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METHOD FOR MANUFACTURING A STRIP OF COMPOSITE MATERIAL INTENDED TO FORM A TUBULAR STRUCTURE AND CORRESPONDING INSTALLATION

Abstract

A method that includes: butting together end regions of unconnected strip parts, and applying heat and pressure to create a welded joint between the end regions;
at least one end region presents a rear zone and a front zone projecting from the rear zone, the front zone being delimited by two front zone lateral edges each presenting at least one point positioned at a distance from a respective extension of each lateral edge of the rear zone.
The front zone of an end region of a first strip part is situated facing an end region of a second strip part when the end regions are butted together.

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Background/Summary

[0001] The present invention relates to a method for manufacturing a strip of composite material intended to form a tubular structure, the method comprising the following steps: [0002] butting together end regions of unconnected strip parts, each strip part being formed of a polymer matrix and fibers or film embedded in the matrix, [0003] applying heat and pressure to produce a welded joint between the end regions.
[0004] Such a strip of composite material is intended, for example, to form the tubular structure of a pipe, in particular a Thermoplastic Composite Pipe (TCP), or a Hybrid Flexible Pipe (HFP).
[0005] Such tubular structures are manufactured by winding at least one strip of composite material around a support and welding the successive strip windings together with a high-temperature weld, for example using a laser.
[0006] Such a technique is particularly suitable when the composite strip comprises a polyetheretherketone (PEEK) matrix that provides tubular structures with excellent mechanical properties, in conjunction with the reinforcing fibers it contains.
[0007] Such pipes thus present the advantage of being lightweight, yet highly resistant to internal pressure within the pipe, or to external pressure applied to the pipe.
[0008] Composite strips intended for forming such internal structures are currently produced by fabricating several strip parts from a single piece, then butt-welding the strip parts together to produce a strip of greater length, which is compatible with the length of the pipe to be produced.
[0009] A welded joint is formed between the free ends of successive strip parts. In this respect, WO2021/094718 describes a method for making welds on composite strip parts. The end regions of the strip parts are brought together and butt-welded together after heating Is applied.
[0010] Even if the welding is carried out with great care, any significant variation in thickness at the joint can lead, when the strip windings are exposed to the laser, in order to produce the tubular structure, to a local temperature increase at the joint, which can reach over 550° C.
[0011] At this temperature, flash phenomena or local combustion can occur. Combustion debris, contaminants or holes are then formed around the joint. In addition, crack initiation and/or adhesion defects may appear in this zone.
[0012] These phenomena occurring at the joints between strip parts are therefore troublesome, as the maximum achievable length of a unitary strip part is generally around 500 m, which implies several joints along the strip, if the latter is of substantial length.
[0013] One aim of the invention is therefore to provide a method for manufacturing a composite material strip from butt-joined unit strip parts, without adhesive or glue, in which subsequent welding of the composite strip to form a tubular structure is not substantially affected by the presence of joints between the unit strip parts.
[0014] To this end, the subject matter of the invention is a method for manufacturing as defined above, characterized in that at least one end region presents a rear zone in which the lateral edges of the strip part are parallel to one another, and a front zone projecting from the rear zone, the front zone being delimited by two lateral edges each presenting at least one point, in particular at least

one segment, positioned at a distance from a respective extension of each lateral edge of the rear zone, between the respective extensions of each lateral edge of the rear zone, [0015] the front zone of an end region of a first strip part being located facing an end region of a second strip part when the end regions are butted together.
[0016] The method according to the invention may comprise one or more of the following features, taken alone or in any technically possible combination: [0017] the application of heat and pressure includes heating by induction of a heating region of a metal support on which the end regions of the strip parts are arranged; [0018] the method comprises arranging an induction coil facing the heating region of the metal support, and circulating a variable electric current through the induction coil to generate by Joule effect heat by currents induced in the heating region; [0019] the method comprises the displacement of a pressure-applying wedge on the heating region, and applying pressure to the end regions of the strip parts between the metal support and the wedge; [0020] when butting together the end regions, at least one lateral edge of the front zone is an inclined lateral edge, the angle of inclination of the inclined lateral edge relative to the longitudinal axis of the strip part in the end region is between 20° and 80°, in particular between 30° and 60°, even more particularly between 35° and 55°; [0021] when butting together the end regions, the front zone of the end region comprises an inclined lateral edge and an additional inclined lateral edge, the additional inclined lateral edge being inclined relative to the longitudinal axis of the strip part by an angle of inclination opposite to the angle of inclination of the inclined lateral edge relative to the longitudinal axis of the strip part; [0022] the additional inclined lateral edge intersects the inclined lateral edge at an end point of the strip part; [0023] each end region presents a rear zone in which the lateral edges of the strip part are parallel to one another, and a front zone projecting from the rear zone, the front zone being delimited by two lateral edges each presenting at least one point, in particular at least one segment, positioned at a distance from a respective extension of each lateral edge of the rear zone, between the respective extensions of each lateral edge of the rear zone, the front zone of an end region of a first strip part being located facing the rear zone of an end region of a second strip part when the end regions are butted together [0024] the application of heat and pressure to weld the end regions together is carried out without the application of material, in particular without the application of a film to the surface of each end region; [0025] when the end regions are butted together, the overlap between the end region of a first strip part and the end region of a second strip part, measured along the longitudinal axis of each end region, is greater than 10 mm, and in particular between 15 mm and 30 mm; [0026] the matrix is made of a polymer selected from among the PEK (polyetherketone), the PEEK (polyetheretherketone), the PEEKK (polyetheretherketoneketone), the PEKK (polyetheretherketone), the PEKEKK (polyetherketoneetherketoneketone), the PAI (polyamide-imide), the PEI (polyether-imide), the PSU (polysulfone), the PPSU (polyphenylsulfone), the PES (polyether sulfone), the PAS (polyarylsulfone), the PPE (polyphenylene ether), the PPS (polyphenylene sulfide), the LCP (liquid crystal polymers), the PPA (polyphthalamide), their copolymers and/or mixtures thereof, and wherein the fibers are selected from among carbon fibers, glass fibers, aramid fibers, and/or basalt fibers, the fibers advantageously forming a mat, or wherein the film is a polyketone yarn, in particular unfilled PEEK (polyetheretherketone).
[0027] The invention also has as its object the use of at least one strip of composite material produced by the method for manufacturing such as defined above to form, advantageously by winding and heating, a tubular structure, in particular a tubular structure of a flexible pipe.
[0028] The invention also has as its object an installation for manufacturing a strip of composite material intended to form a tubular structure, the installation comprising: [0029] a supply or manufacturing station able to supply unconnected strip parts, each strip part being formed from a polymer matrix and fibers embedded in the matrix, [0030] a welding station including a support presenting a heating region intended for butting together the end regions, and a heat and pressure application device for producing a welded joint between the end regions, [0031] characterized in

that the supply and manufacturing station includes a cutting apparatus configured to form at least one end region presenting a rear zone in which the lateral edges of the strip part are parallel to each other, and a front zone projecting from the rear zone, the front zone being delimited by two lateral edges each presenting at least one point, in particular at least one segment, positioned at a distance from a respective extension of each lateral edge of the rear zone, between the respective extensions of each lateral edge of the rear zone.
[0032] The installation according to the invention may comprise one or more of the following features, taken alone or in any technically possible combinations: [0033] the support is a metal support, the heat and pressure application device being able to heat by induction the heating region of the metal support on which the end regions of the strip parts are arranged, the heat and pressure application device comprising an induction coil positioned facing the heating region of the metal support, and a variable electric current source able to supply the induction coil to generate, by the Joule effect, heat by currents induced in the heating region; [0034] the heat and pressure application device comprises a movable pressure applying wedge on the heating region, able to apply pressure to the end regions of the strip parts between the metal support and the wedge; [0035] the cutting apparatus includes a base defining a groove for receiving a strip part, and a cutting wedge, mounted movably relative to the base between a position for loading/unloading a strip part and a position for cutting the strip part, the cutting apparatus advantageously including guides for displacing the cutting wedge.

Description

[0036] The invention will be better understood on reading the following description, given by way of example only, and made with reference to the appended drawings, on which:
[0037] FIG. **1** is a schematic view of a composite material strip obtained by the method for manufacturing according to the invention;
[0038] FIG. **2** is a schematic view of two parts of composite strip intended to be butt-welded together when implementing the method according to the invention, each strip part presenting a free end region in the form of a tip
[0039] FIG. **3** is a partial schematic perspective view of a welding station of a first installation for manufacturing composite strips according to the invention;
[0040] FIG. **4** is a schematic view of a block diagram representing an installation for manufacturing a flexible pipe including a tubular structure made from the composite strip of FIG. **1**;
[0041] FIG. **5** is a schematic view of a laser welding station for the composite strip manufactured by the method according to the invention;
[0042] FIG. **6** is a partially exploded perspective view of one example of a flexible pipe including a tubular structure produced from a plurality of composite strips obtained by the method according to the invention; and
[0043] FIG. **7** is a schematic perspective view of a cutting apparatus for producing parts of composite strips intended to be welded together.
[0044] A method according to the invention is intended to manufacture a strip **2** of composite material, an example of which is partially represented in FIG. **1**, and which will hereinafter be referred to as a “composite strip”.
[0045] The composite strip **2** is intended to be wound and welded to produce a tubular structure **4**, in particular, an internal tubular structure **4** of a flexible fluid conveying pipe **10**, an example of which can be seen in FIG. **6**.
[0046] The flexible pipe **10** is, for example, a Thermoplastic Composite Tube (TCP) or a Hybrid Flexible Pipe (HFP) in the example of FIG. **6**.
[0047] The tubular structure is, for example, a tubular structure **4** for reinforcing the flexible pipe

10.

[0048] The flexible pipe **10** includes a central section **12**, illustrated in part in FIG. **6**. It includes, at each axial end of the central section **12**, an end fitting (not visible).

[0049] With reference to FIG. **6**, the pipe **10** delimits an internal passage **13** for the circulation of a fluid, advantageously a petroleum fluid. The internal passage **13** extends along an axis A-A′, between the upstream end and the downstream end of the pipe **10**. It opens out through the end fittings.

[0050] The flexible pipe **10** is intended to be arranged across a body of water in a fluid production installation, particularly for hydrocarbons. The body of water is, for example, a sea, lake or ocean. The depth of the body of water below the fluid exploitation installation is, for example, between 500 m and 4000 m. The fluid exploitation installation includes a surface assembly and a bottom assembly (not shown) or two surface assemblies which are advantageously connected to each other by the flexible pipe **10**.

[0051] The surface assembly is floating, for example. It is advantageously formed by a floating production, storage and offloading (FPSO) unit, a floating liquefied natural gas (FLNG) unit, a semi-submersible platform or an offloading buoy. Alternatively, the surface assembly can be a rigid, fixed jacket type structure or an oscillating structure attached to the seabed, for example a TLP (Tension Leg Platform).

[0052] In this example, the flexible pipe **10** is a partially or fully submerged riser connecting the bottom assembly to the surface assembly. Alternatively, the flexible pipe **10** is fully immersed in the water body and connects, for example, two bottom assemblies (not shown) to each other.

[0053] Another alternative consists of a flexible pipe **10** partially submerged in the water body connecting, for example, two surface assemblies (typically an offloading buoy and an FPSO). This is particularly the case with flexible OOL (Oil Offloading Line) lines.

[0054] As illustrated in FIG. **6**, the pipe **10** delimits a plurality of concentric layers around the axis A-A′, which extend continuously along the central section **12** to the end fittings located at the ends of the pipe.

[0055] In the example of FIG. **6**, the pipe **10** includes at least one inner tubular sheath **20** based on a polymer material, advantageously constituting a pressure sheath, and the reinforcement tubular structure **4**, applied around the tubular sheath **20** by being bonded thereto. Alternatively, the pipe **10** is devoid of the internal tubular sheath **20**, the reinforcement tubular structure **4** therefore being watertight.

[0056] The pipe **10** also advantageously includes a plurality of layers of tensile armor **24**, **25** arranged externally relative to the reinforcement tubular structure **4** by not being connected to the reinforcement tubular structure **4**.

[0057] Advantageously, and according to the desired use, the pipe **10** also includes anti-wear layers **26**, interposed between the reinforcement tubular structure **4** and the tensile armor layers **24**, **25**, as well as within the tensile armor layers **24**, **25**. It also advantageously includes a reinforcement ribbon **28**, wound around the tensile armor layers **24**, **25** and an outer sheath **30**, intended to protect the pipe **10**.

[0058] As known, the tubular sheath **20** is intended to seal off the fluid transported in the passage **13**. The tubular sheath **20** also has as its function the protection of the reinforcement tubular structure **4** from abrasion caused by the presence of abrasive particles, for example sand, within the fluid conveyed through the passage **13**.

[0059] The tubular sheath **20** is formed of a polymer material, preferably thermoplastic. For example, the polymer forming the tubular sheath **20** is based on a polyolefin such as polyethylene, on a polyamide such as PA11 or PA12, or on a fluoropolymer such as polyvinylidene fluoride (PVDF).

[0060] Alternatively, the tubular sheath **20** is formed from a high-performance polymer such as the PEK (polyetherketone), the PEEK (polyetheretherketone), the PEEKK (polyetheretherketoneketone), the PEKK (polyetherketoneketone), the PEKEKK (polyetherketoneetherketoneketone), the PAI (polyamide-imide), the PEI (polyether-imide), the PSU (polysulfone), the PPSU (polyphenylsulfone), the PES (polyethersulfone), the PAS (polyarylsulfone), the PPE (polyphenyleneether), the PPS (polyphenylene sulfide), the LCP (liquid-crystalline polymers), the PPA (polyphthalamide) and/or mixtures thereof, or blends with the PTFE (polytetrafluoroethylene) or the PFPE (perfluoropolyether).

[0061] The thickness of the tubular sheath **20** is, for example, between 1 mm and 20 mm.

[0062] The tubular sheath **20** is formed from a tube of polymer material, a strip of assembled polymer material, or an impregnated polymer mat.

[0063] When the tubular sheath **20** is formed from a tube, it is advantageously obtained by extrusion of a thermoplastic tube chosen in particular from among the polymers mentioned above.

[0064] When the tubular sheath **20** is formed from a strip of assembled polymer material, it is advantageously produced by extruding and winding thermoplastic strips of a polymer as described above. Preferably, the turns of a first layer are contiguous (edge-to-edge without overlap), and the turns of an upper layer are arranged so as to have an overlap of two adjacent lower strips ensuring the seal of the tubular sheath **20**.

[0065] According to the preferred embodiment, the flexible pipe **10** has no internal carcass, and is referred to as a “smooth bore”. The inner surface of the tubular sheath **20** directly delimits the internal passage **13**.

[0066] According to one alternative not shown, the flexible pipe includes an internal carcass located inside the tubular sheath **20** and is referred to as a “rough bore”. The function of the internal carcass is to increase the crush resistance of the flexible pipe, and it is formed, for example, by a profiled, spirally wound metal strip. Advantageously, the turns of the strip are hooked to one another, which allows crushing forces to be absorbed.

[0067] In the example represented in FIG. **6**, the flexible pipe **10** includes an inner armor layer **24** and an outer armor layer **25**, around which the outer sheath **30** is arranged.

[0068] Each armor layer **24**, **25** includes longitudinal armor elements **50** wound with a long pitch around the axis A-A′ of the pipe.

[0069] “Wound with a long-pitch” means that the absolute value of the helix angle relative to the A-A′ axis is less than 50° and is typically between 25° and 45°.

[0070] The armor elements **50** of a first layer **24** are generally wound according to an opposite angle relative to the armor elements **50** of a second layer **25**. Thus, if the winding angle relative to the axis A-A′ of the armor elements **50** of the first layer **24** is equal to +φ, with φ being between 25° and 45°, the winding angle relative to the axis A-A′ of the armor elements **50** of the second layer **25** arranged in contact with the first layer **24** is, for example, −φ, with φ between 25° and 45°.

[0071] The armor elements **50** are formed, for example, by metal wires. Alternatively, the armor elements **50** are formed by flat composite wires or ribbons reinforced with carbon fibers.

[0072] The reinforcement tubular structure **4** may present a low tensile strength and tend to elongate under the effect of axial forces, the armor layers **24**, **25** take up the axial forces and thus prevent elongation of the tubular structure **4**.

[0073] The outer sheath **30** is intended to prevent fluid permeation from the outside of the flexible pipe **10** to the inside. Advantageously, it is produced in a polymer material, in particular based on a polyolefin material such as polyethylene, a polyamide based material such as PA11 or PA12, or a fluoropolymer based material such as polyvinylidene fluoride (PVDF).

[0074] The thickness of the outer sheath **30** is, for example, between 5 mm and 15 mm.

[0075] Each anti-wear layer **26** is formed, for example, of PA (polyamide), PE (polyethylene), PVDF (polyvinylidene fluoride), PEEK (polyetheretherketone), PEKK (polyetherketoneketone). An anti-wear layer **26** is arranged between the reinforcement tubular structure **4** and the first tensile armor layer **24**. A further anti-wear layer **26** is positioned between each pair of armor layers **24**, **25**, advantageously as specified in API Standard 17J, 4th edition May 2014.

[0076] The reinforcement ribbon **28** is formed, for example, of a high-strength anti-buckling layer. This layer is made of aramid, for example. The ribbon is wound around the outermost armor layer **25**, between the armor layer **25** and the outer sheath **30**, advantageously as shown in API Standard 17J, 4th edition May 2014.

[0077] In this example, the reinforcement tubular structure **4** is applied directly to the tubular sheath **20**. It is assembled on the tubular sheath **20** to form a bonded assembly with the tubular sheath **20**.

[0078] The reinforcement tubular structure **4** is a composite structure. It includes at least one, preferably a plurality of laminated composite reinforcement layers, and optionally, an anti-delamination layer interposed between at least two reinforcement layers.

[0079] Each laminated reinforcement layer includes a superposition of composite reinforcement layers. The thickness of each composite layer is generally between 0.10 mm and 0.30 mm, for example between 0.12 mm and 0.17 mm, or between 0.22 mm and 0.27 mm.

[0080] In the example represented in FIG. **6**, each composite reinforcement layer includes a polymer matrix **40** and the reinforcement fibers **42** embedded in the matrix **40**. Alternatively, at least one composite reinforcement layer includes a film embedded in the polymer matrix **40**.

[0081] Preferably, the matrix **40** is formed from a polymer, particularly a thermoplastic polymer. The polymer of the tubular sheath **20** is advantageously of the same type as that of the matrix **40**. By "of the same type" is meant, for the purposes of the present invention, that the polymer of the tubular sheath **20** and the polymer of the matrix **40** are able to melt and form a homogenous mixture, without phase separation, after cooling.

[0082] For example, the polymer forming matrix **40** is based on a polyolefin such as polyethylene, based on a polyamide such as PA11 or PA12, or based on a fluoropolymer such as polyvinylidene fluoride (PVDF).

[0083] Alternatively, the matrix **40** is formed based on a high-performance polymer such as the PEK (polyetherketone), the PEEK (polyetheretherketone), the PEEKK (polyetheretherketoneketone), the PEKK (polyetherketoneketone), the PEKEKK (polyetherketoneetherketoneketone), the PAI (polyamide-imide), the PEI (polyether-imide), the PSU (polysulfone), the PPSU (polyphenylsulfone), the PES (polyethersulfone), the PAS (polyarylsulfone), the PPE (polyphenyleneether), the PPS (polyphenylene sulfide), the LCP (liquid-crystalline polymers), the PPA (polyphthalamide) and/or their mixtures thereof, or blends with the PTFE (polytetrafluoroethylene) or the PFPE (perfluoropolyether).

[0084] The reinforcement fibers **42** are, for example, carbon fibers, glass fibers, aramid fibers and/or basalt fibers.

[0085] The reinforcement fibers **42** generally have a maximum tensile strength greater than 2 GPa, advantageously greater than 3 GPa and for example between 3 GPa and 6 GPa, such as measured at 23° C. according to ASTM Standard D885M—10A(2014)e1.

[0086] In the present application, the terms "ultimate tensile strength" and "tensile strength" have the same meaning and refer to the ultimate tensile strength measured in a tensile test applied according to the longitudinal direction of the reinforcing fibers.

[0087] In addition, the reinforcement fibers **42** advantageously present a tensile modulus greater than 50 GPa, ranging for example, between 70 GPa and 500 GPa, in particular between 50 GPa and 100 GPa for glass fibers, between 100 GPa and 500 GPa for carbon fibers and between 50 GPa and 200 GPa for aramid fibers, as measured at 23° C. according to ASTM Standard D885M—10A(2014)e1.

[0088] In the present application, the terms "tensile modulus", "Young's modulus" and "tensile modulus of elasticity" have the same meaning and refer to the elastic modulus measured in a tensile test.

[0089] The density of the reinforcement fibers **42** is generally between 1.4 g/cm.sup.3 and 3.0 g/cm.sup.3.

[0090] For example, the reinforcement fibers **42** are arranged unidirectionally in the matrix **40**. Therefore, they are parallel to one another. Alternatively, the reinforcement fibers **42** are crossed according to two orthogonal directions or are even arranged randomly in the matrix (not shown).
[0091] The diameter of the reinforcement fibers **42** is, for example, less than 100 microns, and is notably between 4 microns and 10 microns for carbon reinforcing fibers.
[0092] Preferably, each composite reinforcement layer of the tubular structure **4** is formed by winding at least one composite strip **2** manufactured by the method according to the invention, an example of which can be seen in FIG. **1**.
[0093] Each composite strip **2** presents several layers of fibers **42** embedded in an elongated matrix **40**. It presents a length greater than at least 10 times its width and at least 10 times its thickness.
[0094] For example, the length of each composite strip **2** is greater than 100 m and is generally between 100 m and 4500 m. In particular, the width of each composite strip **2** is between 6 mm and 50 mm. The thickness of each composite strip **2** is advantageously between 0.1 mm and 1 mm.
[0095] Thus at 23° C., each composite strip **2** presents a tensile modulus greater than 10 MPa, in particular between 30 GPa and 170 GPa, such as measured by Standard NF EN 2561, January 1996, an elongation at break greater than 0.3%, in particular between 1% and 5%, such as measured by Standard NF EN 2561, January 1996, and a maximum tensile strength greater than 100 MPa, in particular between 350 MPa and 3500 MPa, such as measured by Standard NF EN 2561, January 1996.
[0096] Advantageously, each composite strip **2** comprises a PEEK or a PVDF matrix reinforced with unidirectional carbon fibers oriented parallel to the longitudinal axis of the strip.
[0097] As will be seen below, during the production of each reinforcement layer, the or each composite strip **2** is helically wound around the axis A-A′ of the tubular sheath **20** and is heated to cause partial melting of the matrix **40**, and bonding with the successive turns of the composite strip **2**, and/or with adjacent layers which may be other reinforcement layers, anti-delamination layers or the tubular sheath **20**.
[0098] The absolute value of the winding helix angle γ of each composite strip **2** relative to the axis A-A′ of the pipe **10** is, for example, between 50° and 85°, preferably between 55° and 80°. This ensures elongation of the composite under the effect of the internal pressure, and adequate cooperation with the armor layers **24**, **25**.
[0099] The combination of a winding angle γ of the composite strips **2** with an absolute value of between 50° and 85°, advantageously between 55° and 80°, preferably between 60° and 80°, with a winding angle φ of the reinforcement elements **50** with an absolute value of between 25° and 45°, prevents elongation of the reinforcement tubular structure **4** through the compensating effect produced by the reinforcement layers **24**, **25**.
[0100] The optimum combination between the winding angles γ, φ drastically reduces the stresses in the tubular assembly formed by the inner sheath **20** and the reinforcement tubular structure **4**, and therefore the thickness required to resist bending, internal pressure and/or collapse forces.
[0101] In addition, thanks to the axial stiffness of the reinforcement tubular structure **4**, the tensile armor layers **24**, **25**, in cooperation with the reinforcement tubular structure **4**, are more resistant to axial compression under the external pressure conditions of the deep sea.
[0102] In addition, the winding angle φ of the reinforcement elements **50**, with an absolute value of between 25° and 45°, taken in combination with the angle γ of winding of the composite strips **2**, with an absolute value of between 50° and 85°, allows compression of the reinforcement tubular structure **4**, reducing the minimal bending radius (“MBR”).
[0103] The permissible tensile deformation at the extrados of the tubular assembly formed by the inner sheath **20** and the reinforcement tubular structure **4** is greater than 1%, advantageously greater than 2%, preferably greater than 3%. This deformation induces the winding radius compatible with most manufacturing and installation equipment.
[0104] According to the invention, with reference to FIG. **1**, the composite strip **2** is formed from a

plurality of strip parts **60**A, **60**B which are butted together by welding to form a joint **62**.
[0105] The number of strip parts **60**A, **60**B butted together to form a strip **2** is, for example, greater than or equal to 2, and is in particular between 2 and 20.
[0106] The number of strip parts **60**A, **60**B may be equal to 2, in particular when a strip **2** breaks during manufacture, or if a visible defect in the strip **2** is noticed when the machine is at a standstill.
[0107] The number of strip parts **60**A, **60**B can be greater, in particular when manufacturing a long strip **2**, for example greater than 350 m, and in particular, of the order of 1000 m. In this case, at least 3 strip parts **60**A, **60**B of the order of 300 m are assembled.
[0108] As illustrated in FIG. **2**, each strip part **60**A, **60**B includes a polymer matrix **40**, and reinforcement fibers **42**, as described above.
[0109] Each strip part **60**A, **60**B presents an end region **64**A, **64**B intended to be applied to the end region **64**B, **64**A of another strip part **60**B, **60**A to form the joint **62** by welding.
[0110] In the example illustrated in FIG. **2**, each end region **64**A, **64**B comprises a male front zone **66**A, **66**B presenting at least one edge **68**, **70** inclined relative to a longitudinal axis F-F′ of the strip part **60**A, **60**B. It also presents a rear zone **72**A, **72**B presenting lateral edges **74**, **76** parallel to each other and parallel to the axis F-F′, the rear zone **72**A, **72**B being intended to be brought into contact with the front zone **66**B, **66**A of another strip part **60**B, **60**A.
[0111] As will be seen below, the superimposition of the two end regions **64**A, **64**B having a male front zone **66**A, **66**B allows surprisingly, despite the increase in thickness relative to the male-female splicing, to nevertheless obtain an assembly that retains adequate flexibility for winding and unwinding the strip **2**.
[0112] The excess thickness is symmetrically distributed and reaches its maximum at an imaginary line **71**, which is the intersection of the two male front zones **66**A and **66**B. However, this excess thickness is much less than in the case of overlapping end regions without a bevel. Furthermore, the shear stress decreases towards the imaginary line **71** and increases up to the tip of the front zone **66**A, **66**B.
[0113] In this example, the length of the end region **64**A, **64**B is greater than 5 mm, in particular, greater than 10 mm, and is, for example, between 15 mm and 25 mm. This length corresponds to the length of the joint **62** on the composite strip **2** obtained after welding.
[0114] Preferably, each front zone **66**A, **66**B presents a length H between ⅓ of the width L of the rear zone **72**A, **72**B and the width L of the rear zone **72**A, **72**B.
[0115] In particular, this length H is between 5 mm and 15 mm, in particular between 8 mm and 12 mm.
[0116] The width L is advantageously between 10 mm and 30 mm, in particular 12 mm, 18 mm, 22 mm or 25 mm.
[0117] Thus, each joint **62** presents a minimal excess thickness, while maintaining sufficient tensile strength and curvature during installation.
[0118] As will be seen below, such a configuration keeps the energy of the laser beam intended to assemble the reinforcement tubular structure **4** substantially constant, despite the local excess thickness.
[0119] This unexpectedly avoids varying the energy of the laser beam following a change in the thickness of the strip **2**, and therefore generating a variation in the heating temperature of the strip **2**, which can recurrently reach 550° C.
[0120] The problems associated with overheating or underheating are therefore largely avoided. It is well known that the slightest overheating can generate flashes, or conversely, the slightest underheating can lead to insufficient melting of the strip (unconsolidated or glued, resulting in delamination or bubbling).
[0121] Another surprising advantage of superimposing the end regions **64**A, **64**B presenting the male front zones **66**A, **66**B is that the reinforcement fibers **42** are bonded over a sufficient length to

withstand stresses. The excess matrix **40** fills and impregnates the shorter fibers **42** across the width at a distance from the center, as if there were no joint. Surprisingly, micrographic cross-sections of the joint **62** show no singularity.

[0122] Each front zone **66**A, **66**B projects from the respective rear zone **72**A, **72**B. It is delimited by two lateral edges **68**, **70**, each of which presents at least one point, in particular at least one segment, positioned at a distance from the respective extension of each lateral edge **74**, **76** of the rear zone **72**A, **72**B.

[0123] The front zone **66**A, **66**B thus presents at its free end a width strictly less than that of the rear zone **72**A, **72**B. Advantageously, the width of the front zone **66**A, **66**B decreases continuously from the rear zone **72**A, **72**B toward the free end.

[0124] Advantageously, each front zone **66**A, **66**B includes an inclined edge **68** and an additional inclined edge **70** extending on either side of the longitudinal axis F-F′. In this example, the inclined edge **68** and the additional inclined edge **70** intersect on the strip part **60**A, **60**B and together define an end point **78** of the strip part **60**A, **60**B. The front zone **66**A, **66**B thus presents a triangular shape having the end point **68** as its vertex.

[0125] The angle of inclination θ of the inclined edge **68** relative to the longitudinal axis F-F′ is, for example, between 20° and 80°, in particular, between 30° and 60°, even more particularly between 35° and 55°.

[0126] The additional inclined edge **70** advantageously presents an angle of inclination −θ opposite to the angle of inclination θ of the inclined edge **68**.

[0127] The angle of inclination −θ of the additional inclined edge **70** is, for example, between −20° and −80°, in particular between −30° and −60°, even more particularly between −35° and −55°.

[0128] The length H of the front zone **66**A, **66**B, taken along the axis F-F′ between the end point **78** and the projection on the axis F-F′ of the points of intersection of the inclined edges **68**, **70** with the respective lateral edges **74**, **76**, is equal to the length of the rear zone **72**A, **72**B intended to receive the front zone **66**B, **66**A of the other strip part **60**B, **60**A.

[0129] The method for manufacturing the strip **2** is implemented in a manufacturing installation represented schematically in FIG. **3**.

[0130] The installation advantageously includes a station **82** for supplying or manufacturing the strip parts **60**A, **60**B, comprising if necessary a device **84** for cutting each inclined edge **68**, **70**. The installation includes a welding station **86** intended to weld together the end regions **64**A, **64**B thus formed.

[0131] The supply or manufacturing station **82** is able to supply or manufacture the strip parts **60**A, **60**B of composite material presenting a matrix **40** and the fibers **42** as described above.

[0132] The maximum length of the strip parts **60**A, **60**B formed in the station **82** is, for example, less than 5000 m. This length is, for example, greater than 350 m, and in particular between 500 m and 1500 m.

[0133] In one embodiment, the contour of the strip parts **60**A, **60**B initially supplied or manufactured by the station **82** is rectangular. The cutting apparatus **84** is then able to cut each inclined edge **68**, **70** in the end region **64**A, **64**B of each strip part **60**A, **60**B. Cutting is performed with a blade and/or by laser cutting.

[0134] In the example illustrated in FIG. **7**, the cutting apparatus **84** includes a base **200** defining a groove **202** for receiving a strip part, a cutting wedge **204**, mounted movably relative to the base **200** between a position for loading/unloading a strip part **60**A, **60**B and a position for cutting the strip part **60**A, **60**B. The cutting apparatus **84** advantageously includes guides **206** for displacing the cutting wedge **204**.

[0135] The base **200** presents a cutting end **208** with a contour identical to the contour of the front zone **66**A, **66**B of each end region **64**A, **64**B.

[0136] The cutting wedge **204** also presents a contour cutting end **210** identical to the contour of the front zone **66**A, **66**B of each end region **64**A, **64**B. The cutting end **210** is provided with at least

one blade **211** projecting toward the base **200** along the contour of the cutting end **210**.
[0137] The displacement guides **206** are formed, for example, by the parallel rods **212** projecting from the base **200**. Each rod **212** is received in a complementary through passage **214** formed through the cutting wedge **204**.
[0138] To realize the cut, a strip part **60**A, **60**B initially supplied or manufactured by the station **82** with a rectangular contour, is introduced into the groove **202** of the base **200**, with the cutting wedge **204** occupying its loading/unloading position.
[0139] The cutting wedge **204** is then passed into its cutting position in the vicinity of the base **200**. The blades **211** located at the cutting end **210** cut the lateral edges **68**, **70** of the front zone **66**A, **66**B, along the contour of the cutting end **208** of the base **200**.
[0140] Alternatively, the strip parts **60**A, **60**B supplied or manufactured by the station **82** present the or each inclined edge **68**, **70** in the end region **64**A, **64**B of each strip part **60**A, **60**B. In this case, the installation is devoid of a cutting station **84**.
[0141] As illustrated in FIG. **3**, the welding station **86** includes a metal support **88**, intended preferably to be heated by induction, and advantageously at least one induction coil **90** intended to be positioned opposite a heating region **91** of the metal support **88**, and at least one movable wedge **92** for applying pressure.
[0142] Alternatively, the welding station **86** includes a non-inductive heating device.
[0143] The wedge **92** is movable relative to the metal support **88** between a retracted position for positioning the end regions **64**A, **64**B of the strip parts **60**A, **60**B and a position for applying pressure to the end regions **64**A, **64**B of the strip parts **60**A, **60**B.
[0144] The metal support **88** presents an upper surface **94** intended to receive each strip part **60**A, **60**B in abutment and to bring the end regions **64**A, **64**B into superimposition on one another in the heating region **91** facing the induction coil **90**.
[0145] The metal support **88** is made of aluminum or tool steel, for example.
[0146] The induction coil **90** is able to be supplied with a variable electric current from a source (not shown), to generate in the heating region **91** of the metal support **88**, located facing the coil **90**, the induced currents able to heat the metal support **88** by the Joule effect.
[0147] The thickness of the metal support **88** up to the surface **94**, taken in the heating region **91** facing the induction coil **90**, is for example less than 5 mm, and is, in particular, between 1 mm and 3 mm.
[0148] The currents induced by the coil **90** in the heating region **91** are able to increase the temperature of the metal support **88** in the heating region **91** to a temperature greater than the melting temperature of the polymer, that is, 340° C., and in particular to a temperature of between 345° C. and 360° C. for a PEEK matrix. The heating by induced current preferably allows to obtain a temperature rise gradient greater than 15° C./s, in particular between 17° C./s and 25° C./s.
[0149] This temperature is sufficient to cause at least partial melting of the polymer matrix **40** of the end regions **64**A, **64**B.
[0150] The wedge **92** internally defines an indentation **96** of parallelepiped volume and width corresponding to the width of the strip **2** taken between the parallel lateral edges **74**, **76**.
[0151] The wedge **92** is movable relative to the upper surface **94** of the metal support **88** between the retracted position and the position applied to the metal support **88**.
[0152] When applied to the surface **94**, the wedge **92** applies pressure to the overlapping end regions **64**A, **64**B, ensuring mixing between the polymer matrices **40** and the reinforcement fibers **42** of each of the end regions **64**A, **64**B to produce the joint **62** after cooling.
[0153] A method for manufacturing the composite strip **2** in the installation will now be described.
[0154] Initially, the strip parts **60**A, **60**B are manufactured separately from each other and/or are supplied to the supply and/or manufacturing station **82**.
[0155] In the case where the strip parts **60**A, **60**B initially present a rectangular contour, the end regions **64**A, **64**B are fed into the cutting apparatus **84** to be cut there and form the inclined edge **68**

and the additional inclined edge **70**, with the angle of inclination θ or −θ defined above.
[0156] Having done this, the strip parts **60**A, **60**B are arranged on the upper surface **94** of the metal support **88**.
[0157] In the heating region **91**, the front zone **66**A of an end region **64**A of a first strip part **60**A is arranged in contact with, and above, the rear zone **72**B of an end region **64**B of a second strip part **60**B.
[0158] As a result, the front zone **66**B of the end region **64**B of the second strip part **60**B is arranged below the rear zone **72**A of the end region **64**A of the first strip part **60**A.
[0159] Once this has been done, the welding station **86** is activated to form the joint **62**. To this end, an alternating current is supplied to the induction coil **90**, which generates induced currents in the metal support **88**, and a heating of the upper surface **94** by the Joule effect.
[0160] This heating causes at least partial melting of the polymer matrix **40** of the end regions **64**A, **64**B.
[0161] The movable wedge **92** is then displaced from its retracted position to its position applied to the end regions **64**A, **64**B of the strip parts **60**A, **60**B. The polymer matrices **40** of the end regions **64**A, **64**B mix and form the joint **62**.
[0162] Then, the power supply to the coil **90** being switched off, the polymer matrix **40** in the region of the joint **62** cools and solidifies to form the joint **62**.
[0163] It should be noted that the trace of the inclined edges **68**, **70** of each end region **64**A, **64**B remains advantageously visible on the outer surface of the strip **2**, even after welding.
[0164] The strip **2** is then wound onto a reel, for use in an installation **98** for manufacturing the flexible pipe **10**, represented schematically in FIG. **4**.
[0165] The installation **98** includes a station **100** for supplying the sheath **20**, possibly a pre-compaction station **102**, a station **104** for forming the tubular structure **4** and possibly a post-compaction station **106**.
[0166] The installation **98** advantageously includes a station **108** for winding the armor layers **24**, **25** and a station **110** for forming the outer sheath **30**.
[0167] The station **100** for supplying the sheath **20** is able to manufacture and/or unwind the sheath **20** along a longitudinal axis A-A′, with a view to its introduction into successive stations **102**, **104**, **106**. The sheath **20** thus defines a cylindrical outer surface **112** (see FIG. **5**) on which the tubular structure **4** is formed.
[0168] The forming station **104** is illustrated schematically in FIG. **5**. It includes a frame **120** delimiting a central passage **122** for circulation of the sheath **20** along a central axis A-A′, a device **124** for parallel winding of a plurality of strips **2** onto the outer surface **112** defined here by the sheath **20**, and at least one device **126** for heating the strips **2**.
[0169] The forming station **104** also includes a compacting device **128**.
[0170] The frame **120** here includes a fixed structure fixed to the floor, at least one rotary support element formed by a mobile cage **132** mounted movable in rotation on a fixed structure about the central axis A-A′, and a mechanism **134** for driving the mobile cage **132** in rotation relative to the fixed structure.
[0171] The mobile cage **132** includes a drum **136** rotatable about the central axis A-A′ and a support **138** carried by the drum **136** at a distance from the central axis A-A′.
[0172] The central passage **122** passes through the drum **136**.
[0173] The winding device **124** is mounted on the support **138** of the movable cage **132** to be driven in rotation together with the movable cage **132** about the axis A-A′.
[0174] The winding device **124** includes a plurality of unwinders **142**, and the elements (not shown) for guiding the strips **2** coming from each unwinder **142** to guide them toward the outer surface **112**, keeping them parallel.
[0175] Each unwinder **142** is able to unwind respectively, at least one strip **2** intended to form a reinforcement layer.

[0176] Each unwinder **142** includes at least one reel on which at least one strip **2** is wound.
[0177] The guide elements include guides for aligning the strips **2** parallel to one another along an axis inclined relative to the central axis A-A′ by an angle equal to the helix angle γ, to allow the strips **2** coming from each unwinder **142** to be wound helically around the outer surface **112** when the mobile cage **132** rotates about the axis A-A′.
[0178] The heating device **126** is also carried by the support **138** of the moving cage **132**. It is positioned facing the outer surface **112**, in the region where the strips **2** are applied to the outer surface **112**. It includes, for example, a laser, a lamp, in particular, a xenon lamp, an infrared lamp, a pulsed light device, an ultrasonic welding device and/or a hot air blower device.
[0179] The heating device **126** is able to soften, advantageously to melt, the thermoplastic matrix **40** of the strip **2** to allow its complementary application to the outer surface **112**.
[0180] In this example, the compacting device **128** includes a common frame with the frame **120** of the forming station **104**. It includes at least one roller train **150** carried by the movable cage **132** to be driven jointly in rotation with the movable cage **132** about the central axis A-A′ relative to the outer surface **112**. The compacting device **128** also includes an approach mechanism **152**, able to displace each roller train **150** toward the central axis A-A′.
[0181] The compacting device **128** is, for example, of the type described in the Applicant's patent application FR3079162 of the Applicant.
[0182] A method for manufacturing a tubular structure **4** according to the invention in the installation **98** will now be described, in the example of making a flexible pipe **10**.
[0183] Initially, the sheath **20** is manufactured and/or supplied in the supply station **100**. It is fed to the structure **4** forming station **104** and is displaced in translation through the station **104** for forming the structure **4** along the axis A-A′ by a device for driving in translation.
[0184] Advantageously, prior to the station **104**, the sheath **20** passes through the pre-compaction station **102**. The sheath **20** first passes through a heating device **126**, to bring its outer surface **112** to a temperature above 100° C., and in particular between 100° C. and 350° C.
[0185] The roller trains **150** are driven in rotation around the sheath **20**. The rollers are applied to the outer surface **112** to make it as cylindrical as possible.
[0186] Then, the sheath **20** is introduced into the central passage **122** of the forming station **104**.
[0187] In this station **104**, a plurality of reinforcement layers are formed from the strips **2**.
[0188] For each reinforcement layer, a plurality of strips **2** are unwound in parallel from the unwinders **142** of the winding apparatus **124**. The guide elements keep the strips **2** parallel to each other, with controlled clearance.
[0189] The parallel strips **2** pass in front of the heating device **126**, where they are advantageously heated to a temperature of between 150° C. and 450° C., said temperature depending on the nature of the thermoplastic polymer constituting the matrix **40** of the strips **2**.
[0190] When the matrix **40** of the strips **2** is made of PEEK (melting point around 350° C.), the temperature at which the strips **2** are heated by the heating device **126**, is advantageously between 350° C. and 450° C., preferably between 380° C. and 420° C. When the matrix **40** of the strips **2** is made of PVDF (melting point around 180° C.), the temperature at which the strips **2** are heated by the heating device **126** is advantageously between 180° C. and 280° C., preferably between 200° C. and 250° C. This advantageously leads to at least partial melting of the matrix **40**.
[0191] As the moving cage **132** is driven in rotation about the axis A-A′, and the sheath **20** is displaced in translation along the axis A-A′, the strips **2** are wound helically around the outer surface **112** defined by the sheath **20** or defined by a layer formed around the sheath **20**, with a helix angle equal to γ.
[0192] Immediately after winding, the roller train **150**, driven in rotation jointly with the moving cage **132**, is applied to the strips **2**.
[0193] The tubular structure **4** thus formed then passes into the post compaction station **106**. The outer surface **112** of the tubular structure **4** is then softened as it passes through a heating device

and is then compacted again by rotating roller trains **150**. The rollers of the roller train **150** roll according to a helical path along the respective strips **2**, ensuring minimal disorganization of the reinforcing fibers **42**.

[0194] Advantageously, the operations of pre-compaction (station **102**), formation of the tubular structure (station **104**) and post-compaction (station **106**) are repeated (loop **101** on FIG. **2**) to form further reinforcement layers with other strips **2**, as described previously.

[0195] Thus, the tubular structure **4** is manufactured layer by layer, with a new outer layer being added at each passage through the station **104**, with a thickness substantially equal to that of a strip **2**. These operations can be repeated several dozen times, particularly when the thickness of the strip(s) **2** present a thickness significantly less than the final wall thickness of the tubular structure **4**.

[0196] In addition, the characteristics of the strips **2** and/or the laying and/or compaction parameters can be modified each time a new layer is added. For example, the helix angle of the strips **2** can possibly be modified, in particular, to cross the fibers of two superimposed layers.

[0197] The tubular structure **4** then passes through the winding station **108**, to allow the armor layers **24**, **25** to be positioned.

[0198] The armor elements **50** of the tensile armor layers **24**, **25** are wound around the reinforcement tubular structure **4**, in a manner not bonded to the reinforcement tubular structure **4**. Advantageously, an anti-wear layer **26** is interposed between the reinforcement tubular structure **4** and the first tensile armor layer **24**, and between each pair of tensile armor layers **24**, **25**.

[0199] Then, advantageously, a reinforcing ribbon **28** is wound around the outermost tensile armor layer **25**.

[0200] Then, in the outer sheath forming station **110**, the outer sheath **30** is formed around the tensile armor layers **24**, **25**.

[0201] The composite strips **2** manufactured by the method according to the invention are therefore particularly suitable for use in the formation of a tubular structure **4** of a flexible pipe **10** in a station **104** comprising a heating device **126**, for example a laser.

[0202] For the manufacture of the strip **2**, the use of a welding station **86** operating by induction, associated with the use of unconnected strip parts **60**A, **60**B presenting an end region **64**A, **64**B having at least one inclined edge **68**, **70** allows a weld joint **62** to be made between the strip parts **60**A, **60**B which is robust, while presenting low stiffness, and adequate tensile strength to be unwound from each unwinder **142** and wound onto the outer surface **112**.

[0203] The presence of the joints **62** realized by welding between the parts of the strips **60**A, **60**B with the aid of induction heating avoids producing locally high temperatures when passing through the station **104**, in particular when this station comprises a laser heating device **126**. No flash or combustion effects are observed at the joint **62**.

[0204] The joint **62** between the strip parts **60**A and **60**B remains simple and quick to realize, and does not produce holes, debris or areas presenting delamination.

[0205] The end regions **64**A, **64**B of the strip parts **60**A, **60**B can be easily prepared for welding by simple cutting.

[0206] The application of heat and pressure to weld the end regions **64**A, **64**B together is carried out without applying a film to the surface of each end region **64**A, **64**B.

[0207] This makes it possible to produce a continuous strip of great length, directly usable for the manufacture of tubular structures **4**, particularly within a flexible pipe **10** intended for great depths.

[0208] In one alternative (not shown), at least one end region **64**A, **64**B presents a male front zone **66**A, **66**B which is not necessarily triangular.

Claims

1. A composite material strip manufacturing method, the strip being configured to form a tubular structure, the method comprising: butting together end regions of unconnected strip parts, each strip part being formed of a polymer matrix and fibers embedded in the matrix or a film embedded in the matrix, applying heat and pressure to produce a joint by welding between the end regions, at least one of the end regions having a rear zone having rear zone lateral edges parallel to one another, and a front zone projecting from the rear zone, the front zone being delimited by two front zone lateral edges each presenting at least one point positioned at a distance from a respective extension of each rear zone lateral edge between the respective extensions of each rear zone lateral edge, a front zone of an end region of a first strip part among the strip parts being located facing an end region of a second strip part among the strip parts when butting together the end regions.
2. The method according to claim 1, comprising arranging the end regions of the strip parts on a heating region of a metal support, applying heat and pressure including heating by induction the heating region of the metal support.
3. The method according to claim 2, comprising arranging an induction coil facing the heating region of the metal support and circulating a variable electric current through the induction coil to generate heat by Joule effect via currents induced in the heating region of the metal support.
4. The method according to claim 3, comprising displacing a wedge in the heating region, and applying pressure to the end regions of the strip parts between the metal support and the wedge.
5. The method according to claim 1, wherein, when butting together the end regions, at least one lateral edge of the front zone is an inclined lateral edge, an angle of inclination of the inclined lateral edge relative to a longitudinal axis of the strip part in the end region being between 20° and 80°.
6. The method according to claim 1, wherein, when butting together the end regions, the front zone of the end region comprises an inclined lateral edge and an additional inclined lateral edge, the additional inclined lateral edge being inclined relative to a longitudinal axis of the strip part by an angle of inclination opposite to an angle of inclination of the inclined lateral edge relative to the longitudinal axis of the strip part.
7. The method according to claim 6, wherein the additional inclined lateral edge intersects with the inclined lateral edge at an end point of the strip part.
8. The method according to claim 1, wherein each of the end regions has a rear zone having rear zone lateral edges parallel to one another, and a front zone projecting from the rear zone, the front zone being delimited by two front zone lateral edges, each front zone lateral edges presenting at least one point positioned at a distance from a respective extension of each rear zone lateral edge between the respective extensions of each rear zone lateral edge, a front zone of an end region of a first strip part among the strip parts being located facing a rear zone of an end region of a second strip part among the strip parts when butting together the end regions.
9. The method according to claim 1, wherein applying heat and pressure to weld the end regions together is carried out without application of material.
10. The method according to claim 1, wherein, when butting together the end regions an overlap between an end region of the first strip part among the strip parts and an end region of the second strip part among the strip parts, measured along a longitudinal axis of each end region is greater than 10 mm.
11. The method according to claim 1, wherein the matrix is made of a polymer chosen from PEK (polyetherketone), PEEK (polyetheretherketone), PEEKK (polyetheretherketoneketone), PEKK (polyetherketoneketone), PEKEKK (polyetherketoneetherketoneketone), PAI (polyamide-imide), PEI (polyether-imide), PSU (polysulfone), PPSU (polyphenylsulfone), PES (polyethersulfone), PAS (polyarylsulfone), PPE (polyphenylene ether), PPS (polyphenylene sulfide), LCP (liquid crystal polymers), PPA (polyphthalamide), copolymers and mixtures thereof, and wherein the fibers are selected from carbon fibers, glass fibers, aramid fibers, and basalt fibers.

12. A method to form a tubular structure comprising using at least one strip of composite material produced by the manufacturing method according to claim 1.

13. A composite material strip manufacturing installation, the composite strip being configured to form a tubular structure, the installation comprising: a supply or manufacturing station configured to supply unconnected strip parts, each strip part being formed from a polymer matrix and fibers embedded in the matrix, a welding station including a support having a heating region configured to butt weld the end regions, and a heat and pressure applicator configured to procure a joint by welding the end regions, the supply and manufacturing station including a cutter configured to form at least one end region presenting a rear zone having rear zone the lateral edges parallel to one another, and a front zone projecting from the rear zone, the front zone being delimited by two front zone lateral edges, each front zone lateral edge presenting at least one point, positioned at a distance from a respective extension of each rear zone lateral edge between the respective extensions of each rear zone lateral edge.

14. The installation according to claim 13, wherein the support is a metal support, the heat and pressure applicator being configured to heat by induction the heating region of the metal support on which the end regions of the strip parts are configured to be arranged, the heat and pressure applicator comprising an induction coil positioned facing the heating region of the metal support, and a variable electric current source able to supply the induction coil to generate by Joule effect, heat by currents induced in the heating region.

15. The installation according to claim 14, wherein the heat and pressure applicator comprises a moveable wedge configured to apply pressure on the heating region to the end regions of the strip parts between the metal support and the wedge.

16. The installation according to claim 13, wherein the cutter includes a base defining a groove configured to receive a strip part, a cutting wedge mounted movably relative to the base between a position for loading/unloading a strip part and a position for cutting the strip part.