangement and the end portion attachment arrangement. However, it is also possible to embody such that the heat insulating members P are attached along the entire length of the cylindrical tube 1 in the end face attachment arrangement.

[0125]

(3) In the foregoing embodiments, the connecting members B, the coupling members 7 and the heat insulating members P are formed of a same material. However, the connecting members B, the coupling members 7 and the heat insulating members P may be formed of different materials.

[0126]

(4) In the foregoing embodiments, the material of the heat insulating member P is urethane resin. However, the material of the heat insulating member P is not limited thereto. For instance, the material of the heat insulating member P may be a synthetic resin such as polyethylene resin, nitrile rubber (NBR), etc. or a natural resin such as natural rubber (NR), or the like. Similarly, the material of the connecting member B and the coupling member 7 may be a synthetic resin such as polyethylene resin, nitrile rubber (NBR), etc. or a natural resin such as natural rubber (NR), or the like.

[0127]

(5) In the foregoing embodiments, there was disclosed the case in which on the outer circumferential portion of the cylindrical tube 1, three layers of heat insulating walls are formed as a plurality of heat insulating walls. However, it is also possible to embody with forming two layers of heat insulating walls or four or more layers of heat insulating walls.

[0128]

(6) In the foregoing embodiments, there was disclosed the case in which the slit 12 is formed in the elongate square-shaped body 11 as the connecting member B. However, it is also possible to embody the invention with omission of forming the slit 12.

[0129]

(7) In the foregoing embodiments, there was disclosed the case in which the connecting member B having a flat face engageable with the receded portion 10 having the inner surface 10u and the outer surface 10g is constituted as the elongate square-shaped body 11 having the square-shaped cross section. As the connecting member B having a flat face, various modifications are possible in the cross sectional shape of the connecting member B having a flat face such as forming it as an elongate body having a cross sectional shape with convexly tapered opposed sides.

[0130]

Incidentally, the arrangements disclosed in the foregoing embodiments (including the further embodiments) may be used in any combinations with the arrangements disclosed in any other embodiment unless contradiction results from such combinations. Further, it is noted that the embodiments disclosed in this detailed disclosure are only exemplary and embodiments of the present invention are not limited thereto, but may be modified in any appropriate matter within a range not deviating from the object of the present invention.

DESCRIPTION OF REFERENCE SIGNS

[0131]

- 1: cylindrical tube
- 5: end face
- 7: coupling member
- 7a: retaining coupling portion
- 8: receded groove portion
- 8a: retaining groove portion
- 10: receded portion
- 12: slit
- 20: cutaway portion
- 20a: retaining receded portion
- 21A: main body portion
- 21a: retaining protruding portion
- B: connecting member
- P: heat insulating member
- PA: semi-circular heat insulating member
- U: engaging groove portion
- V: engagement portion

CLAIMS

1. A heat insulation structure for a cylindrical tube configured such that on an outer circumferential portion of a cylindrical tube in which cold fluid flows, there are provided semi-circular heat insulating members halved in a circumferential direction of the cylindrical tube with an adjacent pair of heat insulating member end portions thereof being coupled to each other via a connecting member elongate in an axial direction of the cylindrical tube, at each one of two opposed positions located in the circumferential direction of the cylindrical tube with end faces thereof being placed in abutment against each other., wherein:

at each one of the pair of heat insulating member end portions at one of the two opposed positions, as a groove-like engagement portion to which the connecting member is to be engaged, there is provided a cutaway portion formed by cutting away an inner portion of the heat insulating member end portion in the radial direction of the cylindrical tube along the circumferential direction of the cylindrical tube, the cutaway portion being provided, on the radially outer side of the cylindrical tube, with a retaining receded portion that is receded outwards in the radial direction of the cylindrical tube;

the connecting member at one of the two opposed positions includes a main body portion having a cross sectional shape engageable with the cutaway portion respectively of the pair of heat insulating member end portions and a pair of retaining protruding portions engageable with the retaining receded portion;

at each one of the pair of heat insulating member end portions at the other of the two opposed positions, as a groove-like engagement portion to which the connecting member is to be engaged, there is provided a receded portion that is receded from the end face along a tangential direction of the cylindrical tube is provided in the form of a flat face with an inner surface and an outer surface thereof disposed side by side along the radial direction of the cylindrical tube extending along the tangential direction of the cylindrical tube; and

the connecting member at the other of the two opposed positions has a cross-sectional shape provided in the form of a flat face along the inner surface and the

outer surface of the receded portion of each of the pair of heat insulating member end portions.

2. A heat insulation structure for a cylindrical tube configured such that on an outer circumferential portion of a cylindrical tube in which cold fluid flows, there are provided semi-circular heat insulating members halved in a circumferential direction of the cylindrical tube with an adjacent pair of heat insulating member end portions thereof being coupled to each other via a connecting member elongate in an axial direction of the cylindrical tube, at each one of two opposed positions located in the circumferential direction of the cylindrical tube with end faces thereof being placed in abutment against each other., wherein:

at each one of the pair of heat insulating member end portions at the two opposed positions, includes, as a groove-like engagement portion to which the connecting member is to be engaged, there is provided a cutaway portion formed by cutting away an inner portion of the heat insulating member end portion in the radial direction of the cylindrical tube along the circumferential direction of the cylindrical tube, the cutaway portion being provided, on the radially outer side of the cylindrical tube, with a retaining receded portion that is receded outwards in the radial direction of the cylindrical tube; and

the connecting member at each one of the two opposed positions includes a main body portion having a cross sectional shape engageable with the cutaway portion respectively of the pair of heat insulating member end portions and a pair of retaining protruding portions engageable with the retaining receded portion.

3. The heat insulation structure for a cylindrical tube of claim 1, wherein:

the connecting member in the form having a flat face is formed of a material capable of elastic deformation; and

at one engaging portion of a pair of engaging portions of the connecting member to be engaged to the receded portion adjacent thereto, there is formed a

slit which separates this engaging portion in the radial direction of the cylindrical tube.

4. The heat insulation structure for a cylindrical tube of claim 1, wherein:

the connecting member in the form having a flat face is formed of a material capable of elastic deformation; and

at each one of a pair of engaging portions of the connecting member to be engaged to the receded portion adjacent thereto, there is formed a slit which separates this engaging portion in the radial direction of the cylindrical tube.

5. The heat insulation structure for a cylindrical tube of any one of claims 1-4, wherein on the outer circumferential portion of the cylindrical tube, a plurality of heat insulating walls provided in a cylindrical shape and having different diameters of the halved semi-circular heat insulating members are provided to form a plurality of layers.

6. The heat insulation structure for a cylindrical tube of any one of claims 1-5, wherein:

at a position adjacent in the axial direction of the cylindrical tube to a disposing position of the semi-circular heat insulating members coupled to each other via the connecting member on the outer circumferential portion of the cylindrical tube, arc-shaped heat insulating members divided into plurality in the circumferential direction of the cylindrical tube are provided, at each one of a plurality of opposed positions in the circumferential direction of the cylindrical tube with end faces thereof being placed in abutment against each other, such that a pair of heat insulating member end portions adjacent each other are coupled to each other via a coupling member which is formed elongate along the axial direction of the cylindrical tube;

at each one of the pair of heat insulating member end portion coupled via the coupling member, as an engaging groove portion for the coupling member, a receded groove portion receded from the end face in the circumferential direction

of the cylindrical tube is formed, at an outer portion of this receded groove portion in the radial direction of the cylindrical tube, with a retaining groove portion receded to the outer side in the radial direction of the cylindrical tube; and

the coupling member includes a main body coupling portion having a cross sectional shape engageable with the receded groove portion of each one of the pair of heat insulating member end portions and a pair of retaining coupling portions engageable with the retaining groove portion.

7. The heat insulation structure for a cylindrical tube of claim 6, wherein on the outer circumferential portion of the cylindrical tube, a plurality of heat insulating walls provided in a cylindrical shape and having different diameters of a plurality of arc-shaped heat insulating members coupled to each other via the coupling member are provided to form a plurality of layers.