

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 a new method of manufacturing of the flexible plastic tubing with the embedded electrically conductive wire/s.

BACKGROUND OF THE INVENTION

US5637168A disclosed an Apparatus and Method for making flexible tubing with helically wound heating conductor.

Flexible tubing with helically wound heating conductor method involves the ability to include at least one (1) electrically conductive wire on a plastic ribbon, where the ribbon is wound along an axis into a tube with one edge of each lap overlapping and heat-bonded to an edge of the preceding lap. These tubings are commonly used in medical applications such as breathing equipment, where transparency and the ability to be heated using heating wires provide an easy solution to control not only the presence of moisture but also to harmoniously warm and adjust the device to the desired temperature. There have been various enhancements to the method of fabrication of these tubings, where unfortunately the cost of production still remains high due to the high rejection levels arising from highly complex technical processes in manufacturing and the high investment incurred due to the complexity of the equipment needed.

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 is the main underlying reason that is affecting the quality issue. The electrically conductive wires are integrated after extrusion of the ribbon and overlay onto the plastic ribbon, which includes guides to receive and maintain a certain distance between each wire, i.e. the pitch size and then in the last operation, the electrically conductive wires are to be covered by a profile. A typical extrusion process will generate guides on the ribbon that are not particularly difficult to produce. However, the critical step will be to ensure that the wires will never misalign out of these guides and have 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 profile is not acceptable. Assuming at the beginning of the process there is misalignment of the wires in the profile in the first layer, any subsequent overlapping profile layers formed will “amplify” the problems inherent to the first layer, thus increasing the risk of failure due to such misalignment.

Another aspect refers to the motor attached to the full 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 of course, to control the speed of the unwinding of each wire. Considering 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 intervention of sensors to control the tension of each wire could be an acceptable solution to manage the unwinding speed of each spindle, but it would still be necessary to add brake motor to counter-act the inertia of the wire bobbins relative to their fluctuating weight.

The objective of this presentation of the Prior Art example is to convey the message that a new, innovative and simplified solution will help to reduce the cost of such tubing, 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 conductive wires through a wire insert via the back of the tool die directly inside the extruder and not as it is done as per described in the prior art, which is after extrusion of the ribbon and during the winding of the flexible tube.

The embodiment of the present invention disclosed a method of manufacturing the flexible tubing whereby the electrically conductive wires are extruded through a wire insert via the back of the tool die directly inside the extruder together with the polymeric resin instead of having it done separately outside as described in the current prior art. The present invention employs a winding roll mechanism that facilitates the extrusion of the extruded flat plastic ribbon using an extruder and a die tool (for the plastic ribbon), an extruded profile using another extruder and another die tool (for the plastic profile),

wherein the profile is overlapping the plastic ribbon with the profile consisting of at least one or more conductive wires. The plastic ribbon itself is helically wrapped such that its edges overlap and is simultaneously heat-bonded together to form the wall of the flexible tubing. The die tool for the plastic ribbon includes an easy adjustable system to tweak the thickness of the plastic ribbon during the extrusion process, hence removing the need to stop the whole production in case of wear and tear or inconsistent parameters. Typically, the plastic used to make the flexible tubing has to be of a medical-grade and has to be compatible in terms of the ability to be heat-bonded with the extruded profile that is overlapping the plastic ribbon. The plastic resin for the ribbon and the profile is usually different and is extruded out by two (2) different extruders. Moreover, on the profile side, other than having the plastic resin to act as a “shield” for the embedded wire conductor, there is also an option or possibility to use plastic resin that is electrically insulating and yet is conductive enough to conduct away any heat generated from the embedded wire. There are surface protrusions that act as guides (hereafter referred to as “guides” in subsequent writeup here) being formed onto the plastic ribbon being extruded out. These guides are formed with the aid of the tooling die so as to align the plastic ribbon and the extruded profile together when being extruded out.

For this present invention, the electrically heated conductor consists of at least one or more conductive wires that can be extruded through a wire insert via the back of the tool die in order to ensure precise positioning of the wire in the profile. The electrically conductive wires may also be fed from the top or from any angle via the wire insert through the tool die before being extruded out together with the plastic material. Hence regardless of which direction or angle, most importantly the wire/s will have to be fed through a wire insert first before it is extruded together through the tool die. 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 if more than one. This tool die is directly connected to the extruder. What happens here is that another plastic resin is then extruded at the concurrently together with the conductive wire/s. The end result is that the wire/s is/are then embedded inside within a layer of extruded plastic encapsulating it. This is termed as the extruded profile and is extruded out and overlaps onto the plastic ribbon with a heat-bonded adhesion.

Furthermore, for this present invention, the wire/s that is/are embedded inside the layer of extruded plastic (i.e. the extruded profile) may not necessary be restricted to just function as an electrically heating element for heating the flexible medical tubing. It has other purposes and functions too. One option or possibility would be that the wire serves to act as a form of added reinforcement for the flexible tubing since the profile with the embedded wire overlaps and heat-bonded onto the ribbon. This added reinforcement makes the tubing more collapse-resistant. Another option is that the wire can serve to transmit and exchange useful data between each end of the flexible tubing. The wire can be used to carry an electrical signal from the mask end to the machine end, hence transmitting data for parameters such as temperature, humidity, pressure, flow, sound, motion etc.

The present invention presented at least three (3) different possible arrangements of manufacturing the flexible tubing with embedded electrically conductive wire/s or conductor. All these possible arrangements are similar in a way that the electrically conductive wire/s will have to be extruded through a wire insert first, wherein this wire insert can be via the back of the tool die or situated on top of the tool die. As described previously, one involves having two (2) different and separate extruders and two (2) separate dies, i.e. one for the plastic ribbon and one for the plastic profile with the

electrically conductive wire/s being extruded concurrently together. However, there can be another alternative way for this present invention to get the same end result. This involved having both the plastic ribbon and the plastic profile being co-extruded from two separate extruders but via a single combined tool die, i.e. using co-extrusion process. Instead of having two (2) separate tool dies, using a single combined tool die gives the added advantage of minimizing the factory floor area needed. However, using two (2) separate tool dies provides the possibility to update and to quick change each side independently, which will remove the need to redo a full die tool if, for example there is a request to increase the number of conductive wires from three to four. Last but not least, the third (3rd) possible arrangement involves also using two (2) different and separate extruders and two (2) separate tool dies in which one (1) of the tool die is for extruding the plastic profile. For this third (3rd) possible arrangement, the electrically conductive wire/s will be inserted from the top or at different angles from the top via the wire insert through the die in the extruder such that the extruded plastic profile is extruded in a downwards direction concurrently with the wire being encapsulated within the plastic profile.

The design and layout of the present invention differs from the Prior Art and has the following advantages:

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

The profile consists of the conductive wire/s encapsulated by a layer of extruded plastic resin, whereby the conductive wire/s is introduced directly at the extruder side (via the wire insert in the tool die in order to ensure precise positioning of the wire) and is extruded at the same time concurrently with a layer of plastic resin over it, thus encapsulating the wire/s. This is different from the Prior Art whereby the conductive wire/s is fed from a separate wire-feeding machine and overlay

onto the guides of the plastic profile, followed by its corresponding plastic resin being extruded from another extruder, before the conductive wire/s is being encapsulated by the extruded plastic resin and heat-bond onto the plastic ribbon. Hence this means that there is a possibility of the conductive wire/s being misalign or shift out of alignment from the guides, thus affecting the performance of the electrically conductive wire since it would not be well insulated.

However, the above disadvantage will not exist in the present invention since these conductive wire/s are extruded concurrently with the plastic resin before it is heat-bonded to the plastic ribbon, thus ensuring alignment. The conductive wire/s are encapsulated within a layer of polymer plastic at the beginning of the extrusion process, which means that the wire/s are well insulated. By having the wire/s well insulated, 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 proposed is able to provide the flexibility of increasing the number of conductive wire/s (example from three to four wires) and yet able to be well-spaced and not easily misalign.

2. *Minimized Quality Issues:*

The concept proposed in the present invention is able to minimize the quality issues that is being faced by the current Prior Art. This is because the conductive wire/s is being extruded concurrently at the same time with the plastic resin directly at the extruder side, thus minimizing the potential problems faced by the Prior Art. Having lower quality issues would result in savings in material costs and time.

3. *Minimized Production Downtime:*

By minimizing the quality issues faced as mentioned above in point 2, there will be lesser production downtime since the rejects yield will be lower/reduced as well. By having lesser rejects, it would also mean that the productivity of the line increases since more useful parts can be produced within a certain period of time. Higher productivity would mean better costs savings per part for every flexible tubing that is being produced.

Alternatively other than having the guides formed on the plastic ribbon as described in the previous paragraphs, another method disclosed here in the present invention involves guides being formed onto the plastic profile being extruded out. These guides are formed with the aid of the tooling die so that the wires can be align on the guides at the plastic profile side, such that it encapsulates the wires before the profile overlaps onto the plastic ribbon in a helical manner. The wires are inserted from the top or at different angles via the wire insert through the tool die. The wires can then be laid onto the guides at the profile side by the mechanical winding force of the mandrel such that the plastic on the profile side will encapsulate the wires as it overlaps with the plastic ribbon which is also turning in a helical manner on a winding roll. Hence this method also eliminates the possibility of the electrically conductive wires being misaligned as described in the Prior Art highlighted in previous paragraphs.

Hence to conclude, the present invention discloses methods of making flexible tubing that is able to overcome the problems associated with using the Prior Art. These can be summarized as follows:

1. Ribbon Side: Guides formed on the Ribbon Side.

Profile Side: Having the electrically conductive wire being inserted from either:

- the back of the wire insert of the tooling die in the extruder; or
- the top of the wire insert of the tooling die in the extruder;
- followed by having the profile being extruded out with the conductive wire being encapsulated within the extruded plastic before overlay onto the ribbon side.

2. Ribbon Side: No guides, but will be extruded out as usual on the winding roll.

Profile Side: The conductive wires can be inserted from the top or at different angles from the top via the wire insert through the tool die in the extruder. Guides are formed on the profile side, whereby the electrically conductive wires are laid on the guides at profile side by the mechanical winding force of the mandrel or winding roll such that it will encapsulate the wires before overlap on the ribbon side in which it is also turning in a helical manner on the winding roll.

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 various key components and functions for the embodiment of the present invention.

Figure 2 illustrates another view of the system described in **Figure 1**.

Figure 3 illustrates a cross-sectional view of the end product showing the placement of the plastic ribbon, the encapsulated conductive wire and the plastic profile.

Figure 4 illustrates an enlarged section of the plastic profile encapsulating at least one or more electrically conductive wire.

Figure 5 illustrates an enlarged section of the plastic ribbon with a guide.

Figure 6 illustrates another overall perspective view of the various key components of the functions for the embodiment of the present invention.

Figure 7 illustrates another overall perspective view highlighting the electrically conductive wire being fed from the top.

Figure 8 illustrates a perspective view highlighting guides on profile section.

Reference numbers

1	Apparatus
2	Ribbon
3	Profile
3a.	Guides on Profile
4	Die (for Ribbon)
5	Die (for Profile)
6	Flexible Tubing
7	Winding Rolls
8	Rotating Shaft
9	Wire Conductor / Electrically Conductive Wire
10	Guide
11	Combined Die (for both Ribbon and Profile)
12	Disc Coupling
20	Extruder (for Ribbon)
30	Extruder (for Profile)

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 a focus on the embedded electrically conductive wire. More particularly, the invention relates to a new method of manufacturing of the flexible plastic tubing with the embedded electrically conductive wire that is able to minimize wire misalignment, minimizes quality issues 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** appropriately spaced about evenly for winding and rotationally advancing the helically wound flexible tubing **6**. The winding rolls **7** typically consists of rollers or mandrels that are appropriately spaced evenly for rotation. The winding rolls **7** rotate in unison in a certain manner, i.e. clockwise or anti-clockwise direction depending on the requirement. The rotation of the winding rolls will help to rotationally advance or drive the helically wound flexible tubing **6** forward. The presence of the disc coupling **12** on the rotating shaft **8** helps to control the pitch size of the helically wound flexible tubing **6**, which is formed from the plastic profile **3** which overlays onto the plastic ribbon **2** as illustrated in **Figure 1 and 2**.

The apparatus **1** in **Figure 1** also illustrates die **4** connected to an extruder **20** which is extruding the plastic ribbon **2** which has a guide **10** as shown in **Figure 5** whereby

Figure 5 illustrates an enlarged section of the plastic ribbon **2** with a formed guide **10**. The extruded plastic ribbon **2** is wrapped around the winding rolls **7** which are rotating in unison together (either clockwise or anti-clockwise depending on the requirement) and advancing forward concurrently to form the base material for the flexible tubing **6**. The other extruder **30** extrudes out the plastic profile **3** via die **5** which when extruded out, it already incorporates one or more heated conductor or electrically conductive wires embedded within the plastic resin as well as guide **10** (i.e. shown in **Figure 4** which illustrates an enlarged section of the plastic profile **3** encapsulating at least one or more electrically conductive wire) to heat-bond nicely at a certain designated angle onto the guide **10** in the plastic ribbon **2**. The pitch size formed from the plastic profile **3** which overlays over the plastic ribbon **2** is controlled by the presence of the disc coupling **12** on the rotating shaft **8** as illustrated in **Figure 1** and **2**.

Although **Figure 1** illustrates two (2) different and separate extruders **20** and **30** using two separate and independent die **4** and die **5**, it should be understood that both the plastic ribbon **2** and the plastic profile **3** may be co-extruded from two separate extruders via a single combined tool die, i.e. using co-extrusion process. This will be described further in detail in the subsequent paragraphs using **Figure 6**.

Figure 2 illustrates another view of the system described in **Figure 1**. As illustrated in both **Figure 1** and **2**, plastic ribbon **2** is extruded out from extruder **20** via die **4** and is wrapped around the winding rolls **7** which are rotating in unison together (either clockwise or anti-clockwise depending on the requirement) and advancing forward concurrently to form the base material for the flexible tubing **6**. The plastic ribbon **2** is wrapped around in successive layers to form a certain thickness as shown in the cross-sectional view in **Figure 3**. The die 4 for the plastic ribbon 2 includes an easy adjust

system to tweak the thickness of the plastic ribbon **2** during the extrusion process, hence removing the need to stop the whole production in case of wear and tear or inconsistent parameters. Meanwhile in the other extruder **30** connected via die **5**, at least one (1) or more electrically conductive wire (or heated conductor) is being fed through a wire insert via the back of the tool die **5** in order to ensure precise positioning of the wire. 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). This tool die **5** is directly connected to the extruder **30**. What happens here is that another plastic resin is then extruded at the same time concurrently together with the conductive wire/s. The end result is that the wire/s are then embedded inside within a layer of extruded plastic encapsulating it. This is termed as the extruded profile **3** and is extruded out and overlaps onto the plastic ribbon **2** before it is heat-bonded onto the ribbon **2**. The presence of the disc coupling **12** on the rotating shaft **8** helps to control the pitch size which is formed from the plastic profile **3** when it overlays over the plastic ribbon **2**. By incorporating the thin electrically conductive wire/wires to be encapsulated within a layer of extruded plastic via the wire insert at the extruder end **30**, any quality issues faced would be controlled at the source of the production rather than at the end of the whole manufacturing process, thus saving time and material costs as any issues faced would be rectified earlier and quickly.

Figure 3 illustrates a cross-sectional view of the end product flexible tubing showing the placement of the plastic ribbon **2** and the plastic profile **3** which encapsulates the conductive wire or heated conductor (hidden from this view). The design is such that the plastic polymer material encapsulating the conductive wire or heated conductor is of a certain thickness such that the heat generated from the conductive wire will not be easily lost to the ambient environment. Also, the placement of the conductive wire or heated

conductor will be such that it is close to the flexible tubing side or plastic ribbon **2** side so as to facilitate effective heat-transfer. At least one (1) or more electrically conductive wires can be encapsulated within the plastic polymeric material forming the plastic profile **3**. For two (2) or more conductive wires, these wires can be placed side-by-side close to each other, and yet not being able to touch each other. The plastic polymer material chosen for this process will need to be medical-grade and also able to be heat-bonded to each other. Moreover, the plastic material chosen when solidified, will need to be flexible enough and yet offer enough crush resistance for its daily usage.

Figure 6 illustrates another alternative way for the present invention to get the same end result. This involved having both the plastic ribbon **2** and the plastic profile **3** being co-extruded from two separate extruders **20** and **30** but via a single combined tool die **11**, i.e. using co-extrusion process. Instead of having two (2) separate tool dies, using a single combined tool die **11** gives the added advantage of minimizing the factory floor area needed. Essentially the single combined tool die **11** is able to first have the plastic ribbon **2** extrude out from one extruder **20** onto the winding rolls **7** which are rotating in unison together and advancing forward concurrently to form the base material for the flexible tubing **6**. This is followed by the plastic profile **3** being extruded out from the other extruder **30** via the single combined tool die **11** and overlay onto the plastic ribbon **2**. Similar to the operation described in **Figure 1 and 2**, the plastic profile **3** that is being extruded out already has conductive wire/s being embedded inside the layer of extruded plastic encapsulating it. The presence of the disc coupling **12** helps to control the pitch size formed from the plastic profile **3** when it overlays onto the plastic ribbon **2**.

However, using two (2) separate tool dies as shown in **Figure 1 and 2** provides the possibility to update and to quick change each side independently, which will remove the

need to redo a full die tool if, for example there is a request to increase the number of conductive wires from three to four.

Figure 7 illustrates another overall perspective view highlighting the electrically conductive wire **9** being fed from the top. **Figure 7** is quite similar to **Figure 1** in that it also consists of two (2) different and separate extruders **20** and **30** using two separate and independent die **4** and die **5**. The only difference is that now the electrically conductive wire **9** is fed from the top as opposed to via the back of the die **5** as shown in **Figure 1**. Electrically conductive wire **9** is being fed from the top into the wire insert via the tool die **5** for the profile **3**. The profile **3** with the conductive wire **9** being encapsulated will be extruded out downwards and will then be overlaid onto the ribbon **2** as illustrated in **Figure 7** by the mechanical winding force of the winding roll. Take note that other than from the top, the electrically conductive wire **9** can also be fed at different angles from the top via the wire insert through the tool die. The rest of the process is the same as what was described in **Figure 1**.

Figure 8 illustrates another method disclosed here in the present invention whereby it involves guides being formed onto the plastic profile being extruded out. As illustrated in **Figure 8**, these guides denoted as **3a** are formed with the aid of the tooling die so that the wires **9** can be align on the guides **3a** at the plastic profile side denoted as **3**, such that it encapsulates the wires **9** before the profile **3** overlaps onto the plastic ribbon **2** in a helical manner. The wires **9** can be inserted from the top or at different angles from the top via the wire insert through the tool die in the extruder. After that, the wires **9** are then laid onto the guides **3a** at the profile side **3** such that the plastic on the profile side **3** will encapsulate the wires **9** as it overlaps with the plastic ribbon **2** by the mechanical winding force of the winding roll or mandrel turning in a helical manner. Hence this

method also eliminates the possibility of the electrically conductive wires being misaligned as described in the Prior Art highlighted in previous paragraphs.

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.