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**Titre : FABRICATION D’UN CORPS TUBULAIRE COMPRENANT DEUX COUCHES, OU PLUS, DE BANDES COURBÉES DE MANIÈRE HELICOIDALE**

**Title: PRODUCTION OF TUBULAR BODY COMPRESSING TWO OR MORE LAYERS OF HELICALLY BENDED STRIPS**

**Fig. 6**

![Diagram of tubular body with layers and arrows indicating the process](image_url)

**Abstrait/Abstract:**
Process for the manufacture of an elongated, multilayered tubular body (1) comprising an elongated, tubular inner hollow core (5), optionally an elongated, tubular inner casing (4) and an elongated, tubular outer casing, the inner casing, when present, surrounding the hollow core, the outer casing surrounding the inner casing, when present, or otherwise the hollow core, the outer casing comprising at least two layers (2, 3), each layer consisting of one or more longitudinally preformed, flat elongated metal strips, the preforming of the strips such that the strips have been bent helically in such a way that the consecutive windings of the helix or helices touch or almost touch to each other, each strip in one layer overlapping with other strips in other layers, the layers in the outer casing being bound to each other by an adhesive.
Title: PRODUCTION OF TUBULAR BODY COMPRISING TWO OR MORE LAYERS OF HELICALLY BENDED STRIPS

Abstract: Process for the manufacture of an elongated, multilayered tubular body (1) comprising an elongated, tubular inner hollow core (5), optionally an elongated, tubular inner casing (4) and an elongated, tubular outer casing, the inner casing, when present, surrounding the hollow core, the outer casing surrounding the inner casing, when present, or otherwise the hollow core, the outer casing comprising at least two layers (2, 3), each layer consisting of one or more longitudinally preformed, flat elongated metal strips, the preforming of the strips such that the strips have been bent helically in such a way that the consecutive windings of the helix or helices touch or almost touch to each other, each strip in one layer overlapping with other strips in other layers, the layers in the outer casing being bound to each other by an adhesive.
PRODUCTION OF TUBULAR BODY COMPRISING TWO OR MORE LAYERS OF HELICALLY BENDED STRIPS

This invention relates to a process for the manufacture of a tubular body. More particularly the invention concerns the manufacture of an elongated, multilayered tubular body comprising an elongated inner hollow core, an elongated inner casing and an elongated outer casing, the inner casing surrounding the hollow core, the outer casing surrounding the inner casing, the outer casing comprising at least two layers of longitudinally preformed, flat metal strips. The preforming of the metal strips comprises especially bending the strips in such a way that each strip is converted into a helix by plastic deformation. The preformed metal strip can be made, for example, of a high strength steel, especially steels with a high proportion of its material in the martensitic phase. The inner casing can be made, for example, of a corrosion resistant material. Such tubular bodies have the advantage that high internal pressures can be withstood for a pipe having a relatively small wall thickness, hence for a relatively low weight tubular body.

In general, it is advantageous to try to minimize the weight of pipelines (per meter), while at the same time maintaining the specifications of the maximum allowable pressure at which the pipeline can be operated. Or, expressed in a different way, it is advantageous to increase the maximum allowable pressure at which the pipeline can be operated, while the weight (per meter)
remains the same. Thus a substantial saving in material costs may be obtained, while also a saving in transportation costs will be obtained.

It is known that natural gas and liquid petroleum products may contain undesired contaminants, especially undesired acidic contaminants as carbon dioxide and hydrogen sulphide. Further, organic acids as well as chlorides may be present. It is also known that under standard operating conditions of pressure and temperature, pipelines formed of conventional materials carrying such contaminated products may be subject to failure, for instance due to stress corrosion cracking. Such failures may result in longitudinally extending fractures of the pipelines.

Previous attempts to reduce the risk of such failures have involved the use of corrosion inhibitors, added to the products being carried by the pipelines. Unfortunately, this may result in unacceptable costs including not only the cost of the inhibitors and adding them to the products but also the cost of removing and recovering the corrosion inhibitors in due course from the products carried by the pipelines. The use of corrosion inhibitors is also not advisable, particularly in offshore pipelines, due to potential environmental problems created if there is an escape of the corrosion inhibitors from the pipelines.

Alternative ways of reducing the risk of cracking, especially stress corrosion cracking, in pipes by reducing the tensile stress on the part of the pipes in contact with the contaminated products being carried have been proposed. These include the use of pipes formed of, for example, two tubes inserted one inside the other and to then during production mechanically forcing the inner
pipe into contact with the outer pipe so that the inner pipe after completion of this operation has a compressive stress and the outer pipe has a tensile stress. This process is known as "auto-frettage" and one way of carrying out this operation mechanically is described in U.S. Patent No. 4,823,847. It will be appreciated that the two pipes must be made to very tight tolerances if one is to be able to insert one into the other and perform an auto-frettage step without adversely damaging the inner pipe. It will also be appreciated that this particular auto-frettage operation is only suitable for use in small lengths of pipe and suffers from the disadvantage of being a time consuming and therefore expensive operation to carry out. A further disadvantage of the production of a pipeline from such small lengths of pipe, typically 8 to 10 meter lengths, is that it will involve numerous joints being made which in themselves are points of weakness in a pipeline.

Tubular bodies of a different kind are known from US Patent No. 4,657,049 in which metal strips are helically wound in overlapping fashion and embedded in an adhesive matrix to produce a rigid tubular structure. US Patent No. 3,530,567 describes a method of forming a tube by helically winding a metal strip in self-overlapping fashion so that the thickness of the wall of the tube at any point is formed from a plurality of laps. In order to remove the helical ridges on the internal bore of the tube formed by the edges of the strip, the laps of the strip material are flattened one against the other after winding by expanding the tubular structure beyond the yield point of the metal strips. Such a procedure presents significant manufacturing difficulties.
In GB 2280889 a method is disclosed to form a hollow elongated or tubular body which comprises helically winding at least one strip of material in self-overlapping fashion to provide a multi-layer tubular structure. In this arrangement the strip is longitudinally pre-formed to provide a transverse cross-section having at least one step which, in each convolution of the strip accommodates the overlapping portion of the next convolution. A tubular body having a wall thickness formed of a plurality of laps may thus be continuously made from a single strip of material, the wall thickness generally being one strip thickness greater than the number of steps formed in the cross-section of the strip. A similar tubular body is described in WO 2006/016190.

The production of preformed self overlapping strips requires specialized, expensive, heavy and energy consuming equipment. Further, the process is quite sensitive, and causes stress concentration (expressed by the stress concentration factor) that may weaken the strength of the pipe. Bending a profiled strip causes an uneven distribution of stress across the strip which may result in early failure. This is especially disadvantageous when long tubular elements are to be made and used.

The object of the present invention is to provide a tubular body and a method of forming the same in which the risk of stress corrosion cracking is reduced and in which one or more of the other above-mentioned disadvantages of the known pipes and methods of forming same are alleviated. The new tubular body comprises two or more relatively simple preformed metal strips, preferably around a relatively light inner casing. The
preformed metal strip is a simple flat, prebended strip without any profile. The pre-bending results in a helical shape. The preformed metal strips in the finished tubular body are not self overlapping. The inner casing is preferably corrosion resistant. In this way the requirements of the pipeline (corrosion resistance and strength) are, at least partly, separated. The inner casing provides especially the corrosion resistance, the outer layers provide the major part of the strength (axial as well as radial). The hollow core in the centre of the elongated body is the space for the transport of gas and/or liquids.

Thus, the present invention concerns a process for the manufacture of an elongated, multilayered tubular body comprising an elongated, tubular inner hollow core, an elongated, tubular inner casing and an elongated, tubular outer casing, the inner casing surrounding the hollow core, the outer casing surrounding the inner casing, the outer casing comprising at least two layers, each layer consisting of one or more longitudinally preformed, flat elongated metal strips, the preforming of the strips such that the strips have been bent helically in such a way that the consecutive windings of the helix or helices touch or almost touch to each other, each strip in one layer overlapping with other strips in other layers, the layers in the outer casing being bound to each other by an adhesive,

the process comprising providing an elongated inner casing, providing one or more first flat elongated metal strips, plastically preforming the one or more first metal strips in a bending process to obtain one or more helices and applying the one or more preformed first metal strips onto the inner casing to form the first
layer of the outer casing, providing and applying adhesive, providing one or more second flat, elongated metal strips, plastically preforming the one or more second metal strips in a bending process to obtain one or more helices and applying the preformed one or more second metal strips on the first layer of the outer casing to form the second layer of the outer casing, optionally followed by the further provision and application of one or more additional layers of adhesive and preformed flat, elongated metal strips.

By virtue of the feature that flat metal strips are used to prepare the flat preformed helix shaped outer casing layers, hardly any failures will be present in the preformed strip, for instance due to stress concentration. Especially when using high strength steel alloy, e.g. with a high proportion of its crystal grains in the martensitic phase, tubular bodies are obtained which can withstand high pressures. The use of especially corrosion resistant inner casings will reduce any stress corrosion. By using overlapping layers of preformed strips in the outer casing a substantial portion of the axial load may be taken up by the outer casing. The tubular bodies of the present invention may withstand the same internal pressure, while a material weight saving of 40% or more is obtained when compared with standard pipe. Especially the combination of high martensitic phase content steel strips and pre-bending is advantageous as without pre-bending the finished pipe product will contain a large amount of elastic deformation energy, which makes the production process as well as any repairs a difficult procedure.

The pre-bending of the strip involves applying suitable forces to obtain a helix shaped strip by plastic
deformation of the metal. In the case that a layer is
formed by one metal strip, the diameter of the helix
(without any forces causing elastic deformation) is of
the same order of magnitude as the inner casing, while
the consecutive windings of the helix just touch to each
other or show a small gap or overlap that can be overcome
by elastic deformation of the metal only, to obtain a
small gap as defined below. The diameter of the helix may
be between 0.6 and 1.4 times the diameter of the inner
casing, suitably, the diameter of the helix is between
0.8 and 1.25 times the diameter of the inner casing,
preferably between 0.9 and 1.12, more preferably between
0.97 and 1.04.

It will be understood that the diameter of
consecutive layers in the finished tubular body need to
be slightly larger than the previous layer. In the case
of two (or more) metal strips in the same layer of the
tubular body, the distance between consecutive windings
in the helix (containing the two (or more) strips) is the
width of two (or more) strips, optionally together with
two (or more) small gaps or overlaps as defined below.
Please note that in the case of two (or more) metal
strips in one layer, the next layer may be of the same
structure or may comprise less or more strips. In order
to obtain the desired overlap of the consecutive layers
(in which the gap or the contacting line between two
windings of a helix (as well as any gaps or contacting
lines in the case of two or more strips in one helix) is
covered by a helix of the consecutive layer over the
total length of the pipe) it is necessary that the pitch
of each helix in a layer, comprising the one or more
strips, is the same for all layers. Preferably each layer
consists of one or two metal strips, more preferably one
metal strip. It will be clear that each strip in the layer is a flat strip without any profile.

In principle, the length of the elongated tubular body may vary from one meter to 40 km or even more. Suitably the length is at least 10 meters, preferably between 100 meters and 20 km, more preferably between 500 m and 5 km. In principle a continuous method can be used to make the tubular method of the invention. Thus, only a restricted number of joints are required for long distance pipe lines. The elongated tubular body of the present invention comprises two or more layers in the outer casing, in each layer the windings of the flat metal strip lay adjacent to each other, without any overlap.

In principle there are no restrictions as to the diameter of the tubular body. Suitably the inner hollow core has a diameter of between 5 and 250 cm, preferably between 10 and 150 cm, more preferably between 15 and 125 cm. The outer casing will comprise at least two layers. When using only one layer, the axial load resistance would be too low. In principle, there is no limit to the maximum number of layers, but a practical number will be up till 24, especially up till 20. Suitably the outer casing comprises between 2 and 16 layers, preferably between 2 and 10 layers, more preferably between 3 and 8 layers, especially 4 – 6 layers. It will be appreciated that more layers will result in pipes that can withstand higher pressures. Also a higher axial strength is obtained.

The elongated tubular body, when comprising one strip in each layer, suitably has a ratio circumference/strip width between 3 and 40, preferably 4 and 28, more preferably between 6 and 20, the circumference being the
circumference of the smallest layer (or the first layer around the hollow core) of the outer casing. In the case of more than one strip in a layer, the strip width is defined as the sum of the strip widths in that layer.

The distance between two windings in one layer in the outer casing is preferably relatively small. In that way the forces can be transferred relatively easy without any potential problems with respect to cracking of adhesive layers. Suitably, the axial gap, if present, between two consecutive helix windings is at most a quarter of the strip width, preferably at most a sixth of the strip width, more preferably at most a tenth of the strip width. Sufficient overlap between the layers is thus obtained to transfer the forces. Suitably the gap between two windings of the strip is at most 1 cm, preferably at most 0.4 cm, more preferably at most 0.1 cm.

The distance between the inner casing and the first layer in the outer casing is suitably at most 2 mm, preferably between 0.01 and 1 mm. In a similar way, the distance between two layers in the outer casing is at most 2 mm, preferably between 0.01 and 1 mm. Normally the gap between the inner casing and the first layer and between the layers in the outer casing will be filled with adhesive. In a preferred embodiment, in which the tubular body is treated by an auto-frettage technique, most empty spaces, preferably all empty spaces, between the inner casing and the layers, will be removed. In the case of one metal strip in a layer, each strip in a layer overlaps another strip in another layer in a longitudinal section for 10 till 90%., preferably for 25 till 75%, more preferably for 40 till 60%. For the longitudinal section especially reference is made to Figure 2. In the case of two similar strips in a layer, in a similar way as
indicated above, an optimum overlap is obtained. In the case of two (or more) dissimilar layers a symmetric arrangement usually results in the best overlap. When different numbers of strips are present in adjacent layers, some strips will overlap for 100%, the other layers preferably overlap in the way as described above. See also Figure 5.

The process of the present invention uses an inner casing. Preferably an inner casing. When an inner casing is present, this may be a permanent casing (e.g. metal, especially stainless steel, see below for a more extensive description), or a temporary or sacrificial casing, e.g. paper or cardboard or a soluble polymer. In those cases the inner casing is used in the manufacturing of the elongated tubular body and, usually, removed before any actual use.

The process of the invention is especially carried out in a continuous way. In that way it is possible to make long or even very long tubular bodies, up till several thousands of meters or even more. In the continuous manufacturing mode, there is suitably a continuous supply of inner casing, for instance by the batch production of relatively small parts, e.g. 8 till 12 meters, followed by a welding process to form one long inner casing. The bended flat metal strips are continuously wound around the long inner casing. The starting metal strip may be provided in rolls comprising several thousands meters of strip. By welding several strips together even longer strips may be obtained.

The outer casing of the elongated tubular body is suitably made of steel, stainless steel, titanium or aluminium, preferably a high strength steel as further defined above, especially steels with a high proportion
of its material in the martensitic phase. Steel with a high amount of martensitic crystal grains is preferred in view of its high strength. The use of such steels results in tubular structures of relatively high strength and low weight. These steels have tensile strengths between 900 MPa and 1500 MPa. These steels may be obtained from Mittal Steel under the trade name “MartINsite”.

The elongated tubular body as described above is suitably made of a metal strip having a Specified Minimum Yield Stress (SMYS) of at least 100,000 lbs/square inch, preferably between 150,000 and 300,000 lbs/square inch, more preferably between 180,000 and 250,000 lbs/square inch.

It is a preferred option to protect the elongated tubular body according as discussed above by one or more protective layers. Thus, the tubular body preferably has a protective casing/coating on the outside of the outer casing. Suitable protective casings are metal casings, for example aluminium casings, steel casings etc.

Suitable coatings are polymer coatings, for example PE (polyethylene), PP (polypropylene), PU (polyurethane) and/or PVC (polyvinyl chloride) coatings, or bitumen based coatings as well as corrosion protecting paints. Combinations and/or the use of several layers of coatings may also be used. The protective layers may be applied by conventional techniques, for example winding, extrusion, coating etc.

The elongated tubular bodies may be applied with one or more insulating layers, e.g. mineral wool layers, glass fibre layers etc.

The elongated tubular body as discussed above suitably comprises an adhesive layer comprising a strip of adhesive applied to the inner casing and/or between
the layers in the outer casing. In principle every
adhesive may be used (liquid, powder etc.), but from a
practical point of view a strip is preferred. Preferably,
the adhesive layer comprises a curable polymer,
preferably a film based epoxy having a textile carrier,
more preferably Cytec FM 8210-1.

In the elongated tubular body as discussed above, the
metal strip suitably has a width of at least 10 mm, more
suitably at least 20 mm, preferably between 5 cm and 50
cm, more preferably between 10 and 35 cm, and a thickness
of 0.2 - 5 mm, preferably 0.4 - 4 mm, more preferably
0.8 - 2 mm. The claimed process especially relates to a
process in which the provision of the inner casing or the
mandrel, the provision of the first and second metal
strips and optionally any further metal strips, the
bending of the first and second and optionally any
further metal strips and the application of the adhesive
is carried out in a simultaneous way. In this way all
activities are carried out at the same time and the
tubular body is manufactured in one go. In the case that
the outer casing contains a relatively large number of
layers, e.g. four layers or more, there may be two
simultaneous manufacturing steps, one in which e.g. half
of the layers are applied to the inner casing or the
mandrel and a second step in which the other half are
applied.

In the preferred case in which an inner casing is
present, optionally a layer of adhesive is applied
between the inner casing and the first layer of the outer
casing before the one or more first metal strips are
applied on the inner casing.

In a preferred embodiment the layers of preformed
metal strip are applied onto a revolving inner casing,
preferably a continuously moving and revolving inner casing.

In another preferred embodiment the inner casing is a non-revolving inner casing, and the layers of metal strip are applied onto the inner casing by winding the strips around the inner casing, preferably the inner casing is a continuously moving and non-revolving inner casing.

In the present process, the inner casing is preferably made in a continuous process, including any sub-continuous processes. Thus, the inner casing is suitably be made in a continuous way from flat metal sheets by rolling a metal sheet into a tube, preferably cold rolling, followed by longitudinally welding the rolled sheet, especially laser welding, and connecting the welded tubes to each other, preferably by welding, especially laser welding. Preferably the rolling process is done in two steps, each step converting half of the sheet into half of the tube, preferably using a three rollers assembly to bend the sheet.

In another embodiment the inner casing is made in a continuous way from flat metal sheets by pressing, preferably in a two stage pressing process, followed by longitudinally welding the rolled sheet, especially laser welding, and connecting the welded tubes to each other, preferably by welding, especially laser welding.

Another embodiment comprises the continuous manufacture of the inner casing by helically winding a flat metal strip and welding the winded strip.

In still another embodiment the inner casing is made in a continuous way by extrusion of a polymer, preferably an organic polymer.

The process of the invention also comprises the use of an adhesive being a curable adhesive, preferably
applied on a fabric strip, the process in that case further comprising the curing of the adhesive.

The preformed flat elongated metal strip is suitably made by plastic deformation of a flat elongated metal strip in a roll forming box comprising an assembly of mandrels, preferably 2 to 5 mandrels, more preferably 3 mandrels. The mandrels may be of the same size or of a different size. In the case of a three mandrel system, the actually bending (or preforming) is done around the middle mandrel (see also Figure 6). The size of this mandrel is suitably between 1 and 30 cm, preferably between 2 and 20 cm. The size of the other mandrels may be smaller or larger, but is preferably such that there is sufficient space for bearing and drivers. Preferably all mandrels are provided with drivers to pull the metal strip through the roll forming box. Preferably the strip is fed into the roll forming box via a guiding element, the guiding element comprising an elongated box provided with a elongated slit, the width of the slit slightly larger than the metal strip, preferably the slit up till 2 mm larger than the width of the metal strip, preferably up till 1 mm, more preferably up till 0.5 mm. The elongated flat metal strip is fed to the under an angle, the angle being the angle between the strip and the normal of the mandrels in the roll forming box. Due to this angle, the metal strip will be sliding or slipping over the mandrels. Suitably the flat elongated metal strip is fed to the mandrels under a feed angle of 0.6 to 1.4, preferably 0.8 to 1.2, times the angle alpha, the angle alpha being the same as the angle alpha in the finished tubular body (see also Fig. 4).

Suitably, the slit of the guiding element comprises two rows of rollers or bearings to guide the flat
elongated metal strip, the two rows of rollers or bearings forming the edges of the slit and made from a material, especially a metal or alloy, with a higher hardness that the hardness of the metal strip.

Suitably, the distance between the guiding box and the mandrel is less than 5 cm, preferably less than 1 cm, more preferably less than 0.5 mm. A relatively short distance is preferred, thus avoiding wrinkling of the metal strip.

The invention also comprises the use of an elongated tubular body as described above in the transport of hydrocarbons as oil and or gas optionally containing hydrogen sulphide and/or carbon dioxide. In addition to oil and gas also water may be present. Further, the tubular bodies can be used for the transport of carbon dioxide, hydrogen, water, steam, ethane, ethene, naphtha etc. A very suitable use is the transport of crude oil and/or natural gas, from offshore platforms to the shore as well as onshore. Another suitable use is the transport of refined oil products, gasoline, gasoil, kerosene, naphtha and LPG.

The use is suitably carried out at temperatures between -20 °C up till 130 °C, preferably between -5 °C and 50 °C. The pressure in the tubular body is suitably between 1 and 300 bar, more suitably between 10 and 250 bar, especially between 30 and 200 bar.

The elongated tubular body can be made by the application of preformed metal strip together with an adhesive around a tubular inner casing. Preferably a curable adhesive is used. After curing, the tubular body is preferably subject to an auto-frettage operation. Such operations are known in the art. The tubular body is pressurised to a certain pressure above the operating
pressure, causing the inner casing to yield but the windings to expand within their elastic limit. Once this pressure is relaxed, the windings are left in a state of residual tension and the inner casing is left in a state of residual compression. Keeping the liner well below its yield stress gives two advantages when the pipe is subsequently cycled in pressure at or below its maximum operating pressure: (a) much lower cyclic tensile stresses on the inner core mean fatigue is greatly reduced; and (b) the liner is relatively low tension or in compression, thus reducing stress corrosion cracking.

The invention will be described hereinafter in more detail and by way of example, with reference to the accompanying drawings, in which:

Fig. 1 schematically shows a side view of an embodiment of the tubular body (without outer coating) according to the invention; and

Fig. 2 schematically shows a longitudinal section through the tubular body according to the invention (including an outer coating).

Fig. 3 schematically shows a radial section of the tubular body of Fig. 2.

Fig. 4 shows a part of a flat elongated strip.

Fig. 5 shows a longitudinal section through a tubular body in which the layers comprise different numbers of strips.

Fig. 6 shows a cross view of a roll forming box.

Fig. 7 shows a top view of a guiding box.

Referring to Figures 1, 2 and 3 there is shown a tubular body 1 including two overlapping, elongated metal strips 2 and 3, helically wound around an internal casing 4, the internal casing 4 surrounding the hollow core 5. Each layer consists of one metal strip. The
overlap between the strips in the two layers is 50%. Strips 2 and 3 are made of high strength steel. Strip 3 is helically wound around the internal casing 4. Strip 2 is helically wound in a 50% overlapping mode around strip 3. Between the internal casing 4 and strip 3, and between strip 3 and strip 2 there is a thin layer of adhesive. Around the outer metal strip 2 there is a thin layer of a protective coating. Figure 4 shows the elongated metal strip 3. In the process according to the invention the strip is helically bended around lines perpendicular to line 1, e.g. 1′, 1′′ and 1′′′. It will be clear that during the bending process the line around which the metal strip is bended, will shift continuously in the direction of bending. The distance C-C′ is the gap between two windings of strip 3. The angle α is the angle between lines BA and BC. Figure 5 shows a part of a three layered tubular body, the first layer comprising 4 strips, the second layer comprises 2 strips and the third layer comprises only one strip. The strip width for each layer (or the pitch of the helix) is the strip width of the metal strips and any gaps between the strips.

Figure 6 shows three mandrels 11, 12 and 13. Flat elongated metal strip 15 is fed into guiding box 14. It is helically bended by the action of the three mandrels.

Figure 7 shows the top view of Fig. 6 in the direction of the arrow A.

Suitable applications for the tubular bodies of the present invention are onshore and offshore pipelines, subsea risers, well casings and pipe-in-pipe applications.
CLAIMS

1. A process for the manufacture of an elongated, multilayered tubular body comprising an elongated, tubular inner hollow core, an elongated, tubular inner casing and an elongated, tubular outer casing, the inner casing surrounding the hollow core, the outer casing surrounding the inner casing, the outer casing comprising at least two layers, each layer consisting of one or more longitudinally preformed, flat elongated metal strips, the preforming of the strips such that the strips have been bent helically in such a way that the consecutive windings of the helix or helices touch or almost touch to each other, each strip in one layer overlapping with other strips in other layers, the layers in the outer casing being bound to each other by an adhesive,

the process comprising providing an elongated inner casing, providing one or more first flat elongated metal strips, plastically preforming the one or more first metal strips in a bending process to obtain one or more helices and applying the one or more preformed first metal strips onto the inner casing to form the first layer of the outer casing, providing and applying adhesive, providing one or more second flat, elongated metal strips, plastically preforming the one or more second metal strips in a bending process to obtain one or more helices and applying the preformed one or more second metal strips on the first layer of the outer casing to form the second layer of the outer casing, optionally followed by the further provision and application of one or more additional layers of adhesive
and preformed flat, elongated metal strips, especially a process in which the provision of the inner casing, the provision of the first and second metal strips and optionally any further metal strips, the bending of the first and second and optionally any further metal strips and the application of the adhesive is carried out in a simultaneous way.

2. A process according to claim 1, in which a layer of adhesive is applied to the inner casing before the one or more first metal strips are applied on the inner casing.

3. A process according to any of claims 1 to 2, in which the inner casing or the mandrel is a non-revolving inner casing, and the layers of metal strip are applied onto the inner casing or the mandrel by winding the strips around the inner casing or the mandrel, preferably the inner casing or the mandrel is a continuously moving and non-revolving inner casing.

4. A process according to any of claims 1 to 3, in which the inner casing is made in a continuous way from flat metal sheets by rolling a metal sheet into a tube, preferably cold rolling, followed by longitudinally welding the rolled sheet, especially laser welding, and connecting the welded tubes to each other, preferably by welding, especially laser welding, preferably a process in which the rolling process is done in two steps, each step converting half of the sheet into half of the tube, preferably using a three rollers assembly to bend the sheet.

5. A process according to any of claims 1 to 3, in which the inner casing is made in a continuous way from flat metal sheets by pressing, preferably in a two stage pressing process, followed by longitudinally welding the rolled sheet, especially laser welding, and connecting
the welded tubes to each other, preferably by welding, especially laser welding.

6. A process according to any of claims 1 to 3, in which the inner casing is made in a continuous way by helically winding a flat metal strip and welding the winded strip.

7. A process according to any of claims 1 to 6, in which the preformed flat elongated metal strip is made by plastic deformation of a flat elongated metal strip in a roll forming box comprising an assembly of mandrels, preferably 2 to 5 mandrels, more preferably 3 mandrels.

8. A process according to claim 7, in which the strip is fed into the roll forming box via a guiding element, the guiding element comprising an elongated box provided with a elongated slit, the width of the slit slightly larger than the metal strip, preferably the slit up till 2 mm larger than the width of the metal strip, preferably up till 1 mm, more preferably up till 0.5 mm, especially a process in which the flat elongated metal strip is fed to the mandrels under a feed angle of 0.6 to 1.4, preferably 0.8 to 1.2, times the angle alpha, the angle alpha being the same as the angle alpha in the finished tubular body.

9. A process according to claim 7 or 8, in which the slit of the guiding element comprises two rows of rollers or bearings to guide the flat elongated metal strip, the two rows of rollers or bearings forming the edges of the slit and made from a material, especially a metal or alloy, with a higher hardness that the hardness of the metal strip.

10. A process according to any of claims 15 to 18, in which the distance between the guiding box and the mandrel is less than 5 cm, preferably less than 1 cm, more preferably less than 0.5 mm.