A pipe (10) such as a composite pipe for use in applications in, e.g., the oil and gas industry, and methods of manufacture thereof, comprises a connection portion (20) adapted to engage a structure. The connection portion (20) is formed integrally with the pipe by melting and solidifying the material of the pipe and the connector to fuse said pipe and connector together.
Pipe with Connector and Method for Forming Same

FIELD OF THE INVENTION

The present invention relates to connecting composite pipes for use in applications, e.g., the oil and gas industry, which include an integrated connector, e.g. an end connector, and to methods of manufacturing such.

BACKGROUND TO THE INVENTION

Composite pipes are used in many industries, such as in the oil and gas industry for the confined transportation of fluids and equipment associated with hydrocarbon recovery from a subterranean reservoir. For example, composite risers, flow lines and jumpers are known in the art.

Such pipes are manufactured in sections of various lengths, which sections may require connecting to secure one pipe section to another pipe section, or to another piece of equipment or apparatus such as a container, a tank, a manifold, a pump or the like.

Typically, connection between an end portion of a pipe and an end portion of another pipe or another member may occur by use of a connector, which may abut and/or partially overlap the end portions of the pipe(s)/other member. Such indirect connections may cause damage to the pipe and/or failure of the connection. This may be of particular relevance when composite pipes are used, for example when a composite pipe possesses heterogeneous mechanical properties resulting from a particular orientation of the fibres within the matrix.

A composite pipe with a connector is disclosed in WO 2007/027089, wherein a connector is formed during the process of manufacturing the pipe.

SUMMARY OF THE INVENTION

An aspect of the present invention relates to a method of forming a pipe with an integral connector, comprising:

- providing a preformed pipe comprising a composite material having at least a matrix and a plurality of reinforcing elements embedded within the matrix;
- mounting a connector relative to the preformed pipe; and
- melting and solidifying the material of the pipe and the connector to fuse said pipe and connector together.
Accordingly, such fusion between the pipe and the connector may define a consolidated or monolithic structure. This may integrally secure the connector and the pipe.

Fusing the connector on a preformed pipe may avoid complexities associated with forming a connector as part of the pipe design and manufacturing process.

The connector, when fused and consolidated with the pipe, may subsequently be used to connect the pipe to a further component or structure, such as another connection member, another pipe or the like.

The connector may comprise or define a flange structure. The connector may define a threaded structure. The connector may define a load shoulder profile. The connector may define a no-go profile. The connector may define a connect profile, such as a quick connect profile. For example, the connector may define one or more collets. The connector may define one or more recesses configured to receive, for example in a locking manner, complimentary elements, such as collet elements, of a structure to which connection is to be made.

A structure to which the pipe is or is to be connected may comprise a further pipe such as an end region thereof, or an auxiliary structure, e.g. equipment such as a container, a tank, a manifold, a pump or the like.

In use, the connector may be configured to permit the pipe to be connected to a structure directly, or indirectly, e.g. via an interface such as one or more engagement members adapted to engage an end region of the pipe.

The connector may comprise one or more receiving portions, e.g. holes or apertures, arranged for receiving fixing members such as bolts, screws or the like. The one or more receiving portions may be substantially axial, e.g. substantially aligned with or parallel to an axis, e.g. a longitudinal axis, of the pipe. By such provision, axial connection of the pipe with a structure, e.g. further pipe or auxiliary structure, may be possible.

In use, the one or more receiving portions of the pipe may be substantially aligned with one or more receiving portions of a further pipe or with one or more receiving portions of an auxiliary structure. By such provision, the pipe may be secured or attached to the further pipe or the auxiliary structure by provision of fixing members such as bolts, screws or the like.

The connector may be secured or attached to a further pipe or an auxiliary structure, e.g. a connection portion thereof, by provision of clips, clamps or the like.
The connector may comprise an end face or end surface for engaging, e.g. contacting or abutting a structure, e.g. further pipe or auxiliary structure.

The connector may comprise a composite material formed of at least a matrix and one or more reinforcing elements embedded within the matrix.

The one or more reinforcing elements of the composite material of the pipe and/or the connector may comprise one or more reinforcing fibres, nanotubes, carbon nanotubes or the like.

The method may comprise melting the matrix material of the pipe and connector such that the matrix of the pipe and connector become fused. Such an arrangement may establish a matrix which extends continuously between the pipe and connector.

The pipe and connector may comprise similar composite materials, such as similar matrix material. This arrangement may facilitate improved fusion between the pipe and connector, avoiding any issues with potential material incompatibilities.

In some embodiments the pipe and connection may comprise dissimilar composite materials, such as dissimilar matrix materials, reinforcing element material or the like.

The method may comprise melting the material of the connector and the pipe in the region of a boundary therebetween.

The method may comprise melting the material of the connector subsequent to, prior to and/or simultaneously with the step of mounting said connector on the pipe.

The method may comprise melting the material of the pipe subsequent to, prior to and/or simultaneously with the step of mounting the connector on the pipe.

The method may comprise simultaneously melting the material of the pipe and the material of the connector when mounted relative to each other. Such simultaneous melting may facilitate and robust fusion to be achieved between the connector and the pipe.

The method may comprise heating the material of one or both of the pipe and connector using at least one of electromagnetic energy such as microwave radiation, optical radiation, an electric current, mechanical excitation, acoustic energy, a chemical reaction, friction heating and the like.

The method may comprise heating the material of one of the pipe and connector by heat energy from the other of the pipe and connector, for example heat energy from the other of the pipe and connector when in a molten state. For example, the material of one of the pipe and connector may be at a temperature which is
sufficient to cause melting of the material of the other of the pipe and connector, at
least in a boundary region thereof. In such an arrangement heating may be also
supplemented with heat from another source.

The method may comprise directly mounting the connector on or relative to the
pipe such that direct engagement is achieved therebetween.

The method may comprise locating one or more intermediate components
between the pipe and connector. Such an intermediate component may be melted to
be fused with the pipe and connector. Such an intermediate component may be
utilised to provide heat energy suitable for melting itself, the pipe and/or the connector.

The method may comprise mounting the connector relative to an end region of
the pipe.

The method may comprise mounting the connector on an outer surface of the
pipe, an inner surface of the pipe and/or to abut an end face of the pipe.

The method may comprise providing an at least partially preformed connector
and mounting said preformed connector relative to the pipe. For example, a connector
component may be preformed by any suitable manner, such as by moulding,
machining, by winding or otherwise of an elongate composite tape, roving, tow or the
like.

The step of mounting the connector relative to the pipe may comprise at least
partially forming the connector on the pipe, e.g. by fabricating the connector on the
pipe. In such an embodiment fusing of the pipe and connector may be achieved during
forming of the connector and/or subsequent to such forming.

The method may comprise forming the connector by manipulating, e.g. winding,
an elongate composite tape, roving, tow or the like, on an outer surface of the pipe, e.g.
en end region thereof. In such an arrangement the shape, size and configuration of the
connector may be determined and/or controlled during manipulation, e.g. winding, of
the elongate composite tape, roving, tow or the like.

The method may comprise moulding, e.g. injection moulding, the connector on
the pipe, e.g. on an end portion thereof.

The method may comprise providing a mould on, against, or around the pipe,
e.g. on, against or around an end portion thereof.

The method may comprise providing a material, such as a composite material,
within the mould, e.g. by moulding, e.g. by injection moulding.

The method may comprise heating the mould and/or the pipe.

The method may comprise removing the mould.
The method may comprise further forming steps, such as machining steps. For example, the method may comprise providing receiving portions, e.g. holes or apertures, on the connector, during the fabricating step, e.g. during tape manipulation, moulding, for example by drilling, providing longitudinal movement of the mould, generally referred to as "side-action", or the like.

The method may comprise fusing the connector on the pipe in situ, e.g. subsea.

The connector may have an outer diameter, circumference or perimeter larger than an outer diameter, circumference or perimeter of the pipe, e.g. of a main or central portion thereof. By such provision, the integrally formed structure may provide and/or exhibit improved structural integrity to accommodate load at point of connection.

The end face or end surface of the connector may have an outer perimeter or circumference substantially circular, elliptic, square, rectangular, triangular, etc, in shape.

The pipe may comprise an internal bore defining an inner surface or inner diameter or perimeter of the pipe.

The end face or end surface of the connector may extend between an inner surface of the pipe, and an outer perimeter or circumference of the end face or end surface of the connector. In such instance the inner perimeter or circumference of the connector may comprise the inner perimeter or circumference of the pipe. In such instance the end face or end surface of the pipe may be substantially aligned or flush with the end face or end surface of the connector.

The end face or end surface of the connector may extend between an outer surface of the pipe and the outer perimeter or circumference of the end face or end surface of the connector. In such instance the end face or end surface of the pipe may protrude forward of the end face or end surface of the connector.

The end face or end surface of the connector may extend between an inner perimeter or circumference of the end face or end surface of the connector and an outer perimeter or circumference of the end face or end surface of the connector. In such instance the end face or end surface of the connector may protrude forward of the end face or end surface of the pipe.

The inner diameter or perimeter of the pipe may be substantially similar to the inner diameter or perimeter of the connector.

The outer diameter or perimeter of the pipe may be substantially similar or marginally smaller than the inner diameter or perimeter of the connector. In such instance an outer surface of the pipe, e.g. of the end region thereof, may be integrally
connected, e.g. melted, fused, heat welded, adhesive bonded, etc to the inner surface of the connection portion.

The matrix material of the pipe and/or of the connector may comprise a polymer. The matrix material may comprise a thermoplastic component. The matrix material may comprise a thermoset component. The matrix material may comprise a polyaryl ether ketone, a polyaryl ketone, a polyether ketone (PEK), a polyether ether ketone (PEEK), a polycarbonate or the like, or any suitable combination thereof. The matrix material may comprise a polymeric resin, such as an epoxy resin or the like.

The reinforcing fibres may comprise continuous or elongate fibres. The reinforcing fibres may comprise any one or combination of polymeric fibres, e.g. aramid fibres, or non-polymeric fibres, e.g. carbon, glass or basalt fibres or the like. The reinforcing fibres may comprise discontinuous fibres, e.g. chopped mat or fibres.

Another aspect of the present invention relates to a pipe with an integral connector, comprising:

- a pipe comprising a composite material formed of at least a matrix and a plurality of reinforcing elements embedded within the matrix; and
- a connector mounted and fused to the pipe after said pipe has been formed.

The pipe may be formed according to the aspect defined above.

Another aspect of the present invention may relate to a pipe comprising a connection portion adapted to engage a structure, wherein at least the connection portion comprises a composite material formed of at least a matrix and one or more reinforcing elements embedded within the matrix, and wherein the connection portion is formed integrally with the pipe.

The connection portion may be formed integrally with or may comprise an end region of the pipe.

The pipe may comprise a composite material formed of at least a matrix and one or more reinforcing elements embedded within the matrix.

The one or more reinforcing elements of the composite material of the connection portion and/or the pipe may comprise one or more reinforcing fibres, nanotubes, or the like.

The connection portion may have an outer diameter, circumference or perimeter larger than an outer diameter, circumference or perimeter of the pipe, e.g. of a main or central portion thereof. By such provision, the integrally formed structure may provide and/or exhibit improved structural integrity to accommodate load at point of connection.
The connection portion may comprise a flange.

The structure to which the pipe is or is to be connected may comprise a further pipe such as an end region thereof, or an auxiliary structure, e.g. equipment such as a container, a tank, a manifold, a pump or the like.

In use, the connection portion may be configured to permit the pipe to be connected to the structure directly, or indirectly, e.g. via an interface such as one or more engagement members adapted to engage an end region of the pipe.

The connection portion may comprise one or more receiving portions, e.g. holes or apertures, arranged for receiving fixing members such as bolts, screws or the like.

The one or more receiving portions may be substantially axial, e.g. substantially aligned with or parallel to an axis, e.g. a longitudinal axis, of the pipe. By such provision, axial connection of the pipe with a structure, e.g. further pipe or auxiliary structure, may be possible.

In use, the one or more receiving portions of the pipe may be substantially aligned with one or more receiving portions of a further pipe or with one or more receiving portions of an auxiliary structure. By such provision, the pipe may be secured or attached to the further pipe or the auxiliary structure by provision of fixing members such as bolts, screws or the like.

The connection portion of the pipe may be secured or attached to a further pipe or an auxiliary structure, e.g. a connection portion thereof, by provision of clips, clamps or the like.

The connection portion may comprise an end face or end surface for engaging, e.g. contacting or abutting the structure, e.g. further pipe or auxiliary structure, e.g. a further connection portion thereof.

The end face or end surface of the connection portion may have an outer perimeter or circumference substantially circular, elliptic, square, rectangular, triangular, etc, in shape.

The pipe may comprise an internal bore defining an inner surface or inner diameter or perimeter of the pipe.

The connection portion may comprise an internal bore defining an inner surface or inner diameter or perimeter of the connection portion.

The end face or end surface of the connection portion may extend between an inner surface of the pipe, and an outer perimeter or circumference of the end face or end surface of the connection portion. In such instance the inner perimeter or circumference of the connecting portion may comprise the inner perimeter or
circumference of the pipe. In such instance the end face or end surface of the pipe may be substantially aligned or flush with the end face or end surface of the connection portion.

The end face or end surface of the connection portion may extend between an outer surface of the pipe and the outer perimeter or circumference of the end face or end surface of the connection portion. In such instance the end face or end surface of the pipe may protrude substantially forward of the end face or end surface of the connection portion.

The end face or end surface of the connection portion may extend between an inner perimeter or circumference of the end face or end surface of the connection portion and an outer perimeter or circumference of the end face or end surface of the connection portion. In such instance the end face or end surface of the connection portion may protrude substantially forward of the end face or end surface of the pipe.

In one embodiment, the connection portion may be formed using an elongate composite tape, roving, tow or the like which may be manipulated, for example wound, to form the connection portion. In such an arrangement the shape, size and configuration of the connection portion may be determined and/or controlled during manipulation, e.g. winding, of the elongate composite tape, roving, tow or the like.

In such instance, the connection portion may be formed during, or subsequent to, manufacture of the pipe.

In another embodiment, the connection portion may be formed by fabricating, e.g. moulding, the connection portion on a pipe.

The connection portion may be moulded, e.g. injection moulded, on the pipe, e.g. on an end portion thereof.

In such instance, the connection portion may be formed subsequent to manufacture of the pipe, and may be formed integrally with the pipe.

In another embodiment, the connection portion may be formed by integrally connecting, e.g. welding, fusion, heat welding, adhesive bonding, etc, the connecting portion to the pipe, e.g. to an end portion thereof.

In such instance, the connection portion may be formed subsequent to manufacture of the pipe, and may be formed integrally with the pipe.

The connection portion may be formed on the pipe in situ, e.g. in situ application or use of the pipe, e.g. subsea.

The pipe may be formed in situ, e.g. in situ application or use of the pipe, e.g. subsea.
The inner diameter or perimeter of the pipe may be substantially similar to the inner diameter or perimeter of the connection portion. In such instance the end face or end surface of the pipe may be integrally connected, e.g. melded, fused, heat welded, adhesive bonded, etc to a rear end face or rear end surface of the connection portion.

The outer diameter or perimeter of the pipe may be substantially similar or marginally smaller than to the inner diameter or perimeter of the connection portion. In such instance an outer surface of the pipe, e.g. of the end region thereof, may be integrally connected, e.g. melded, fused, heat welded, adhesive bonded, etc to the inner surface of the connection portion.

The matrix material of the pipe and/or of the connection portion may comprise a polymer. The matrix material may comprise a thermoplastic component. The matrix material may comprise a thermoset component. The matrix material may comprise a polyaryl ether ketone, a polyaryl ketone, a polyether ketone (PEK), a polyether ether ketone (PEEK), a polycarbonate or the like, or any suitable combination thereof. The matrix material may comprise a polymeric resin, such as an epoxy resin or the like.

The one or more reinforcing elements of the composite material of the connection portion and/or the pipe may comprise one or more reinforcing fibres, nanotubes, or the like.

The reinforcing fibres may comprise continuous or elongate fibres. The reinforcing fibres may comprise any one or combination of polymeric fibres, e.g. aramid fibres, or non-polymeric fibres, e.g. carbon, glass or basalt fibres or the like. The reinforcing fibres may comprise discontinuous fibres, e.g. chopped mat or fibres.

The reinforcing nanotubes may comprise, e.g. carbon nanotubes.

A further aspect of the present invention may relate to a method of manufacturing a pipe comprising a connection portion adapted to engage a structure, wherein at least the connection portion comprises a composite material formed of at least a matrix and one or more reinforcing elements embedded within the matrix, and wherein the connection portion is formed integrally with the pipe, the method comprising integrally forming the connection portion with the pipe.

The method may comprise integrally forming the connection portion with an end region of the pipe.

The pipe may comprise a composite material formed of at least a matrix and one or more reinforcing elements embedded within the matrix.
The one or more reinforcing elements of the composite material of the connection portion and/or the pipe may comprise one or more reinforcing fibres, nanotubes, or the like.

In one embodiment, the method may comprise forming the connection portion using an elongate composite tape, roving, tow or the like.

The method may comprise manipulating, e.g. winding, the elongate composite tape, roving, tow or the like, on an outer surface of the pipe, e.g. end region thereof, to form the connection portion. In such an arrangement the shape, size and configuration of the connection portion may be determined and/or controlled during manipulation, e.g. winding, of the elongate composite tape, roving, tow or the like.

In the tape winding arrangement it should be noted that as the pipe is already preformed the tape will be directly laid on the outer surface of the preformed pipe.

The method may comprise winding an increasing amount of composite material, e.g. elongate composite tape, roving, tow or the like, from a region of the pipe distal from end thereof, to an end region of the pipe. In such instance the method may comprise forming a substantially conical or tapered connection region.

The method may further comprise providing receiving portions, e.g. holes or apertures, on the connection portion, e.g. by machining the connection portion, for example by drilling.

In another embodiment, the method may comprise forming the connection portion on the pipe, e.g. by fabricating the connection portion on the pipe.

The method may comprise moulding, e.g. injection moulding, the connection portion on the pipe, e.g. on an end portion thereof.

In such instance, the method may comprise forming the connection portion subsequent to manufacture of the pipe.

The method may comprise providing a pipe.

The method may further comprise providing a mould on, against, or around the pipe, e.g. on, against or around an end portion thereof.

The method may further comprise providing a composite material within the mould, e.g. by moulding, e.g. by injection moulding.

The method may further comprise heating the mould and/or the pipe.

The method may further comprise removing the mould.

The method may comprise providing receiving portions, e.g. holes or apertures, on the connection portion, during the fabricating step, e.g. during moulding, for
example by providing longitudinal movement of the mould, generally referred to as "side-action".

The method may comprise providing receiving portions, e.g. holes or apertures, on the connection portion, e.g. by machining the connection portion, for example by drilling.

In another embodiment, the method may comprise integrally connecting the connection portion to the pipe.

In such instance, the method may comprise forming the connection portion subsequent to manufacture of the pipe.

The method may comprise providing a pipe.

The method may further comprise integrally connecting, e.g. welding, fusing, heat welding, adhesive bonding, etc, the connecting portion to the pipe, e.g. to an end portion thereof.

The method may comprise contacting an end face or end surface of the pipe with a rear end face or rear end surface of the connection portion, and integrally connecting, e.g. welding, fusing, heat welding, adhesive bonding, or the like. In such instance the method may comprise heating at least the interface or contact surfaces between the end face or end surface of the pipe and the rear end face or rear end surface of the connection portion, e.g. by laser irradiation, ultrasonic frequency, or the like. The method may comprise applying pressure between the end face or end surface of the pipe and the rear end face or rear end surface of the connection portion.

The method may comprise contacting an outer surface of the pipe, e.g. of the end region thereof, with an inner surface of the connection portion, and integrally connecting, e.g. welding, fusing, heat welding, adhesive bonding, or the like. In such instance the method may comprise heating at least the interface between the outer surface of the pipe and the inner surface of the connection portion, e.g. by laser irradiation, ultrasonic frequency, or the like.

The method may comprise forming the connection portion on the pipe in situ, e.g. subsea.

Particular features of the pipe and/or of the connection portion of the pipe according to the first aspect of the invention may apply to the method according to the second aspect of the invention, and are therefore not repeated here for brevity.

Although in the aspects defined above a connector is provided on a pipe. However, the various processes and features may be of utility in securing any desired
component to a pipe. For example, an aspect of the present invention may relate to a method of forming a pipe with an integral component, comprising:

providing a preformed pipe comprising a composite material having at least a matrix and a plurality of reinforcing elements embedded within the matrix;

mounting a component relative to the preformed pipe; and

melting and solidifying the material of the pipe and the component to fuse said pipe and connector together.

A further aspect may relate to a pipe with an integral component, comprising:

a pipe comprising a composite material formed of at least a matrix and a plurality of reinforcing elements embedded within the matrix; and

a component mounted and fused to the pipe after said pipe has been formed.

**BRIEF DESCRIPTION OF THE DRAWINGS**

These and other aspects of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figures 1a to 1c show a longitudinal cross-sectional view of a method for manufacturing a pipe comprising a connection portion in accordance with an embodiment of one or more aspects the present invention;

Figures 2a to 2c show a longitudinal cross-sectional view of an alternative embodiment of a method for manufacturing a pipe comprising a connection portion in accordance with an embodiment of one or more aspects the present invention; and

Figures 3a to 3c show a longitudinal cross-sectional view of an alternative embodiment of a method of manufacturing a pipe comprising a connection portion in accordance with an embodiment of one or more aspects the present invention.

**DETAILED DESCRIPTION OF THE DRAWINGS**

A method of manufacturing a pipe, generally identified by reference numeral 10, in accordance with an embodiment of the present invention is shown in Figures 1a to 1c. The method comprises integrally forming by fusing together a connection portion or connector 20 with the pipe 10 after the pipe 10 has been manufactured. The connection portion 20 is adapted to engage a separate structure (not shown), such as a further pipe, e.g. an end region thereof, or an auxiliary structure, e.g. equipment such as a container, a tank, a manifold, a pump or the like. Both the pipe 10 and the connection portion 20 comprise a composite material formed of at least a matrix and one or more reinforcing fibres embedded within the matrix.
The pipe 10 may be suitable for use in a number of applications, such as in the recovery of hydrocarbons from a subterranean reservoir. For example, the pipe may be used as a riser, flow line, jumper, coiled tubing or the like.

In this embodiment, the method comprises integrally forming the connection portion 20 with an end region 12 of the preformed pipe 10.

An end portion 12 of the preformed pipe 10 prior to forming the connection portion 20 is shown in Figure 1a.

In this embodiment, the method comprises forming the connection portion 20 using an elongate composite member such as tape, roving, tow or the like (not shown).

As shown in Figure 1b, the method comprises manipulating, e.g. winding, the elongate composite tape, roving, tow or the like, on an outer surface 14 of the preformed pipe end 12, to form the connection portion 20. In such an arrangement the shape, size and configuration of the connection portion 20 can be determined and/or controlled during manipulation, e.g. winding, of the elongate composite tape, roving, tow or the like.

During or subsequent to forming the connector 20 the material, and specifically the matrix, of the connector 20 and pipe 10 are melted to establish fusion therebetween to define a consolidated or integrated structure. Such melting may be achieved by, for example, laser radiation or the like.

The method comprises winding an increasing amount of composite material, e.g. elongate composite tape, roving, tow or the like, from a region 13 of the pipe distal from end thereof, to an end region 12 of the pipe, thereby forming a substantially conical or tapered connection region 22.

In this embodiment, the pipe 10 is substantially annular.

The connection portion 20 has an outer diameter, circumference or perimeter 26 larger than an outer diameter, circumference or perimeter 16 of the distal region 13 of the pipe 10. By such provision, the integrally formed connection portion 20 may provide and/or exhibit improved structural integrity to accommodate load at point of connection.

In this embodiment, the connection portion 20 defines a flange.

As shown in Figure 1c, the method further comprises providing receiving portions 30, which in this embodiment comprise holes or apertures 31, on the connection portion 20. The receiving portions 30 are manufactured by machining the connection portion 20, for example by drilling holes or apertures 31 into the connection portion 20.
The holes or apertures 31 are arranged for receiving fixing members such as bolts, screws or the like (not shown) for connecting the connection portion 20 to a separate structure.

The holes or apertures 31 are substantially axial, e.g. substantially aligned with or parallel to an axis (i-i) to facilitate axial connection of the pipe 10 with a structure such as a further pipe or an auxiliary structure.

The connection portion 20 comprise an end face or end surface 24 for engaging, e.g. contacting or abutting the structure, e.g. further pipe or auxiliary structure, e.g. a further connection portion thereof.

The end face or end surface 24 of the connection portion 20 has an outer perimeter or circumference 26 substantially circular, elliptic, square, rectangular, triangular, etc, in shape, which in this embodiment is circular.

The end face or end surface 24 of the connection portion 20 extends between an inner surface 17 of the pipe 10 defining an internal bore 18, and an outer perimeter or circumference 26 of the end face or end surface 24 of the connection portion 20. In this embodiment, an end face or end surface 11 of the pipe 10 is substantially aligned or flush with the end face or end surface 24 of the connection portion 20.

Referring now to Figures 2a to 2c, there is shown a method of manufacturing a pipe 110 according to a second embodiment of the present invention. The pipe 110 is generally similar to the pipe 10 of Figure 1, like parts being denoted by like numerals, but incremented by 100°.

In this embodiment, the method comprises forming the connection portion 120 on the preformed pipe 110 by moulding the connection portion 120 on an end portion 112 of the pipe 110. In such instance, the method comprises forming the connection portion 120 subsequent to manufacture of the pipe 110.

As illustrated on Figure 2b, the method comprises providing a preformed pipe 110, and providing a mould 140 on an end portion 112 of the pipe 110.

The method further comprises providing a molten composite material within the mould 140, e.g. via inlet or feed port 142. The pipe material, specifically the matrix of the pipe material, is melted to establish fusion between the pipe 110 and the moulded connector 120. Such melting of the pipe material may be achieved by heat provided from the molten composite material which is delivered or injected into the mould 140. In other embodiments such melting of the pipe material may be achieved by supplementary heat from a heat source, radiation source or the like.
Upon completion of the moulding step, e.g. upon at least partial solidification and/or curing of the moulded material, the method further comprises removing the mould 140 from the pipe 110.

As shown in Figure 2c, the method further comprises providing receiving portions 130, which in this embodiment comprise holes or apertures 131, on the connection portion 120. In this embodiment, the holes or apertures 131 are manufactured during the moulding step by providing longitudinal movement of the mould 140, generally referred to as "side-action", along a direction of arrows 144.

Referring now to Figures 3a to 3c, there is shown a method of manufacturing a pipe 210 accordingly to a third embodiment of the present invention. The pipe 210 is generally similar to the pipe 10 of Figure 1, like parts being denoted by like numerals, but incremented by "200".

As shown on Figure 3a, the method comprises providing a preformed pipe 210 and a preformed connection portion 220. Thus, in this embodiment, the method comprises integrally forming the connection portion 220 with the pipe 210 subsequent to manufacture of the pipe 210 and of the connection portion 220.

As shown in Figures 3b and 3c, the method comprises contacting an outer surface 214 of an end region 212 the pipe 210 with an inner surface 227 of the connection portion 220. In this embodiment, the outer diameter or perimeter 216 of the pipe 210 is marginally smaller than to the inner diameter or perimeter 229 of the connection portion 220. By such provision the end portion 212 of the pipe 210 may be provided within the connection portion 220 such that the outer surface 214 of the pipe 210 is provided proximal the inner surface 227 of the connection portion 220. In this embodiment, the outer surface 214 of the pipe 210 and the inner surface 227 of the connection portion 220 define an interface 250.

The method further comprises melting and fusing together the material of the pipe 210 and connector 220 in the region of the interface 250 to define a consolidated or integral structure. In such instance the method may comprise heating at least the interface 250 between the outer surface 214 of the pipe 210 and the inner surface 227 of the connection portion 220, e.g. by laser irradiation, ultrasonic frequency, or the like.

In this embodiment, receiving portions 230 in the form of holes or apertures 231 are provided on the connection portion 220 prior to integrally forming the pipe 210 with the connection portion 220. However, it will be appreciated that in alternative embodiments the receiving portions 230 may be may be manufactured subsequent to integrally forming the pipe 210 with the connection portion 220, e.g. by machining the
connection portion 220, for example by drilling holes or apertures 231 into the connection portion 220.

In an alternative embodiment, the inner diameter or perimeter 216 of the pipe 210 may be substantially similar to the inner diameter or perimeter 229 of the connection portion 220. In such instance the method may comprise integrally fusing the end face or end surface 211 of the pipe 210 with a rear end face or rear end surface 228 of the connection portion 220.

It should be understood that the embodiments described herein are merely exemplary, and that various modifications may be made thereto without departing from the scope of the invention. For example, in the embodiments described above a flange type connector is provided. However, other connectors are possible, such as male/female type stab-in connector, threaded connector, latch connector, or the like. Also, the methodology of the present invention may be used to secure components other than connectors to a composite pipe.
CLAIMS:

1. A method for forming a pipe with an integral connector, comprising:
   providing a preformed pipe comprising a composite material having at least a
   matrix and a plurality of reinforcing elements embedded within the matrix;
   mounting a connector relative to the preformed pipe; and
   melting and solidifying the material of the pipe and the connector to fuse said
   pipe and connector together.

2. The method according to claim 1, wherein the connector comprises a
   composite material formed of at least a matrix and one or more reinforcing elements
   embedded within the matrix.

3. The method according to claim 2, wherein the one or more reinforcing elements
   of the composite material of the pipe and/or the connector comprises one or more
   reinforcing fibres, nanotubes, carbon nanotubes or the like.

4. The method according to claim 2 or 3, comprising melting the matrix material of
   the pipe and connector such that the matrix of the pipe and connector become fused.

5. The method according to claim 2, 3 or 4, wherein the pipe and connector
   comprise similar matrix material.

6. The method according to any preceding claim, comprise melting the material of
   the connector and the pipe in the region of a boundary therebetween.

7. The method according to any preceding claim, comprising melting the material
   of the connector subsequent to, prior to and/or simultaneously with the step of
   mounting said connector on the pipe.

8. The method according to any preceding claim, comprising melting the material
   of the pipe subsequent to, prior to and/or simultaneously with the step of mounting the
   connector on the pipe.
9. The method according to any preceding claim, comprising simultaneously melting the material of the pipe and the material of the connector when mounted relative to each other.

10. The method according to any preceding claim, comprising heating the material of one or both of the pipe and connector using at least one of electromagnetic energy such as microwave radiation, optical radiation, an electric current, mechanical excitation, acoustic energy, a chemical reaction and friction heating.

11. The method according to any preceding claim, comprising heating the material of one of the pipe and connector by heat energy from the other of the pipe and connector.

12. The method according to claim 11, wherein heat energy from the other of the pipe and connector is provided when said other of the pipe and connector is in a molten state.

13. The method according to any preceding claim, comprising directly mounting the connector on or relative to the pipe such that direct engagement is achieved therebetween.

14. The method according to any preceding claim, comprising locating one or more intermediate components between the pipe and connector.

15. The method according to claim 14, wherein the intermediate component is melted to be fused with the pipe and connector.

16. The method according to claim 14 or 15, wherein the intermediate component is utilised to provide heat energy suitable for melting itself, the pipe and/or the connector.

17. The method according to any preceding claim, comprising mounting the connector relative to an end region of the pipe.
18. The method according to any preceding claim, comprising mounting the connector on an outer surface of the pipe, an inner surface of the pipe and/or to abut an end face of the pipe.

19. The method according to any preceding claim, comprising providing an at least partially preformed connector and mounting said preformed connector relative to the pipe.

20. The method according to any preceding claim, wherein the step of mounting the connector relative to the pipe comprise at least partially forming the connector on the pipe.

21. The method according to claim 20, wherein fusing of the pipe and connector is performed during forming of the connector and/or subsequent to such forming.

22. The method according to claim 20 or 21, comprising forming the connector by manipulating an elongate composite tape, roving or tow on an outer surface of the pipe.

23. The method according to claim 20, 21 or 22, comprising moulding the connector on the pipe.

24. The method according to claim 23, comprising:
   providing a mould on, against, or around the pipe; and optionally
   providing a material within the mould; and optionally
   heating the mould and/or the pipe.

25. The method according to any one of claims 20 to 24, comprising providing receiving portions on the connector during the fabricating step.

26. The method according to any preceding claim, comprising fusing the connector on the pipe in situ.

27. The method according to any preceding claim, wherein the connector defines an outer diameter, circumference or perimeter larger than an outer diameter, circumference or perimeter of the pipe.
28. The method according to any preceding claim, wherein the end face or end surface of the connector extends between an inner surface of the pipe, and an outer perimeter or circumference of the end face or end surface of the connector.

29. The method according to any one of claims 1 to 27, wherein the end face or end surface of the connector extends between an outer surface of the pipe and the outer perimeter or circumference of the end face or end surface of the connector.

30. The method according to any preceding claim, wherein an end face of the connector is aligned with an end face of the pipe.

31. The method according to any one of claims 1 to 29, wherein an end face of the pipe protrudes forward of the end face of the connector.

32. The method according to any one of claims 1 to 28, wherein the end face of the connector protrudes forward of the end face of the pipe.

33. The method according to any preceding claim, wherein the connector comprises at least one of a flange structure, a thread structure, a load shoulder profile, a no-go profile and a quick connect profile.

34. The method according to any preceding claim, wherein the connector comprises one or more receiving portions arranged for receiving fixing members.

35. A pipe with an integral connector, comprising:
   a pipe comprising a composite material formed of at least a matrix and a plurality of reinforcing elements embedded within the matrix; and
   a connector mounted and fused to the pipe after said pipe has been formed.

36. A pipe manufactured by the method according to any one of claims 1 to 34.
INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2012/00023

A. CLASSIFICATION OF SUBJECT MATTER

INV. F16L47/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:
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Date of mailing of the international search report: 05/07/2012

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