

METHOD OF MAKING FLEXIBLE TUBING WITH EMBEDDED WIRE CONDUCTOR

FIELD OF INVENTION

The present invention relates to the field of flexible plastic tubing with a focus on the embedded electrically conductive wire/s. More particularly, the invention relates to different possible arrangements of the tool die design to manufacture the flexible plastic tubing with the embedded electrically conductive wire/s.

BACKGROUND OF THE INVENTION

Flexible tubing with helically wound heating conductor is commonly used in medical applications such as breathing equipment, CPAP (Continuous Positive Airway Pressure) machine, etc. where transparency and the ability to be heated using heating wires provide a solution to control not only the presence of moisture but also to suitably heat-up and adjust the air in the device to the desired temperature. For such flexible tubing, the electrically conductive wire itself is typically encapsulated by a plastic material and is termed as the “helix” throughout this writeup. Next the word “ribbon” refers to the plastic film for the flexible tubing, and shall be used throughout this writeup to mean as such. Flexible tubing with helically wound heating conductor usually involves having at least one (1) electrically conductive wire encapsulated within a plastic helix. The helix overlaps the plastic ribbon where the ribbon is wound along an axis into a tube with one edge of each lap overlapping another and bonded by heat.

In the current Prior Art, there have been various enhancements to the method of fabrication of these flexible tubing. An example of such a prior art is US5637168A

which disclosed an Apparatus and Method for making flexible tubing with helically wound heating conductor.

There are some potential issues in the Prior Art which will be highlighted here. For simplicity, the word “conductor” here refers to “electrically conductive wire” and shall be used throughout this writeup to mean as such. Firstly, it is important to understand that the area available for the electrically conductive wires to be placed is very small which can be in the range from 2mm to 3mm. The electrically conductive wires are integrated via external guides to facilitate the wires to sit in and maintain a certain distance between each wire, i.e., the pitch size, followed by overlaying onto the extruded plastic ribbon. Subsequently this is then followed by having the electrically conductive wires to be covered by a helix which is also made of plastic. However, the critical step will be to ensure that the wires are not misalign out of these guides and to end up having a small thin area being exposed. Another issue will be the possibility for the electrically conductive wires to shift on a guide already occupied by another wire, which can be damaging to the tubing since this would affect the electrical insulation of each wire and thus shorten the lifespan of the tubing.

Therefore, any slight variation in positioning and alignment of the wires on the helix is not acceptable. Assuming at the beginning of the process there is misalignment of the wires in the helix in the first layer, any subsequent overlapping helix layers formed will “amplify” the problems inherent to the first layer, thus increasing the risk of failure due to such misalignment.

Another potential issue to address would be related to the motor attached to the full extrusion system mentioned in the Prior Art, whereby the speed of unwinding of each

electrically conductive wire has to be combined with the extrusion flow from the extruder, which in turn will also have to be proportional to the winding of the ribbon. In fact, the extruder is a major factor contributing to the thickness and quality of the ribbon. The next key point to take note is the rotating speed of the rolls during the winding of the ribbon, which has to be correlated to the speed of the extruder, whereby if it is too fast, it would result in the breakage of the ribbon and where it is too slow, it would jam up the ribbon formation. The last aspect will be to engage the electrically conductive wires one by one into the guides and at the same time, to control the speed of the unwinding of each wire. Assuming that if the feeding was too slow, the wire would break or damage the ribbon and if it is too fast, it would jam the entire process. The introduction of sensors to control the tension of each wire could be an acceptable solution to manage the unwinding speed of each wire spindle, but it would still be necessary to add brake motor to counter-act the inertia of the wire spindle relative to their fluctuating weight.

The objective of this presentation of the Prior Art example is to convey the message that there is a new, innovative and simplified solution which is what the present invention is going to propose. The solution described below will demonstrate the advantages of the present invention, whereby the key difference will be to insert the requested electrically conductive wires through a wire insert via the back of the tool die or at any angle from the top of the tool die using different tool designs and configuration that are not described in the patented WO 2019/231396A1. With the exception of the patented WO 2019/231396A1, the rest of the solutions proposed by other designs in the prior art typically do not have wires going through the wire insert at the back or top of the tool die. Instead, these prior arts have their wires that are applied on the plastic ribbon directly after extrusion and during the winding of the flexible tube.

The embodiment of the present invention disclosed different possible arrangements of the tool die design to manufacture the flexible tubing with embedded electrically conductive wire/s or conductor. These tool designs and configurations are different from those described in the patented WO 2019/231396A1. The proposed arrangements in this present invention are similar whereby the electrically conductive wires are individually fed through a wire insert via the back of the tool die or at any angle from the top of the tool die in order to ensure precise positioning of the wire within the extruded helix.

There are **three (3)** possible arrangements of the tool die design proposed in this present invention, which involve either:

- (a) Having two (2) different and separate extruders position on the same side of the mandrel but using a single combined tool die with two (2) separate orifices, i.e., there will be one orifice for extruding plastic ribbon whereby the plastic ribbon itself is helically wrapped such that its edges overlap and is simultaneously bonded by heat together to form the wall of the flexible tubing. There is also another orifice for extruding plastic helix with the electrically conductive wire/s being inserted through a wire insert at different angles from the top of the tool die such that the conductive wire is then overlay onto the plastic ribbon. The extruded plastic helix then overlaps on the plastic ribbon such that there is precise positioning of the wire/s within the extruded helix, with the plastic helix embedded with at least one or more conductive wires; or
- (b) Having two (2) different and separate extruders position on the same side of the mandrel but using a single combined tool die with three (3) separate orifices, i.e., one orifice for extruding the plastic ribbon whereby the plastic ribbon itself is helically wrapped such that its edges overlap and is simultaneously bonded by

heat together to form the wall of the flexible tubing. The second (2nd) orifice is for feeding the electrically conductive wire via a wire insert at the back of the tool die, whereby the electrically conductive wire coming out from the orifice is then overlay onto the plastic ribbon. The third (3rd) orifice is for the separate extrusion of the plastic helix itself, whereby the extruded plastic helix encapsulates the electrically conductive wire such that there is precise positioning of the wire within the extruded helix, followed by having the helix overlapping the plastic ribbon with the helix embedded with at least one or more conductive wires; or

- (c) Having two (2) different and separate extruders position on the same side of the mandrel and using two (2) separate independent tool dies with each tool die having an individual orifice; i.e., one tool die with orifice for extruding the plastic ribbon whereby the plastic ribbon itself is helically wrapped such that its edges overlap and is simultaneously bonded by heat together to form the wall of the flexible tubing. The second tool die will allow for feeding the electrically conductive wire/s through a wire insert at different angles from the top of the tool die followed by overlaying the electrically conductive wire/s (or heated conductor) onto the extruded plastic ribbon. The second tool die with also have an orifice for extruding the plastic helix and overlaying the plastic helix onto the electrically conductive wire/s such that there is precise positioning of the wire/s within the extruded helix embedded with at least one or more conductive wires.

For arrangements (a) and (b) mentioned above, using a single combined tool die gives the added advantage of minimizing the factory floor area needed. Besides, for the three (3) arrangements mentioned above, the plastic resin for the ribbon and the helix is usually different and is extruded out by two (2) different extruders. These extruder machines are all position on one side of the winding rolls mechanism or the mandrel,

thus also minimizing the factory floor area needed as well as to facilitate ease of operating the entire extrusion process for the flexible tubing.

Due to the nature of the wire embedded inside the flexible tubing, there is a possibility of misalignment and hence these different configurations as proposed in the present invention are meant to eradicate such issues. It also helps to have the guides to facilitate the alignment of the wires (i.e., the pitch side) at the plastic helix side, such that the wires can sit in nicely before the extruded helix overlaps the wires onto the plastic ribbon in a helical manner.

Regardless of the proposed three (3) different arrangements as mentioned in the present invention, it is vital that the wire/s will have to be fed through a wire insert first before it is applied onto the extruded plastic helix extruded from another orifice. The design of the wire insert is interchangeable such that it can incorporate at least one (1) or more electrically conductive wire or wires i.e., multi-wires.

Furthermore, for this present invention, the wire/s that is/are embedded inside the extruded helix may not necessary be restricted to just function as an electrically heating element for heating the air inside the flexible medical tubing. It has another function to transmit and exchange useful data between one end to the other end of the flexible tubing. Such data can be temperature, humidity, pressure, flow, sound, motion etc.

The design and layout of the present invention has the following advantages as compared to the Prior Art:

1. ***Minimized Wire Misalignment:***

The present invention disclosed three (3) different possible manufacturing arrangements. These three (3) arrangements are different from the rest in the Prior Art. Regardless of the chosen arrangement, the conductive wire/s are first inserted via a wire insert (i.e., can be from the back or the top depending on the arrangement chosen). The conductive wire/s are then extruded concurrently with overlaid plastic resin as the helix portion before it is bonded by heat to the plastic ribbon, thus ensuring alignment. By having the wire/s well encapsulated, the possibility of having the electrically conductive wire/s to perform the function of heating or even transmitting data will not be compromised or affected. Moreover, the current design arrangements proposed in the present invention is able to provide the flexibility of increasing the number of conductive wire/s (for example from three to four wires) and yet able to be well-spaced and not easily misalign.

2. *Minimized Production Downtime:*

By minimizing the issues faced as mentioned above in point 1, one can choose to apply (depending on the manufacturing environment) any of the three (3) configurations proposed in this present invention on one's production floor for making embedded wire flexible tubes. Each of this configuration serves to give good cycle time, and best quality embedded wire flexible tube, thus giving good product yield and better cost savings per part for every flexible tube being produced.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings attached here are to aid comprehension of the description of the invention here. The drawings are not to scale and they are to be used for merely illustrating the principles and concepts of the invention only.

To aid in comprehension of the invention, the drawings are separated into the various Figures as described below:

Figure 1 illustrates an overall perspective view of the first (1st) manufacturing method highlighting the various key components and functions for the embodiment of the present invention.

Figure 2 illustrates an overall perspective view of the second (2nd) manufacturing method highlighting the various key components and functions for the embodiment of the present invention.

Figure 3 illustrates an overall perspective view of the third (3rd) manufacturing method highlighting the various key components and functions for the embodiment of the present invention.

Reference numbers

1	Apparatus
2	Ribbon
3	Helix
4	Combined Die (for both Ribbon and Helix)
5	Wire Insert
6	Flexible Tubing
7	Winding Rolls
8	Rotating Shaft
9	Wire Conductor / Electrically Conductive Wire
10	Disc Coupling
11	Guides
20	Extruder
30	Extruder
40	Die (for Ribbon)
50	Die (for Helix)

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT OF THE PRESENT INVENTION

In the following description, details are provided to describe the embodiment of the application. It shall be apparent to the person skilled in the art, however, that the embodiments may be practiced without such details.

The present invention here relates to the field of flexible plastic tubing with embedded electrically conductive wire. More particularly, the invention discloses three (3) possible arrangement of manufacturing the flexible plastic tubing with the embedded electrically conductive wire to minimize wire misalignment and reduces production downtime.

Figure 1 illustrates an overall perspective view of the various key components and functions for the embodiment of the present invention. It illustrates the apparatus **1** which includes the rotating shaft **8** having winding rolls **7** that are spaced evenly for winding and rotationally advancing the helically wound flexible tubing **6**. The winding rolls **7** typically consists of rollers or mandrels that are spaced evenly for rotation. The winding rolls **7** rotate in unison in a certain manner, i.e., in an anti-clockwise direction with advancing forward vector force to drive the helically wound flexible tubing **6** forward in order to facilitate the ease of winding the plastic ribbon **2**. The presence of the disc coupling **10** on the rotating shaft **8** helps to control the pitch size of the helically wound flexible tubing **6**, which is formed from the plastic helix **3** which overlays onto the plastic ribbon **2** as illustrated in **Figure 1**.

Figure 1 illustrates the first (1st) arrangement that involved having both the plastic ribbon **2** and the plastic helix **3** being co-extruded from two separate extruders **20** and **30** but via a single combined tool die **4** with two (2) separate orifices. Instead of having two

(2) separate tool dies, using a single combined tool die **4** gives the added advantage of minimizing the factory floor area needed as well as to facilitate ease of operating the entire extrusion process for the flexible tubing. Essentially the single combined tool die **4** has an orifice that is able to have the plastic ribbon **2** extrude out from one extruder **20** onto the winding rolls **7**. These winding rolls **7** are rotating in unison together in an anti-clockwise direction with advancing forward vector force concurrently to form the base material for the flexible tubing **6**. This is followed by having the electrically conductive wire **9** being fed at different angles from the top via the wire insert **5**. The design of the wire insert **5** is interchangeable such that it can incorporate at least one (1) or more electrically conductive wire or wires (i.e., multi-wires). What happens here is that after coming out from wire insert **5**, the electrically conductive wire **9** is then overlay onto the plastic ribbon **2**. At the same time, the plastic helix **3** is then extruded outwards from a second orifice in the same tool die and overlaying the plastic helix **3** onto the electrically conductive wire **9**. The end result is that the wire/s is/are then embedded inside within the extruded plastic helix **3** encapsulating it. The presence of the disc coupling **10** helps to control the pitch size formed from the plastic helix **3** when it overlays onto the plastic ribbon **2**.

Figure 1 also illustrates that the two (2) different and separate extruders **20** and **30** are positioned on one side (or the same side) of the winding rolls **7** / mandrel, thus minimizing the factory floor area needed as well as to facilitate ease of operating the entire extrusion process for the flexible tubing. Having extruders **20** and **30** on the same side of the winding rolls **7** / mandrel will minimize the floor space needed for the extrusion and also make it easier for the operator to operate the entire extrusion process for the flexible tubing **6**.

Figure 2 illustrates the second (2nd) manufacturing arrangement to manufacture flexible tubing that involved having both the plastic ribbon **2** and the plastic helix **3** being co-extruded from two separate extruders **20** and **30** but via a single combined tool die **4** with three (3) separate orifices. As illustrated in **Figure 2**, there is one orifice for extruding plastic ribbon **2**, with the plastic ribbon **2** helically wrapped around the winding rolls **7** or mandrel such that its edges overlap and is simultaneously bonded by heat together to form the wall of the flexible tubing **6**. The winding rolls **7** / mandrel rotate in unison in an anti-clockwise direction with advancing forward vector force concurrently to form the base material for the flexible tubing **6**. Concurrently, there is a second orifice for feeding the electrically conductive wire/s **9** (or heated conductor) through a wire insert **5** via the back of the same tool die **4** directly connected to the extruder; and followed by overlaying the electrically conductive wire/s **9** (or heated conductor) coming out onto the extruded plastic ribbon **2**. There are guides **11** that helps to facilitate the alignment of the wires (i.e., the pitch side) at the plastic helix **3** side so that the wires can sit in nicely. At the same time, there is a third orifice for extruding the plastic helix **3** and overlaying the plastic helix **3** onto the electrically conductive wire/s **9** such that there is precise positioning of the wire/s **9** within the extruded helix **3**. The extruded helix **3** consists of at least one (1) or more electrically conductive wire **9** (or heated conductor) being embedded inside, with the plastic helix **3** being wrapped and bonded by heat around the plastic ribbon **2** forming the flexible tubing **6**.

Similar to **Figure 1**, **Figure 2** also illustrates that the two (2) different and separate extruders **20** and **30** are positioned on one side of the winding rolls **7** / mandrel, thus minimizing the factory floor area needed as well as to facilitate ease of operating the entire extrusion process for the flexible tubing. Having extruders **20** and **30** on the same side of the winding rolls **7** / mandrel will minimize the floor space needed for the

extrusion and also make it easier for the operator to operate the entire extrusion process for the flexible tubing **6**.

Figure 3 illustrates the third (3rd) manufacturing arrangement to produce flexible tubing involving two (2) separate independent tool die, with each tool die 40 & 50 having an individual orifice. It involves one tool die 40 with an orifice for extruding plastic ribbon 2, with the plastic ribbon **2** helically wrapped around the winding rolls **7** / mandrel such that its edges overlap and is simultaneously bonded by heat together to form the wall of the flexible tubing **6**, with the winding rolls **7** / mandrel rotating in unison in an anti-clockwise direction with advancing forward vector force concurrently to form the base material for the flexible tubing **6**. Concurrently, there is a second (2nd) tool die 50 to allow for feeding the electrically conductive wire/s **9** (or heated conductor) through a wire insert **5** at different angles from the top via the second tool die **50**, and followed by overlaying the electrically conductive wire/s **9** (or heated conductor) onto the extruded plastic ribbon **2**. The plastic helix **3** from the orifice in the second tool die **50** is then extruded out and overlay onto the electrically conductive wire/s **9** such that there is precise positioning of the wire/s **9** within the extruded helix **3**. As illustrated in **Figure 3**, the plastic ribbon **2** and the plastic helix **3** are co-extruded separately from two separate extruders denoted as **20** and **30**, with the two (2) extruders position on the same side of the winding rolls **7** / mandrel. This makes it easier for the operator to operate the entire extrusion process for the flexible tubing **6**.

Therefore, the present invention presented different possible arrangements of manufacturing the flexible tubing with embedded electrically conductive wire/s or conductor.

While what has been described hereinabove is the preferred embodiment of the invention, those skilled in the art will understand that numerous modifications may be made without departing from the spirit and scope of the invention. The embodiments described herein are meant to be illustrative only and should not be taken as limiting the invention, which can be expressly set forth in the following claims.

CLAIMS

What is claimed is:

1. A **method** for manufacturing of a flexible plastic tubing using a **single combined tool die with three (3) orifices**, whereby it comprises of the following:
 - (a) one orifice for extruding plastic ribbon, with the plastic ribbon helically wrapped around the winding rolls or mandrel such that its edges overlap and is simultaneously bonded by heat together to form the wall of the flexible tubing, with the winding rolls / mandrel rotating in unison in an anti-clockwise direction with advancing forward vector force concurrently to form the base material for the flexible tubing; and concurrently
 - (b) second orifice for feeding the electrically conductive wire/s (or heated conductor) through a wire insert via the back of the same tool die directly connected to the extruder; and followed by
 - (c) overlaying the electrically conductive wire/s (or heated conductor) onto the extruded plastic ribbon; and concurrently
 - (d) a third orifice for extruding the plastic helix and overlaying the plastic helix onto the electrically conductive wire/s such that there is precise positioning of the wire/s within the extruded helix; whereby
 - (e) the extruded helix consists of at least one (1) or more electrically conductive wire (or heated conductor) being embedded inside, with the plastic helix being wrapped and bonded by heat around the plastic ribbon forming the flexible tubing; and whereby
 - (f) the plastic ribbon and the plastic helix are co-extruded separately from two separate extruders position on the same side of winding rolls / mandrel.

2. A **method** for manufacturing of a flexible plastic tubing using a **single combined tool die with two (2) orifices** whereby it comprises of the following:
- (a) one orifice for extruding plastic ribbon, with the plastic ribbon helically wrapped around the winding rolls / mandrel such that its edges overlap and is simultaneously bonded by heat together to form the wall of the flexible tubing, with the winding rolls / mandrel rotating in unison in an anti-clockwise direction with advancing forward vector force concurrently to form the base material for the flexible tubing; and concurrently
 - (b) feeding the electrically conductive wire/s (or heated conductor) through a wire insert at different angles from the top via the wire insert through the same tool die in the extruder, and followed by
 - (c) overlaying the electrically conductive wire/s (or heated conductor) onto the extruded plastic ribbon; followed by
 - (d) extruding the plastic helix outwards from a second orifice in the same tool die and overlaying the plastic helix onto the electrically conductive wire/s such that there is precise positioning of the wire/s within the extruded helix; whereby
 - (e) the plastic ribbon and the plastic helix are co-extruded separately from two separate extruders with the two (2) extruders position on the same side of the winding rolls / mandrel; wherein
 - (f) the plastic helix consists of at least one (1) or more electrically conductive wire (or heated conductor) being embedded inside.
3. A **method** for manufacturing of a flexible plastic tubing using **two (2) separate independent tool die, with each tool die having an individual orifice,** whereby it comprises of the following steps:

- (a) one tool die with an orifice for extruding plastic ribbon, with the plastic ribbon helically wrapped around the winding rolls / mandrel such that its edges overlap and is simultaneously bonded by heat together to form the wall of the flexible tubing, with the winding rolls / mandrel rotating in unison in an anti-clockwise direction with advancing forward vector force concurrently to form the base material for the flexible tubing; and concurrently
- (b) second tool die to allow for feeding the electrically conductive wire/s (or heated conductor) through a wire insert at different angles from the top via the second tool die in the extruder, and followed by
- (c) overlaying the electrically conductive wire/s (or heated conductor) onto the extruded plastic ribbon; and followed by
- (d) extruding the plastic helix from the orifice in the second tool die and overlaying the plastic helix onto the electrically conductive wire/s such that there is precise positioning of the wire/s within the extruded helix; whereby
- (e) the plastic ribbon and the plastic helix are co-extruded separately from two separate extruders, with the two (2) extruders position on the same side of the winding rolls / mandrel; wherein
- (f) the plastic helix consists of at least one (1) or more electrically conductive wire (or heated conductor) being embedded inside.