Title: APPARATUS FOR AND METHOD OF MANUFACTURING A HELICALLY WOUND TUBULAR STRUCTURE

Abstract: A winding apparatus for and method of manufacturing helically wound tubular structures (116) includes a rotating inner faceplate (74) upon which are mounted a forming station for forming a supply of strip material before it is wound into a desired structure and a plurality of inner supports in the form of rollers (110) mounted for rotation about an axis and with said inner faceplate and a plurality of outer driven rollers (92) provided on an outer faceplate (118). The inner rollers (110) are mounted for radial movement relative to the inner faceplate (74). In operation, the inner rollers (110) act to support an inner portion S1 of strip material wound thereon whilst allowing it to be supplied from an inner diameter thereof to said forming station and the outer rollers (92) act to support an outer portion S2 of said strip. Said outer rollers are driven as and when necessary to transfer material to the inner portion S1 and the radial position of the inner rollers increases as strip material is consumed from an inner diameter, thereby to maintain support of the strip supply regardless of the amount that has been consumed.
APPARATUS FOR AND METHOD OF MANUFACTURING A HELICALLY WOUND TUBULAR STRUCTURE

The present invention relates to a winding apparatus and a method of manufacturing structures and relates particularly to the manufacture of pipes and longitudinal structures formed by winding strips of material, such as metal, Kevlar, plastic, glass fibre, composites of such materials or strips formed from layers comprising one or more of said materials in a helical relationship. Other structures such as storage vessels, towers and support structures may also benefit from features described herein.

Presently it is known to manufacture tubular structures by winding pre-formed metal strip onto a rotating mandrel such that the strip is deposited onto the mandrel in a self-overlapping manner. The strip is retained in place by mechanical deformation of an edge thereof such that it interlocks with an adjacent edge, thereby to retain the strip in place on the final structure. EP0335969 discloses an apparatus for forming a helically wound tubular structure formed from a flat strip of metal wound onto a mandrel. The flat strip is fed from one or other of a pair of supply spools mounted concentrically with the axis of the tubular structure to be made. A rotating winding head is used to wind the strip onto the mandrel and includes a plurality of powered forming rollers which impart an initial form to the cross section of the metal strip before it is passed to a final set of rollers that lay the strip onto the mandrel. An edge of the strip is then swaged over so that it becomes mechanically locked to the previous layer over which it is wound. This is a complex process. Also provided is a mechanism for ensuring the strip supply is maintained constant and this mechanism includes speed control of the forming rollers. The coaxial supply bobbins are fed from an external supply spool so as to maintain the supply thereof. A welding station is used to join one end of the strip material to another.
US4738008 discloses a winding apparatus for forming a non-rotating helix of metal strip having a rotating store of metal strip provided radially outward of a winding head and means for providing the store of material to the winding head which rotates at a different speed to the store of material. In this process it is necessary to stop the process when the strip material has been consumed and a fresh supply thereof is added before production can be commenced. This can be a very lengthy process.

It is an object of the present invention to provide an apparatus for and method of manufacturing tubular structures which reduces and possibly overcomes some of the problems associated with the prior art.

Accordingly, the present invention provides a winding apparatus comprising; an inner faceplate rotatably mounted for rotation about a longitudinal axis X-X and having an output station thereon; and an outer faceplate radially outward of said inner faceplate; wherein said inner faceplate includes a plurality of strip supports at an outer diameter thereof and onto which, in operation, a supply of material may be wound, and wherein said strip supports are radially adjustable thereby to accommodate a change in diameter of any supply of any material supplied thereto. Such an arrangement allows for the supply of strip material from an inner diameter thereof whilst also preventing a gap appearing between the supply of material and the inner supports and thus reduces and possibly eliminates unbalanced forces that might be created by unsupported strip material as it rotates about axis X.

Preferably, the supports comprise a plurality of rollers mounted for radial adjustment within radially extending slots within said outer faceplate.

Advantageously, one or more of said rollers may be mounted for rotation about a longitudinal axis at a first end of a pivot arm the otherwise free end of which is pivotally mounted to said inner faceplate.
Preferably, said apparatus further includes a plurality of second strip supports at an outer diameter of said outer faceplate.

Advantageously, said apparatus further includes a strip driving mechanism for rotating a supply of strip material supplied to said apparatus about said longitudinal axis X-X.

Preferably, said strip driving mechanism comprises a plurality of driven rollers at an outer diameter of said second faceplate which, in operation, engage with an outer diameter of a supply of strip material supplied to said apparatus. Said driven rollers may also comprise the second strip supports.

Advantageously, the apparatus further includes a strip brake for preventing rotation of an outer diameter of any strip material supplied to said apparatus relative to said faceplate. Said brake may comprise a friction brake.

Preferably, said brake comprises a driven roller having a brake system.

Advantageously, said apparatus further includes a pair of feed rollers mounted on an outer diameter of said outer faceplate for receiving a supply of strip material to said apparatus and for guiding said strip towards said inner faceplate. The apparatus may also include a strip clamping and cutting station. Said feed rollers may also form a strip clamp.

Preferably, said inner faceplate further includes a central bore for receiving a supply of core material onto which strip supplied to said apparatus may be wound.
Advantageously, said apparatus further includes a core supply mechanism for supplying a continuous or semi-continuous supply of core material to said apparatus.

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

Figures 1 to 3 are partial cross-sectional views of different types of tubular structure that may be formed by the apparatus described herein;

Figure 4 is a schematic side elevation of an apparatus according to aspects of the present invention;

Figure 5 is a cross-sectional side view of a winding head according to one aspect of the present invention;

Figure 6 is a front view of the forming head shown in figure 5 and for reasons of clarity omits some features shown in figure 5;

Figure 7 is a detailed front view of the forming head taken in the direction of arrow A in figure 5;

Figures 8 to 14 are end views of the winding head and illustrate various stages in the operation thereof; and

Figure 15 illustrates one possible alternative form of the inner support rollers and their mounting on the inner faceplate.

Referring now to Figure 1 of the drawings, a tubular body indicated generally at 10 forms a pipe for use in a pipe system such as a pipeline carrying hot fluids (which may also be under pressure). The tubular body may comprise an inner portion in the form of an inner hollow core 12 which may be formed by any one of a number of forming processes known to those skilled in the art and an outer casing discussed in detail later herein and which may also be load carrying. In the preferred process the inner pipe comprises a continuously formed core, as will also be discussed in detail later herein however, one may have a core made
from a plurality of discrete lengths inter-engaged with each other so as to form a long length. The outer casing indicated generally at 14 is formed on the inner hollow core 12 by helically winding a strip 16 of material onto the outer surface 12a of the core 12 in abutting or self-overlapping fashion similar to the manner which is described in detail for the formation of a pipe on a mandrel in the specific descriptions of the applicants U.K. Patent No. 2,280,889 and U.S. Patent No. 5,837,083. The strip may be wound under tension and may have one or more transverse cross-sectional steps 18 and 20 each of which is preferably of a depth corresponding to the thickness of the strip 16. The steps 18, 20 are preferably preformed within the strip 16, each extending from one end of the strip 16 to the other to facilitate an over-lapping centreless winding operation in which each convolution of the strip accommodates the overlapping portion of the next convolution. Whilst the strip may comprise any one of a number of materials such as a plastic, a composite material or indeed metal, it has been found that metal is particularly suitable in view of its generally high strength capability and ease of forming and joining as will be described later herein. Examples of suitable metals include steel, stainless steel, titanium and aluminium, some of which are particularly suitable due to their anti-corrosion capabilities. The internal surface 16i of the strip 16 and the outer surface of the pipe 12o may be secured together by a structural adhesive, as may the overlapping portions of the strip. The use of an adhesive helps ensure that all individual components of the tubular member 10 strain at a similar rate. The application of the adhesive may be by any one of a number of means but one particularly suitable arrangement is discussed in detail later herein together with a number of other options.

Figure 2 illustrates an alternative arrangement in which the flat strip 16 is formed such that step 28 divides the strip into longitudinal portions and is also provided with ridges 30 running longitudinally thereof. The ridges are shaped to produce an external ridge and an internal groove into which an external ridge of a previously deposited portion nestles during forming.
Figure 3 illustrates a still further arrangement in which the strip comprises a simple flat strip wound in abutting relationship and provided in multiple layers which may be staggered as shown.

Referring now more particularly to figure 4, from which it will be seen that an apparatus 50 for manufacturing helically wound structures comprises: an optional pre-forming portion 52, in which a core 54 is formed; a forming station, shown schematically at 56 and described in detail later herein; and a post forming section, shown generally at 58 and including a number of optional features discussed later. In one arrangement of the optional pre-forming portion 52 there is provided a store of flat strip material in the form of a roll of metal strip 60 and a plurality of feed rollers 62 which feed the strip to forming rollers 64 and 66 which in turn roll the edges of the strip together around a central mandrel 68 so as to form a tubular structure 54 having confronting edges abutting each other (not shown). A welding apparatus shown generally at 70 and including a welding head 72 is used to weld together the confronting edges in a manner well known in the art and therefore not described further herein. An alternative core forming process might comprise the manufacture of a plurality of discrete lengths of tubular structure, each of which are provided with inter-engaging features on confronting ends thereof such as to allow a plurality of said lengths to be assembled into a long section of core. When employing such a core arrangement one may replace the strip forming and welding arrangement with a suitable feed mechanism (not shown) for feeding a plurality of said discrete lengths into the forming station in a continuous manner. Once formed, the core of whatever description is fed into the forming station 56, which is best seen with reference to figures 5 and 6.

Referring to the drawings in general but particularly figure 5 which is a side elevation of the forming station 56 and comprises a faceplate 74 upon which are mounted a plurality of forming rollers 76 and a set of diameter defining rollers, shown generally at 78. As shown, the forming rollers are profiled so as to form a
cross-sectional form to the strip as best seen in figures 1 or 2. It will, however, be
appreciated that the forming rollers could impart an alternative form to the strip or
may, in some circumstances, be eliminated all together. When provided, the
forming rollers are best provided as a plurality of confronting rollers (best seen in
figure 5) between which the strip 80 is sandwiched as it passes therebetween so
as to impart the desired profile into the strip in a progressive manner, with each
pair of rollers increasing the deformation of the strip until the final desired profile
is formed. As shown, the forming rollers are each driven by means of a drive gear
82 each of which is mounted for rotation about an axis on said faceplate and
engages on one side with a forming roller and on another side with a sun gear 84
formed on a rotating or non rotating roller portion 86, which is described in detail later
herein. As the faceplate 74 rotates in the direction of arrow D (figure 6) gears 76
and 82 rotate therewith but as they are coupled to the sun gear 84 they are
caused to rotate about their axes and drive the strip through the pinch formed
between confronting forming rollers 76. As shown, the forming rollers are each
slightly staggered along longitudinal axis X and the axis of rotation of each roller
varies in accordance with the spiral angle as the strip 80 passes from the supply
to thereof to the diameter defining rollers 78. It will, however, be appreciated that a
simpler non staggered arrangement may be used where there is sufficient room
to shape the strip and then position it correctly before applying it to the diameter
defining rollers 78. It will be appreciated that both the forming rollers and / or the
diameter defining rollers may be driven by a servo system or motor shown
schematically at 79.

In order to ensure an even feed of strip material from a supply thereof it may be
desirable to provide a supply thereof in the form of stock supply 88. Advantageously this stock supply may be provided in a cassette or stock support
90 comprising a plurality of support rollers 92 positioned outside of said forming
station and being circumferentially spaced around longitudinal axis X. Said
support rollers 92 cooperate with a portion of the stock of strip material 88 and
allows the stock to rotate in the direction of arrow D about axis X. The strip
material 80 is removed from an inner diameter of said stock thereof and fed via a first strip supply guide roller 94 mounted for rotation on said faceplate 74 about an axis angled relative thereto. In order to drive the faceplate 74 one may provide a motor 96 and gear drive 98 coupled to a ring gear 100 provided on a back plate 102 which is directly linked to face plate 74 via annular portion 104 through which non rotating portion 86 extends. Also shown in figures 5 and 6 are a plurality of inner strip supports in the form of a plurality of rollers 110 provided at an outer diameter of said inner faceplate 74. The rollers of figure 5 are pivotally mounted to the inner faceplate 74 by means of pivot arms 112 which are circumferentially spaced around the circumference thereof and pivotally mounted thereto by means of pin arrangements shown at 114. Whilst the operation of these rollers will be described in more detail later herein, it will be appreciated that the rollers are allowed to move out radially by pivoting about pins 114 and thus continue supporting the supply of strip material 88 as it is consumed from an inner diameter. An actuator shown schematically at 116 may be provided to move the rollers 110 outwardly. Alternatively, they may be urged outwardly by way of springs or another such mechanism (not shown). Referring now once again to figure 5 from which it will be appreciated that the outer support rollers 92 are mounted in circumferentially spaced relationship around an outer faceplate 118 and may be provided with a drive mechanism shown generally at 120 in figure 6 and seen in part in figure 5. The drive mechanism comprises a motor or servo mechanism 122 having a gear 124 which drives ring gear 126 which is coupled to the outer support rollers so as to drive said rollers as and when desired. Other forms of drive mechanism will present themselves to those skilled in the art and include but are not limited to direct drive mechanisms such as individual motors and possibly a collective drive mechanism employing a chain drive, neither of which are shown. In operation the motor 122 drives gear 124 which turns 126 which drives rollers 92 which in turn drive the outer diameter of the strip material in the direction of arrow D in figure 6.
The diameter defining roller arrangement seen generally at 78 which, between them, act to curve the strip material by plastically deforming it around one of the rollers such as to define the diameter of the exiting strip are not central to the present application and the reader’s attention is drawn to the present applicant’s patent application PCT/GB2006/050471 which describes this feature in detail. An optional adhesive applicator 130 may also be mounted on the faceplate 74 for rotation therewith. The applicator may take a number of forms for supplying adhesive to the strip after it has been formed and one particular arrangement is shown in which a storage cassette 132 (fig 6) is provided with a roll of adhesive strip 134. The storage cassette 132 is mounted for rotation about a spindle 136 mounted on the faceplate 74 for rotation therewith such that, upon rotation of the faceplate, adhesive strip may be dispensed onto the surface of the strip 80 as it is lain down onto the core 54 (figure 5). The strip of adhesive may be provided in the form of a strip having a backing (not shown) and this backing may be removed by backing removing means (not shown) prior to said adhesive being applied. It will be appreciated from the cross-sectional view of figure 5 that the faceplate 74 includes a central hole 140 for receiving a core or liner 54 onto which said strip material 80 may be wound so as to form a final structure 142. The central hole may be provided with a central support trunion 86 having a hollow centre which defines said central aperture 140 for receiving said core or liner 54. When provided, the trunion may be mounted within said central hole 114 by means of bearings 142, such that said faceplate 74 can rotate about said trunion 86. Referring now once again to figure 4, an optional post forming section 58 may include such things as an optional drive mechanism 152 and adhesive curing heater 154.

Referring to the drawings in general, it will be appreciated that a tubular structure may be manufactured by causing the faceplate 74 to rotate. This action in turn will cause the strip material 80 to be drawn from the cassette, passed through and around inner rollers 110 and to forming rollers 76 before being passed into diameter defining rollers 78 at which point the desired diameter is formed by
appropriate positional control of the forming rollers. As the strip exits the diameter defining rollers it is directed towards the core 54 and wrapped therearound in a self overlapping or abutting relationship as shown in figures 1 to 3. Before the strip is finally deposited onto the core it may be supplemented by an adhesive dispensed as a strip thereof from dispenser 130. Continuous rotation of faceplate 74 will cause continuous deformation and deposition of the strip 80 and this process will continue so long as there is a supply of strip material within the cassette store. Once the strip material has been depleted it is necessary to transfer fresh material onto the apparatus from a supply station (not shown) and weld one end to the other before recommencing operations. This process is described in detail later herein. It will also be appreciated that some forms of structure need not have a core and the above process may be undertaken without a core being supplied to the faceplate. In such an arrangement it may be necessary to provide a support to the initial portion of tubular structure formed but once an initial portion has been formed the structure will be self supporting as new layers are effectively deposited down on a stable multi layer structure. Structures without cores are, therefore, within the scope of the present invention.

Referring now briefly to figure 7 which illustrates the inner support rollers in more detail, it will be appreciated that, whilst the supports and the mechanism associated with their radial movement may take any one of a number of forms, the arrangement of figure 7 is particularly compact and allows the diameter of the structure to be kept to a minimum. The features of figure 7 that might possibly not be appreciated from figure 5 include the way in which the rollers may nestle in optional cutouts 150 provided around the circumference of portion 102 and the way the pivot arms 112 may be curved or profiled to reflect that of the outer diameter at which they lie when retracted (as shown). Straight arms 112 are a suitable alternative. The arc subscribed by the deployment of the rollers is illustrated by arrows D having their center of radius at pivot point 114.
It will be appreciated that whilst the inner rollers 110 and the faceplate are shown in two different planes in Figure 5, they may be provided in the same plane. In such an arrangement the forming rollers 76 and diameter defining rollers 78 are simply provided at a diameter smaller than that of the support rollers 110, as shown in Figure 7. Figures 8 to 14 illustrate a set of clamp/feed rollers 160 positioned at an outer diameter of the winding head, the function of which will be described later herein.

Also shown schematically in figure 5 is a locking arrangement 170 comprising an actuator 172, bolt 174 and corresponding hole 176 provided on the outer portion 118 and best seen in Figure 5. This may be replaced or supplemented by stopping motor 120 and preventing it rotating, thereby to prevent rollers 92 from rotating which will, in turn, prevent S2 rotating.

The various stages of the winding process and replenishment steps will now be more particularly described with reference to figures 8 to 14.

In Figure 8 there will be seen a completely wound supply of strip material 88 which has been wound onto the winding head by rotating inner faceplate 74 and thereby drawing a length of strip material onto the inner rollers 110. This "winding on" process is continued until the space between the inner and outer rollers is filled, at which point the apparatus is ready to commence pipe production. During the winding on process an amount of pipe may be produced as the supply of strip material therefore is taken from an inner diameter of the coil of material 88. It will be appreciated that by virtue of the difference in diameters of the pipe and that upon which the inner support rollers any material being supplied to the winding head will be supplied at a faster rate than it is being consumed and, consequently, one is able to add stock whilst producing a pipe. Alternatively, one may clamp the strip material so as to prevent it being supplied to the forming rollers and simply complete the re-stocking thereof by rotating the winding head and winding a fresh supply thereonto.
Figure 9 illustrates the next step in the process at which point several meters of strip material has been wound onto the former so as to produce a section of pipe. Once the rollers have reached a desired outer diameter the strip material is driven to a convenient stopping position by driven rollers 92 and motor 120 before being reversed so as to allow the free end of strip 80a to be taken back into clamp rollers 160 where it is clamped in position in preparation for the next step of joining a new piece of strip material thereto. At this point rollers 110 are retracted, as shown, and create a space between themselves and an inner diameter of the outer portion S2 of strip material.

Figure 10 illustrates a new length of strip material 80b being welded to the otherwise free end 80a of strip 80 before clamp rollers 160. At this point the outer diameter of the stock of material 88 is stationary and the inner winding head is still in motion such as to produce a pipe and to draw a supply of strip material from S2 onto the inner rollers 110 where it forms portion S1. This process is shown part completed in figure 11 and wholly almost completed in figure 12. The production process may continue whilst the new strip is welded onto the old strip and finished by, for example, grinding down the weld.

Figure 13 illustrates the next step of the process at which point clamp 160 is released and a fresh supply of material is drawn from the source thereof.

Figure 13 to 14 illustrates the refreshing step in which new strip material continues to be supplied to the outer diameter of the stock thereof until the gap between it and the outer rollers 92 has been filled. At this point the supply of strip material may be stopped, the strip is cut at clamp 160 and the new free end 80a is allowed to pass through clamp rollers 160 such that it is free to rotate with the stock of material 88, as shown in figure 8. Alternatively, the joining step may be completed quickly whilst the process continues. The above sequence of steps is
repeated as often as necessary until the desired length of pipe has been produced.

Figure 15 illustrates an alternative form of inner roller arrangement in which the rollers 110 are mounted for radial displacement in radially extending slots 180 provided on an inner portion 102 of larger diameter than that shown in figure 5. One of the advantages of this arrangement resides in the possibility of allowing the rollers 92 to move to a larger diameter than might be possible with the arrangement of figure 5 before replenishment of the strip is necessary. This will have a positive impact on the number of times a replenishment exercise must be conducted before a given length of pipe is produced.

Additional features of this machine include feedback control from the computer to ensure the product diameter is maintained within desired limits and/ or altered according to desired parameters. It will be appreciated that as one can control the degree of plastic deformation of the strip as it passes through the radius forming rollers 78 one can also control the final diameter of any tubular structure formed by this apparatus.

It will be appreciated that the described arrangement ensures an even supply of material. It also forms a complex interlocking profile in the material and winds the material onto a core at predetermined curvature, thereby providing a robust structure in the final windings as well as a suitable tensile compression.

It will also be appreciated that the apparatus may be used on strips of other materials such as Kevlar, plastic, glass fibre, composites of such materials or strips formed from layers comprising one or more of said materials. Indeed the machine lends itself particularly to use with some of these materials as it is able to pre-tension the strip as it is wound onto the final form of the tubular structure being formed. When used with composite materials having a portion of metal in the strip provided either as a layer or as part of any woven form thereof, said
metal will act to maintain a degree of rigidity in the strip that will assist with the location thereof on the rollers and in maintaining a final curvature. Materials such as glass-fibre or Kevlar may be reinforced by a resin or other such material in the manner well known to those skilled in the art and, therefore, not described further herein. Clearly, any such materials may simply be wound into the desired shape without needing to be provided with a cross-sectional profile as described earlier herein.

Additionally, this arrangement advantageously provides a means of continuous or near continuous supply of winding material. Downtime for reloading of the apparatus with new stock is reduced, thereby also facilitating greater uniformity of the helical winding produced.

It will also be appreciated that the above described method and apparatus may be used to cover an already existing pipeline with an outer casing. In this arrangement the already existing pipeline forms a core and the machine simply rotates around the core and moves therealong so as to lay down the outer wrap of strip material onto the pipeline. Such an approach could be employed when one wishes to repair or strengthen an already existing pipeline.

Still further, it will be appreciated that if portion 86 (fig5) is driven then it may benefit from being separately supported for rotation in bearings 200 provided in a fixed structure 202 and further provided with a drive mechanism shown generally at 204 and including, for example, a motor 206, driving gear 208 and driven gear 210, the latter of which is provided on portion 86. Preferably, the controller is also connected to the motor for control thereof and for this purpose one may also provide control line 212 shown generally in figure 6.
CLAIMS

1. A winding apparatus comprising;
   i) an inner faceplate rotatably mounted for rotation about a longitudinal axis X-X and having an output station thereon; and
   ii) an outer faceplate radially outward of said inner faceplate;

wherein said inner faceplate includes a plurality of strip supports at an outer diameter thereof and onto which, in operation, a supply of material may be wound, and wherein said strip supports are radially adjustable thereby to accommodate a change in diameter of any supply of any material supplied thereto.

2. A winding apparatus as claimed in claim 1 wherein said strip supports comprise a plurality of rollers mounted for radial adjustment within radially extending slots within said outer faceplate.

3. A winding apparatus as claimed in claim 1 wherein said strip supports comprise a plurality of rollers, one or more of which is mounted for rotation about a longitudinal axis at a first end of a pivot arm the otherwise free end of which is pivotally mounted to said inner faceplate.

4. A winding head as claimed in any one of claims 1 to 3 wherein said apparatus further includes a plurality of second strip supports at an outer diameter of said outer faceplate.

5. A winding head as claimed in any one of claims 1 to 4 wherein said apparatus further includes a strip driving mechanism for rotating a supply
of strip material supplied to said apparatus about said longitudinal axis X-X.

6. An apparatus as claimed in claim 5 wherein said strip driving mechanism comprises a plurality of driven rollers at an outer diameter of said second faceplate which, in operation, engage with an outer diameter of a supply of strip material supplied to said apparatus.

7. An apparatus as claimed in claim 6 wherein said driven rollers also comprise the second strip supports.

8. An apparatus as claimed in any one of claims 1 to 7 wherein the apparatus further includes a strip brake for preventing rotation of an outer diameter of any strip material supplied to said apparatus relative to said faceplate.

9. A winding apparatus as claimed in claim 8 wherein said brake comprises a friction brake.

10. A winding apparatus as claimed in claim 8 or claim 9 wherein said brake comprises a driven roller having a brake system.

11. An apparatus as claimed in any one of claims 1 to 10 wherein said apparatus further includes a pair of feed rollers mounted on an outer diameter of said outer faceplate for receiving a supply of strip material to said apparatus and for guiding said strip towards said inner faceplate.

12. An apparatus as claimed in any one of claims 1 to 9 wherein said apparatus further includes a strip clamping and cutting station.

13. An apparatus as claimed in claim 12 in which said feed rollers also form a strip clamp.
14. An apparatus as claimed in any one of claims 1 to 13 wherein said inner faceplate further includes a central bore for receiving a supply of core material onto which strip supplied to said apparatus may be wound.

15. An apparatus as claimed in claim 14 wherein said apparatus further includes a core supply mechanism for supplying a continuous or semi-continuous supply of core material to said apparatus.

16. A method of forming a tubular article on an apparatus having; an inner faceplate rotatably mounted for rotation about a longitudinal axis X and having an output station thereon; and an outer faceplate radially outward of said inner faceplate; wherein said inner faceplate includes a plurality of strip supports at an outer diameter thereof and onto which, in operation, a supply of material may be wound, and wherein said strip supports are radially adjustable thereby to accommodate a change in diameter of any supply of any material supplied thereto, said method including the steps of:
   i) winding a supply of strip material onto said inner supports;
   ii) passing a supply of said strip material from an inner diameter thereof through said inner supports to an inner diameter of said inner faceplate;
   iii) rotating said faceplate so as to cause said strip material to be so transferred; and
   iv) displacing said inner rollers radially outwardly during strip supply so as to maintain support for said strip material at an inner diameter thereof.

17. A method as claimed in claim 16 and wherein said apparatus includes a strip forming station on said inner faceplate, said method including the
step of supplying said strip to said forming station and causing formed strip to be deposited in a spiral fashion so as to form a tubular structure.

18. A method as claimed in claim 16 or 17 wherein said outer rollers are driven rollers and the method includes the step of stopping said rollers and, hence the outer portion S2 of said material, retraction of said inner rollers to an inner diameter so as to allow the removal of strip material from an inner diameter of S2 and deposition thereof at an outer diameter of an inner portion S1 supported by said inner supports.

19. A method as claimed in claim 18 wherein said apparatus further includes a strip feed/clamp at an outer diameter of said apparatus and the method includes the further step of slowing the outer diameter S2 and then reversing it so as to allow an otherwise free end of said strip material to be fed back into said clamp and joining a fresh supply of strip material to said otherwise free end.

20. A method as claimed in claim 19 and including the further step of releasing said clamp and causing fresh material to be added to said inner diameter S1 by rotating said inner faceplate.
INTERNATIONAL SEARCH REPORT

International application No
PCT/GB2010/050055

A CLASSIFICATION OF SUBJECT MATTER

INV. B21C37/12 B21C49/00 B29C53/68 B65H20/26
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
B21C B29C B65H

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C

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* Special categories of cited documents

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Date of the actual completion of the international search 19 April 2010

Date of mailing of the international search report 03/05/2010

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Fax (+31-70) 340-3016

Authorized officer
Ritter, Florian

Form PCT/ISA/210 (second sheet) (April 2005)
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