

METHOD AND EQUIPMENT FOR PRODUCING
PROTECTIVE-COATED STEEL PIPE

2212590

This invention relates to a method of, and equipment for, producing a protective-coated steel pipe
5 having a thermoplastic synthetic resin coating formed on the outer peripheral surface thereof for use, for example, as a foundation pile in civil engineering works.

Some of the structures such as bridges and piers
10 built on the seabed are supported on bearing piles which are driven into the bottom of the seabed. In this case, steel posts are disposed between such a structure and the tops of the bearing piles. The portions of the steel posts which are in contact with
15 the surface of the sea, as well as the portions thereof positioned thereabove, are exposed alternately to sea water and air owing to the ebb and flow of the tide and by being splashed by waves, so those portions are most likely to be corroded. Therefore, anti-corrosive
20 measures for those portions are particularly important. The following are examples of conventional corrosion-proof steel pipes used for this purpose:

(1) a corrosion-proof steel pipe with a urethane-
or epoxy-based coating material applied as thick as
25 3mm or so;

(2) a protective-coated steel pipe comprising a steel pipe and a coating (e.g. a melt-extruded coating of polyethylene) formed on the outer peripheral surface of the steel pipe by extruding molten polyolefin resin
30 continuously onto that surface; and

(3) a helical tape-wound pipe of which the tape winding is applied in a construction work site such as that disclosed in Japanese Patent Laid-Open Application No. 40925/86. The tape is elongate and has a generally
35 rectangular cross-section defined by an upper face, a lower face opposite to the upper face, and two opposing

side faces which are shorter than the upper and lower faces. Elsewhere in this specification, reference is made to sheets of protective material, and the sheets can be regarded as having the same faces as the tape.

5 Such conventional corrosion-proof steel pipes are associated with the following problems.

 In the pipe (1), the cost of the coating material is high.

 In the case of the pipe (2) which involves the
10 polyethylene melt-extrusion coating method, the manufacturing equipment is very expensive and the cost of transportation of the steel pipe after anti-corrosion processing is high because vulnerable coating must be well protected during delivery. Further, the
15 pipe may be flawed during handling in transit, thus requiring considerable labour for its repair.

 In the case of the pipe (3), a heat-shrinkable polyolefin tape having an adhesive layer formed of a thermoadherent polyolefin which has an adherent
20 functional group is wound helically around the peripheral surface of the steel pipe pile while being partially overlapped with one edge region of the lower face of one winding overlapping the opposite edge region of the upper face of the immediately preceding
25 winding. In such a protected steel pipe pile, a gap is formed adjacent the overlapped part of the tape and the pipe, which gap causes corrosion. Additionally, it is difficult to form the tape winding start and end in good shape.

30 Further, in seasons or districts wherein the climate temperature is low, the heat-shrinkable polyolefin ^{tape}~~tape~~ hardens and loses flexibility out of doors. Consequently, when pushed against the surface of the steel pipe, the tape does not fit closely on the
35 surface, and even when the steel pipe is preheated to a predetermined temperature, the shape of the tape just

after pressure bonding thereof to the pipe is unstable and there remains a gap between the tape and the steel pipe. This affects the pipe even after pressure bonding of the tape to the pipe and prevents the tape
5 from forming a uniform coating.

According to one aspect of the present invention, there is provided a method of producing a protective-coated steel pipe, which comprises:

winding a belt-like thermoplastic synthetic resin
10 sheet helically around the outer peripheral surface of a preheated steel pipe while contacting adjacent side faces of the sheet in a face-to-face relation to each other without overlap; and

heat melt-bonding the sheet to the pipe and the
15 contacting adjacent side faces to each other by applying pressure as the sheet begins to melt.

Preferably the method also includes preheating a length of the thermoplastic synthetic resin sheet to at least room temperature to impart flexibility thereto
20 prior to abutment of that length of the sheet with the outer peripheral surface of the steel pipe.

Preferably a coating having relatively weak bonding force is formed beforehand on the outer peripheral surface of the steel pipe in zones
25 corresponding to the winding start and end portions of the sheet, then the thermoplastic synthetic resin sheet is wound and melt-bonded around the outer peripheral surface of the steel pipe so as to cover both coated zones and the pipe between these zones, and thereafter
30 cuts are made in end portions of the melt-bonded sheet at the inner boundary of the zones whilst the end portions are at elevated temperature.

Preferably the method also includes subsequently removing said coating and any overlying unwanted sheet
35 material from the zones beyond the cuts.

Preferably, the method includes subsequently applying sealant to the end regions of the melt-bonded

sheet after removal of the coating and unwanted sheet material.

According to another aspect of the present invention, there is provided equipment suitable for
5 producing a protective-coated steel pipe by winding a belt-like thermoplastic synthetic resin sheet helically around the outer peripheral surface of a preheated steel pipe by rotating the pipe at a constant speed and
10 subjecting the sheet and pipe to relative movement in the pipe axis direction, the equipment including:

a sheet feed means for feeding the thermoplastic synthetic resin sheet obliquely with respect to the longitudinal direction of the steel pipe so that adjacent side faces of the sheet contact each other
15 without overlapping of the sheet; and

a sheet pressing means for pressing the contacted side faces of the sheet, which has begun to melt on the outer peripheral surface of the steel pipe, against the outer peripheral surface of the pipe to heat melt-bond
20 the sheet to the pipe and heat melt-bond the contacting adjacent side faces to each other.

Preferably the equipment also includes a sheet preheating means disposed between the sheet feed means and the sheet pressing means to preheat the
25 thermoplastic synthetic resin sheet to at least room temperature.

The present invention also provides equipment for producing a protective-coated steel pipe which includes:

30 a pipe heating means;

a sheet feed means for feeding a thermoplastic synthetic resin sheet obliquely with respect to the preheated steel pipe so that the side faces of the sheet are in contact with each other without
35 overlapping of the sheet, the sheet feed means having a rotary shaft which supports the thermoplastic synthetic resin sheet in a coilwise wound condition and which can be inclined with respect to the longitudinal direction

of the steel pipe so as to be aligned with the sheet feed direction;

5 a sheet pressing means for pressing the contacted side faces elastically against the outer peripheral surface of the steel pipe as the pipe is rotating about a shaft at a constant speed, the sheet pressing means having a sheet pressing roll capable of having its rotational axis set in a direction perpendicular to the direction in which the sheet is fed from the sheet feed
10 means; and

a horizontal slide means for adjusting the sheet winding angle and winding pitch with respect to the steel pipe, the horizontal slide means having a mechanism for moving the sheet feed means and the sheet
15 pressing means relatively in the longitudinal direction of the steel pipe.

The present invention makes it possible to provide method and equipment for preparing a protective-coated steel pipe, in a construction work site, by helically
20 winding a thermoplastic synthetic resin coating around the outer peripheral surface of a preheated steel pipe without leaving an air gap underneath the coating.

The present invention also provides a method for processing coating ends of a protective-coated steel
25 pipe whereby the winding start and end portions of a thermoplastic synthetic resin coating wound helically around the outer peripheral surface of a preheated steel pipe can be removed in a simple manner.

The present invention also makes it possible to
30 provide method and equipment wherein a synthetic resin sheet is preheated and thereby can be wound uniformly around the outer peripheral surface of a steel pipe in completely close contact therewith out of doors even when the outside air temperature is low.

35 The present invention makes it possible to provide an inexpensive equipment capable of effecting protective coating work at a construction work site.

For a better understanding of the present

invention and to show how the same may be carried into effect, reference will now be made, by way of example, to Figures 3 to 13 of the accompanying drawings, Figures 1 and 2 illustrating a known arrangement. In

5 the drawings:-

Fig. 1 is an enlarged sectional view of sheet seam portions of a conventional protective-coated steel pipe;

10 Fig. 2 is a side view showing unnecessary portions at the coating ends of the conventional protective-coated steel pipe;

Fig.3 is a side view of a protective-coated steel pipe producing equipment according to an embodiment of the present invention;

Fig.4 is a schematic front view of a principal portion of Fig.3;

Fig.5 is an enlarged sectional view of confronted sheet seam portions before pressing by a confronted seam pressing means;

Fig.6 is an enlarged sectional view of the confronted sheet seam portions after pressing by the confronted seam pressing means;

Fig.7 is a schematic side view of a protective-coated steel pipe producing equipment according to another embodiment of the present invention;

Fig.8 is a schematic side view of a protective-coated steel pipe according to a modification in the invention;

Fig.9 is a schematic side view explanatory of a processing method for coating ends of a protective-coated steel pipe according to the invention;

Fig.10 is a side view of a principal portion of a protective-coated steel pipe producing equipment further embodying the invention;

Fig.11 is a front view thereof;

Fig. 12 is a plan view showing a rotating condition of sheet pressing rolls; and

Fig. 13 is an explanatory view of a deairing means.

5 The protective-coated steel pipe of the foregoing Japanese laid-open patent application 40925/86 shown in Fig. 1 comprises a steel pipe pile 10 and a heat-shrinkable polyolefin tape 14 having an adhesive layer 12 and wound around the peripheral surface of the steel
10 pipe pile 10. In this steel pipe, a gap 18 is formed in the portion 16 of overlap of the edge regions of the tape 14. The ingress of water, etc. into the gap 18 causes rusting, with the result that the polyolefin tape 14 peels off.

15 Moreover, as the gap 18 formed along the helically overlapped portion 16 is helically continuous over the length of the steel pipe, it is likely that the aforesaid rusting, etc. will occur over the whole length of the steel pipe.

20 In the present invention, a belt-like thermoplastic synthetic resin sheet is wound around the outer peripheral surface of a preheated steel pipe so that adjacent side faces of the sheet are in contact with each other in side face-to-side face
25 relation without overlapping, and then, when the thus-contacted adjacent side faces begin to melt, they are melt-bonded together while both side faces are pressed simultaneously by a sheet

pressing means. Therefore, such overlapped portion
30 16 as in the conventional protective-coated steel pipe is not formed; that is, the gap 18 is not formed. Consequently, the likelihood of such phenomena as rusting caused by the ingress of water into the gap and the resulting peeling-off of the protective coating, is
35 minimised or obviated.

The thermoplastic synthetic resin used in the

method of the present invention may be a conventional resin which has not been subjected to a treatment for imparting heat-shrinkability thereto.

Referring now to Figs. 3 and 4, there is

- 5 illustrated a protective-coated steel pipe producing equipment according to an embodiment of the present invention. This equipment is constructed so that a thermoplastic synthetic resin sheet 104 having a thickness of 2-4 mm (e.g. 3 mm) and a width of 100-
10 1,000 mm (e.g. 500 mm) can be helically wound around the outer peripheral surface of a steel pipe 102 having an outside diameter of 660 mm.

In this embodiment, in consideration of weathering resistance, a polyethylene sheet is used as the thermoplastic synthetic resin sheet 104. More specifically, the polyethylene sheet 104 is a two-layer polyethylene sheet having an outer surface formed of an ordinary polyethylene and an inner surface formed of an adhesive, modified polyethylene. Preferably, the latter adhesive, modified polyethylene is one obtained by reacting a low- or high-density polyethylene with maleic anhydride. Any other known adhesive functional group than maleic anhydride group may be incorporated in such polyethylene. Further, other polyolefins than polyethylene, or copolymers with vinyl acetate, are also employable examples of the thermoplastic synthetic resin. If necessary, the thermoplastic synthetic resin may contain additives and fillers such as, for example, anti-oxidant and carbon black.

A sheet feed means 110 is for feeding the thermoplastic synthetic resin sheet 104 wound coilwise around a reel 114 mounted on a horizontal rotary shaft 112, continuously at an oblique angle with respect to the longitudinal direction of the steel pipe 102.

The rotary shaft 112 is rotatably supported on a support frame 116, with a brake 118 mounted on a shaft

end. The brake 118 is for imparting an appropriate resistance to the thermoplastic synthetic resin sheet coil being delivered from the reel 114 to thereby strain the sheet 104 to the extent of preventing
5 loosening of the sheet. For example, it may be a friction brake of a simple type such that the braking strength can be adjusted by adjusting the nut tightening force.

10 A guide roll 120 is suspended through an arm 122 from the distal end of the support frame 116.

The sheet feed means 110 is attached to a horizontal support 124 and it can turn within a horizontal plane about a swing shaft 142 by the operation of a handle (not shown).

15 To the underside of the horizontal support 124 is secured a holding arm 132 of a sheet pressing means 130. The sheet pressing means 130 has a plurality of sheet pressing rolls 128 for pressing the thermoplastic synthetic resin sheet 104 against the outer peripheral
20 surface of the steel pipe 102. The sheet pressing rolls 128 are horizontally pivotable with the sheet feed means 110 through a connecting arm 134 whereby the rotational axes of the rolls 128 can be set in a direction perpendicular to the feeding direction of the
25 sheet.

Further provided is a horizontal slide means 150 for moving the sheet feed means 100 and the sheet pressing means 130 linearly horizontally in the pipe

axis direction integrally through the horizontal support 124 to thereby adjust the winding angle and pitch of the thermoplastic synthetic resin sheet 104 to be wound helically around the steel pipe 102.

In this embodiment, a feed handle 152 of the horizontal slide means 150 is operated to make pre-adjustments so that the thermoplastic synthetic resin sheet 104 is helically wound around the steel pipe 102 so that adjacent side faces thereof are contacted in a face-to-face relationship.

The horizontal slide means 150 is not always necessary for winding the sheet in such fashion, but the provision thereof permits shifting of the sheet feed means 110 and the sheet pressing means 130, so it is advantageous in that it is possible to immediately cope with changes in shape and size of the steel pipe 102 and in size of the thermoplastic synthetic resin sheet 104.

On the lower surface side of the horizontal support 124 is further mounted a seam pressing means 170. In this embodiment, the seam pressing means 170 is provided with a pair of rollers which are mounted on a bracket 172 in conformity with the curvature of the outer surface of the steel

13

pipe 102, and a pressing means 176 such as, for example, an air cylinder (or a spring mechanism).

In Fig.4, which is a front view of the steel pipe 102 shown in Fig.3, the rollers 174 are disposed along a confronted seam 180 constituted by the contacting side faces of the sheet 104 in conformity with a preset sheet winding angle in order to press the seam 180 of the thermoplastic synthetic resin sheet 104 helically wound around the steel pipe 102.

The sheet feed means 110, sheet pressing means 130 and seam pressing means 170 are mounted on a base 200 through a post 202. The base 200 is mounted on a car 208 which travels on a track 204 through wheels 206. The car 208 in this embodiment is driven through a chain (not shown) which is driven by an electric motor 210 mounted on the base 200. To the car 208 is fixed a long cantilever 214 for insertion into the steel pipe 102, and to the distal end of the cantilever 214 is attached a gas burner 216 for heating the steel pipe 102 from the inner surface side. The steel pipe 102 is mounted on drive rolls 220 which are disposed in the space above the track 204, the pipe being rotatable at a constant speed about the axis thereof.

The reference numeral 228 denotes a worm jack for retracting the sheet feed means 110, sheet pressing means 130 and seam pressing means 170, to respective positions above the steel pipe 102.

The operation of this equipment will be described below.

The steel pipe 102 is placed on the drive rolls 220 and is rotated about its axis in the direction of arrow 240 at a constant speed. It is then preheated to about 200°C at _____ its outer peripheral surface by means of the gas burner 216 inserted in the interior of the pipe. This preheating temperature has been determined experimentally in the following manner.

In order to prevent peeling-off of the polyethylene coating in sea water over a long period of time, it is preferable that a primer, e.g. epoxy primer, be applied in advance onto the outer peripheral surface of the steel pipe 102.

However, the epoxy primer, including both one-can and two-pack types, contains volatile matter so it evolves gas at ^{the} a heat-melting temperature (140-240°C) of polyethylene, thus causing the polyethylene coating to be swollen or wrinkled. To remove the gas in advance, it is necessary to heat the primer to a

temperature above the heat-melting temperature of polyethylene to expel the volatile matter for drying.

In this connection, experiments were made to determine an epoxy primer preheating temperature for drying in which the epoxy primer applying temperature to steel pipe was set at 80°C.

(1) Epoxy primer was applied to steel pipes and then dried at 160°C. Subsequently the polyethylene resin sheet was melt-bonded thereto by heating at 190°C. The sheet was swollen throughout the surface thereof.

(2) Epoxy primer was applied to steel pipes and then dried at 200°C. Subsequently the polyethylene resin sheet was melt-bonded thereto by heating at 190°C. The sheet was not swollen.

(3) Epoxy primer was applied to steel pipes and then dried at 250°C. Subsequently the polyethylene resin sheet was melt-bonded thereto by heating at 190°C. The sheet was not swollen but had a deteriorated bonding strength.

From the above results, the most suitable preheating temperature was found to be 200°C ie higher by 10°C than the heat-melting temperature 190°C of the polyethylene resin sheet.

The thermoplastic synthetic resin sheet 104 is fed to the outer peripheral surface of the preheated, hot steel pipe 102 continuously at an oblique angle with respect to the pipe axis, namely, obliquely at a predetermined angle, from the sheet feed means 110 through the guide roll 120. This sheet feeding operation is performed while the car 208 on the track 204 is moved, allowing the sheet feed means 110 to move at a constant speed along the pipe axis, under operation of the motor 210.

The sheet 104 thus fed is wound under pressure around the outer peripheral surface of the steel pipe by means of the sheet pressing rolls 128. This winding is performed while adjacent side faces of the sheet are contacted in a face-to-face relation. Since the sheet 104 expands thermally, the confronted seam 180 swells to form a peak as it softens and begins to melt as shown in Fig. 5. The thus-swollen confronted seam 180 is pressed by the rollers 174 of the seam pressing means 170, whereby the air present between the swollen portion of the sheet 104 and the steel pipe surface is expelled, so that the confronted seam 180 as well as the sheet 104 and the outer peripheral surface of the steel pipe 102 are melt-bonded in a closely contacted state, as shown

in Fig. 6. In this way the thermoplastic synthetic resin sheet 104 helically wound around the steel pipe 102 is firmly melt-bonded to the outer peripheral surface of the pipe without leaving any gap. After winding ^{to} ~~by~~ a predetermined length, the sheet 4 is cut with a cutter.

Thus, a good protective coating having neither an overlapped portion of the sheet 104 nor remaining air is formed on the outer peripheral surface of the steel pipe 102.

Referring now to Fig.7, there is illustrated another embodiment, in which the foregoing sheet feed means 110, sheet pressing means and ^{seam} pressing means, as well as a gas burner 316 attached to a cantilever 314, and a cooling device 318 for cooling the inner surface of the steel pipe 102 after heat melt-bonding of the sheet to the pipe, are all fixed to a stationary frame 340. On the other hand, on a car 308 adapted to travel on a track 304 are mounted drive rolls 320 together with a drive motor (not shown) for rotating the steel pipe. The car 308 contains an electric motor to drive wheels 306.

The steel pipe 102 is placed on the drive rolls 320 and conveyed in the pipe axis direction at a

constant speed by the car 308 while being rotated about the pipe axis at a constant speed.

This embodiment is advantageous in that the worker can perform operations at the same place without changing place.

The protective-coated steel pipe producing equipment of this embodiment is far simpler in structure and less expensive than conventional polyethylene melt-extruding and coating equipment. Besides, no special installing foundation is needed, so the transport and installation of the equipment are easy. Once the equipment is transported to a construction work site and installed, it becomes possible to effect the production of the protective-coated steel pipe. Consequently, the cost required for transporting factory-manufactured protective-coated steel pipes to the work site can be cut down to a great extent.

The following description is now provided about an example of using a sheet preheater in the invention.

Fig. 8 is a side view of a principal portion of the equipment of Fig. 3, with a modification added thereto. In the modification shown in Fig. 8, the sheet is preheated. More specifically, the belt-like thermoplastic synthetic resin sheet is preheated to room

temperature or thereabouts before being helically wound around the outer peripheral surface of the steel pipe which has been preheated. By so doing, the sheet which has become hard under a low-temperature environment becomes more compatible with the steel pipe surface.

Between the sheet feed means 110 and the sheet pressing means 130 is disposed a preheating means 400 for preheating the thermoplastic synthetic resin sheet 104 which is fed out of the sheet feed means. Where the outside air temperature is low, the sheet 104 which is fed in a hard condition by the sheet feed means 110 is preheated by the preheating means 400 and given flexibility thereby. The preheating means 400 is formed in the shape of a box covered with a heat insulating material, through which the sheet 104 can pass throughout its entire width. Heating may be done using a built-in electric heater or gas heater, or by introducing heated air from the exterior. A heating temperature which permits the thermoplastic synthetic resin sheet 104 to be heated to room temperature of 20°C or thereabouts is sufficient. However, when it is taken into account that the heating temperature differs depending on the kind, thickness and width of the sheet, it is desirable to set it in the range of 20° to 60°C.

The operation of the sheet heating means will be described below.

As an example, the preheating temperature of the sheet preheating means for softening the sheet was determined experimentally in the following manner.

A hard polyethylene sheet 104 having a thickness of 3 mm and a width of 500 mm was heat melt-bonded to the steel pipe 102 without preheating when the outside air temperature was 2°C; as a result, air remained between the sheet and the outer peripheral surface of the steel pipe 102, causing swelling. On the other hand, when the sheet was preheated up to 20°C by the sheet preheating means 400, the compatibility between the sheet 104 and the steel pipe 102 was remarkably improved, causing no swelling.

On the basis of such experimental results the thermoplastic synthetic resin sheet 104 was preheated up to 20°C by the sheet preheating means 400 and then fed to the outer peripheral surface of the steel pipe 102 which was hot because of having been preheated to 200°C, from an oblique angle with respect to the pipe axis, continuously through the guide roll 120. This sheet feeding operation is performed while the steel pipe 102

is moved relatively in the pipe axis direction and at the same time rotated at a constant speed.

The sheet 104 thus fed is brought into pressure contact with the outer peripheral surface of the steel pipe 102 by means of the sheet pressing rolls 128 and wound therearound in this state. Even when the outside air temperature is low, since the sheet 104 has been preheated by the sheet preheating means 400 and thereby softened, it is easily compatible with the steel pipe surface and so can be easily wound therearound without leaving air between the sheet and the pipe. In this way there is performed a helical winding of the sheet and the sheet is heat melt-bonded firmly to the outer peripheral surface of the pipe 102. After winding by a predetermined length, the sheet 104 is cut with a cutter.

Thus, even under a working environment wherein the outside air temperature is low, a good protective coating free of residual air can be formed on the outer peripheral surface of the pipe.

Although in the above embodiment the sheet preheating means 400 is disposed between the sheet feed means 110 and the guide roll 120, this arrangement does not constitute any limitation. For example, the sheet

preheating means 400 may be disposed between the guide roll 120 and the sheet pressing rolls 128, or the guide roll 120 itself may be heated, so long as the thermoplastic synthetic resin sheet 104 can be preheated before it is pressed against the steel pipe surface.

The following description is now provided about how to process the winding start and end portions of the sheet on the same pipe as in the above embodiment.

In a conventional steel pipe 20 shown in Fig .2, a tape 22 is strongly bonded to the pipe not only in a range L which requires coating but also at unnecessary portions 24 of both ends which should be removed. Therefore, much labor is needed to remove the tape from those portions. For example, it has heretofore been necessary to reheat to let the tape peel off or use a peeling device to remove the tape mechanically.

In the present invention, cuts are made at high temperature in the winding start and end portions of the thermoplastic resin sheet which has been melt-bonded to the outer peripheral surface of the steel pipe. These cuts form uniform openings in the sheet when cooled. Therefore, if a less adhesive coating is wound around the outer peripheral surface of the steel pipe in advance and the portions to be removed are put

thereon, it will be possible to remove sheet end portions easily from the said openings.

Referring now to Fig .9, before the thermoplastic synthetic resin sheet 104 is wound around the outer peripheral surface of the steel pipe 102, a coating 450 comprising a thin tape which is not so strong in bonding force is formed beforehand on the outer peripheral surface of the steel pipe at the start and end portions of a range L which requires coating, namely, at the winding start and end portions of the sheet. The coating 450 may be wound one turn perpendicularly to the pipe axis.

The preheated steel pipe 102 is slowly moved relatively in the pipe axis direction while rotating about the pipe axis at a constant speed. This relative movement may be done by moving the steel pipe 102 or by moving the thermoplastic synthetic resin sheet 104. The sheet 104, which is belt-like, is fed to the heated outer peripheral surface of the steel pipe 102 continuously obliquely at a predetermined angle with respect to the pipe axis. By adjusting the feed angle and feed pitch, it is possible to wind the sheet so that the side-faces of the sheet are in close contact.

The sheet 104 is partially put on the coating 450 at its winding start and end portions as shown in Fig. 9.

While the sheet 104 is wound helically around the steel pipe 102, it is pressed against the outer peripheral surface of the pipe elastically using, for example, pressing rollers to thereby expel the air present between the sheet seam 180 and the outer peripheral portion of the steel pipe 102, allowing the sheet to be heat melt-bonded in a closely contacted state.

Cuts 452 are made at high temperature in the boundaries between the range L and the unnecessary portions at the sheet winding start and end portions. This can be done easily by merely pushing the edge of a cutter against a predetermined part of the steel pipe 102 being rotated.

While the winding and melt-bonding of the thermoplastic synthetic resin sheet 104 proceeds successively from a predetermined position on the steel pipe 102, the portion of the sheet which has already been melt-bonded to the pipe is cooled forcibly. For example, the cooling is done by spraying cooling water from the inner surface side of the steel pipe 102 or by

spraying water or air from the outer surface of the pipe. When the steel pipe 102 _____ is cooled, the thermoplastic synthetic resin sheet 104 shrinks and so the cuts 452 open uniformly. Consequently, the unnecessary portions at both ends of the sheet 104 can be easily removed from the outer peripheral surface of the steel pipe 102 together with the less adhesive coating 450.

If necessary, the coating ends after removal of the unnecessary portions may be treated with a sealing agent. Thus, the unnecessary portions at the protective coating ends can be removed extremely easily.

Referring now to Figs. 10 to 13, there is illustrated a sheet pressing means embodying the invention. Fig. 10 is a side view of a principal portion wherein the thermoplastic synthetic resin sheet 104 which has been fed to the outer periphery of the steel pipe 102 is pressed against the outer periphery of the steel pipe elastically by the sheet pressing means 130 and a deairing means 530.

A lateral beam 250 is attached to an upper part of the post 202 vertically pivotably in an upwardly projecting fashion. The underside of the lateral beam

250 is supported by a worm jack 228, the lower end of which is supported by the post 202.

The lateral beam 250 is provided at its front end surface with a horizontal slide means 150 wherein a slide 124 is horizontally slid in the axial direction of the steel pipe 102 by means of a rotary feed handle 152. Further, a swing means 140 is attached to the front end portion of the horizontal slide 124 so that it can swing in a horizontal plane about a swing shaft 142 by turning a handle (not shown). The sheet feed means 110 and a roll bracket 134 of the sheet pressing means 130 are attached to the swing means 140 so as to be swingable horizontally.

The sheet pressing means 130 is attached to the underside of the horizontal slide 124 through an arm 132. Fig. 11 is a front view of the sheet pressing means 130.

Sheet pressing rolls 128 each have an outer peripheral portion formed of a heat resisting silicone rubber for example and a rotating shaft supported by a roll bracket 512. On the upper surface of each bracket 512 are erected a swingable and vertically movable floating support shaft 510 and a swing operating shaft 516. In Fig. 11, the swing operating shaft 516 is shown

for only the leftmost roll bracket and is not shown for the others. The floating support shaft 510 is disposed just above the rotating shaft of each roll 128, while the swing operating shaft 516 is erected at an end portion of the roll bracket 512 in a somewhat spaced relation to the shaft 510. A bearing 514 with the floating support shaft 510 inserted therethrough is fixed to the front end face of the arm 132 (see Fig.10). Between the bearing 514 and the roll brackets 512 are interposed coil springs 518 which press the sheet pressing rolls 128 elastically toward the outer peripheral surface of the steel pipe 102.

The plural sheet pressing rolls 128 constructed as above are arranged at equal intervals in the longitudinal direction of the pipe 102 within the range of the width of the thermoplastic synthetic resin sheet 104. The swing rotating shafts 516 of the rolls 128 are connected interlockably through a link mechanism (not shown). Further, a swing connecting arm 134 extending downwards from one end thereof fixed to the swing shaft of the swing means 140 is slidably fitted at the other end thereof on the leftmost swing operating shaft 516 in Fig. 11.

On the downstream side of the sheet pressing rolls 128 there is disposed the deairing means 530 which presses the thermoplastic synthetic resin sheet 104 elastically throughout the entire width thereof against the outer peripheral surface of the steel pipe 102.

As shown in Fig. 10, the deairing means 530 is mounted on a ledge 252 jutting from a middle part of the post 202. More specifically, a cross feed shaft 254 is supported on the ledge 252 so as to be movable in the transverse direction of the steel pipe 102. To one end of the cross feed shaft 254 are attached a pair of curved arms 256, and a bearing bracket 540 movable along the outer peripheral surface of the steel pipe 102 is mounted on the curved arms 256, the bearing bracket 540 being normally fixed in a predetermined position by means of a handle 542.

Fig. 13 is an enlarged view of the bearing bracket 540 of the deairing means 530, in which a straightening roll 532, a back-up roll 548 and two cooling rolls 550 are rotatably supported by the bearing bracket 540. The straightening roll 532 is a hollow roll made of silicone rubber, with compressed air being fed into the hollow portion from an end of the roll. As the straightening roll 532 of the deairing means, it is

not limited to a pneumatic rubber roll; there may be used a sponge roll, a brush roll or a metallic roll, if the roll is well compatible with unevenness of the outer peripheral surface of the steel pipe and can press the sheet throughout the entire width thereof. The cooling rolls 550 are also hollow and each constituted by an iron pipe, with cold water being fed into the interior of the pipe.

The operation of the equipment shown in Fig. 10 will now be described. With operation of the swing means 140 the support frame 116 of the sheet feed means 110 swings horizontally about the swing shaft 142 of the swing means, so that an appropriate sheet feed angle can be set accurately and easily.

At the same time, the swing connecting arm 134 fixed to the swing shaft 142 of the swing means 140 also swings. Interlockedly, the swing operating shaft is operated, so that, as shown in Fig. 12, the five sheet pressing rolls 128 connected by a link mechanism 29 pivot integrally about the respective floating support shafts (see Fig. 11) and obliquely intersect the pipe axis as indicated by solid lines in Fig. 12. Thus the rolls 128 can be positioned

so that their rotational axes are set in a direction perpendicular to the sheet feed direction to bring the sheet 104 into pressure contact with the steel pipe 102.

If the sheet pressing rolls 128 are replaced by a single roll, there is only one steel pipe pressing point when the roll is positioned obliquely with respect to the pipe axis, so it is impossible to press the sheet uniformly throughout the entire width thereof. There may be used a roll having a concavely curved surface in conformity with the curved surface of the steel pipe, but in this case many rolls are needed for different diameters of rolls.

The sheet pressing rolls 128 are divided plurally and each is supported by the floating support shaft 510, so even if there is an uneven portion, such as a weld bead, or the steel pipe 102, the rolls each individually can get over such uneven portion by virtue of the resilience of each coil spring 518. Therefore, it is possible to prevent the protective coating from changing in thickness according to unevenness of the steel pipe surface.

Further, the horizontal slide 124 is moved longitudinally of the steel pipe 102 by operating the feed handle 152 of the horizontal slide means 150, whereby the sheet feed means 110 and the sheet pressing

means 130 can be shifted. Therefore, the equipment can immediately cope with changes in shape and size of the steel pipe 102 or heat deformation of the thermoplastic synthetic resin sheet 104. Consequently it is easily possible to maintain the helical shape of the wound sheet always in an appropriate condition and ensure a desired winding spacing.

The thermoplastic synthetic resin sheet 104 which has been softened by the heat of the steel pipe 102 and brought into pressure contact with the outer peripheral surface of the pipe by means of the sheet pressing rolls 128 is then pressed throughout the entire width of the sheet by the straightening roll 532 shown in Fig. 13. The straightening roll 532 is easily deformable elastically and well compatible with the unevenness of the pipe outer peripheral surface, so the air remaining in an uneven portion such as ^aweld bead can be expelled. Consequently, the sheet 104 can be contacted more closely with the outer peripheral surface of the steel pipe to expel the residual air completely.

When the sheet 104 ^{is} ~~was~~ wound around the pipe by a predetermined length, it is cut with a cutter.

--According to the present invention, as set forth hereinabove, the thermoplastic synthetic resin sheet can

be helically wound around the steel pipe and heat melt-bonded to the pipe in close contact with the entire pipe surface, so it is possible to effectively prevent the occurrence of the peeling-off phenomenon due to rusting caused by the residual air between the protective coating and the outer peripheral surface of the steel pipe.

Besides, the steel pipe protective coating can be provided less expensively than that according to the coating material applying method. Further, the equipment is of an extremely simple structure, requiring neither a special installing foundation nor such a large-scaled manufacturing equipment as in the conventional polyethylene melt-extrusion coating method. Therefore, it becomes possible to perform a protective coating work at a construction work site; as a result, the product transporting cost and labour can be greatly reduced.



CLAIMS:

1. A method of producing a protective-coated steel pipe, which comprises:

winding a belt-like thermoplastic synthetic resin sheet helically around the outer peripheral surface of a preheated steel pipe while contacting adjacent side faces of the sheet in a face-to-face relation to each other without overlap; and

heat melt-bonding the sheet to the pipe and the contacting adjacent side faces to each other by applying pressure as the sheet begins to melt.

2. A method according to claim 1, which also includes preheating a length of the thermoplastic synthetic resin sheet to at least room temperature to impart flexibility thereto prior to applying the length of the sheet to the outer peripheral surface of the steel pipe.

3. A method according to claim 1 or claim 2, wherein a coating having relatively weak bonding force is formed beforehand on the outer peripheral surface of the steel pipe in zones corresponding to the winding start and end portions of the sheet, then the thermoplastic synthetic resin sheet is wound and melt-bonded around the outer peripheral surface of the steel pipe so as to cover both coated zones and the pipe between those zones, and thereafter cuts are made in the end portions of the melt-bonded sheet at the inner boundary of the zones whilst the end portions are at elevated temperatures.

4. A method according to claim 3, which includes subsequently removing said coating and any overlying unwanted sheet material from the zones beyond the cuts.

5. A method according to claim 4, which includes subsequently applying sealant to the end regions of the melt-bonded sheet after removal of the coating and the unwanted sheet material.



6. A method according to claim 1, substantially as described with reference to Figures 3 to 13 of the accompanying drawings.

7. A protective-coated steel pipe whenever
5 produced by a method according to any preceding claim.

8. Equipment suitable for producing a protective-coated steel pipe by winding a belt-like thermoplastic synthetic resin sheet helically around the outer peripheral surface of a preheated steel pipe
10 by rotating the pipe at a constant speed and subjecting the sheet and pipe to relative movement in the pipe axis direction, the equipment including:

a sheet feed means for feeding the thermoplastic synthetic resin sheet obliquely with respect to the
15 longitudinal direction of the steel pipe so that adjacent side faces of the sheet contact each other without overlapping of the sheet; and

a sheet pressing means for pressing the contacted side faces of the sheet, which has begun to melt on the
20 outer peripheral surface of the steel pipe, against the outer peripheral surface of the pipe to heat melt-bond the sheet to the pipe and to heat melt-bond the contacting adjacent side faces to each other.

9. Equipment according to claim 8, which also
25 includes a sheet preheating means disposed between the sheet feed means and the sheet pressing means to preheat the thermoplastic synthetic resin sheet to at least room temperature.

10. Equipment for producing a protective-coated
30 steel pipe which includes:

a pipe heating means;

-- a sheet feed means for feeding a thermoplastic synthetic resin sheet obliquely with respect to the preheated steel pipe so that the side faces of the
35 sheet are in contact with each other without overlapping of the sheet, the sheet feed means having a



rotary shaft which supports the thermoplastic synthetic resin sheet in a coilwise wound condition and which can be inclined with respect to the longitudinal direction of the steel pipe so as to be aligned with the sheet feed direction;

5 a sheet pressing means for pressing the contacted side faces elastically against the outer peripheral surface of the steel pipe as the pipe is rotating about a shaft at a constant speed, the sheet pressing means
10 having a sheet pressing roll capable of having its rotational axis set in a direction perpendicular to the direction in which the sheet is fed from the sheet feed means; and

a horizontal slide means for adjusting the sheet
15 winding angle and winding pitch with respect to the steel pipe, the horizontal slide means having a mechanism for moving the sheet feed means and the sheet pressing means relatively in the longitudinal direction of the steel pipe.

20 11. Equipment according to claim 8, 9 or 10, wherein the sheet pressing means comprises a rigid roller.

12. Equipment according to claim 8, 9 or 10, wherein the sheet pressing means is a resiliently
25 flexible roller.

13. Equipment according to claim 8, substantially as hereinbefore described with reference to, and as illustrated in, Figures 3, 4 and 7; or Figures 3, 4, 7 and 8; or Figures 10 to 13 of the accompanying
30 drawings.
