

PIPE AND METHOD OF JOINING PIPES

FIELD OF THE INVENTION

The present invention relates to pipes and a method of joining pipes. In particular, the invention relates to pipes for use in the oil and gas industry.

BACKGROUND TO THE INVENTION

The following discussion of the background to the invention is intended to facilitate an understanding of the present invention. However, it should be appreciated that the discussion is not an acknowledgment or admission that any of the material referred to was published, known or part of the common general knowledge in any jurisdiction as at the priority date of the application.

Pipes are typically used to convey and transport fluids, which include but are not limited to gases and liquids. Pipes or pipe segments may be joined together by methods known in the art to create a suitable pipeline, where such methods include but are not limited to welding.

Typically, a subsea pipeline network is developed by assembling a large number of pipe segments either onshore or offshore. Offshore pipeline construction involves two major procedures: 1) assembling a few pipe segments into a line on board a pipe-laying vessel; and 2) lowering the line while connecting pipe segments to the line to install a full line along the desired route. Examples of installation methods include the S-Lay, J-Lay, Pull/tow and Reel-Lay. The choice of the installation method usually depends on factors such as physical and environmental conditions, availability of equipment and costs, water depth, pipeline length and diameter.

Assembling a large number of pipe segments on board a pipe-laying vessel requires a massive and complex set-up on-board, which comprises of equipment such as pipe handling conveyors, welding stations, X-ray equipment and joint-coating modules. This on-site pipeline assembly approach, referred to as lay-barge construction, is known for its versatility and self-contained nature as it

needs relatively little external support. However, the costs associated with deploying such a vessel is huge.

When assembling the large number of pipe segments offshore, the welding step usually involves several steps at multiple stations. Since cement coated mild steel pipes are typically used for the pipelines, joining these pipes at their naked ends through welding makes the joints vulnerable to corrosion when being laid in a subsea environment. Accordingly, post-treatment of the welded joints, such as applying an additional coating to protect the welded joints from corrosion, is required because welding makes the joints vulnerable to corrosion. Consequently, this contributes to making the assembling step tedious and time consuming. In addition, the equipment for the multiple stations meant only for the different stages of welding makes the assembly facility complex and expensive.

In view of the foregoing limitations, there exists a need to develop a pipe that is corrosion-resistant, particularly when subjected to welding. In addition, there is also a need to develop a simple and cost effective method of joining corrosion-resistant pipes.

SUMMARY OF THE INVENTION

According to a first aspect of the present invention, there is provided a pipe comprising: a first end portion comprising a first corrosion-resistant material; a second end portion comprising a second corrosion-resistant material; and a middle portion located between the first end portion and the second end portion; wherein the middle portion comprises a material that is different from the first and second corrosion-resistant materials.

Preferably, the first end portion, second end portion and middle portion form a unitary pipe structure.

Preferably, the first corrosion-resistant material is the same as the second corrosion-resistant material.

Preferably, the first corrosion-resistant material is different from the second corrosion-resistant material.

Preferably, the material of the middle portion and the first and second corrosion-resistant materials are metals and/or metal alloys.

Preferably, the material of the middle section comprises mild steel.

Preferably, the first and second corrosion-resistant materials comprise
5 stainless steel, zinc, titanium or a titanium alloy.

Preferably, the pipe further comprises a corrosion-resistant coating on an inner surface of the middle portion.

Preferably, the pipe further comprises a corrosion-resistant coating on an outer surface of the middle portion.

10 Preferably, the corrosion-resistant coating covers at least a portion of an inner and/or outer surface of the first end portion and/or at least a portion of an inner and/or outer surface of the second end portion.

Preferably, the corrosion-resistant coating comprises cement, stainless steel, zinc, titanium or a titanium alloy.

15 Preferably, the first end portion, second end portion and middle portion are arranged coaxially in series.

Preferably, the pipe is an oil and gas pipe.

According to a second aspect of the present invention, there is provided a method of joining pipes, comprising: providing two or more pipes as described
20 above; and joining the pipes to form a corrosion-resistant joint between one end portion and another end portion.

Preferably, the step of joining the pipes makes use of heat.

Preferably, the step of joining the pipes comprises friction welding or arc welding.

25 Preferably, the method further comprises the step of coating a corrosion-resistant coating on an inner surface of the middle portion.

Preferably, the method further comprises the step of coating a corrosion-resistant coating on an outer surface of the middle portion.

Preferably, the method further comprises the step of coating the corrosion-
30 resistant coating on at least a portion of an inner and/or outer surface of the first

end portion and/or at least a portion an inner and/or outer surface of the second end portion.

Preferably, the corrosion-resistant coating comprises cement, stainless steel, zinc, titanium or a titanium alloy.

5 Preferably, the method further comprises the step of placing an intermediate corrosion-resistant portion between one pipe and another pipe.

BRIEF DESCRIPTION OF THE DRAWINGS

10 The invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Fig. 1 illustrates an embodiment of pipes of the present invention adapted to connect to one another;

15 Fig. 2(a) provides a perspective view of an embodiment of pipes of the present invention. Fig. 2(b) illustrates a longitudinal cross-sectional view of the interior of a pipe in accordance with an embodiment of the present invention;

Fig. 3 illustrates the steps of forming and fabricating a pipe in accordance with an embodiment of the present invention;

Fig. 4 illustrates the joining via rotational friction welding, of two pipes in accordance with another embodiment of the present invention;

20 Fig. 5(a), 5(b) and 5(c) illustrate the joining via rotational friction welding, of two pipes comprising a corrosion-resistant coating in accordance with an embodiment of the present invention;

25 Fig. 6 illustrates the joining via rotational friction welding, of two pipes using an intermediate corrosion-resistant portion in accordance with another embodiment of the present invention;

Fig. 7(a), 7(b) and 7(c) illustrate the joining via rotational friction welding, of two pipes comprising a corrosion-resistant coating in accordance with an embodiment of the present invention.

30 Other arrangements of the invention are possible and, consequently, the accompanying drawings are not to be understood as superseding the generality of the preceding description of the invention.

PREFERRED EMBODIMENTS OF THE INVENTION

Particular embodiments of the present invention will now be described with reference to the accompanying drawings. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of the present invention. Other definitions for selected terms used herein may be found within the detailed description of the invention and apply throughout the description. Additionally, unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one or ordinary skill in the art to which this invention belongs. Where possible, the same reference numerals are used throughout the figures for clarity and consistency.

Unless specified otherwise, the terms “comprising” and “comprise”, and grammatical variants thereof, are intended to represent “open” or “inclusive” language such that they include recited elements but also permit inclusion of additional, unrecited elements.

Unless specified otherwise, the term “about” typically means $\pm 5\%$ of the stated value, more typically $\pm 4\%$ of the stated value, more typically $\pm 3\%$ of the stated value, more typically $\pm 2\%$ of the stated value, even more typically $\pm 1\%$ of the stated value, and even more typically $\pm 0.5\%$ of the stated value.

The term “pipe” or “pipe structure” used throughout the specification will have the ordinary meaning in the art and will be understood by a skilled person to refer to a structure, means or conduit for conveying or transporting fluids. For example, a pipe or pipe structure can comprise of more than one tubular portions or hollow cylinders, usually but not necessarily of circular cross-section, such as a first end portion, a second end portion and a middle portion located between the first end portion and the second end portion. Examples of fluids include but are not limited to liquids, gases, emulsions, suspensions, slurries, powders and masses of small solids.

The term “unitary” used throughout the specification will have the ordinary meaning in the art and will be understood by a skilled person to refer to a structure that is a single unit. For example, a unitary pipe structure is defined herein as a

pipe structure that is a one-piece, uniform pipe structure that does not require the use of an intermediate portion separate from the pipe structure to join two pipes together. Preferably, the surface of a unitary pipe structure is continuous. It will be appreciated that if a unitary unit has been fabricated using pre-fabricated parts, it will not be possible to disassemble the unitary unit into its parts without destroying and/or damaging the unitary unit and/or its parts.

The term "material" used throughout the specification will have the ordinary meaning in the art and will be understood by a skilled person to refer to a substance or a mixture of substances, which may or may not be corrosion-resistant. Examples of a material include a metal, metal alloy, ceramic, concrete and plastic.

The term "corrosion-resistant" used throughout the specification will have the ordinary meaning in the art and will be understood by a skilled person to refer to a material that can substantially withstand damage caused by oxidization or other chemical reactions. When used in the context of a corrosion-resistant joint, such a joint can substantially withstand damage caused by oxidation or other chemical reactions. In other words, a corrosion-resistant joint is not vulnerable to corrosion. Preferably, a corrosion-resistant joint does not require post treatment, such as applying an additional coating to protect the joint from corrosion.

The term "joint" used throughout the specification will have the ordinary meaning in the art and will be understood by a skilled person to refer to the area where a portion of an article, e.g. a pipe is connected to a portion of another article, e.g. a pipe. For example, a joint is formed when a second end portion of pipe 10 is joined to a first end portion 12' of another pipe 10' (Fig. 4).

The terms "mild steel" and "low-carbon steel" are used interchangeably and when used throughout the specification will have the ordinary meaning in the art and will be understood by a skilled person to refer to the most common form of steel because of its relatively low cost compared to stainless steel. Mild steel or low-carbon steel is defined herein as an alloy which has high tensile strength and is less corrosion-resistant than stainless steel.

The term "stainless steel" used throughout the specification will have the ordinary meaning in the art and will be understood by a skilled person to refer to a steel alloy which does not stain, corrode or rust as easily as mild steel (it "stains less"), but it is not stain-proof. Stainless steel differs from mild steel by the amount of chromium present. The amount of chromium present is sufficient so that a passive film of chromium oxide, which prevents corrosion, may form.

The term "alloy" used throughout the specification will have the ordinary meaning in the art and will be understood by a skilled person to refer to a mixture of metals or a mixture of a metal and another element.

The term "coaxial" used throughout the specification will have the ordinary meaning in the art and will be understood by a skilled person to refer to a configuration wherein two or more three-dimensional linear forms share a common axis. For example, when a first end portion, a middle portion and a second end portion of a pipe are arranged coaxially in series, fluids, such as liquids and gases, emulsions, suspensions, slurries, powders and masses of small solids, are conveyed in a fluid-like manner.

Exemplary, non-limiting embodiments of a pipe will now be disclosed. Unless otherwise indicated, exemplary, non-limiting embodiments of the pipe will be described using pipe 10 in Fig. 1 as an illustration. The pipe 10 comprises three portions: a first end portion 12, a middle portion 14 and a second end portion 16. The first end portion 12, middle portion 14 and second end portion 16 may be arranged coaxially in series. The middle portion 14 is located between the first end portion 12 and the second end portion 16. Pipe 10 is preferably a one-piece, unitary pipe structure where more preferably, the inner and/or outer surface of the first end portion 12, middle portion 14 and second end portion 16 are continuous. The first end portion 12, middle portion 14 and second end portion 16 may be fused/joined by means known in the art, which include but is not limited to welding, to form the one-piece, unitary pipe 10. These portions may also be forged to form the one-piece, unitary pipe 10. Having the first end portion 12 and second end portion 16 in the pipe 10 avoids the need for separate components

such as an intermediate portion for joining two pipes together. This may lead to a shorter assembly time and result in a more efficient method of joining pipes.

The portions of pipe 10 may be adapted to achieve a maximum surface area of contact. The first end portion 12, the second end portion 16 and the middle portion 14 of the pipe are preferably a tubular portion or hollow cylinder, usually but not necessarily of circular cross-section. In addition, the interface surfaces of the portions are preferably continuous along the same plane. Consequently, the surface area of contact may be significantly greater than portions having non-cylindrical shapes, such as a conical or a frustoconical shape. This may lead to the formation of a stronger joint which is more corrosion-resistant. In another preferred embodiment, the portions of pipe 10 are not threaded, be it helically threaded or concentrically threaded. This may advantageously overcome the need to make threaded portions, which may require more complex machinery and more time to manufacture than non-threaded portions. Under severe operating conditions (compression and excess torque), particularly in the context of oil and gas pipes, deformations can occur in threaded portions and result in unsealing of the threaded joint. As the portions of pipe 10 are not threaded (i.e. unthreaded), the welded joint is tighter and forms a stronger weld which may be more resistant to deformations under severe operating conditions. Furthermore, joining the pipes through welding may be easier and faster. This is because pipes having threaded ends (male or female connectors) need a very precise alignment before they are connected through end to end, which results in more time spent in aligning such pipes. It is significantly more challenging to connect pipes having threaded ends, for instance, through welding, because even a slight misalignment in the male and female connectors may result in permanent damage. Consequently, the damaged pipe would not be usable, which results in an increase in costs. Due to the delicate nature of the threads, pipes having threaded ends are vulnerable to damage during the process of connecting, transporting, handling and aligning of these pipes. Advantageously, the aforementioned challenges are circumvented because the portions of pipe 10 are not threaded.

Consequently, pipe 10 of the present invention is adapted to connect to another pipe 10' through welding, preferably friction welding.

The first end portion 12 and the second end portion 16 can have similar and/or different cross-sectional inner and/or outer diameters. Preferably, the first end portion 12 and the second end portion 16 have a similar circular cross-section of a desired inner diameter. The middle portion 14 may have a circular cross-section having a similar inner diameter as the first end portion 12 and the second end portion 16. Alternatively, the middle portion 14 may have a circular cross-section of a different inner diameter from the first end portion 12 and the second end portion 16.

Pipe 10 is preferably used in conveying fluids in the oil and gas industry. Typically, corrosion of oil and gas pipes occur when the pipe material is damaged and exposed to the environment, where such pipe material is subjected to oxidization and/or other chemical reactions. Such corrosion not only increases costs in maintenance, but it can lead to a potential safety hazard when it is overlooked or proper maintenance is not in place. Consequently, there is a need for corrosion-resistant pipes to reduce maintenance costs and the safety risks that corrosion poses. Advantageously, the choice of material used for the first end portion 12, the second end portion 16 and the middle portion 14 of the pipe 10 may result in a relatively low cost pipe having high tensile strength and which is corrosion-resistant. The first end portion 12 may comprise a first corrosion-resistant material. The second end portion 16 may comprise a second corrosion-resistant material. The first corrosion-resistant material may be the same as the second corrosion-resistant material. Alternatively, the first corrosion-resistant material may be different from the second corrosion-resistant material. The first and second corrosion-resistant materials may be a metal or metal alloy. The metal or metal alloy of the first and second corrosion-resistant materials may include but is not limited to stainless steel, zinc, titanium or a titanium alloy. The middle portion 14 may comprise a material that is different from the first and second corrosion-resistant materials. The material of the middle portion 14 may be a metal or metal alloy which may or may not be corrosion-resistant. Examples

of the material used for the middle portion 14 include but is not limited to aluminium, aluminium alloy, zinc, titanium, titanium alloy, mild steel, copper-based alloy and beryllium-based alloy.

5 In a preferred embodiment, the corrosion-resistant material for the first end portion 12 and the second end portion 16 is stainless steel, while the material for the middle portion 14 is mild steel. Mild steel is known to be stiff and strong, and is more widely used than stainless steel due to its relatively lower cost. However, stainless steel is more corrosion-resistant than mild steel. By combining the use of mild steel and stainless steel for the various portions of the pipe 10, a relatively low cost pipe having high tensile strength and corrosion resistance may be obtained. Advantageously, there is no need for post treatment of a welded joint after two pipes of the present invention are joined together or the need for a separate intermediate portion for welding two pipes of the present invention together. In particular, there is no need for an additional corrosion-resistant coating after welding two pipes together. Consequently, this may reduce the requirement of huge and complex equipment for pipe assembly onshore or on board a pipe-laying vessel, and may reduce the overall cost of installation, at the same time, provide substantially complete corrosion protection to the welded joints such that the life span of the pipeline may be increased. Furthermore, the resultant pipeline network may advantageously be able to resist collapse if subjected to high seawater pressure at large depths.

Typically, pipes are coated with a corrosion-resistant coating prior to being joined together. However during the joining process, e.g. via welding, the corrosion-resistant coating and/or the pipe material becomes damaged around the joint area, thereby exposing the pipes to the environment and causing them to be susceptible to corrosion. Therefore, pipes known in the art (i.e. pipes that do not have a stainless steel first end portion 12 and a stainless steel second end portion 16) will require post-joining treatment, such as the application of an additional corrosion-resistant coating, so that the welded joint would be made corrosion-resistant.

The length of the first end portion 12, middle portion 14 and second end portion 16 may be adjusted to suit various needs and applications. The length of the first end portion 12 and the second end portion 16 may be selected such that a corrosion-resistant joint may be formed when two pipes are joined together. In addition, the length of the middle portion 14 may be selected such that the resultant pipe 10 has the properties suited for the desired application, such as tensile strength. Advantageously, the selection of the length of the first end portion 12, middle portion 14 and second end portion 16 may result in a cost effective pipe having properties suited for the desired application. For instance, in a preferred embodiment, the pipe 10 comprises three portions, wherein the length of the first end portion 12 is about 0.5 m, the length of the middle portion 14 is about 14.0 m and the length of the second end portion 16 is about 0.5 m. As such, the amount of stainless steel used is significantly less than the amount of mild steel used. This may advantageously lead to a relatively low cost pipe having high tensile strength and corrosion resistance.

Pipe 10 can comprise a corrosion-resistant coating. The middle portion 14 may further comprise a corrosion-resistant coating on an inner surface of the middle portion 14. In some embodiments, the corrosion-resistant coating on the inner surface of the middle portion 14 can have a thickness between about 2 mm to about 5 mm. In addition, the middle portion 14 may further comprise a corrosion-resistant coating on an outer surface of the middle portion 14. In some embodiments, the corrosion-resistant coating on the outer surface of the middle portion 14 can have a thickness between about 2 mm to about 5 mm. The corrosion-resistant coating may cover at least a portion of the first end portion 12 and/or at least a portion of the second end portion 16. The corrosion-resistant coating includes but is not limited to resins, polymers (e.g. polytetrafluoroethylene (PTFE)), ceramics (e.g. cement), metals (e.g. titanium and zinc) and metal alloys (e.g. stainless steel and titanium alloy).

As illustrated in Fig. 2(a) and 2(b) and in accordance with a preferred embodiment of the invention, pipe 10 can comprise a first corrosion-resistant coating 18 on the inner surface of the entire length of middle portion 14, extending

to a portion of first end portion 12 and a portion of second end portion 16. In addition, a second corrosion-resistant coating 20 may be applied on the outer surface of the entire length middle portion 14, which can extend to cover a portion of first end portion 12 and a portion of second end portion 16. The corrosion-resistant coating 18 and corrosion-resistant coating 20 include but are not limited to resins, polymers (e.g. polytetrafluoroethylene (PTFE)), ceramics (e.g. cement), metals (e.g. titanium and zinc) and metal alloys (e.g. stainless steel and titanium alloy). In a preferred embodiment, the corrosion-resistant coating 18 and corrosion-resistant coating 20 each extends over about 12 m length of a pipe which has a total length of about 15.0 m.

Other materials and/or coatings may be provided in the inner (interior) or outer (exterior) surfaces of the first end portion 12, second end portion 16 and/or middle portion 14 of the pipe which may be metallic or non-metallic and which may be provided to perform a function or functions other than/as well as corrosion resistance, such as ensuring the flow properties of the pipe, insulating the pipe, or other protective functions.

Exemplary, non-limiting embodiments of a method of joining pipes will now be disclosed.

Fig. 3 illustrates a method of forming and fabricating a pipe of the present invention comprising the step of providing a first end portion 12 comprising a first corrosion-resistant material, a second end portion 16 comprising a second corrosion-resistant material and a middle portion 14 comprising a material that is different from the first corrosion-resistant material and the second corrosion-resistant material. The first end portion 12, middle portion 14 and second end portion 16 may be arranged coaxially in series such that the middle portion 14 is located between to the first end portion 12 and the second end portion 16. The first end portion 12, middle portion 14 and second end portion 16 are then joined such that a one-piece pipe 10, having a unitary pipe structure is formed. The first end portion 12, middle portion 14 and second end portion 16 may be fused/joined by means known in the art, which include but is not limited to welding. These portions may also be forged to form the one-piece, unitary pipe 10. Regardless

of the means used to fuse/join the first end portion 12, middle portion 14 and second end portion 16, a corrosion-resistant coating may be applied to the inner and/or outer surface of the first end portion 12, middle portion 14 and second end portion 16 after these portions have been fused/joined together.

5 In accordance with another embodiment, the method of joining pipes comprises the step of providing two or more pipes as described above and joining the pipes to form a corrosion-resistant joint between one end portion and another end portion. As illustrated in Fig. 4, the method of joining pipes comprises the step of providing a first pipe 10, providing a second pipe 10', and joining the first
10 pipe 10 to the second pipe 10'. It will be appreciated that there will be various ways of joining pipe 10 to pipe 10', which include, joining the second end portion 16 of pipe 10 to the first end portion 12' of pipe 10'; joining the first end portion 12 of pipe 10 to the second end portion 16' of pipe 10'; or joining the first end portions 12, 12' or the second end portions 16, 16' of pipes 10, 10' together.

15 The first end portion (12, 12') and the second end portion (16, 16') advantageously allows two pipes (10, 10') to be joined by a method which makes use of heat. In some embodiments, the working temperature may be between about 900°C to about 1100°C. The step of joining the first pipe 10 to the second pipe 10' may comprise friction welding, such as linear friction welding, rotational
20 friction welding and friction stir welding, or arc welding.

 In accordance with a preferred embodiment, the step of joining the first pipe 10 to the second pipe 10' comprises friction welding, or more preferably, rotational friction welding. In friction welding, there is almost no generation of heat in parts other than the surface of the portions being joined, and plastic flow occurs
25 at the surface of the portions to be joined. Accordingly, not only is the energy sufficiently high, but there are other excellent merits such as the attainment of maximum bond strength through this solid-state joining process. Furthermore, friction welding affords a range of selection of combination of corrosion-resistant metals of different kinds. Friction welding creates a resulting joint of forged quality
30 which can have the same properties as the pre-welded material. Regardless of the type of welding used, a strong joint which is not vulnerable to corrosion can

be formed between the first and/or second end portions of pipes 10, 10'. Advantageously, the joining of the first pipe 10 to the second pipe 10' can occur without reducing the mechanical characteristics of the joined portions or causing significant dimensional changes. More advantageously, post-treatment of the welded joint, which can comprise applying an additional coating to protect the welded joint from corrosion, is not required because of the formation of a strong joint that is not vulnerable to corrosion. In other words, the strong welded joint does not need to be coated any further. Thus, the set-up on-board a pipe-laying vessel can be smaller, less complex and cheaper. In addition, there is a savings in time because of the less complex approach.

In a preferred embodiment and as illustrated in Figs. 4, 5(a), 5(b) and 5(c), if both the first pipe 10 and second pipe 10' have a small cross-section, the second pipe 10' may be rotated about its longitudinal axis L, in the direction as indicated by the arrow 22, through a known rotating mechanism and pressurized in, for example, axially towards the direction indicated by the arrow 24 (direction of the welding (or forging) force), against the first pipe 10, such that a strong joint which is not vulnerable to corrosion is formed.

Rotational friction welding is known in the art and by way of example and with reference to Figs. 5(a)-(c), the pipe 10' is rotated at a frequency of about 400 to about 1200 revolutions per minute (rpm), and the first pipe 10 and second pipe 10' are preferably pressed together at a pressure of about 14,000 pounds per square inch (psi) to about 60,000 psi.

Alternatively, and as illustrated in Figs. 6, 7(a), 7(b) and 7(c), if both the first pipe 10 and second pipe 10' have a large cross-section such that rotation is not possible, an intermediate corrosion-resistant pipe portion 26 such as a stainless steel pipe portion of similar cross-section but having a shorter length can be placed between the first pipe 10 and second pipe 10', such that the intermediate stainless steel pipe portion 26 can be rotated about the longitudinal axis L, in the direction indicated by the arrow 22', through a known rotating mechanism and pressurized in, for example, axially towards the direction indicated by the arrow 24' (direction of the welding (or forging) force), against the first pipe 10 to achieve

friction welding. Thus, friction welding can be achieved at both ends of the intermediate corrosion-resistant pipe portion 26. Advantageously, the resultant connected pipes retain their mechanical characteristics and do not have significant dimensional changes.

5 Alternatively, if both the first pipe 10 and second pipe 10' have a large cross-section, friction stir welding may be used instead. Advantageously, friction stir welding is a "green" technology due to its energy efficiency, environment friendliness, and versatility.

10 The method may further comprise coating a corrosion-resistant coating on an inner surface of the middle portion 14. The method may further comprise coating a corrosion-resistant coating on an outer surface of the middle portion 14. Such coatings can be carried out by methods and mechanisms known in the art. Depending on application, the coating of the inner and/or outer surfaces of the middle portion 14 can occur before or after the joining of the pipes of the present
15 invention. The corrosion-resistant coating may cover at least an inner and/or outer surface of a portion of the first end portion 12 and/or at least an inner and/or outer surface of a portion of the second end portion 16. The corrosion-resistant coating includes but is not limited to resins, polymers (e.g. polytetrafluoroethylene (PTFE)), ceramics (e.g. cement), metals (e.g. titanium and zinc) and metal alloys
20 (e.g. stainless steel and titanium alloy).

 The disclosed method can be advantageously applied to the S-lay or J-lay systems, where the pipeline assembly is done at the installation site, on board a pipe-laying vessel.

25 The pipes and method of the present invention may be applicable for environments where there is a high risk of corrosion, such that the present invention may have applications beyond that of offshore applications.

 Furthermore, although individual embodiments have been discussed it is to be understood that the invention covers combinations of the embodiments that have been discussed as well.

Claims

1. A pipe, comprising:

a first end portion comprising a first corrosion-resistant material;

a second end portion comprising a second corrosion-resistant material; and

a middle portion located between the first end portion and the second end portion;

wherein the middle portion comprises a material that is different from the first and second corrosion-resistant materials.

2. The pipe of claim 1, wherein the first end portion, second end portion and middle portion form a unitary pipe structure.

3. The pipe of claim 1 or 2, wherein the first corrosion-resistant material is the same as the second corrosion-resistant material.

4. The pipe of claim 1 or 2, wherein the first corrosion-resistant material is different from the second corrosion-resistant material.

5. The pipe of any one of the preceding claims, wherein the material of the middle portion and the first and second corrosion-resistant materials are metals and/or metal alloys.

6. The pipe of claim 5, wherein the material of the middle section comprises mild steel.

7. The pipe of claim 5, wherein the first and second corrosion-resistant materials comprise stainless steel, zinc, titanium or a titanium alloy.

8. The pipe of any one of the preceding claims, further comprising a corrosion-resistant coating on an inner surface of the middle portion.

5 9. The pipe of any one of the preceding claims, further comprising a corrosion-resistant coating on an outer surface of the middle portion.

10. The pipe of claims 8 or 9, wherein the corrosion-resistant coating covers at least a portion of an inner and/or outer surface of the first end portion and/or at least a portion of an inner and/or outer surface of the second end portion.

11. The pipe of any one of claims 8 to 10, wherein the corrosion-resistant coating comprises cement, stainless steel, zinc, titanium or a titanium alloy.

12. The pipe of any one of the preceding claims, wherein the first end portion, second end portion and middle portion are arranged coaxially in series.

13. The pipe of any one of the preceding claims, wherein the pipe is an oil and gas pipe.

14. A method of joining pipes, comprising:

- 25 a. providing two or more pipes according to any one of claims 1 to 13; and
- b. joining the pipes to form a corrosion-resistant joint between one end portion and another end portion.

15. The method of claim 14, wherein the step of joining the pipes makes use of heat.

16. The method of claim 15, wherein the step of joining the pipes comprises friction welding or arc welding.

5 17. The method of any one of claims 14 to 16, further comprising the step of coating a corrosion-resistant coating on an inner surface of the middle portion.

10 18. The method of any one of claims 14 to 17, further comprising the step of coating a corrosion-resistant coating on an outer surface of the middle portion.

15 19. The method of claim 17 or 18, further comprising the step of coating the corrosion-resistant coating on at least a portion of an inner and/or outer surface of the first end portion and/or at least a portion an inner and/or outer surface of the second end portion.

20 20. The method of any one of claims 17 to 19, wherein the corrosion-resistant coating comprises cement, stainless steel, zinc, titanium or a titanium alloy.

25 21. The method of any one of claims 14 to 20, further comprising the step of placing an intermediate corrosion-resistant portion between one pipe and another pipe.