

Description

Title of the invention: System for paying out and folding a metal sheet to produce a strake

Technical field

[0001] The invention relates to the field of sealed and thermally insulating tanks, with membranes, for storing and/or transporting fluids, such as a cryogenic fluid.

[0002] It relates more particularly to a system for folding and for paying out a metal sheet to produce a strake, intended for the construction of a seal-tight membrane of a fluid storage tank.

Technological background

[0003] In the state of the art, notably from the document FR2968284, a sealed and thermally insulating tank for storing liquefied natural gas is known comprising a multilayer structure, namely from the outside to the inside of the tank, a secondary thermally insulating barrier fixed to a supporting structure, a secondary sealing membrane, a primary thermally insulating barrier and a primary sealing membrane. The secondary and primary thermally insulating barriers are each formed by juxtaposed insulating caissons. The secondary and primary sealing membranes each comprise a continuous sheet of metal strakes. The metal strakes comprise a flat central band and raised lateral edges which are tightly welded to welding supports retained on the insulating caissons.

[0004] The strakes are formed and paid out in situ inside the tank by means of a paying-out and folding system, as described for example in the document FR3020773. The folding and paying-out system makes it possible to pay out a metal sheet inside the tank and simultaneously fold its lateral edges in order to fashion a strake with raised lateral edges. Such a system comprises driving rollers that make it possible to ensure the paying out of the metal plate, forming rollers that make it possible to fold the lateral edges and bearing rollers that make it possible to press the metal sheet against the forming surface of the forming rollers. The forming rollers have, in the longitudinal direction of the machine, increasing folding angles so as to gradually fold the raised lateral edges of the metal plate.

[0005] After the strakes have been formed and paid out in the tank and before the tank is loaded with liquefied gas, the internal faces of the strakes turned towards the interior of the tank are subjected to pollutions, such as dust, that can degrade their surface condition. In particular, the internal faces of strakes are likely to be covered with wood dust which absorbs ambient moisture, which leads to surface rusting phenomena. Thus, the

elimination of such dust and of the potential traces of rusting create additional surface treatment operations before the inspection of the tank and the commissioning thereof.

Summary

[0006] One idea on which the invention is based is to simply and reliably obtain a satisfactory surface condition of the metal strakes.

[0007] According to a first embodiment, the invention provides a system for paying out and folding a metal sheet to produce a metal strake intended for the construction of a seal-tight membrane of a fluid storage tank; the paying-out and folding system comprising:

- a chassis;
- at least one driving roller mounted to be rotationally mobile on the chassis about a first horizontal axis in order to ensure the advance of the metal sheet in a direction of advance; and
- a plurality of forming members supported by the chassis and comprising at least one first forming member and one second forming member respectively conformed to fold a first lateral edge and a second lateral edge of the metal sheet according to a determined angle relative to the first axis; the paying-out and folding system further comprising a protection film and a protection film deposition device configured to deposit the protection film on the metal sheet.

[0008] Thus, by virtue of such a system, the strakes are protected by the protection film until the tank is inspected, which makes it possible to obtain a satisfactory surface condition of the metal strakes.

[0009] Furthermore, the deposition of the protection film is performed simultaneously with the paying out and folding of the strakes, such that its impact on the strake production time is negligible.

[0010] According to other advantageous embodiments, such a folding system has one or more of the following features.

[0011] According to one embodiment, the protection film deposition device is mounted on the chassis.

[0012] According to one embodiment, the forming members are forming rollers.

[0013] According to one embodiment, the protection film deposition device is positioned downstream of the forming members in the direction of advance.

[0014] According to one embodiment, the protection film deposition device is arranged to deposit the protection film on a flat central band of the metal sheet, the flat central band

being formed between the first lateral edge and the second lateral edge. The protection film is thus not likely to hamper the subsequent strake welding operations.

[0015] According to one embodiment, the protection film deposition device comprises:

- a reel on which the protection film is wound, said reel being mounted to be rotationally mobile on the chassis; and
- a top roller mounted to be rotationally mobile about a second axis of rotation, the first and the second forming members being positioned laterally on either side of the top roller, when said first and second forming members (25, 26) are considered in projection according to the direction of advance in a plane which is orthogonal to the direction of advance and which passes through the second axis, such that the top roller can press the protection film against the flat central band.

[0016] According to one embodiment, the second axis of rotation is parallel to the first axis of rotation.

[0017] According to one embodiment, the protection film deposition device also comprises a bottom roller mounted to be rotationally mobile about a third axis of rotation parallel to the second axis of rotation, the bottom roller being positioned below the top roller and being arranged so as to allow the passage of the flat central band and of the protection film between the bottom roller and the top roller.

[0018] According to one embodiment, one out of the top roller and the bottom roller is mounted to be vertically mobile on the chassis and a strain member exerts on said top roller or bottom roller a force having a vertical component directed towards the other of the top roller and bottom roller.

[0019] According to one embodiment, the protection film is produced in a material chosen from among the polyolefins, such as polyethylene and polypropylene, the polyesters and the polyvinyl materials, such as polyvinyl chloride (PVC) or polyvinyl acetate.

[0020] According to one embodiment, the protection film is electrostatically charged or has a face coated with an adhesive.

[0021] According to one embodiment, the invention also provides a method for paying out and folding a metal sheet to produce a strake intended for the construction of a seal-tight membrane of a fluid storage tank, the method comprising:

- paying out a metal sheet on a reel and ensuring the advance of the metal sheet in a direction of advance by means of at least one driving roller that is rotationally mobile according to a first horizontal axis;
- folding a first lateral edge and a second lateral edge of the metal sheet according to a

determined angle relative to the first axis;

- depositing a protection film on the metal sheet as the metal sheet is paid out.

[0022] According to one embodiment, the protection film is deposited on a flat central band of the metal strake, the flat central band being formed between the first lateral edge and the second lateral edge.

[0023] According to one embodiment, the protection film is deposited at a distance of between 2 and 7 cm from the first lateral edge and from the second lateral edge.

[0024] According to one embodiment, the paying out of the metal sheet, the folding of the first lateral edge and of the second lateral edge of the metal sheet and the deposition of the protection film are performed, in situ, inside the storage tank.

Brief description of the figures

[0025] The invention will be better understood, and other aims, details, features and advantages thereof will become more clearly apparent from the following description of several particular embodiments of the invention, given purely in an illustrative and nonlimiting manner, with reference to the attached drawings.

[0026] [fig. 1] figure 1 is a cut-away perspective partial view of a sealed and thermally insulating tank wall comprising sealing membranes with strakes.

[0027] [fig. 2] figure 2 is a schematic view, in cross section, of a strake fitted with a protection film.

[0028] [fig. 3] figure 3 is a schematic view of a paying-out and folding system.

[0029] [fig. 4] figure 4 is a schematic view of a lateral block of the first forming unit of the paying-out and folding system of figure 3.

[0030] [fig. 5] figure 5 is a schematic view of a lateral block of the last forming unit of the paying-out and folding system of figure 3.

[0031] [fig. 6] figure 6 is a schematic view of figure 3 in cross section in a plane orthogonal to the direction of advance of the metal sheet.

Description of embodiments

[0032] By convention, the terms “outer” and “inner” are used to define the relative position of an element with respect to another, with reference to the inside and the outside of the tank.

[0033] In figure 1, a wall of a sealed and thermally insulating tank is represented. The sealed and thermally insulating tank is intended to store a liquefied gas which is, for example,

chosen from among liquefied natural gas (LNG) and liquefied petroleum gas (LPG), for example.

[0034] The wall of the tank comprises, from the outside to the inside of the tank, a supporting structure 1, a secondary thermally insulating barrier 2 which is formed by insulating caissons 3 juxtaposed on the supporting structure 1 and anchored thereto by secondary retaining members 4, a secondary sealing membrane 5 supported by the insulating caissons 3, a primary thermally insulating barrier 6 formed by insulating caissons 7 juxtaposed on and anchored to the secondary sealing membrane 5 by primary retaining members 8 and a primary sealing membrane 9, borne by the insulating caissons 7 and intended to be in contact with the liquid contained in the tank.

[0035] The supporting structure 1 can notably be a self-supporting metal sheet or, more generally, any type of rigid partition having appropriate mechanical properties. The supporting structure can notably be formed by the hull or the double hull of a ship. The supporting structure comprises a plurality of walls defining the general form of the tank.

[0036] Each insulating caisson 3, 7 has a substantially rectangular parallelepipedal form. Each insulating caisson 3, 7 comprises a bottom panel and a cover panel that are parallel. Supporting webs are interposed between the bottom panel and the cover panel, at right angles thereto. The supporting webs are positioned parallel to one another and form between them compartments for housing a powdery heat-insulating lining.

[0037] The primary 9 and secondary 5 sealing membranes are composed of a continuous sheet of metal strakes 10 which are positioned alternately with welding supports 11 onto which the metal strakes 10 are welded.

[0038] The metal strakes 10 are, for example, made of Invar®: that is to say an alloy of iron and nickel whose expansion coefficient typically lies between $1.2 \cdot 10^{-6}$ and $2 \cdot 10^{-6} \text{ K}^{-1}$, but other metals or alloys are also possible, such as stainless steel, aluminium or an alloy of iron with high manganese content whose expansion coefficient is of the order of $7.5 \cdot 10^{-6} \text{ K}^{-1}$ for example.

[0039] Each metal stake 10 comprises, in the widthwise direction, a flat central band 12 intended to rest against the cover panel of the insulating caissons 3, 7 and raised lateral edges 13. The raised lateral edges 13 are at right angles to the flat central band 12. The metal strakes 10 are intended to extend substantially from one end to the other of each wall of the tank. The raised lateral edges 13 of the metal strakes 10 are tightly welded to the welding supports 11 which are retained on the insulating caissons 3, 7.

[0040] As represented in figure 2, the metal strakes 10 of the primary sealing membrane 8 are, when paid out, equipped with a protection film 14 on their internal face, that is to say on the face intended to be placed in contact with the liquefied gas. The protection film 14 is intended to protect the metal strake 10, notably from dust, during the production of the tank, and is intended to be removed before the tank is put into operation, that is to say before it is filled for the first time with liquefied gas.

[0041] It is also possible to cover the metal strakes 10 of the secondary sealing membrane 5 with a protection film 14 which is intended to be removed before the insulating caissons 7 of the primary thermally insulating barrier 6 are put in place.

[0042] The protection film 14 is positioned against the internal surface of the flat metal band 12 of the metal strakes 10 and does not cover their raised lateral edges 13. The protection film 14 thus does not risk hampering the operations of welding of the raised lateral edges 13 onto the welding supports 11. Advantageously, the protection film 14 is positioned at a distance from each of the two raised lateral edges 14 of between 2 and 7 cm, for example of the order of 5 cm. Thus, the protection film 14 is positioned at a sufficient distance from the raised lateral edges 13 not to be damaged by the welding machine which welds the raised lateral edges 14 to the welding supports 11. In particular, such a distance allows the protection film 14 not to be damaged by the rollers of the electrode wheel welding machine or by the heating of the raised lateral edges 14 generated under the effect of the electrode wheel welding method.

[0043] The protection film 14 is made of polymer. Advantageously, the protection film 14 is made of polyolefin such as polyethylene and polypropylene, of polyester or of a polyvinyl material, such as polyvinyl chloride (PVC) or polyvinyl acetate, for example.

[0044] The protection film 14 advantageously has a thickness of between 0.05 and 1 mm, for example of the order of 0.1 mm.

[0045] According to one embodiment, the protection film 14 adheres to the metal strake 10 by electrostatic adhesion. In this case, the protection film is advantageously a PVC.

[0046] According to another embodiment, the protection film 14 adheres to the metal strake 10 by means of an adhesive. The adhesive is, for example, chosen from among the acrylic glues in emulsion or solution form, the silicone glues or rubber.

[0047] With respect to figure 3, a system for paying out and folding 15 a metal sheet to produce a metal strake 10 is observed.

[0048] The paying-out and folding system 15 comprises a chassis 16, a series of forming units 17, 18, 19 supported by the chassis 15 and a reel support element 34.

[0049] The chassis 16 is equipped with wheels 20 to allow a displacement of the paying-out and folding system 15.

[0050] The metal sheet to be paid out is supplied in the form of a reel 21 which is mounted to be rotationally mobile on a reel support element 17. The paying-out and folding system 15 also comprises a guiding device 22 suitable for ensuring that the metal sheet has, between the reel 21 and the forming units 17, 18, 19, a minimum radius of curvature such that the metal sheet is not damaged as it is paid out. In the embodiment represented in figure 3, the guiding device 22 is an element having a curvilinear guiding surface. The curvilinear guiding surface can notably be equipped with a plurality of rollers mounted to rotate in order to minimize the frictions between the curvilinear guiding surface and the metal sheet to be paid out.

[0051] The forming units 17, 18, 19 make it possible to simultaneously pay out the metal sheet in a direction of advance (arrow f1) and to fashion the raised lateral edges 13 of the metal strakes 10. The forming units 17, 18, 19 gradually fold, by successive steps, the raised lateral edges 13 of the metal sheet until they are brought into the final configuration that is sought for them, in which they extend at right angles to the flat central band 12, on leaving the last forming unit 19.

[0052] In the embodiment represented, the paying-out and folding system 15 is equipped with three forming units 17, 18, 19. Also, by way of example, the first forming unit 17 folds back the lateral edges of the metal sheet relative to the flat central band 12 by an angle of 30°, the second forming unit 18 folds them back by an angle of 60° while the third and last forming unit 19 folds back the lateral edges into their final configuration, in which they extend substantially at right angles to the flat central band 12.

[0053] Each forming unit 17, 18, 19 comprises two lateral blocks. One of the lateral blocks of the first forming unit 17 is represented schematically in figure 4. The lateral blocks of the second forming unit 18 have a structure that is substantially identical to that of the lateral block represented, only the angle of inclination of the forming surface being different.

[0054] Each lateral block comprises a bottom driving roller 23, mounted to be rotationally mobile on the chassis about a horizontal axis and intended to ensure the advance of the metal sheet in the direction of advance f1. The driving roller 23 is driven in rotation by a motor, that is not represented, via transmission means that are not represented. Each lateral block comprises, in addition, a top bearing roller 24, mounted to be rotationally mobile on the chassis along a horizontal axis, parallel to the horizontal axis of the driving roller 23. The bearing roller 24 extends facing the driving roller 23 and makes it possible to hold the metal sheet against the driving roller 23. Moreover, each lateral block comprises

a forming roller 25 mounted to be rotationally mobile relative to the chassis 16, and that makes it possible to fold back a lateral edge of the metal plate. For this, the forming roller 25 has a forming surface which is inclined relative to the horizontal axis so as to fold a lateral edge of the metal sheet according to a determined angle. The forming surface of the forming roller 25 presses the lateral edges of the metal sheet against the bearing roller 24 in order to fashion them.

[0055] Except for the forming rollers of the last forming unit 19, the forming rollers 25 of the other forming units 17, 18 have a conical or thrustoconical form, of revolution, as illustrated in figure 4. Each forming roller 25 is rotationally mobile about the central axis of the cone. The folding angle of the forming roller 25 therefore corresponds to the angle formed at the intersection between the generatrices of the conical surface and a horizontal plane. As an example, the conical forming surface of the forming rollers 25 of the first forming unit 17 has an inclination of 30° relative to a horizontal plane whereas the conical forming surface of the forming rollers 25 of the second forming unit 18 has an inclination of 60° relative to a horizontal plane.

[0056] The forming rollers 26 of the last forming unit 19, one of which is represented in figure 5, for their part have a cylindrical forming surface. The forming roller 26 is mounted to be rotationally mobile about the central axis of the cylinder. The base lines of the cylindrical forming surface are vertical. The forming roller 26 thus makes it possible to fold back the raised lateral edges of the metal sheet at right angles to the flat central band 12.

[0057] More details concerning the structure and the operation of the forming units 17, 18, 19 can be obtained by referring to the document FR3020773.

[0058] Returning to figure 3, it can be seen that the paying-out and folding system 15 also comprises a protection film deposition device 27 which is mounted on the chassis 16. The protection film deposition device 27 comprises a support element 28 on which a reel 29 is rotationally mounted. The protection film 14 is wound around said reel 29. The support element 28 is oriented such that the axis of the reel 29 is horizontal and parallel to the axes of the driving rollers 23 of the forming units 17, 18, 19.

[0059] Moreover, the protection film deposition device 27 comprises at least two rollers, a bottom roller 30 and a top roller 31, intended to be positioned vertically on either side of the metal strake 10. The bottom roller 30 and the top roller 31 are each mounted to be rotationally mobile about a respective axis which is horizontal and parallel to the axes of the driving rollers 23 of the forming units 17, 18, 19.

[0060] In the embodiment represented, the protection film deposition device 27 is positioned at the output of the last forming unit 19, that is to say downstream of the last forming unit 19 in the direction of advance f1 of the metal sheet. The top roller 31 has a length less than that of the flat central band 12 and is intended to be positioned facing the flat central band 12 of the metal strake 10 between the raised lateral edges 13. In other words, as represented in figure 6, the forming rollers 25, 26 are, in projection in the direction of advance in a plane which is orthogonal to the direction of advance and which passes through the axis of rotation of the top roller 31, positioned laterally on either side of said top roller 31. In figure 6, the projections of the forming rollers are illustrated by dotted lines.

[0061] To deposit the protection film 14, one end of the protection film 14 is positioned between the top roller 31 and the flat central band 12 of the metal strake 10. The protection film 14 is thus pressed against the flat central band 12 in such a way that the reel 29 pays out and the protection film 14 is deposited on the flat central band 12 as the metal sheet is paid out.

[0062] Advantageously, in order to ensure that the protection film 14 is pressed with a sufficient force against the strake, the top roller 31 is mobile vertically. Furthermore, a stress member 33 exerts, on the top roller 31, a load having a vertical component directed downward. The stress member 33 is for example an elastic member or a power cylinder.

[0063] Alternatively, the pivot axis of the top roller 31 is fixed relative to the chassis 16 but it is then the bottom roller 30 which is mobile vertically relative to the chassis 16 of the paying-out and folding system 15. In this case, a stress member exerts, on the bottom roller 30, a force in the reverse direction, that is to say that has a vertical component directed upward.

[0064] According to one embodiment, the bottom roller 30 is also driven in rotation by the motor via transmission means that are not represented.

[0065] Although the invention has been described in relation to several particular embodiments, it is clearly obvious that it is in no way limited thereto and that it encompasses all the technical equivalents of the means described and their combinations if the latter fall within the framework of the invention.

[0066] The use of verb "comprise" or "include" and its conjugated forms does not preclude the presence of elements or steps other than those stated in a claim.

[0067] In the claims, any reference symbol between brackets should not be interpreted as a limitation on the claim.

Claims

[Claim 1] System for paying out and folding (15) a metal sheet to produce a metal strake (10) intended for the construction of a seal-tight membrane of a fluid storage tank; the paying-out and folding system (15) comprising:

- a chassis (16);
- at least one driving roller (23) mounted to be rotationally mobile on the chassis (16) about a first horizontal axis in order to ensure the advance of the metal sheet in a direction of advance; and
- a plurality of forming members (25, 26) supported by the chassis and comprising at least one first forming member and one second forming member respectively conformed to fold a first lateral edge and a second lateral edge of the metal sheet according to a determined angle relative to the first axis; the paying-out and folding system (15) further comprising a protection film and a protection film deposition device (27) configured to deposit the protection film (14) on the metal sheet.

[Claim 2] Paying-out and folding system (15) according to Claim 1, wherein the protection film deposition device (27) is positioned downstream of the forming members (25, 26) in the direction of advance.

[Claim 3] Paying-out and folding system (15) according to Claim 1 or 2, wherein the protection film deposition device (27) is arranged to deposit the protection film (14) on a flat central band (12) of the metal sheet (10), the flat central band (12) being formed between the first lateral edge and the second lateral edge (13).

[Claim 4] Paying-out and folding system (15) according to Claim 3, wherein the protection film deposition device (27) comprises:

- a reel (29) on which the protection film (14) is wound, said reel (29) being mounted to be rotationally mobile on the chassis (16); and
- a top roller (31) mounted to be rotationally mobile about a second axis of rotation, the first and the second forming members (25, 26) being positioned laterally on either side of the top roller (31) when said first and second forming members (25, 26) are considered in projection according to the direction of advance in a plane which is orthogonal to the direction of advance and which passes through the second axis, such that the top roller (31) can press the protection film (14) against the flat central band (12).

[Claim 5] Paying-out and folding system (15) according to Claim 4, wherein the protection film deposition device (27) also comprises a bottom roller (30) mounted to be rotationally mobile about a third axis of rotation parallel to the second axis of rotation, the bottom roller (30) being positioned below the top roller (31) and being

arranged so as to allow the passage of the flat central band (12) and of the protection film (14) between the bottom roller (30) and the top roller (31).

[Claim 6] Paying-out and folding system (15) according to Claim 4 or 5, wherein at least one out of the top roller (31) and the bottom roller (30) is mounted to be vertically mobile on the chassis and a strain member exerts on said top roller (31) or bottom roller (30) a force having a vertical component directed toward the other of the top roller (31) or bottom roller (30).

[Claim 7] Paying-out and folding system (15) according to any one of Claims 1 to 6, wherein the protection film (14) is produced in a material chosen from among the polyolefins, the polyesters and the polyvinyl materials.

[Claim 8] Paying-out and folding system (15) according to any one of Claims 1 to 7, wherein the protection film (14) is electrostatically charged or has a face coated with an adhesive.

[Claim 9] Method for paying out and folding a metal sheet to produce a strake intended for the construction of a seal-tight membrane of a fluid storage tank, the method comprising:

- paying out a metal sheet on a reel (29) and ensuring the advance of the metal sheet in a direction of advance by means of at least one driving roller (23) that is rotationally mobile according to a first horizontal axis;
- folding a first lateral edge and a second lateral edge (13) of the metal sheet according to a determined angle relative to the first axis;
- depositing a protection film (14) on the metal sheet as the metal sheet is paid out.

[Claim 10] Paying-out and folding method according to Claim 9, wherein the protection film (14) is deposited on a flat central band of the metal strake, the flat central band being formed between the first lateral edge and the second lateral edge (13).

[Claim 11] Paying-out and folding method according to Claim 10, wherein the protection film (14) is deposited at a distance of between 2 and 7 cm from the first lateral edge and from the second lateral edge (13).

[Claim 12] Paying-out and folding method according to any one of Claims 9 to 11, wherein the protection film (14) is produced in a material chosen from among polyethylene and the polyvinyl materials.

[Claim 13] Paying-out and folding method according to any one of Claims 9 to 12, wherein the protection film (14) is electrostatically charged or has a face, intended to be pressed against the metal sheet, which is coated with an adhesive.

[Claim 14] Paying-out and folding method according to any one of Claims 9 to 13, wherein the paying out of the metal sheet, the folding of the first lateral edge and of

the second lateral edge (13) of the metal sheet and the deposition of the protection film are performed inside the storage tank.