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(54) PROCESS AND APPARATUS FOR THE MANUFACTURE OF TUBULAR FIBROUS PRODUCTS

(71) We, SAINT-GOBAIN INDUSTRIES, a French body corporate, of 62 Boulevard Victor-Hugo, Neuilly-Sur-Seine, France, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a process for manufacture of tubes from fibrous felt containing a polymerisable binder, and to apparatus for carrying out the process. Such tubes may be used for example for thermal insulation of pipes. The fibrous felt may be of glass or other mineral fibre. The binder may be a phenol formaldehyde resin, a urea phenol resin, or a phenol melamine copolymer.

It is an object of the invention to provide for continuous production of tubes of low specific density and good thermal insulating properties.

According to this invention a process for the continuous manufacture of tubes from fibrous felt containing a polymerisable binder comprises:

(a) forming the felt into a tube on a heated, rotatable mandrel, the temperature of the mandrel and the time of stay of the felt thereon being such that a hardened internal tube surface is formed and polymerisation of the binder is started in the region of the internal tube surface;

(b) removing the tube from the mandrel;

(c) causing the external tube surface to contact a smooth heated surface whose temperature and the time of such contact are such that a hardened external tube surface is formed and polymerisation of the binder is started in the region of the external tube surface; and

(d) passing hot gas over the tube so as to bring about substantially uniform polymerisation to a required degree throughout the tube wall thickness.

When the tube is formed on the mandrel the hardened internal surface enables it to be detached from the mandrel surface so that

it may then be removed from the mandrel. 50

Also according to this invention apparatus for continuous manufacture of tubes from fibrous felt containing a polymerisable binder comprises:

a rotatable mandrel; 55

means for heating the mandrel;

rollers which are mounted for contact with a length of felt being formed into a tube on the mandrel;

means for removing a tube formed of felt rolled on the mandrel; 60

a smooth heated surface against which the tube removed from the mandrel is pressed; and

a stove for passing hot gas over the tube, the stove including means adapted to pass tubes successively through it. 65

The invention will now be described by way of example, with reference to the accompanying diagrammatic drawings in which:— 70

Figures 1a and 1b together constitute an elevation of apparatus for carrying out the process of the invention;

Figures 2a to 2d are elevations of a device used for tearing a continuous felt web; 75

Figure 3 is an elevation of a transport device for carrying web lengths from the tearing device to a winding device;

Figure 3a is an elevation of one variation of the device for transporting web lengths; 80

Figure 4 is a perspective view of the winding device;

Figure 5 is a part section through the winding device; 85

Figures 6 and 7 are detail sections of the winding device;

Figure 8 is an end elevation of rollers and mechanism for moving them apart in synchronised manner; 90

Figure 9 is a perspective view of a device for rotating the rollers;

Figure 10 is an elevation of a device for transferring tubes from the winding device to a device for smoothing and polymerising the external surface of the tubes; 95

Figure 11 is an elevation of the smoothing device;

Figure 12 is a plan of the smoothing device;

Figure 13 is an elevation, partly in section, of a polymerisation stove;

5 Figures 14 and 15 show details of a device for moving and rotating tubes in the stove;

Figures 16a to 16f illustrate the movement of a tube inside the stove;

10 Figure 17 is an elevation of a device for cutting the ends of the tubes;

Figure 18 is a perspective view of a device for turning the tubes;

Figure 19 is a perspective view of a device for longitudinally slitting the tubes;

15 Figure 20 is an elevation of the device of Figure 19;

Figure 21 is a transverse section through a tube which has been slit;

20 Figure 22 is a perspective view of a variation of the cutting device;

Figures 23 and 24 are transverse sections through the cutting device of Figure 22;

Figure 25 is a transverse section through a slit tube;

25 Figures 26 to 28 are sections multiple blade knives; and

Figure 29 shows a tube opened out after it has been slit by a plurality of blades.

30 The apparatus shown in Figures 1a and 1b comprises the following parts:

a drying stove 2 into which a conveyor 3 transports a web 1 of a felt of fibres in which a polymerisable binder is distributed. This stove may be of any appropriate type and need not be described;

35 a device 4 for tearing the web 1 into lengths;

a conveyor 5 for transporting the web lengths;

40 a device 6 comprising a rotatable mandrel for winding a web length into tubular form and at the same time for polymerising the internal surface of the tube so formed;

45 a transfer device 7;

a device 8 which is kept supplied with tubes by the transfer device 7, which polymerises the external surface of the tubes, and smoothes them;

50 a stove 9 to complete polymerisation of the tubes;

a cutting device 10 for cutting the ends of the tubes to a required length;

55 a device 11 for longitudinally slitting the tubes;

a packaging station 12 for the split tubes.

60 The device 4 for tearing the web comprises four rollers which are mechanically rotated in time with the conveyor 5. The downstream rollers 14, 14a are constantly rotated at an angular velocity V_2 . The upstream rollers 13, 13a are alternately rotated at the angular velocity V_2 and then braked, using a timing device. Figures 2a to 2d

illustrates operation of the device 4. A length of web has just been formed and its upstream end is held between the rollers 13, 13a which are disconnected and braked. The web is situated opposite a detector device, for example a photosensitive cell 15.

The web leaving the drying stove 2 at a constant velocity V_1 accumulates in the form of a loop at the upstream side of the rollers 13, 13a which remain coupled and braked (Fig. 2b).

The timing device, the operation of which is started by the photosensitive cell 15, causes the rollers 13, 13a to be driven at the angular velocity V_2 at the end of a predetermined time which corresponds to the web lengths. When the loop has been thus taken up, the web is opposite the cell 15 (Fig. 2d) and covers it, so that the rollers 13, 13a are again stopped. Due to the traction on the web of the rotating rollers 14, 14a, it is torn between the rollers 13, 13a and 14, 14a, as shown. The length torn off is conveyed away and a fresh cycle begins.

Referring to Figure 3, the conveyor 5 which carries the web lengths 1a from the tearing device 4 to the winding device 6 has a smooth mat 16 of polyamide which allows the felt to slide without tearing while it is being wound on the mandrel. The winding operation increases the speed of a web length in proportion to the increase in diameter of the tube being formed.

The mat 16 is supported horizontally by 100 rollers 17 of small diameter and is driven by a variable speed drive 18 which also drives the rollers of the tearing device 4.

The downstream end of the conveyor frame which supports the mat 16 ends in a projecting articulated part in which an end roller 19 is adjustable in height, see the dot-dash lines. This arrangement enables the web lengths to be placed into the correct position for winding. 110

Instead of a belt conveyor, a conveyor device as shown in Figure 3a could be used, comprising the rollers 13, 13a and 14, 14a, the mat 16 and a roller 19 which is adjustable in height, the speed of the rollers and mat being increased when the web length is wound on the mandrel and the velocity of the roller 14a being controlled by a tachymetric dynamo 18a which operates in dependence upon one of the rollers which co-operates with the mandrel to wind the web length. 120

The device for forming the tubes will now be described with reference to Figures 4 to 9. It includes a heated mandrel in two 125 parts 20, 20a and three rollers 21 with their axes parallel to the axis of the mandrel and angularly spaced 120° apart around it. These rollers, which serve as guides, are mechanically connected and progressively move away 130

from the axis of the mandrel as the tube is formed.

5 The parts 20, 20a of the mandrel are mounted on carriages 22 which are movably mounted in beams 23 arranged inside a casing 24. The beams 23 are transverse to the direction of movement of the web lengths through the apparatus. Roller bearing slide bars 33 and rollers 33a are provided for the carriage movement. The mandrel parts 20, 20a are rotated by a motor 25 through transmission shafts 26 and the belt drive seen in Figures 4 to 7. Rams 27 for displacing the mandrel parts act on the carriages 22, Figures 4 and 5.

15 The rollers 21 are rotated by a drive motor 28 through reduction gearing 21 and a belt system, Figure 9. The movement of the rollers 21 away from the mandrel is produced by means or rockable arms 30 (Fig. 8) connected to links controlled by a ram 31 and supported by side plates 34. The ends of the arms 30 slide in guide slots 35. Resistances for heating the mandrel parts 20, 20a are supplied with current from an input collector 36 (Fig. 5).

The winding device operates as follows:

30 Before the arrival of a web length 1a the ends of the two mandrel parts 20, 20a are in contact with each other. The mandrels are heated to about 400°C. The upstream end of the web length comes into contact with the mandrel and adheres to it to form the first tube. The internal surface of the tube thereby formed polymerises during the winding operation. The mandrel rotates at a constant speed of 80 to 800 r.p.m. and the web length is wound at an increasing speed. The three rollers 21, which are mechanically connected, simultaneously move apart slowly while exerting a constant pressure on the tube being formed. When winding has been completed, the tube is detached from the mandrel due to the rapid polymerisation of the resin at its internal surface, and at the same time it is kept in rotation by the rollers 21. Outward movement of these rollers and rotation of the mandrel stop when the tube has been completely formed. This period of keeping the tube in position and rotating it by the rollers 21 produces preliminary shaping of the tube and at the same time smoothes its surface in contact with the rollers.

55 At the end of this operation, the rollers 21 rapidly move apart as do also the mandrel parts 20, 20a, and the tube falls. The rollers then immediately return to their position on the mandrel parts to support them while the parts are brought together again and their rotation is resumed. A fresh cycle of winding now begins.

65 The tube 1b leaving the winding device has a hard, smooth internal surface which

has been formed when the felt has come into contact with the heated mandrel, and an external surface which has been subjected to preliminary smoothing by the rollers 21.

The operating cycle of the mandrel and the rollers may be controlled by a photosensitive cell, which is covered by the web lengths coming from the conveyor belt 16. This photosensitive cell starts the cycle after a variable delay which is adjusted according to the time required for the passage from the cell to the mandrel.

70 Referring to Figures 1a, 1b and 10, the transfer device 7 moves the tubes from the winding device 6 to the polymerising device 8. The transfer device 7 receives each tube 1b in a channel 40 arranged horizontally below the winding device. This channel is mounted on a support frame 41 which is hinged on a shaft 42 and moved, as indicated in Figure 10, by a ram 43. At the end of the movement of the ram the tube, supported along its whole length by the channel 40 during the whole of the transfer movement, rolls out of the channel and is deposited transversely on the conveyor belt of the device 7. This device comprises (Figs. 1b, 11 and 12) a supporting framework 44 for supporting at its upper part a device for lifting and adjusting the height of a heating plate 45 which is equipped with an internal electric resistance heater. This lifting device includes a variable speed motor 46 with an electric brake (not shown) and four screw jacks 47 simultaneously driven from the motor. These jacks are connected to the heating plate 45 by rods 48 of adjustable length which are hinged to the heating plate by brackets 49. The heating plate is thus supported horizontally by the jacks.

105 At its lower part, the device 7 comprises a belt 50 driven by a variable speed motor 51 and mounted horizontally between two rollers 52. The upper run of this belt is supported by rollers 53 of small diameter. The belt is guided by two lateral chains (not shown) connected to it.

115 The temperature of the plate 45 is in the region of 400°C.

Tubes 1b transferred by the transfer device pass between the belt 50 and plate 45 and as they move forwards each tube is rolled by the action of the belt and is at the same time lightly pressed against the plate. This corrects the external diameter of each tube and stabilises its shape. At the same time, the external surface of the tube is polymerised by the heat of the plate and acquires a smooth surface such that no rubbing down is required.

120 Tubes from the polymerisation device 8 are transferred to a stove 9 (Figs. 1b and 13 to 16f) for complete and uniform curing of the tubes at a temperature of about 250°C 130

which provides for polymerisation with a minimum of fumes and release of gas. In the course of this curing operation, the tubes are moved completely free of constraint to avoid any risk of separation of the outer fibrous layers of the tubes and to prevent any shock or friction liable to damage the appearance of the tubes. During their stay in the stove, the tubes are kept flat over their whole length and rotated about their axes so that the heat treatment will be uniform.

Immediately after leaving the device 7, in order to derive maximum benefit from the heat supplied by the heating plate 45, each tube is received into a lifting device (Fig. 13) comprising a rockable channel 54 mounted on a lifting rod of a jack 56. A photo-sensitive cell registers the presence of the tube and controls its lifting to the entry level of the stove. During this lifting, the lateral position of the tube is corrected if necessary by recentring guide means, not shown. At the end of the movement of the jack, the channel 54 rocks over and the tube rolls into the stove. A door 61 actuated by a ram 62 retains the tube for a moment before entry. Opening of the door is delayed and restricted to diminish heat loss from the stove.

To increase the length of time of stay of the tubes in the stove, while at the same time reducing the length of the stove, there are several superimposed levels in the stove; there are five levels in the present embodiment.

Each level comprises a layer of rods 63 whose axes are parallel to the tube axes, see Figures 16a to 16f. The ends of the rods rest on pins 64 of a crankshaft 65, and are guided vertically in slots 66 provided in a housing 67, Figure 15. The angular displacement of the pins 64 in relation to each other is such that the rods form a layer in the form of a sine wave. In the present embodiment, one pitch of the crankshaft covers six crank pins staggered by 60°.

The crankshafts 65 are kept permanently in rotation by a variable speed motor 68 by way of a chain 69 in engagement with pinions 70 of the crankshafts (Fig. 13).

Due to the continuous rotation of the crankshafts, each sinusoidal layer formed by the rods 63 is continuously changed in shape while preserving its pitch and amplitude. The tubes are thus subject to a double movement, of translation and rotation, as seen in Figures 16a to 16f which show the displacement of a tube during rotation of one crankshaft. These Figures correspond to successive movements of the crankshaft through 60°. The tube always moves under its own weight into the trough of the sinusoidal layer during its change in shape, the

tube being thus advanced and at the same time rotated.

Each level in the stove comprises two crankshafts of such pitch that the tubes traverse the length of the stove. When the tubes have passed the last transverse rod of one layer, they fall on to the layer of rods of the next level and pass along this level in the same manner, but in the opposite direction. On leaving the lowest layer, the tubes roll down an inclined plane 71 to the cutting device 10.

The stove is heated by gas burners 72 on a platform 73 and above the burners are inverted domes 74 of inoxidizable metal to prevent localised overheating of the lowest level of the stove. A thin perforated metal sheet 75, parallel to and spaced from the upper part of the domes 74 provides for homogeneous distribution of the ascending hot air through the whole height of the stove.

After passing over all the tubes air is exhausted through a chimney 76.

Referring now to Figures 1b and 17, the cutting device 10 for cutting the ends of the tubes includes an elevator to which the tubes fall, the elevator comprising two chains 80 to which projecting plates 81 are attached. The chains are mounted on sprockets 82 and 83, the sprocket 83 being driven from a reduction motor 84.

Lateral guides 85 are fixed at each side of the chains to guide the tubes into the correct position if they have shifted to the left or right. The device 10 also comprises a lower guide device in the form of a metal sheet 90 situated in the plane of the ascending runs of the chains 80 to support the tubes. This plate curves over at the top as shown to form an inclined plane 91. In addition to this guide, there is also an upper guide formed of two guide plates 92 parallel to the metal sheet 90. The distance between the plates 92 and the sheet 90 can be adjusted by two levers 93, 94. Lever 93 is controlled by a handwheel 95 and lever 94 is mounted on a stop device 96.

Whilst on the guides 85, the ends of the tubes are trimmed to length by two circular saws 86.

The cut-off ends fall by gravity down a chute 87 and the tubes then pass over the top of the elevator on to the inclined plane 91 which directs them to the slitting device 11, which will now be described with reference to Figures 18 to 26.

After the tubes have been turned from their transverse disposition into their direction of movement by the device shown in Figure 18 (which comprises a stop 100 and a curved guide slot 101) they fall on to a conveyor composed of diablo-shaped rollers 102. The height of this conveyor is adjustable so that the tubes are moved into the

axis of the knife holder of a slitting tool (Figs. 19 and 20).

This slitting tool comprises a cylindrical rod 103 into which a knife is slotted on a diametrical plane. The knife is a triangular blade the point of which is directed upstream and the base of which is arranged asymmetrically with respect to the axis of the rod so that the blade is composed of a part 104a which cuts right through the wall thickness of the tube and a part 104b which does not cut right through the wall thickness, see Figures 20 and 21.

The rod 103 has a pointed tip 105, over which the tube fits when it arrives at the cutting tool, and a support 106 mounted on a frame 107. On either side of the cutting tool are two side walls 108 each formed by an endless belt with a supporting plate 109 disposed between the two runs of each belt to enable it to resist the pressure exerted on it by the tubes. Drive rollers 110 of the belts 109 are rotated by a variable speed motor 112 in the frame 107. The distance between the belts 109 can be adjusted by an appropriate device (not shown) in the frame 107 and operated by hand-wheels 113.

The movement of the belts 109 drives each tube over the cutting tool so that the blade forms the slits 114 and 115 (Fig. 21). These slits enable the tube to be opened up for use, the incomplete slit 115 leaving sufficient material to enable the tube to be opened up, like a hinge.

In the embodiment of Figure 22, the blade of the cutting tool is arranged so that its parts 104a, 104b slit the tube only through part of its wall thicknesses. The tool has a small cutting wheel 116 arranged upstream of the part 104a of the blade. This wheel cuts a slit limited to part of the wall thickness and it may either be in the plane of the slit formed by the part 104a (Fig. 23) or at an angular displacement from it (Fig. 24). In the former case, slits similar to those produced with the cutting tool of Figure 19 are obtained and in the latter case a slit 118 is formed which is displaced from the incomplete slit 114a (Fig. 25). The distance between these two slits is small so that it is possible to break through the thickness of material separating them when the tube is to be opened out.

By slitting the outside of the tube with the cutting wheel 116 it is possible to obtain a clean cut with no roughness or unevenness on the lips of the slit.

Instead of using a cutting wheel, one could use a cutting blade which, like the cutting wheel, could be arranged either in the plane of the blade 104a or at an angle to it.

The cutting tool may comprise a plurality of blades. Figures 26 to 28 show the

shapes of knives having two, three or four blades. By cutting with such multiple blade knives it is then possible to open out the tube. Figure 29 shows a tube opened out after it has been slit by a four-bladed knife.

Compared with the known apparatus in which the tubes are slit by means of saws, the slitting device described above is simple, produces little dust, and enables slits to be arranged as shown in Figure 25.

Reference is directed under Section 9 of the Patents Act 1949 to Patent No. 970,838.

WHAT WE CLAIM IS:—

1. A process for the continuous manufacture of tubes from fibrous felt containing a polymerisable binder, comprising:—

- (a) forming the felt into a tube on a heated, rotatable mandrel, the temperature of the mandrel and the time of stay of the felt thereon being such that a hardened internal tube surface is formed and polymerisation of the binder is started in the region of the internal tube surface;
- (b) removing the tube from the mandrel;
- (c) causing the external tube surface to contact a smooth heated surface whose temperature and the time of such contact are such that a hardened external tube surface is formed and polymerisation of the binder is started in the region of the external tube surface; and
- (d) passing hot gas over the tube so as to bring about substantially uniform polymerisation to a required degree throughout the tube wall thickness.

2. A process according to claim 1 wherein predetermined lengths of felt are carried successively to the mandrel, each length being wound in layers on the mandrel.

3. A process according to claim 1 or claim 2 wherein the external tube surface is caused to contact the smooth heated surface with light pressure.

4. A process according to claim 1 or claim 2 wherein each tube after leaving the mandrel is rotated about its axis and under compression in contact with the smooth heated surface.

5. A process according to any preceding claim wherein hot gas is passed over a plurality of the tubes within a stove in which hot gas circulates freely about the tubes.

6. A process according to any preceding claim wherein the tubes after heating to bring about the said uniform polymerisation are cut to length.

7. A process according to claim 6 wherein the tubes are slit in the axial direction.

8. A process according to claim 2 wherein the lengths of felt are formed by tearing

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axis of the knife holder of a slitting tool (Figs. 19 and 20).

This slitting tool comprises a cylindrical rod 103 into which a knife is slotted on a diametrical plane. The knife is a triangular blade the point of which is directed upstream and the base of which is arranged asymmetrically with respect to the axis of the rod so that the blade is composed of a part 104a which cuts right through the wall thickness of the tube and a part 104b which does not cut right through the wall thickness, see Figures 20 and 21.

The rod 103 has a pointed tip 105, over which the tube fits when it arrives at the cutting tool, and a support 106 mounted on a frame 107. On either side of the cutting tool are two side walls 108 each formed by an endless belt with a supporting plate 109 disposed between the two runs of each belt to enable it to resist the pressure exerted on it by the tubes. Drive rollers 110 of the belts 109 are rotated by a variable speed motor 112 in the frame 107. The distance between the belts 109 can be adjusted by an appropriate device (not shown) in the frame 107 and operated by hand-wheels 113.

The movement of the belts 109 drives each tube over the cutting tool so that the blade forms the slits 114 and 115 (Fig. 21). These slits enable the tube to be opened up for use, the incomplete slit 115 leaving sufficient material to enable the tube to be opened up, like a hinge.

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Instead of using a cutting wheel, one could use a cutting blade which, like the cutting wheel, could be arranged either in the plane of the blade 104a or at an angle to it.

The cutting tool may comprise a plurality of blades. Figures 26 to 28 show the

shapes of knives having two, three or four blades. By cutting with such multiple blade knives it is then possible to open out the tube. Figure 29 shows a tube opened out after it has been slit by a four-bladed knife.

Compared with the known apparatus in which the tubes are slit by means of saws, the slitting device described above is simple, produces little dust, and enables slits to be arranged as shown in Figure 25.

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1. A process for the continuous manufacture of tubes from fibrous felt containing a polymerisable binder, comprising:—

(a) forming the felt into a tube on a heated, rotatable mandrel, the temperature of the mandrel and the time of stay of the felt thereon being such that a hardened internal tube surface is formed and polymerisation of the binder is started in the region of the internal tube surface;

(b) removing the tube from the mandrel;

(c) causing the external tube surface to contact a smooth heated surface whose temperature and the time of such contact are such that a hardened external tube surface is formed and polymerisation of the binder is started in the region of the external tube surface; and

(d) passing hot gas over the tube so as to bring about substantially uniform polymerisation to a required degree throughout the tube wall thickness.

2. A process according to claim 1 wherein predetermined lengths of felt are carried successively to the mandrel, each length being wound in layers on the mandrel.

3. A process according to claim 1 or claim 2 wherein the external tube surface is caused to contact the smooth heated surface with light pressure.

4. A process according to claim 1 or claim 2 wherein each tube after leaving the mandrel is rotated about its axis and under compression in contact with the smooth heated surface.

5. A process according to any preceding claim wherein hot gas is passed over a plurality of the tubes within a stove in which hot gas circulates freely about the tubes.

6. A process according to any preceding claim wherein the tubes after heating to bring about the said uniform polymerisation are cut to length.

7. A process according to claim 6 wherein the tubes are slit in the axial direction.

8. A process according to claim 2 wherein the lengths of felt are formed by tearing



a continuous felt web by means of sudden pulls on it.

9. A process according to claim 8 wherein at regular intervals of time part of the web is held and a part downstream thereof is pulled to tear a length from the web.

10. A process according to claim 2 wherein the lengths of felt are carried to the mandrel in contact with a smooth support such that each length can slide on the support without tearing while being wound on the mandrel.

11. A process according to any preceding claim wherein the mandrel is heated to a temperature such as to cause adherence of the first turn of felt.

12. A process according to claim 11 wherein a pressure device, movement of which is controlled, is in contact with the tube being wound on the mandrel so as to exert constant pressure on the tube and to keep it in rotation after its hardened internal surface has been detached from the mandrel.

13. A process according to claim 12 wherein a plurality of rollers are disposed round the mandrel to contact the tube for regularity of winding thereof.

14. A process according to any preceding claim wherein the mandrel is disengaged from the tube when the latter has been wound, the tube then falling gravitationally.

15. A process according to any preceding claim wherein, after the tube has been shaped and separated from the mandrel, it is passed between two plane surfaces and is in contact with them, the plane surfaces being moved relative to one another to maintain the tube in rotation, one of the plane surfaces being heated to polymerise and smooth the external tube surface region.

16. A process according to claim 15 wherein one of the plane surfaces is subjected to a translational movement and the other is stationary.

17. A process according to claim 16 wherein the stationary surface is heated.

18. A process according to any preceding claim wherein the tube, after formation of its external surface, is transferred to a stove in which it is rotated about its axis, while the hot gas is passed over it, and also moved in a direction normal to its axis.

19. A process according to claim 18 wherein the tube is moved by successive contacts along the wall of the tube parallel to its axis.

20. A process according to claim 18 or claim 19 wherein the tube is moved in the said direction oppositely several times.

21. A process according to claim 7 wherein each tube is slit along its length by producing a relative movement between the tube and a cutting device.

22. A process according to claim 21

wherein the cutting device is fixed and integrally connected with a centering device which penetrates to the interior of the tube while the latter is moved along its axis.

23. Apparatus for continuous manufacture of tubes from fibrous felt containing a polymerisable binder, comprising:—

a rotatable mandrel;

means for heating the mandrel;

rollers which are mounted for contact with a length of felt being formed into a tube on the mandrel;

means for removing a tube formed of felt rolled on the mandrel;

a smooth heated surface against which the tube removed from the mandrel is pressed; and

a stove for passing hot gas over the tube, the stove including means adapted to pass tubes successively through it.

24. Apparatus according to claim 23 including a device for tearing a web of the felt into predetermined lengths; and a conveyor for transporting the lengths of felt successively to the mandrel.

25. Apparatus according to claim 24 wherein the tearing device comprises two pairs of rollers rotatable at the same speed and in synchronism with the movement of the conveyor, the downstream pair of rollers being continuously rotatable and the upstream pair of rollers being intermittently rotatable so that the web of felt accumulates as a bight when the upstream rollers are not rotated, the bight being taken up when the upstream rollers are rotated so that the web is torn in the zone between the two pairs of rollers when the rotation of the upstream rollers is stopped.

26. Apparatus according to claim 25 wherein duration of an intermittent rotation cycle determines the lengths of felt and is regulated either by a time switch or in accordance with progression of tubes through the stove.

27. Apparatus according to claim 24 wherein the conveyor is a polyamide conveyor belt.

28. Apparatus according to claim 27 wherein a frame supporting the conveyor belt terminates adjacent the mandrel in a hinged projecting portion, the height of which relative to the mandrel is adjustable.

29. Apparatus according to claim 23 wherein the said means for heating is able to heat the mandrel to 400°C.

30. Apparatus according to any of claims 23 to 29 wherein the mandrel is heated electrically.

31. Apparatus according to claim 23 wherein the said rollers are three in number and equiangularly spaced about the mandrel.

32. Apparatus according to claim 31 wherein the rollers are interconnected mechanically and moved away from the mandrel

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simultaneously at low speed to exert constant pressure on the tube during formation.

33. Apparatus according to claim 23 including means for stopping rotation of the mandrel and for moving the rollers apart when a length of felt has been formed into a tube on the mandrel, the rollers keeping the tube in position and in rotation to complete shaping thereof.

34. Apparatus according to claim 33 including means for rapidly releasing the rollers when the tube has been wound.

35. Apparatus according to claim 23 wherein the mandrel is in two axially separate parts, a jack being provided for moving the two parts axially apart for rapidly disengaging them after a tube is formed, and a transfer channel being provided to receive a tube fallen from the separated mandrel parts.

36. Apparatus according to claim 23 wherein the heated surface is a conveyor comprising a fine mesh belt and a heating plate.

37. Apparatus according to claim 36 including means for heating the plate to 400°C.

38. Apparatus according to claim 36 or claim 37 wherein the plate is heated electrically.

39. Apparatus according to any of claims 36 to 38 including a lifting system to place the plate into a position parallel to and above the belt.

40. Apparatus according to any of claims 23 to 39 wherein the stove comprises transverse horizontal bars on which tubes rest without contact between adjacent tubes, which bars are given a vertical movement of the same amplitude for all the bars but displaced in phase from one bar to the next so that the bars displace the tubes to pass them through the stove and to rotate each about its axis.

41. Apparatus according to claim 40 wherein each bar is supported at its ends on the pins of a crank disc, the discs being relatively angularly displaced, such that the axes of the bars define a sinusoidal waveform which is moved by rotation of the discs.

42. Apparatus according to claim 40 or claim 41 wherein the ends of the bars engage in vertical guides.

43. Apparatus according to any of claims 40 to 42 wherein the stove comprises a plurality of levels through which the tubes pass in succession, the direction of movement of the tubes in the stove being reversed from one level to the next.

44. Apparatus according to claim 40 wherein movement of tubes from one level to the next is by gravity.

45. Apparatus according to any of claims 40 to 44 having a single drive for movement of all the bars.

46. Apparatus according to any of claims 40 to 45 wherein a door is adapted to halt each tube momentarily before it enters the stove to position it parallel to the bars.

47. Apparatus according to any of claims 40 to 46 wherein the stove is heated by rows of gas burners arranged at its base and beneath deflectors.

48. Apparatus according to claim 47 wherein the burners are capable of heating gas in the stove to 250°C.

49. Apparatus according to any preceding claim wherein an elevator transfers tubes from the said heated surface to an upper level of the stove, the elevator having a V-shaped member at its top to accommodate a tube which element pivots to transfer the tube into the stove.

50. Apparatus according to any preceding claim wherein tubes leaving the stove fall to a lift which is displaceable between two fixed lateral guides for centering the tubes and to conduct them to two rotatable circular saws for cutting the ends off the tubes.

51. Apparatus according to claim 50 wherein the lift comprises two chains having plates which carry the tubes.

52. Apparatus according to claim 51 wherein the tubes during cutting are supported by a plate parallel to the rising runs of the chains, the space between the plate and the said runs being adjustable to the tube diameter.

53. Apparatus according to any of claims 23 to 52 including a device for longitudinally slitting the tubes, the device comprising a fixed knife formed by a triangular blade with a point directed to the advancing tubes, which blade is integrally connected to a cylindrical centering device whose diameter is less than the internal diameter of the tubes and which is introduced into the tubes while the blade slits them.

54. Apparatus according to claim 53 wherein, during slitting, the tubes are supported and displaced by belts which form side walls parallel to the axis of the centering device.

55. Apparatus according to claim 54 wherein the distance between the belts can be varied according to the external diameter of the tubes.

56. Apparatus according to claim 54 or claim 55 wherein plates are provided between belt runs.

57. Apparatus according to any of claims 53 to 56 wherein the tubes are transferred to the slitting device by a conveyor with rollers of adjustable height.

58. Apparatus according to claim 57 wherein, before being transferred to the slitting device, the tubes are pivoted by a stop

(27)



and a guide slot to align them with the axis of the roller conveyor.

- 5 59. A process for the continuous manufacture of tubes from fibrous felt substantially as herein described with reference to the drawings.

60. Apparatus for continuous manufacture of tubes from fibrous felt constructed

and arranged substantially as herein described and shown in the accompanying 10 drawings.

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