

MULTI-LAYER PIPE MANUFACTURING APPARATUS AND METHOD OF MANUFACTURING MULTI-LAYER PIPES USING THE SAME

Technical Field

5 The present invention relates generally to a multi-layer pipe manufacturing apparatus and a method of manufacturing a multi-layer pipe using the same. More particularly, the present invention relates to an apparatus for simultaneously bonding a plurality of pipes both mechanically and metallurgically with relatively simple configuration and process to economically
10 manufacture a multi-layer pipe, and a method of manufacturing the multi-layer pipe using the same.

Background Art

Generally, a multi-layer steel pipe including a double-layer steel pipe is manufactured with an adhesive or thermal
15 bonding using a difference in thermal expansion coefficients.

Recently, such a multi-layer steel pipe has been manufactured using metallurgical bonding, mechanical bonding, and thermal bonding.

The mechanical bonding may use a hydraulic forming method, a stretch reducing mill (SRM) rolling method or the like,
20 wherein the hydraulic forming method is a method that generates a bonding force using plastic deformation of an inner pipe and recovered elasticity of an outer pipe, and the SRM rolling method is a method that realizes mechanical bonding used in
25 manufacturing a seamless steel pipe.

Although the hydraulic forming method employs a hydro-forming method where fluid such as gas, water or the like is supplied in the inner pipe so that the inner pipe is expanded with hydraulic pressure and is bonded onto the outer pipe, it
30 has problems of a restricted length of a product, increased cost of preparing a die for each size for manufacture of a multi-layer pipe, and increased cost and time due to the complex process of supply, post-treatment or the like of working fluid.

Further, the SRM rolling method also has problems in that mass-production equipment is needed in hot rolling using rolls, and a process of manufacturing a matrix pipe by inserting an inner pipe into an outer pipe is not performed smoothly.

5 **Disclosure**

Technical Problem

Accordingly, the present invention has been made keeping in mind the above problems occurring in the related art, and the present invention is intended to propose an apparatus for
10 simultaneously bonding a plurality of pipes both mechanically and metallurgically with a relatively simple configuration and process to economically manufacture a multi-layer pipe, and a method of manufacturing the multi-layer pipe using the same.

Technical Solution

15 In order to achieve the above object, according to one aspect of the present invention, there is provided an apparatus for manufacturing a multi-layer pipe. The apparatus includes: a ram extruding a matrix pipe, which is formed by inserting one or more insert pipes having different diameters into a
20 receiving pipe, with a constant compression force; a heat-treatment unit heat-treating the matrix pipe extruded from the ram; and a drawing unit drawing, with a constant drawing force, the matrix pipe passing through the heat-treatment unit into a multi-layer pipe having a predefined diameter.

25 The compression force and the drawing force may be identical or different.

An outer surface of an outermost insert pipe inserted into the receiving pipe may come into contact with an inner surface of the receiving pipe, and an outer surface of another insert
30 pipe inserted into a former-inserted insert pipe inserted into the receiving pipe may come into contact with an inner surface of the former-inserted insert pipe.

The heat-treatment unit may be a heat furnace accommodating the matrix pipe extruded from the ram, or a high-

frequency induction heater arranged along a direction in which the matrix pipe extruded from the ram is formed.

5 The high-frequency induction heater may include a single-frequency generator for high-frequency induction heating bonding of the receiving pipe and the insert pipes that are formed of the same material to constitute the matrix pipe, and a multi-frequency generator for high-frequency induction heating bonding of the receiving pipe and the insert pipes, respectively, that are respectively formed of different materials to constitute the matrix pipe.

The matrix pipe may be heat-treated at a temperature ranging from 150 °C to 1350 °C by the heat furnace or the high-frequency induction heater.

15 The drawing unit may include a die having an extrusion hole section through which the multi-layer pipe is extruded from the ram into a smaller outer diameter relative to that of the matrix pipe, a clamp clamping an end of the multi-layer pipe extruded from the die, and a carrier carrying the multi-layer pipe with a constant drawing force along a direction of the multi-layer pipe being extruded, the clamp being provided to the carrier.

25 The extrusion hole section may include a first end hole having a first diameter that is disposed on a first side of the die so as to face the ram, a middle hole disposed in the die concentrically with the first end hole and having a second diameter smaller than the first diameter, a second end hole disposed on a second side of the die opposite to the first side, concentrically with the middle hole and having the second diameter, a first extrusion guide part connecting the first end hole and the middle hole and having a diameter decreasing towards the carrier, and a second extrusion guide part connecting the middle hole and the second end hole and having a constant diameter towards the carrier, wherein the first diameter corresponds to an outer diameter of the matrix pipe and the second diameter corresponds to an outer diameter of the multi-layer pipe.

The extrusion guide parts may be provided with a duplex physical vapor deposition (PVD) coating layer or a diamond-like-carbon (DLC) coating layer.

5 The drawing unit may further include a mandrel extending from the carrier towards the ram separately from the clamp and disposed at the center of the clamp so as to, when inserted into the multi-layer pipe, maintain an inner diameter of the multi-layer pipe to be constant.

10 The mandrel may be provided, on an outer surface thereof, with a duplex physical vapor deposition (PVD) coating layer or a diamond-like-carbon (DLC) coating layer.

15 The clamp may be provided with a plurality of chucks attached to the carrier and radially arranged so as to be separated from or to contact an outer surface of the multi-layer pipe.

The receiving pipe and the insert pipes may be formed of the same material or different materials.

The receiving pipe and the insert pipes may be any one of an electric resistance welding (ERW) pipe and a seamless pipe.

20 The insertion pipe may be formed of one of stainless steel, aluminum, aluminum alloy, copper, copper alloy, nickel, nickel alloy, and a combination thereof.

25 The receiving pipe may be formed of one of carbon steel, cobalt-base alloy steel, aluminum, aluminum alloy, brass, high manganese steel, and a combination thereof.

30 The receiving pipe or the insert pipe may be provided, on an outer or inner surface thereof, with a plurality of reinforcing ribs spaced at regular intervals and linearly extending along a longitudinal direction of the receiving pipe or the insert pipe, the reinforcing ribs having alternating linear ridges and valleys.

The receiving pipe or the insert pipe may be provided, on an outer or inner surface thereof, with a plurality of reinforcing ribs spaced at regular intervals and involutely

extending along a longitudinal direction of the receiving pipe or the insert pipe, the reinforcing ribs having alternating involute ridges and valleys.

5 The apparatus may further include a rotary actuator provided in one or both of the ram and the drawing unit and driven to rotate the extruded matrix pipe or the drawn multi-layer pipe in one direction.

10 In another aspect of the present invention, there is provided a method of manufacturing a multi-layer pipe using an apparatus for manufacturing a multi-layer pipe, the method including: a first stage of forming a matrix pipe by inserting one or more insert pipes having different diameters into a receiving pipe; a second stage of introducing the matrix pipe into a ram to extrude the matrix pipe with a constant
15 compression or extrusion force; a third stage of introducing the matrix pipe extruded from the ram into a heat-treatment unit to heat-treat the matrix pipe; and a fourth stage of clamping an end of the matrix pipe heat-treated by the heat treatment unit and drawing the matrix pipe with a constant
20 drawing force to form a multi-layer pipe having a desired diameter, using a drawing unit.

An outer surface of an outermost insert pipe inserted into the receiving pipe may come into contact with an inner surface of the receiving pipe, and an outer surface of another insert
25 pipe inserted into a former-inserted insert pipe inserted into the receiving pipe may come into contact with an inner surface of the former-inserted insert pipe.

In the third stage, the matrix pipe extruded by the ram may be heat-treated at a temperature ranging from 150 °C to
30 1350 °C by a heat furnace accommodating the matrix pipe or a high-frequency induction heater arranged along a circumferential face of the matrix pipe.

Advantageous Effects

According to the above-mentioned configuration, the
35 present invention provides the following effects.

With the configuration in which the matrix pipe is formed by inserting the insert pipe(s) into the receiving pipe, the matrix pipe is extruded with a constant extrusion force by the ram, the matrix pipe is heat-treated by the heat-treatment unit, and the matrix pipe is compressed and drawn with a constant force into a multi-layer pipe having a desired diameter by the drawing unit, a high-quality multi-layer pipe having improved formability, corrosion resistance, and strength can be obtained with relatively simple configuration and relatively low cost.

Further, mechanical bonding of a plurality of pipes including the receiving pipe and the insert pipe(s) suitable to increase corrosion resistance and strength of the pipes can be obtained with a simple configuration, and at the same time, the receiving pipe and the insert pipe(s) can be metallurgically bonded together through hot forming by the heat-treatment unit such as the heat furnace or the high-frequency induction heater, thereby providing excellent manufacturing efficiency in situ with low cost.

Further, with the configuration in which the drawing force and the extrusion force are held identically or differently by the drawing unit and the ram, respectively, and respective layers of the multi-layer pipe, i.e. the receiving pipe and the insert pipe(s), which constitute the matrix pipe, are precisely size-controlled, with the thicknesses thereof maintained to be constant during extrusion using the mandrel while clamping the multi-layer pipe by the clamp, thus a multi-layer pipe having improved layer-bonding force and dimension precision can be obtained.

Description of Drawings

FIG. 1 is an entire configuration of a multi-layer pipe manufacturing apparatus according to an embodiment of the present invention;

FIG. 2 is an enlarged conceptual view of a section A of FIG. 1;

FIG. 3 is a cross-sectional conceptual view illustrating a detailed structure of a die of a drawing unit, without a matrix pipe and a multi-layer pipe from the section A of FIG. 1;

5 FIG. 4 is a flow block diagram of a method of manufacturing a multi-layer pipe using the multi-layer pipe manufacturing apparatus according to an embodiment of the present invention; and

10 FIGS. 5 and 6 are perspective views illustrating the structures of a receiving pipe or an insert pipe for a multi-layer pipe to be manufactured by the multi-layer pipe manufacturing apparatus according to an embodiment of the present invention.

DESCRIPTION OF SIGNS

	100... ram
15	200... heat-treatment unit
	300... drawing unit
	310... die
	310a... first side
	310b... second side
20	310h... extrusion hole section
	311... first end hole
	312... second end hole
	313a... first extrusion guide part
	313b... second extrusion guide part
25	314... middle hole
	320... clamp
	321... chuck
	330... carrier

340... mandrel

400... receiving pipe

401, 402... reinforcing rib

500... insert pipe

5 501, 502... reinforcing rib

600... matrix pipe

700... multi-layer pipe

D1... first diameter

D2... second diameter

10 S1... first stage

S2... second stage

S3... third stage

S4... fourth stage

Best Mode

15 The advantages and features of the present invention and methods accomplishing the same will be apparent when referring to following embodiments to be described in detail, in conjunction with the accompanying drawings.

20 The present invention may not, however, be limited to the embodiments disclosed, but be embodied in many different forms.

Here, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art to which the present invention pertains.

25 Therefore, the present invention is only defined by the scope of claims.

Therefore, in some embodiments, well-known components, operations, and techniques may not be described in detail in order to prevent the present invention from being interpreted

ambiguously.

The same reference numerals refer to similar elements throughout the drawings. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the invention.

As used herein, the singular forms "a", "an", and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising", or "includes" and/or "including", when used in this specification, specify the presence of stated features, but do not preclude the presence or addition of one or more other features.

Unless otherwise defined, the meaning of all terms (including technical and scientific terms) used herein is the same as that commonly understood by one of ordinary skill in the art to which the present invention belongs.

It will be further understood that terms, such as those defined in commonly used dictionaries, will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

Reference will now be made in greater detail to a preferred embodiment of the invention with reference to the accompanying drawings.

FIG. 1 is an entire configuration of a multi-layer pipe manufacturing apparatus according to an embodiment of the present invention, FIG. 2 is an enlarged conceptual view of a section A of FIG. 1, and FIG. 3 is a cross-sectional conceptual view illustrating a detailed structure of a die of a drawing unit, without a matrix pipe and a multi-layer pipe from the section A of FIG. 1.

As can be seen from the drawings, the present invention includes a ram 100, a heat-treatment unit 200, and a drawing unit 300.

The ram 100 extrudes a matrix pipe 600, which is formed by

inserting one or more insert pipes 500 having different diameters into a receiving pipe 400, with a constant compression force (see solid arrow of FIG. 1).

5 The heat-treatment unit 200 heat-treats and performs hot forming on the matrix pipe 600 extruded from the ram 100 so as to obtain metallurgical bonding between the receiving pipe 400 and the insert pipe 500, which constitute the matrix pipe 600.

10 The drawing unit 300 draws, with a constant drawing force (see solid arrow of FIG. 1), the matrix pipe 600 passing through the heat-treatment unit 200 into a multi-layer pipe 700 having a predefined diameter so as to obtain mechanical bonding between the receiving pipe 400 and the insert pipe 500, which constitute the matrix pipe 600.

15 Thus, a high-quality multi-layer pipe 700 having improved formability, corrosion resistance, and strength can be obtained with relative simple configuration and relatively low cost.

20 Further, since mechanical bonding of a plurality of pipes including the receiving pipe 400 and the insert pipe(s) 500 suitable to increase corrosion resistance and strength of the pipes can be obtained with a simple configuration, and at the same time, the receiving pipe 400 and the insert pipe(s) 500 can be metallurgically bonded together through hot forming by the heat-treatment unit 200 such as the heat furnace or the high-frequency induction heater, the multi-layer pipe 700 can
25 be formed with low cost.

The present invention can employ the above embodiment and other embodiments to be described.

30 A high-quality multi-layer pipe 700 having no surface and mechanical defects can be obtained only when the compression force of the ram 100 and the drawing force of the drawing unit 300 are substantially the same or slightly different.

35 Of course, the compression force of the ram 100 and the drawing force of the drawing unit 300 may be the same and may be properly regulated depending on materials and properties of the receiving pipe 400 and the insert pipe 500 along with a

design of the multi-layer pipe 700 to be manufactured.

5 An outer surface of an outermost insert pipe 500 inserted into the receiving pipe 400 may come into contact with an inner surface of the receiving pipe 400, and an outer surface of another insert pipe 500 inserted into a former-inserted insert pipe 500 inserted into the receiving pipe 400 may come into contact with an inner surface of the former-inserted insert pipe 500.

10 That is, like this, in addition to two layers, i.e. the receiving pipe 400 and the insert pipe 500, coming into contact with each other at inner and outer surfaces thereof, respectively, as shown in the drawing, 3 layers, 4 layers or more may come into contact with each other so as to form a multi-layer pipe.

15 Here, the receiving pipe 400 and the insert pipe 500 may be formed of same or different material. For example, the receiving pipe 400 and the insert pipe 500 may comprise an electric resistance welding (ERW) pipe or a seamless pipe so as to form the matrix pipe 600 and the multi-layer pipe 700.

20 The insertion pipe 500 may be formed of one of stainless steel, aluminum, aluminum alloy, copper, copper alloy, nickel, nickel alloy, and a combination thereof.

25 The receiving pipe 400 may be formed of one of carbon steel, cobalt-base alloy steel, aluminum, aluminum alloy, brass, high manganese steel, and a combination thereof.

30 The heat-treatment unit 200 may be a heat furnace accommodating the matrix pipe 600 extruded from the ram 100, or a high-frequency induction heater arranged along a direction in which the matrix pipe 600 extruded from the ram is formed. The matrix pipe 600 may be heat-treated and hot-formed at a temperature ranging from 150 °C to 1350 °C by the heat furnace or the high-frequency induction heater.

35 Here, when the heat-treatment unit 200 is the high-frequency induction heater, it may further include a single-frequency generator (not shown) that generates a single

frequency for high-frequency induction heating bonding of the receiving pipe 400 and the insert pipes 500 that are formed of the same material to constitute the matrix pipe 600.

Further, when the heat-treatment unit 200 is the high-frequency induction heater, it may further include a multi-frequency generator (not shown) that generates multi-frequency for high-frequency induction heating bonding of the receiving pipe 400 and the insert pipes 500, respectively, that are respectively formed of different materials to constitute the matrix pipe 600.

The drawing unit 300 may include a die 310 having an extrusion hole section 310h through which the multi-layer pipe 700 is extruded from the ram 100 into a smaller outer diameter relative to that of the matrix pipe 600, a clamp 320 clamping an end of the multi-layer pipe 700 extruded from the die 310, and a carrier 330 carrying the multi-layer pipe 700 with a constant drawing force along a direction of the multi-layer pipe 700 being extruded, wherein the clamp 320 is provided to the carrier 330.

As shown in detail with reference to FIGS. 2 and 3, the extrusion hole section 310h includes first and second end holes 311 and 312, first and second extrusion guide parts 313a and 313b, and a middle hole 314.

The first end hole has a first diameter D1 and is disposed on a first side 310a of the die 310 so as to face the ram 100.

The middle hole 314 is disposed in the die 310 concentrically with the first end hole 311 and has a second diameter D2 smaller than the first diameter D1.

The second end hole 312 is disposed on a second side 310b of the die 310 opposite to the first side 310a, concentrically with the middle hole 314 and has the second diameter D2.

The first extrusion guide part 313a connects the first end hole 311 and the middle hole 314 and has a diameter decreasing towards the carrier 330.

The second extrusion guide part 313b connects the middle hole 314 and the second end hole 312 and has a constant diameter towards the carrier 330.

5 The first diameter D1 corresponds to an outer diameter of the matrix pipe 600 and the second diameter D2 corresponds to an outer diameter of the multi-layer pipe 700.

10 Thus, the matrix pipe 600 coming from the first end hole 311 with a constant compression force gradually decreases in diameter along the first extrusion guide part 313a, and is formed into a multi-layer pipe 700 having a desired second diameter D2 after passing through the middle hole 314, the second extrusion guide part 313b, and the second end hole 312. Then, the multi-layer pipe 700 is drawn and formed while the carrier 330 is moved, with the multi-layer pipe 700 clamped by
15 the clamp 320.

Preferably, the extrusion guide parts 313a and 313b may be provided with a duplex physical vapor deposition (PVD) coating layer or a diamond-like-carbon (DLC) coating layer.

20 Such coating layers serve to provide a lubrication feature when the matrix pipe 600 is extruded with constant compression force and the multi-layer pipe 700 is drawn with constant drawing force, thereby facilitating the forming of the multi-layer pipe 700 through carrying in one direction.

25 Further, according to the present invention, a portion connecting the first and second extrusion guide parts 313a and 313b from the middle hole 314 may be formed to be round, so that, when the matrix pipe 600 of the first diameter D1 shrinks and is formed into the multi-layer pipe 700 of the second diameter D2, surface and internal forming defects of the multi-layer pipe 700 can be minimized.
30

While the carrier 330 is illustrated as a wheeled carrier, the present invention is not limited thereto.

35 The clamp 320 may be provided with a plurality of chucks 321 attached to the carrier 330 and radially arranged so as to be separated from or to contact an outer surface of the multi-

layer pipe 700.

Although not specifically illustrated, the carrier 330 may be applicable to many precisely-displaceable applications and embodiments such as, for example, an LM guide with a clamp 320,
5 a combination of a rack with a clamp 320 and a pinion in which the pinion can be moved in one direction in a state of being engaged with the rack.

The drawing unit 300 may further include a mandrel 340 extending from the carrier 330 towards the ram 100 separately
10 from the clamp 320 and disposed at the center of the clamp 320 so as to, when inserted into the multi-layer pipe 700, maintain an inner diameter of the multi-layer pipe 700 to be constant.

The mandrel 340 may be provided, on an outer surface thereof, with a duplex physical vapor deposition (PVD) coating
15 layer or a diamond-like-carbon (DLC) coating layer.

Such coating layers serve to provide a lubrication feature when the matrix pipe 600 is extruded with constant compression force and the multi-layer pipe 700 is drawn with constant drawing force, thereby facilitating the forming of the multi-
20 layer pipe 700 while the matrix pipe is carried in one direction.

Although not specifically illustrated, the apparatus of the present invention may further include a rotary actuator (not shown) provided in one or both of the ram 100 and the
25 drawing unit 300 and driven to rotate the extruded matrix pipe 600 or the drawn multi-layer pipe 700 in one direction.

The rotary actuator serves to facilitate the extrusion of the matrix pipe 600 by the ram 100 and the drawing of the multi-layer pipe 700 by the drawing unit 300 with less force.

30 A method of manufacturing a multi-layer pipe using the multi-layer pipe-manufacturing apparatus according to an embodiment of the present invention will now be described with reference to FIG. 4.

First, a matrix pipe 600 is formed by inserting one or

more insert pipes 500 having different diameters into a receiving pipe 400 (a first stage S1).

Next, the matrix pipe 600 is introduced into a ram 100 to extrude the matrix pipe 600 with a constant compression or
5 extrusion force (a second stage S23).

Then, the matrix pipe 600 extruded from the ram 100 is introduced into a heat-treatment unit 200 to heat-treat the matrix pipe (a third stage S3).

Subsequently, an end of the matrix pipe 600 heat-treated
10 by the heat treatment unit 200 is clamped and the matrix pipe 600 is drawn with a constant drawing force to form a multi-layer pipe 700 having a desired diameter, using a drawing unit 300 (a fourth stage S4).

Here, the compression force and the drawing force may be
15 the same and may be properly regulated depending on materials and properties of the receiving pipe 400 and the insert pipe 500 along with a design of the multi-layer pipe 700 to be manufactured.

Here, an outer surface of an outermost insert pipe 500
20 inserted into the receiving pipe 400 may come into contact with an inner surface of the receiving pipe 400, and an outer surface of another insert pipe 500 inserted into a former-inserted insert pipe 500 inserted into the receiving pipe 400 may come into contact with an inner surface of the former-
25 inserted insert pipe 500.

That is, like this, in addition to two layers, i.e. the receiving pipe 400 and the insert pipe 500, coming into contact with each other at inner and outer surfaces thereof, respectively, as shown in the drawing, 3 layers, 4 layers or
30 more may come into contact with each other so as to form a multi-layer pipe.

Further, in the third stage S3, specifically, the matrix pipe 600 extruded by the ram 100 may be heat-treated at a temperature ranging from 150 °C to 1350 °C by a heat furnace
35 accommodating the matrix pipe or a high-frequency induction

heater arranged along a circumferential face of the matrix pipe 600.

Thus, according to the present invention, the drawing force of the drawing unit 300 and the extrusion force of the ram 100 may be maintained at the same level and may be held differently depending on materials of the receiving pipe 400 and the insert pipe 500, and then the multi-layer pipe 700 can be drawn and formed by using the mandrel 340 while precisely clamping the multi-layer pipe 700 with the clamp 320.

Further, according to the present invention, respective layers of the multi-layer pipe 700, i.e. the receiving pipe 400 and the insert pipe(s) 500, which constitute the matrix pipe 600, are precisely size-controlled, with the thicknesses thereof maintained to be constant, so that a multi-layer pipe 700 having improved layer-bonding force and dimension precision can be obtained.

Thereafter, correction and faceting processes may be additionally performed on the manufactured multi-layer pipe 700, and a process of checking inner and outer defects of the multi-layer pipe 700 may also be performed.

In the meantime, in order to increase the longitudinal structural strength of the multi-layer pipe 700 in manufacturing the multi-layer pipe 700 using the above-mentioned method, a receiving pipe 400 and an insert pipe 500 as shown in FIGS. 5 and 6 may be employed.

As shown in FIG. 5, the receiving pipe 400 or the insert pipe 500 may be provided, on an outer or inner surface thereof, with a plurality of reinforcing ribs 401 and 501 spaced at regular intervals and linearly extending along a longitudinal direction of the receiving pipe 400 or the insert pipe 500, wherein the reinforcing ribs have alternating linear ridges and valleys.

Thus, when the left pipe is the insert pipe 500 and the right pipe is the receiving pipe 400 in FIG. 5, the reinforcing ribs 501 on the outer surface of the insert pipe 500 are meshed

with linear valleys between the reinforcing ribs 401 on the inner surface of the receiving pipe 400 and then mechanical and metallurgical bonding are performed thereon thereby to form the multi-layer pipe 700 from the matrix pipe 600.

5 Further, as shown in FIG. 6, the receiving pipe 400 or the insert pipe 500 may be provided, on an outer or inner surface thereof, with a plurality of reinforcing ribs 402 and 502 spaced at regular intervals and involutely extending along a longitudinal direction of the receiving pipe 400 or the insert
10 pipe 500, wherein the reinforcing ribs 402 and 502 have alternating involute ridges and valleys.

Thus, when the left pipe is the insert pipe 500 and the right pipe is the receiving pipe 400 in FIG. 6, the reinforcing ribs 502 on the outer surface of the insert pipe 500 are meshed
15 with linear valleys between the reinforcing ribs 402 on the inner surface of the receiving pipe 400 and then mechanical and metallurgical bonding are performed thereon thereby to form the multi-layer pipe 700 from the matrix pipe 600.

Accordingly, the present invention is directed to an
20 apparatus for simultaneously bonding a plurality of pipes both mechanically and metallurgically with a relatively simple configuration and process to economically manufacture a multi-layer pipe, and a method of manufacturing the multi-layer pipe using the same.

25 Although a preferred embodiment of the present invention has been described for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the
30 accompanying claims.

CLAIMS

1. An apparatus for manufacturing a multi-layer pipe, the apparatus comprising:

5 a ram extruding a matrix pipe, which is formed by inserting one or more insert pipes having different diameters into a receiving pipe, with a constant compression force;

a heat-treatment unit heat-treating the matrix pipe extruded from the ram; and

10 a drawing unit drawing, with a constant drawing force, the matrix pipe passing through the heat-treatment unit into a multi-layer pipe having a predefined diameter.

2. The apparatus according to claim 1, wherein the compression force and the drawing force are identical or different.

15 3. The apparatus according to claim 1, wherein an outer surface of an outermost insert pipe inserted into the receiving pipe comes into contact with an inner surface of the receiving pipe, and an outer surface of another insert pipe inserted into a former-inserted insert pipe inserted into the receiving pipe
20 comes into contact with an inner surface of the former-inserted insert pipe.

4. The apparatus according to claim 1, wherein the heat-treatment unit is a heat furnace accommodating the matrix pipe extruded from the ram, or a high-frequency induction heater
25 arranged along a direction in which the matrix pipe extruded from the ram is formed.

5. The apparatus according to claim 4, wherein the high-frequency induction heater includes:

30 a single-frequency generator for high-frequency induction heating bonding of the receiving pipe and the insert pipes that are formed of the same material to constitute the matrix pipe; and

a multi-frequency generator for high-frequency induction

heating bonding of the receiving pipe and the insert pipes, respectively, that are respectively formed of different materials to constitute the matrix pipe.

5 6. The apparatus according to claim 1, wherein the drawing unit includes:

 a die having an extrusion hole section through which the multi-layer pipe is extruded from the ram into a smaller outer diameter relative to that of the matrix pipe;

10 a clamp clamping an end of the multi-layer pipe extruded from the die; and

 a carrier carrying the multi-layer pipe with a constant drawing force along a direction of the multi-layer pipe being extruded, the clamp being provided to the carrier.

15 7. The apparatus according to claim 6, wherein the extrusion hole section includes:

 a first end hole having a first diameter that is disposed on a first side of the die so as to face the ram;

20 a middle hole disposed in the die concentrically with the first end hole and having a second diameter smaller than the first diameter;

 a second end hole disposed on a second side of the die opposite to the first side, concentrically with the middle hole and having the second diameter;

25 a first extrusion guide part connecting the first end hole and the middle hole and having a diameter decreasing towards the carrier; and

 a second extrusion guide part connecting the middle hole and the second end hole and having a constant diameter towards the carrier,

30 wherein the first diameter corresponds to an outer diameter of the matrix pipe and the second diameter corresponds to an outer diameter of the multi-layer pipe.

8. The apparatus according to claim 6, wherein the drawing unit further includes a mandrel extending from the carrier towards the ram separately from the clamp and disposed at the center of the clamp so as to, when inserted into the multi-layer pipe, maintain an inner diameter of the multi-layer pipe to be constant.

9. The apparatus according to claim 6, wherein the clamp is provided with a plurality of chucks attached to the carrier and radially arranged so as to be separated from or to contact an outer surface of the multi-layer pipe.

10. The apparatus according to claim 1, wherein the receiving pipe and the insert pipes are formed of the same material or different materials.

11. The apparatus according to claim 1, wherein the receiving pipe and the insert pipes are any one of an electric resistance welding (ERW) pipe and a seamless pipe.

12. The apparatus according to claim 1, wherein the insertion pipe is formed of one of stainless steel, aluminum, aluminum alloy, copper, copper alloy, nickel, nickel alloy, and a combination thereof.

13. The apparatus according to claim 1, wherein the receiving pipe is formed of one of carbon steel, cobalt-base alloy steel, aluminum, aluminum alloy, brass, high manganese steel, and a combination thereof.

14. The apparatus according to claim 1, wherein the receiving pipe or the insert pipe is provided, on an outer or inner surface thereof, with a plurality of reinforcing ribs spaced at regular intervals and linearly extending along a longitudinal direction of the receiving pipe or the insert pipe, the reinforcing ribs having alternating linear ridges and valleys.

15. The apparatus according to claim 1, wherein the receiving pipe or the insert pipe is provided, on an outer or inner surface thereof, with a plurality of reinforcing ribs spaced at regular intervals and involutely extending along a

longitudinal direction of the receiving pipe or the insert pipe, the reinforcing ribs having alternating involute ridges and valleys.

5 16. The apparatus according to claim 1, further comprising a rotary actuator provided in one or both of the ram and the drawing unit and driven to rotate the extruded matrix pipe or the drawn multi-layer pipe in one direction.

10 17. The apparatus according to claim 6, wherein the extrusion guide parts are provided with a duplex physical vapor deposition (PVD) coating layer or a diamond-like-carbon (DLC) coating layer.

15 18. The apparatus according to claim 8, wherein the mandrel is provided, on an outer surface thereof, with a duplex physical vapor deposition (PVD) coating layer or a diamond-like-carbon (DLC) coating layer.

19. A method of manufacturing a multi-layer pipe using an apparatus for manufacturing a multi-layer pipe, the method comprising:

20 a first stage of forming a matrix pipe by inserting one or more insert pipes having different diameters into a receiving pipe;

a second stage of introducing the matrix pipe into a ram to extrude the matrix pipe with a constant compression or extrusion force;

25 a third stage of introducing the matrix pipe extruded from the ram into a heat-treatment unit to heat-treat the matrix pipe; and

30 a fourth stage of clamping an end of the matrix pipe heat-treated by the heat treatment unit and drawing the matrix pipe with a constant drawing force to form a multi-layer pipe having a desired diameter, using a drawing unit.

20. The method according to claim 19, wherein an outer surface of an outermost insert pipe inserted into the receiving pipe comes into contact with an inner surface of the receiving

pipe, and an outer surface of another insert pipe inserted into a former-inserted insert pipe inserted into the receiving pipe comes into contact with an inner surface of the former-inserted insert pipe.

- 5 21. The method according to claim 19, wherein in the third stage, the matrix pipe extruded by the ram is heat-treated at a temperature ranging from 150 °C to 1350 °C by a heat furnace accommodating the matrix pipe or a high-frequency induction heater arranged along a circumferential face of the matrix
10 pipe.