Variable-diameter lanyards and systems and methods for making the same.

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Abstract
Variable-diameter lanyards and systems and methods for manufacturing the same are disclosed. Variable-diameter lanyards can include a variable diameter core with a woven exterior. Tensile members may be included in the variable-diameter core for structural support and added strength.
FIG. 3
FIG. 13
1500
PROVIDE A VARIABLE-DIAMETER CORE

1503
WEAVE A SHEATH AROUND THE VARIABLE-DIAMETER CORE

FIG. 15

1600
PROVIDE A MATERIAL TO AN EXTRUDER INCLUDING A DIE

1603
FEED A TENSILE MEMBER THROUGH A HYPODERMIC PATH EXTENDING THROUGH A PORTION OF THE DIE

1605
EXTRUDE THE MATERIAL THROUGH THE DIE WHILE THE TENSILE MEMBER IS FED THROUGH THE HYPODERMIC PATH

1607
DYNAMICALLY ADJUST SYSTEM FACTORS OF THE EXTRUDER TO CHANGE AN OUTER DIAMETER OF THE VARIABLE-DIAMETER CORE

1609
WEAVE A SHEATH OVER THE VARIABLE-DIAMETER CORE

FIG. 16
1700

PLACE ONE OR MORE TENSILE MEMBERS INTO A VARIABLE-DIAMETER MOLD

1701

INJECT MATERIAL INTO THE VARIABLE-DIAMETER MOLD

1703

REMOVE THE MATERIAL FROM THE VARIABLE-DIAMETER MOLD TO FORM A VARIABLE-DIAMETER CORE

1705

WEAVE A SHEATH AROUND THE VARIABLE-DIAMETER CORE

1707

FIG. 17
VARIABLE-DIAMETER LANYARDS AND SYSTEMS AND METHODS FOR MAKING THE SAME

CROSS-REFERENCE TO RELATED APPLICATION

[0001] This application claims the benefit of U.S. Provisional Application No. 61/558,835, filed Nov. 11, 2011, the disclosure of which is incorporated by reference herein in its entirety.

BACKGROUND

[0002] Lanyards are commonly used for holding small personal effects such as keys, access badges, and small electronic devices. Lanyards may include a loop of material that is meant to be worn around a person’s neck or wrist and a mechanism for connecting the lanyard to an object.

SUMMARY

[0003] Variable-diameter lanyards and systems and methods for making the same are disclosed.

[0004] A lanyard, according to some embodiments, can include a variable-diameter core. Incorporating such a core into a lanyard can alleviate certain problems associated with typical variable-diameter ropes, including the necessity for complex weave patterns and differences in elasticity along the lanyard’s length. The variable-diameter core may be formed using, for example, a compression molding process, a bump extrusion process, or an injection molding process. In some embodiments, the variable-diameter core can be formed as a single strand with its diameter varying smoothly from one end to the other. In these embodiments, the two ends may be joined together in a device engagement region, which may include a mechanism for attaching the lanyard to an object. In other embodiments, the variable-diameter core can be formed in a closed loop. In these embodiments, the device engagement region may be, for example, the thinnest section of the variable-diameter core.

[0005] According to some embodiments, a variable-diameter core can include one or more tensile members for structural support and added strength. The tensile member or members can be incorporated into the variable-diameter core as part of a molding or extrusion process.

[0006] In addition, any suitable material may be woven onto the variable-diameter core to form a sheath for the lanyard. The woven sheath can protect the lanyard from damage and provide an aesthetically pleasing finish. According to some embodiments, the ends of the woven sheath may be joined together at a point along the length of the lanyard to provide a seamless finish.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] The above and other aspects and advantages of the invention will become more apparent upon consideration of the following detailed description, taken in conjunction with accompanying drawings, in which like reference characters refer to like parts throughout, and in which:

[0008] FIGS. 1A and 1B illustrate different variable-diameter lanyards in accordance with some embodiments;

[0009] FIGS. 2A and 2B show cross-sectional views of a variable-diameter lanyard manufactured using compression molded urethane sheets in accordance with some embodiments;

[0010] FIG. 3 shows an illustrative view of a mold used to manufacture a variable-diameter lanyard in accordance with some embodiments;

[0011] FIG. 4 shows an illustrative perspective view of a mold used to manufacture single-strand variable-diameter lanyards in accordance with some embodiments;

[0012] FIGS. 5A and 5B show illustrative views of a mold used to manufacture a single-strand variable-diameter lanyard in accordance with some embodiments;

[0013] FIGS. 6A-C show cross-sectional views of variable-diameter lanyards manufactured with silicon sheets in accordance with some embodiments;

[0014] FIGS. 7A and 7B show different molds in accordance with some embodiments;

[0015] FIG. 8 is a cross-sectional view of an illustrative extruder in accordance with some embodiments;

[0016] FIGS. 9A and 9B show cross-sectional views of an illustrative die for use in an extrusion process in accordance with some embodiments;

[0017] FIG. 10 is a cross-sectional view of a portion of a mold for a variable-diameter lanyard with several gates for injecting material in accordance with some embodiments;

[0018] FIG. 11 shows a cross-sectional view of an illustrative mold for a variable-diameter lanyard having centered tensile members in accordance with some embodiments;

[0019] FIG. 12A shows a top view of a mold for forming a closed-loop variable-diameter lanyard in accordance with some embodiments;

[0020] FIG. 12B shows a cross-sectional view of an apparatus for centering a tensile member inside a variable-diameter lanyard in accordance with some embodiments;

[0021] FIG. 13 shows a view of a portion of a variable-diameter lanyard including a woven sheath in accordance with some embodiments;

[0022] FIGS. 14A-D show illustrative device engagement regions of variable-diameter lanyards in accordance with some embodiments;

[0023] FIG. 15 is a flowchart of a process for forming variable-diameter lanyards in accordance with some embodiments;

[0024] FIG. 16 is a flowchart of a process for forming variable-diameter lanyards in accordance with some embodiments; and

[0025] FIG. 17 is a flowchart of a process for forming variable-diameter lanyards in accordance with some embodiments.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0026] Systems and methods for forming a lanyard with a variable-diameter core and woven exterior are disclosed. Lanyards, according to some embodiments, can include one or more tensile members embedded in a variable-diameter core. The tensile members can include, for example, strands of Kevlar (or other aramid or para-aramid fiber), xylon, nitinol, steel, or other natural, synthetic, and/or metallic fibers. In general, tensile members can provide structural support and added strength to variable-diameter lanyards as disclosed herein.

[0027] Use of a variable-diameter core can alleviate many of the issues commonly associated with variable-diameter ropes. For instance, typical variable-diameter ropes require complex, expensive weave patterns that add to the manufacturing cost and result in variable elasticity over the length of
the rope. Providing a variable-diameter core in accordance with embodiments disclosed herein may reduce manufacturing cost and complexity while maintaining constant elasticity over the length of the lanyard. Variable-diameter cores, according to some embodiments, may be manufactured using compression molding, bump extrusion, and/or injection molding. Depending on the manufacturing process used, the variable-diameter cores may be manufactured as a closed loop or as a single strand. In single strand embodiments, the ends of the strand can be coupled together in a later manufacturing step.

[0028] Aesthetic appeal and physical protection may be enhanced by weaving a sheath over the variable-diameter core. The woven sheath may include any suitable material, including natural fibers such as cotton, synthetic fibers such as nylon or polyester, and/or other materials including Kevlar, carbon fiber, and metallic fiber. Because it is difficult or impossible to weave a closed loop, in embodiments in which the variable-diameter core is manufactured as a closed loop, the ends of the woven sheath may be joined together in a suitable finishing process. The finishing process may include joining the ends of the woven sheath together using, for example, a splice, crimp, sheath overmold, and/or an adhesive.

[0029] Variable-diameter lanyards, according to some embodiments, may further include a coupling mechanism for attaching the lanyard to an object (e.g., an electronic device, a keychain, and/or an access badge). The coupling mechanism may be part of a cable engagement region of the variable-diameter lanyard and can include, for example, a clip and/or loop. In some embodiments, the coupling mechanism may be a section of the variable-diameter lanyard configured to loop back on itself to secure the lanyard to an object.

[0030] FIG. 1A shows closed-loop variable-diameter lanyard 100a, in accordance with some embodiments. Closed-loop variable-diameter lanyard 100a may have a circular cross-sectional profile with an outer diameter that varies smoothly over its length. For example, closed-loop variable-diameter lanyard 100a may have a minimum diameter at a point along its length that increases gradually to a maximum diameter at an antipodal point. In general, however, the diameter of closed-loop variable-diameter lanyard 100a may be designed to vary in any suitable manner. In one particular example, the radius of closed-loop variable-diameter lanyard 100a may be designed to vary as a sine wave along the lanyard’s length. In some embodiments, closed-loop variable-diameter lanyard 100a can have any suitable cross-sectional shape (e.g., an oval) with dimensions that can vary along the lanyard’s length.

[0031] Closed-loop variable-diameter lanyard 100a can include device engagement region 102a. A device engagement region, as used herein, can refer generally to the section of a variable-diameter lanyard that is configured to attach to an object. As shown, device engagement region 102a represents the thinnest portion of closed-loop variable-diameter lanyard 100a. In some embodiments, device engagement region 102a can be threaded through a hook, loop, or other suitable feature of an object. The antipodal end can then be passed through the resulting loop in device engagement region 102a and pulled to attach closed-loop variable-diameter lanyard 100a to the object. In other embodiments, a mechanism (e.g., a clip) can be attached to device engagement region 102a to attach closed-loop variable-diameter lanyard 100a to an object.

[0032] Closed-loop variable-diameter lanyard 100a may be covered by a woven sheath 104. According to some embodiments, woven sheath 104 may be woven directly onto a variable-diameter core to form the closed-loop lanyard. Because it is difficult or impossible to weave a closed loop, in these embodiments, the ends of woven sheath 104 can be joined together at coupling point 106. The ends may be joined together using, for example, a splice, a crimp, an overmold, or an adhesive. Although coupling point 106 is shown antipodal to device engagement region 102a, coupling point 106 may be placed anywhere on closed-loop variable-diameter lanyard 100a. In some embodiments, coupling point 106 can be hidden by one or more features of device engagement region 102a (e.g., an overmold).

[0033] FIG. 1B shows single-strand variable-diameter lanyard 100b, in accordance with some embodiments. Single-strand variable-diameter lanyard 100b can be identical to closed-loop variable-diameter lanyard 100a, except that it is formed as a single strand with two distinct ends, rather than as a closed loop. Woven sheath 104 of FIG. 1B does not require a coupling point, as it may be woven completely from one end of single-strand variable-diameter lanyard 100b to the other. Each end of woven sheath 104 of FIG. 1B may be finished in any suitable manner (e.g., with a seam). The two ends of single-strand variable-diameter lanyard 100b can be joined together in any suitable manner. For instance, an overmold member can encompass the two ends of single-strand variable-diameter lanyard 100b. In some embodiments, the overmold member can be a flexible molded structure configured to securely couple the two ends together (e.g., with an adhesive or friction). In other embodiments, the overmold member can be a metal member configured to crimp the two ends together.

[0034] As shown in FIG. 1B, single-strand variable-diameter lanyard 100b includes device engagement region 102b at the section where the two ends of the lanyard are coupled together. Device engagement region 102b may include a mechanism (e.g., a clip and/or loop) for attaching single-strand variable-diameter lanyard 100b to an object. For example, device engagement region 102b can include a clip or loop structure coupled to an overmold member.

[0035] According to some embodiments a variable-diameter lanyard can be manufactured using a compression molding process. In one embodiment, a variable-diameter cable can be manufactured by compression molding two urethane sheets together to form a sheath of the variable-diameter lanyard. Using this manufacturing method, the finished lanyard can have a bi-component sheath that encompasses a resin, or other suitable material, and one or more tensile members. The resin further encompasses the tensile members and occupies any void that exists between the tensile members and the inner wall of the variable-diameter lanyard. In addition, the resin secures the tensile members in place within the bi-component sheath.

[0036] FIG. 2A shows a cross-sectional view of variable-diameter core 200 manufactured using compression molded urethane sheets in accordance with some embodiments. Variable-diameter core 200 can include top sheath component 202 and bottom sheath component 203, which may be molded together at mold interface regions 204. Molded together, components 202 and 203 can form the bi-component sheath that encompasses a resin 206 and tensile members 207. As shown, resin 206 can encompass tensile members 207 and directly interface with the inner wall of the bi-component sheath. Tensile members 207 can be coaxially aligned with a
center axis of variable-diameter core 200, though it is under-
stood that due to manufacturing tolerances, tensile members
207 may be positioned off center in various portions of the
bi-component sheath. Variable-diameter core 200 can be
manufactured using a direct wire inlaid bi-component sheath
molding process, which is discussed below in more detail.

Fig. 2B shows a cross-sectional view of variable-
diameter core 210 manufactured using compression molded
urethane sheets in accordance with some embodiments. Vari-
able-diameter core 210 is similar in every respect to variable-
diameter core 200, except for the addition of tube sleeve 212.
Tube sleeve 212 can directly interface with resin 206 and the
inner wall of the bi-component sheath. Variable-diameter
core 210 can be manufactured using a tube inlaid bi-compo-
ment sheath molding process, which is discussed below in
more detail.

Fig. 3 shows a simplified exploded cross-sectional view of a mechanism 300 that can be used to manufacture a
urethane-based variable-diameter core according to some
embodiments. Mechanism 300 can include a top mold 302, a
bottom mold 304, a top urethane sheet 306, a bottom urethane
sheet 308, and an inlaid component 310. Top mold 302 and
bottom mold 304 can be constructed to mold either a closed-
loop variable-diameter core (e.g., for closed-loop variable-
diameter lanyard 100a of Fig. 1A) or a single-strand vari-
able-diameter core (e.g., for single-strand variable-diameter
lanyard 100b of Fig. 1B). Top mold 302 and bottom mold 304
can each have a cavity for shaping the variable-diameter core.

Top mold 302 and bottom mold 304 can be con-
structed from any suitable material capable of permitting a
vacuum to be pulled in the directions shown by arrows 312.
Top mold 302 and bottom mold 304 may be constructed from
a porous material (e.g., aluminum) or can include illustrative
vacuum channels 314. A vacuum may be applied to pull top
urethane sheet 306 onto top mold 302 and another vacuum is
applied to pull bottom urethane sheet 308 onto bottom mold
304. The vacuum can hold top urethane sheet 306 and bottom
urethane sheet 308 in place when top mold 302 and bottom
mold 304 are pressed together.

Top mold 302 and bottom mold 304 can be heated
to promote molding of top urethane sheet 306 and bottom ure-
thane sheet 308. The heat and vacuum can cause top
urethane sheet 306 and bottom urethane sheet 308 to deform
into respective mold cavities of top mold 302 and bottom
mold 304. Top mold 302 and bottom mold 304 can be heated,
for example, by being inserted into an oven or by using
internal heating elements (not shown). When top mold 302
and bottom mold 304 are compressed together, the heat and
pressure can cause top urethane sheet 306 and bottom ure-
thane sheet 308 to mold together, thereby forming the bi-
component variable-diameter core. After the bi-component
variable-diameter core is molded, the excess urethane can be
stripped away.

Inlaid component 310 represents any component or
combination of components placed into the cavity of bottom
mold 304 prior to formation of the bi-component sheath.
In some embodiments, inlaid component 310 can be one or more
tensile members. The tensile members can be secured in place
to maintain a predetermined position within the cavity exist-
ring between the bi-component sheath during the mold forma-
tion process, including during a resin application stage. For
example, tension members (not shown) may be used to hold
the tensile members taut. In addition, an inlaid support mem-
ber (not shown) may be used to further stabilize the tensile
members. In some other embodiments, inlaid component 310
can include one or more removable rods. The removable rods
can be used to form the shape of the bi-component sheath
during compression. Furthermore, the removable rods can be
secured in place using various support members, including an
inlaid component support member.

Urethane sheets 306 and 308 can form the top sheath
component and the bottom sheath component, respectively,
of any cable structure manufactured using this method. Ure-
thane sheets 306 and 308 may be preformed or precast to assist
inlaid component support members (not shown) in holding
inlaid component 310 in place during cable structure man-
ufacture. For example, the sheets may have one or more holes
cut therein to permit inlaid component support member (not
shown) direct access to inlaid component 310.

Fig. 4 shows an illustrative perspective view of bottom
mold 404 used to manufacture single-strand variable-
diameter lanyards in accordance with some embodiments. As
shown, bottom mold 404 is constructed to manufacture three
variable-diameter cores. However, a person skilled in the art
will appreciate that bottom mold 404 can be configured to
manufacture any number (e.g., 1, 2, 10, 50, 100, etc.) of
variable-diameter cores. The mold cavities can all be identical
to produce multiple copies of the same variable-diameter core
structure or different, as depicted in Fig. 4, to produce dif-
ferent variable-diameter core structures.

Fig. 5A shows an illustrative top view of a bottom
mold 504 used to manufacture a single-strand variable-dia-
meter core in accordance with some embodiments. Bottom
mold 504 can be constructed to mold the bottom sheath com-
ponent of a variable-diameter core in which tensile members
510 are inlaid prior to formation of the bi-component sheath.
After a urethane sheath (not shown) is impressed in mold
cavity 505, tensile members 510 can be secured above the
urethane sheath with tension members 514. Tension members
514 can secure tensile members 510 the ends of the variable-
diameter core to ensure adequate tension is provided during
the molding process—this is to ensure that tensile members
510 are maintained in a central position within mold cavity
507 (of Fig. 5B) during a resin injection stage.

Tensile members 510 can also be secured by an
inlaid component support structure (not shown). An inlaid
component support structure can secure tensile members 510
at one or more points along bottom mold 504. This can further
ensure that tensile members 510 remain in a concentric posi-
tion within mold cavity 507. A support structure can be any
suitable structure such as pins, a ring, or rods.

Fig. 5B shows an illustrative cross-sectional view of
top mold 502 and bottom mold 504 compressed together.
The cross-section may be taken along the line A-A of Fig. 5A
(assuming the top mold is on top of the bottom mold). Top
urethane sheet 506 and bottom urethane sheet 508 are shown.
Resin 518 is shown being drawn by a low-pressure vacuum
through one end of mold cavity 507 existing within the bi-
component sheath to the other end. When the resin cures, it
yields a variable-diameter core having a cross-section such as
variable-diameter core 200 of Fig. 2.

Top mold 502 and bottom mold 504 may be com-
pressed together using a relatively low pressure. For example,
compression-molding pressures are typically less than pres-
sures used in injection-molding processes. In addition, use of
a low-pressure vacuum to draw resin through mold cavity 507
also minimizes movement of tensile members 510 and assists
in maintaining an equal distribution of resin around the periphery of tensile members 510.

[0048] According to some embodiments, variable-diameter cores can be manufactured using a direct wire inlaid resin sheath molding process. This process is similar to the process discussed above in connection with FIGS. 3, 4, 5A, and 5B, except that urethane sheets are not used. In these embodiments, a low-pressure vacuum can be applied to draw a resin from one side of the mold to the other side of the mold. The resin can be cured and the mold halves can be separated, thereby yielding a variable-diameter core. The resin used in various embodiments discussed herein can be, for example, polyurethane, thermoset polyurethane, or dual liquid set polyurethane.

[0049] FIG. 6 shows illustrative cross-sectional views of a variable-diameter core that can be manufactured by compression molding two silicone or thermoplastic sheets in accordance with some embodiments. The illustrated cross-sectional views represent a cross-sectional view of a variable-diameter core. Variable-diameter core 600 shows silicone 602 encapsulating tensile members 610. Silicone 602 can form a bi-component sheath around tensile members 610 that directly interfaces with tensile members 610. Mold interface region 603 illustrates the region where a top silicone sheet is molded to a bottom silicone sheet. Variable-diameter core 600 can be manufactured using a direct wire inlaid bi-component sheath molding process, which is similar to the same process discussed above.

[0050] Variable-diameter core 620 has bi-component silicone sheath 602 filled with resin 604, which can encapsulate tensile members 610. Variable-diameter core 630 is similar in every respect to variable-diameter core 620, except for the addition of tube sleeve 606. Tube sleeve 606 can directly interface with the inner wall of the bi-component sheath and resin 604. Variable-diameter core 620 can be manufactured using a tube-inlaid bi-component sheath molding process, which can be similar to the same process discussed above.

[0051] FIG. 7A shows a simplified exploded cross-sectional view of top mold 702, bottom mold 704, top silicone sheet 706, bottom silicone sheet 708, and inlaid component 710 (e.g., tensile members) used to manufacture a silicone-based cable structure, according to some embodiments. Top mold 702 and bottom mold 704 each have a cavity for shaping the variable-diameter core. For example, the mold can be same as those shown in FIG. 4. If desired, the molds can be constructed to yield multiple variable-diameter cores.

[0052] Many of the same attributes discussed above in connection with FIGS. 2-5 are applicable to various manufacturing processes for making silicone-based cable structures, with a few exceptions. Silicone molding may require higher heat and pressure to form the bi-component sheath than urethane. Therefore, molds 702 and 704 may be constructed to withstand higher temperatures. In addition, a vacuum may not be needed to hold the silicone sheets in place during a compression event; therefore solid, non-porous materials can be used.

[0053] FIG. 7B shows an illustrative cross-sectional view of a mold that be used to compress silicone sheets in accordance with some embodiments. Top mold 712 and bottom mold 714 are constructed with cavities 713 and 715, respectively, which may be conductive for holding inlaid component 710 in place. For example, cavity 715 can be deeper than cavity 713 so that inlaid component 710 can be held securely in place in the bottom mold.

[0054] In some embodiments, variable-diameter cores can be constructed using a bump extrusion process. The bump extrusion process used can include controllable system factors for adjusting the dimensions of an extruded variable-diameter core. FIG. 8 is a cross-sectional view of illustrative extruder 800 in accordance with some embodiments. Extruder 800 can receive a material to extrude in a first form, such as pellets, and can transform the material to a form corresponding to a variable-diameter core.

[0055] Extruder 800 can extrude any material suitable to create a variable-diameter core. For example, extruder 800 can use one or more of polyethylene, polypropylene, acetal, acrylic, polyamide (e.g., nylon), polystyrene, acrylonitrile butadiene styrene (ABS), and polycarbonate. Material can be provided to extruder 800 in any suitable form including, for example, in liquid or solid form. In one implementation, pellets or chips of material can be provided to hopper 810 for processing. The material can pass through feedthroat 812 and enter barrel 820. Screw 822 can rotate within barrel 820 to direct material from hopper end 824 of the barrel to die end 826 of the barrel. Drive motor 828 can be mechanically connected to screw 822 such that the screw can rotate to direct material received from hopper 810 toward die end 826. The drive motor can drive screw 822 at any suitable rate or speed, including a variable speed based on a manner in which the process is executed.

[0056] Barrel 820 can be heated to a melt temperature suitable to melt the material provided in hopper 810. For example, barrel 820 can be heated to a temperature in the range of 200°C to 300°C (e.g., 250°C), although the particular temperature can be selected based on the material used. As the material passes through barrel 820, pressure and friction created by screw 822 and heat applied to barrel 820 by a heating component can cause the material to melt and flow. The resulting material can be substantially liquid in a region near die end 826 of barrel 820 so that it may easily flow into die 850. In some cases, different amounts of heat can be applied to different sections of the barrel to create a variable heat profile. In one implementation, the amount of heat provided to barrel 820 can increase from hopper end 824 to die end 826. By gradually increasing the temperature of the barrel, the material deposited in barrel 820 can gradually heat up and melt as it is pushed toward die end 826. This may reduce the risk of overheating, which may cause the material to degrade. In some embodiments, extruder 800 can include cooling components (e.g., a fan) in addition to heating components for controlling a temperature profile of barrel 820.

[0057] In some embodiments, one or more additives can be added to the material within barrel 820 to provide mechanical or finishing attributes to a variable-diameter core. For example, components for providing UV protection, modifying a coefficient of friction of an outer surface of the variable-diameter core, refining a color of the variable-diameter core, or combinations of these can be used. The additives can be provided in hopper 810. Alternatively, the additives can be inserted in barrel 820 at another position along the barrel length. The amount of additives added, and the particular position at which additives are added can be selected based on attributes of the material within the barrel. For example, additives can be added when the material reaches a particular fluidity to ensure that the additives can mix with the material.

[0058] Screw 822 can have any suitable channel depth and screw angle for directing material towards die 850. In some cases, screw 822 can define several zones each designed to
have different effects on the material in barrel 820. For example, screw 822 can include a feed zone adjacent to the hopper and operative to carry solid material pellets to an adjacent melting zone where the solid material melts. The channel depth can progressively increase in the melting zone. Following the melting zone, a metering zone can be used to melt the last particles of material and mix the material to a uniform temperature and composition. Some screws can then include a decompression zone in which the channel depth increases to relieve pressure within the screw and allow trapped gases (e.g., moisture or air) to be drawn out by vacuum. The screw can then include a second metering zone having a lower channel depth to repressurize the fluid material and direct it through the die at a constant and predictable rate.

When fluid material reaches die end 826 of barrel 820, the material can be expelled from barrel 820 and can pass through screen 830 having openings sized to allow the material to flow, but preventing contaminants from passing through the screen. A breaker plate, used to resist the pressure of material pushed towards the die by screw 822, can reinforce the screen. In some cases, screen 830, combined with the breaker plate, can serve to provide back pressure to barrel 820 so that the material can melt and mix uniformly within the barrel. The amount of pressure provided can be adjusted by changing the number of screens used, the relative positions of the screens (e.g., mis-aligning openings in stacked screens), or changing the size of openings in a screen.

The material passing through the screen can be directed by feedpipe 840 towards die 850. Feedpipe 840 can define an elongated volume through which material can flow. Unlike in barrel 820, in which material rotates through the barrel, material passing through feedpipe 840 can travel along the axis of the feedpipe with little or no rotation. This can ensure that when the material reaches the die, there are no built-in rotational stresses or strains that can adversely affect the resulting cable structure (e.g., stresses that cause warping upon cooling).

Flow material passing through feedpipe 840 can reach die 850 where the material is given a profile corresponding to the final conductor structure. Material can pass around pin 852 and through opening 854 of the die. Pin 852 and opening 854 can have any suitable shape including, for example, circular shapes, curved shapes, polygonal shapes, or arbitrary shapes. In some embodiments, pin 852 can be movable within die 850. Additionally, in some embodiments, elements of die 850 can move such that the size or shape of opening 854 can vary. Once material has passed through the die, the material can be cooled to maintain the extruded shape. The material can be cooled using different approaches including, for example, liquid baths (e.g., a water bath), air cooling, vacuum cooling, or combinations of these.

In some embodiments, the die used for extruder 800 can include movable components for adjusting the diameter of material coming out of the die. FIGS. 9A and 9B are cross-sectional views of an illustrative die for use in an extrusion process in accordance with some embodiments. Die 900 can include top die element 902 and bottom die element 904. In some embodiments, top and bottom die elements 902 and 904 can represent top and bottom halves of a cylindrical die element. Die elements 902 and 904 can include angled surfaces 903 and 905, respectively, for guiding material towards opening 906. In some cases, the angled surfaces correspond to surfaces of a cone removed from within die elements 902 and 904.

Die 900 can include pin 910 positioned at least partially within an area enclosed by die elements 902 and 904, such that angled surface 911 corresponds to angled surfaces 903 and 905. Material 901 can flow between angled surface 911 and angled surfaces 903 and 905 to form a variable-diameter core. In some embodiments, pin 910 can include hypodermal path 912 extending through pin 910. For example, hypodermal path 912 can extend through a centerline of pin 910. Tensile members 920 can be fed through the hypodermal path into the extrusion path (e.g., into a region between die elements 902 and 904 and pin 910) and through opening 906. As tensile members 920 are fed through hypodermal path 912, material 901 flowing through the die surrounds tensile members 920 as they exit pin 910. The combination of tensile members 920 and material 901 together form a variable-diameter core 930. Material 901 can form a continuous sheath or covering that encapsulates tensile members 920 and provides both mechanical and cosmetic attributes to the variable-diameter core 930.

In some cases, material 901 can instead be extruded around a rod that is fed through hypodermal path 912. The rod can have any suitable dimensions including, for example, a constant or variable cross section. The rod can be coated or treated so that it minimally adheres to the extruded material. The rod can be removed from the resulting variable-diameter core 930 formed by the extrusion process to form a hollow tube through which tensile members can be fed.

Variable-diameter core 930 can have any suitable size or shape including, for example, a varying outer diameter. Any suitable approach can be used to adjust the amount of material 901 provided through die 900 to form the different regions of variable-diameter core 930. In some embodiments, different portions of the die can move relative to one another. For example, pin 910 can move in direction 914 towards opening 906 to reduce the amount of material 901 flowing between die elements 902 and 904, and pin 910. This may reduce the diameter of variable-diameter core 930. Similarly, pin 910 can move in direction 915 away from opening 906 to increase the amount of material 901 flowing between die elements 902 and 904, and pin 910. This may increase the diameter of variable-diameter core 930. In particular, as shown in FIG. 9B, pin 910 has moved closer to opening 906 of die 900, thereby producing a reduced-diameter section of variable-diameter core 930.

As another example, referring back to FIG. 9A, top die element 902 and bottom die element 904 can move relative to one another to change the size of opening 906. In particular, top and bottom die elements 902 and 904 can move away from each other (e.g., in directions 908a and 908b, respectively) to increase the size of opening 906. When the size of the opening increases, more material 901 can flow through the opening, which increases the diameter of variable-diameter core 930. In another case, top and bottom die elements 902 and 904 can move toward each other (e.g., in directions 909a and 909b, respectively) to decrease the size of opening 906. When the opening size decreases, less material 901 can flow through the opening, which decreases the diameter of variable-diameter core 930.

Other factors relating to the extrusion process can be adjusted to change characteristics of the die to modify the diameter of variable-diameter core 930. For example, the
speed at which tensile members 920 are fed through pin 910 and through opening 906 can be adjusted to change the diameter of variable-diameter core 930. The faster the line speed of the conductor, the smaller the diameter of the resulting variable-diameter core.

[0068] As another example, the speed at which a screw brings material to the die can be adjusted to control the amount of material passing through the die (e.g., one may adjust the RPM of the screw). As yet another example, the amount of heat provided to the barrel can control the viscosity of the material and the pressure of the material within the barrel. As still another example, the melt pressure of the material within the barrel can be adjusted. As still yet another example, a screen and breaker plate used in the extruder can be used to control the amount of material passing from the barrel to the die. As more material passes through the die, the diameter of a resulting variable-diameter core can increase.

[0069] Specific settings for the die position, line speed, heat, screw rotation speed, melt pressure, and air pressure (e.g., from cooling or for controlling the position of a die pin), which collectively can be known as system factors, can be dynamically adjusted during the extrusion process to change the diameter of an extruded variable-diameter core. In particular, by dynamically adjusting system factors, an extruder can create a variable-diameter core that takes on any desired shape with the additional benefit that transition over the length of the variable-diameter core smooth and seamless. The system factors can be adjusted by any suitable component of extruder 800 of FIG. 8 such as, for example, a control station.

[0070] To ensure that an external surface of the variable-diameter core created using an extrusion process as described above is smooth and the material is uniformly distributed around the tensile members, the tensile members may be covered with a sheath that maintains a constant fixed “inner” diameter within the variable-diameter core. Thus, while the “inner” diameter remains constant, the diameter of the variable-diameter core can vary.

[0071] According to some embodiments, a variable-diameter core can be constructed using an injection molding process. In injection molding processes (e.g., liquid injection molding, or “LIM”), a mold is formed around a tensile member and/or a removable rod. The rod is removed after the mold is formed and tensile members are threaded through the cavity. FIG. 10 is a sectional view of an illustrative mold for constructing a variable-diameter core in accordance with some embodiments. Variable-diameter cavity 1010 in mold 1000 can be shaped to create a desired variable-diameter core.

[0072] Variable-diameter cavity 1010 can include one or more tensile members for providing structural support and added strength to a variable-diameter core. To improve the performance and aesthetic appeal of the device, tensile members 1007 can be centered in variable-diameter cavity 1010.

[0073] To protect tensile members 1007, and to provide an aesthetically pleasing variable-diameter core, material 1022 can be provided over the tensile members. In particular, material 1022 can be injected within variable-diameter cavity 1010 to create outer shell 1030 of material 1022 surrounding tensile members 1007. Outer shell 1030 can be constructed from any suitable material including, for example, a material selected for mechanical attributes, cosmetic attributes, industrial design attributes, or combinations of these. In some cases, material 1022 can be selected to provide sufficient resistance to abrasions and other contact forces applied to the cable, while allowing the variable-diameter core to bend freely or comfortably for the user.

[0074] Outer shell 1030 can have any suitable size relative to tensile members 1007. In some embodiments, outer shell 1030 can have a variable-diameter. In some embodiments, the diameter or size of outer shell 1030 can vary in a non-uniform manner, for example to feature a non-circular diameter, a hook, protrusion, or another feature (e.g., for engaging an electrical component, such as an audio output interface or a button assembly).

[0075] Some molding processes including, for example, injection molding, provide for the injection of material within a mold. In some cases, the injection may occur at relatively high pressure. When tensile members are provided in the mold, as shown in mold 1000, the injection of material can cause tensile members 1007 to be displaced in the mold and no longer be centered in variable-diameter cavity 1010. This may cause one or more tensile members 1007 to sag within outer shell 1030, become visible through a thin region of outer shell 1030, or perhaps even extend through outer shell 1030. Therefore, it may be desirable for the mold or system used for molding a variable-diameter lanyard to provide a mechanism for maintaining tensile members centered within the mold.

[0076] As shown in FIG. 10, mold 1000 can include left tube 1020 inserted within an open end of mold 1000. Similarly, mold 1000 can include right tube 1021 inserted within the other open end of mold 1000. Left tube 1020 and right tube 1021 can each include a hollow portion extending along a length of the tube for receiving one or more tensile members 1007. An inner diameter of the tubes can be selected, for example, based on the size of the tensile members placed within the tube. By selecting the inner diameter of a tube relative to the dimensions of the tensile members, the tube can ensure that the tensile members will remain centered within the tube.

[0077] To ensure that the tensile members remain centered within the variable-diameter core, however, it may be necessary to ensure that the tube is centered within the mold. The outer diameter of each tube can be selected based on the dimensions of mold 1000 corresponding to a final diameter for outer shell 1030. In particular, each tube can be sized to substantially fit within the variable-diameter core. In one implementation, the outer diameter selected for each tube can be substantially equal to or marginally smaller than the dimensions of mold 1000. By making the outer diameter of each tube smaller than the smallest dimension of variable-diameter cavity 1010, the tube can slide within mold 1000 as material is injected to create outer shell 1030.

[0078] The tubes can be formed from any suitable material. In some embodiments, the tubes can be formed from a rigid or semi-rigid material such that the tubes can retain the bundles along a centerline of the mold. In particular, the tubes can be rigid so that in regions of the mold having larger outer diameters, the tubes can remain centered due to contact between the tubes and regions of the mold that have smaller outer diameters. In some cases, the tube material can be selected based on thermal properties to ensure, for example, that the integrity of a tube is not affected by the heated material injected into the mold.

[0079] Although mold 1000 shows left tube 1020 and right tube 1021 of the mold, in some embodiments a single tube can be extend from one end of the mold to the other to maintain the tensile members centered. Additionally, in some embodi-
ments, tension can be applied to tensile members 1007 to keep them taut within mold 1000. The tension can serve to maintain tensile members 1007 centered while material 1022 is injected into mold 1000.

[0080] To create outer shell 1030, material can be injected into mold 1000 via gates 1060 located along the length of mold 1000. Gates 1060 can have any suitable size, for example, a size determined from thermal conductive properties of the material 1022 (e.g., how quickly molded material will harden when it flows within the mold), or from an expected rate of flow of the material. Gates 1060 can be located at any suitable positions, and at any suitable number along mold 1000. In the example of FIG. 10, gates 1060 can be placed close to the center of mold 1000 such that material 1022 injected into the mold can simultaneously flow towards each end of mold 1000. In some embodiments, gates 1060 can be positioned closer to the ends of mold 1000 or distributed more even along its length. In other embodiments, a single gate may be used for injection of material 1022.

[0082] Furthermore, the material and mold can be provided such that the material can flow through the entirety of mold 1000 before hardening and securing the tensile members within the variable-diameter core. For example, the material temperature can be controlled to achieve a desired viscosity of material 1022 within mold 1000.

[0083] As the material fronts move when material 1022 is inserted through gates 1060, it may be necessary to remove left tube 1020 and right tube 1021 holding tensile members 1007 so that material 1022 can fill mold 1000 and can adhere to the tensile members. In some embodiments, each tube can be displaced along the axis of the mold in which the tube is placed away from gates 1060. For example, as the material front comes near or into contact with a tube, the tube can retract to allow the material 1022 to surround the tensile members previously retained within the tubes.

[0084] Any suitable approach can be used to remove a tube. In some embodiments, the material front can contact and push away the tubes (e.g., the mold pressure is used to displace a tube). Alternatively, or in addition, one or more actuators, valves, or other mechanisms can be coupled to a tube to remove the tube from a leg in which it is placed, or to control the rate at which the tube is removed (e.g., a motor pulls a tube out of the leg). As another alternative, mold 1000 can be oriented substantially vertically such that it extends along a gravity vector. Then, when material 1022 is injected into mold 1000, gravity can direct material 1022 into the leg, and can assist in removing a tube from the variable-diameter core.

[0085] In some cases, the mold can make use of approaches other than translating tubes to maintain tensile members centered within a variable-diameter core.

[0086] FIG. 11 is a cross-sectional view of illustrative mold 1100 for a variable-diameter core having centered tensile members in accordance with some embodiments. Tensile members 1107 can be placed within mold 1100 and maintained near a centerline of mold 1100.

[0087] One approach for maintaining tensile members 1107 substantially centered can include providing material into mold 1100 such that material fronts of the injected material surround tensile members 1107 from opposite directions. For example, mold 1100 can include gates 1160 placed at 90° intervals around a periphery of mold 1100. As material is inserted into each gate, material fronts 1122 can surround tensile members 1107. By controlling the amount, rate and time at which material is provided in each gate, opposing material fronts 1122 can reach tensile members 1107 at the same time. The opposing material fronts 1122 can then maintain tensile members 1107 substantially near the centerline of mold 1100.

[0088] Mold 1100 can include any suitable configuration of gates through which material may be provided. For example, as shown in FIG. 11, mold 1100 can include four gates 1160 having similar dimensions. As another example, mold 1100 can include another number of gates disposed at equal intervals around mold 1100 (e.g., a number of gates in the range of 2 to 10). Alternatively, if mold 1100 includes gates having different sizes or different properties, the distribution of gates can include uneven intervals selected based on the amount of material flowing into the mold through each gate. For example, a mold having three gates can include a first, larger gate at a first position, and two other, smaller gates, offset from the first gate by 150 degrees (and offset from each other by 60 degrees). In some embodiments, one or more valves can control the amount of flow in each gate.

[0089] According to some embodiments, a closed-loop variable-diameter core can be manufactured using an injection molding process. FIG. 12A shows a top-down view of illustrative mold 1200 for constructing a closed-loop variable-diameter core in accordance with some embodiments. Mold 1200 can be similar to, for example, mold 1000 of FIG. 10, except that rather than including two distinct ends, the mold can form a closed loop. Material can be injected into mold 1200 as described above, through gates 1260. Although only three gates 1260 are depicted in FIG. 12, one skilled in the art can appreciate that any suitable number of gates can be included. Additional opposing gates 1260 may also be included in mold 1200 as described above with respect to FIG. 11.

[0090] Because mold 1200 forms a closed loop, removable tubes cannot be inserted into the mold to aid in centering tensile members. Instead, one or more inlaid members can be inserted into mold 1200 to keep tensile members centered. FIG. 12B shows a cross-sectional view of illustrative inlaid member 1270 in accordance with some embodiments. Inlaid member 1270 can include ring 1272 and spokes 1274 surrounding one or more tensile members 1207 and may be of any suitable thickness. Inlaid members 1270 can be configured to fit inside mold 1200 to keep tensile members 1207 substantially centered in the mold. For that purpose, each inlaid member 1270 may have a different outer diameter according to where it is to be placed in mold 1200. In some embodiments, inlaid members 1270 can be manufactured using a material with a lower melting point than the material injected into mold 1200. In those embodiments, inlaid members 1270 can melt and become incorporated with the injected material into the outer shell of a variable-diameter core.

[0091] FIG. 13 shows a view of a portion of variable-diameter lanyard 1300 including a woven sheath in accordance with some embodiments. Variable-diameter lanyard 1300 can include woven sheath 1380 covering a variable-diameter core with one or more tensile members manufactured according to one of the processes described above. According to some embodiments, woven sheath 1380 may be woven directly onto the variable-diameter core, while in other embodiments woven sheath 1380 can be prepared and either slid or wrapped around the variable-diameter core. Woven sheath 1380 may include any suitable material, including synthetic fibers (e.g., nylon and/or polyester), natural fibers (e.g., cotton), or other
materials such as metal fibers, carbon fibers, or Kevlar. The particular material or materials chosen for woven sheath 1380 may depend on the desired aesthetic or physical properties.

Although this disclosure refers generally to weaving a sheath onto a variable-diameter core, a person skilled in the art will appreciate that any suitable fabric configuration may be employed to form woven sheath 1380. For example, while weaving typically refers to fabrics formed with longitudinal warp threads and lateral weft threads, any other suitable fabric-making process may be used such as, for example, braiding, plaiting, knitting, or felting. It is expressly contemplated that such alternatives fall within the scope of the embodiments described herein.

Because it is difficult or impossible to weave a closed loop, embodiments in which a closed-loop variable-diameter core is used may require two ends of woven sheath 1380 to be joined together. For example, if woven sheath 1380 is woven directly onto a closed-loop variable-diameter core, the start and end points will need to be joined together to produce a finished variable-diameter lanyard. Similarly, if woven sheath 1380 is prepared separately and then wrapped around a variable-diameter core, the sheath will have to be joined at the seam where the two wrapped ends meet. Joining two ends of a woven sheath can include using, for example, a splice, a crimp, an overmold, and/or an adhesive.

Variable-diameter lanyards, according to embodiments disclosed herein, may also include a device engagement region for attaching the lanyard to another object (e.g., an electronic device, keys, and/or an access badge). FIGS. 14A-D show various illustrative device engagement regions 1490a-d of variable-diameter lanyards in accordance with some embodiments.

FIG. 14A shows device engagement region 1490a of a single-strand variable-diameter lanyard in accordance with some embodiments. Device engagement region 1490a can include overmold 1492a and loop 1494a. Overmold 1492a can be structure suitable to securely couple two ends of a single-strand variable-diameter lanyard together. The two ends may be held in place by friction and/or an adhesive, for example. Device engagement region 1490a can further include loop 1494a coupled to overmold 1492a. Loop 1494a may be a loop of a separate material (e.g., a string or cable) that is coupled to overmold 1492a. However, according to some embodiments, loop 1494a may be an extended end of the variable-diameter lanyard that passes through one side of overmold 1492a and loops back to couple to the other side of overmold 1492a. Loop 1494a may be configured to pass through a hook, loop, or other suitable feature of an object. The antipodal end of the variable-diameter lanyard can then be passed through loop 1494a and pulled to attach the variable-diameter lanyard to the object.

FIG. 14B shows a second device engagement region 1490b of a single-strand variable-diameter lanyard in accordance with some embodiments. Device engagement region 1490b can include overmold 1492b, which may be similar to overmold 1492a of FIG. 14B. Attachment mechanism 1494b may be coupled to overmold 1492b. In some embodiments, attachment mechanism 1494b is a clip that is configured to attach to a suitable feature of an object (e.g., a hook or loop).

FIG. 14C shows a device engagement region 1490c of a closed-loop variable-diameter lanyard in accordance with some embodiments. Device engagement region 1490c may represent the thinnest portion of a variable-diameter lanyard. Device engagement region 1490c can be threaded through a hook, loop, or other suitable feature of an object. The antipodal end of the variable-diameter lanyard can then be passed through the resulting loop in device engagement region 1490c and pulled to attach the variable-diameter lanyard to the object.

FIG. 14D shows a second device engagement region 1490d of a closed-loop variable-diameter lanyard in accordance with some embodiments. Device engagement region 1490d can include overmold 1492d and loop 1494d, which may be a portion of a variable-diameter lanyard. For example, overmold 1492d may be coupled to the closed-loop variable-diameter lanyard such that it pinches two portions of the lanyard together resulting in loop 1494d being formed. The antipodal end of the variable-diameter lanyard can then be passed through the loop 1494d and pulled to attach the variable-diameter lanyard to an object.

FIG. 15 is a flowchart of process 1500 for providing a variable-diameter lanyard in accordance with some embodiments. At step 1501, a variable-diameter core can be provided. The variable-diameter core may include one or more tensile members for providing structural support and additional strength to the variable-diameter lanyard. A variable-diameter core may be provided using any suitable process, including the compression molding, bump extrusion, and injection molding process described above with respect to FIGS. 2-12.

Next, at step 1503, a sheath can be woven over the variable-diameter core. The woven sheath may include any suitable material and, in embodiments where the variable-diameter core forms a closed loop, ends of the woven sheath may be joined together using, for example, a splice, a crimp, an overmold, and/or an adhesive. As described above, the woven sheath may be formed using any suitable fabric-making process including, for example, braiding, plaiting, knitting, or felting.

FIG. 16 is a flowchart of process 1600 for providing a variable-diameter lanyard in accordance with some embodiments. At step 1601, a material can be provided to an extruder that includes a die (e.g., extruder 800 of FIG. 8 and die 900 of FIG. 9). Any suitable material may be used for forming a variable-diameter lanyard according to process 1600 including, for example, polyethylene, polypropylene, acetal, acrylic, polyanide (e.g., nylon), polystyrene, acrylonitrile butadiene styrene (ABS), and/or any other suitable plastic material. The material may be added to the extruder in solid form (e.g., pellets) or liquid form. According to some embodiments, the material can be added to a hopper (e.g., hopper 810 of FIG. 8) coupled to the extruder.

Next, at step 1603, one or more tensile members can be fed through a hypodermal path (e.g., hypodermal path 912 of FIG. 9) extending through a portion of the die. For example, tensile member may be fed through the hypodermal path and into an extrusion path to the opening of the extruder. The tensile members may include for example, strands of Kevlar (or other aramid or para-aramid fiber), xylol, nitroil, steel, or other natural, synthetic, and/or metallic fibers.

At step 1605, the material can be extruded through the die while the tensile members are fed through the hypodermal path. In this manner, the tensile members can be encased in the extruded material, which will form a variable-diameter core of a variable-diameter lanyard.

At step 1607, system factors, including a line speed, heat, screw rotation speed, melt pressure, and air pressure, can be adjusted to change the outer diameter of the variable-
diameter core as it is extruded. As the variable-diameter core is extruded, the tensile members can be encased in the material exiting the opening of the extruder.

Next, at step 1609, a sheath can be woven over the variable-diameter core to form a variable-diameter lanyard. Any suitable fabric-making process can be used to form the woven sheath over the variable-diameter lanyard (e.g., weaving, braiding, plaiting, knitting, or felting). Furthermore, the woven sheath can be finished in any suitable fashion including, for example, a coupling point where the ends of the woven sheath meet can be hidden by one or more features of the variable-diameter lanyard (e.g., an overmold).

FIG. 17 is a flowchart of process 1700 for providing a variable-diameter lanyard in accordance with some embodiments. At step 1701, one or more tensile members may be placed into a variable-diameter mold. The tensile members may include for example, strands of Kevlar (or other aramid or para-aramid fiber), xylow, nitinol, steel, or other natural, synthetic, and/or metallic fibers.

At step 1703, a material may be injected into the variable-diameter mold. The material may be injected through one or more gates provided in the mold. The gates may have any suitable size including, for example, a size determined from thermal conductive properties of the material or from an expected rate of flow of the material. Furthermore, the gates may be located at any suitable positions, and in any suitable number, along the variable-diameter mold.

At step 1705, the material may be removed from the variable-diameter mold to form a variable-diameter core. Next, at step 1707 a sheath can be woven over the variable-diameter core to form a variable-diameter lanyard. Any suitable fabric-making process can be used to form the woven sheath over the variable-diameter lanyard (e.g., weaving, braiding, plaiting, knitting, or felting). Furthermore, the woven sheath can be finished in any suitable fashion including, for example, a coupling point where the ends of the woven sheath meet can be hidden by one or more features of the variable-diameter lanyard (e.g., an overmold).

It is to be understood that the steps shown in processes 1500, 1600, and 1700 of FIGS. 15, 16, and 17 are merely illustrative and that existing steps may be modified or omitted, additional steps may be added, and the order of certain steps may be altered.

While there have been described systems and methods for a lanyard with a variable-diameter core and woven exterior, it is to be understood that many changes may be made therein without departing from the spirit and scope of the invention. Insubstantial changes from the claimed subject matter as viewed by a person with ordinary skill in the art, known or later devised, are expressly contemplated as being equivalently within the scope of the claims. Therefore, obvious substitutions now or later known to one with ordinary skill in the art are defined to be within the scope of the defined elements.

The described embodiments of the invention are presented for the purpose of illustration and not of limitation.

What is claimed is:

1. A variable-diameter lanyard, comprising:
   a variable-diameter core comprising one or more tensile members, wherein a diameter varies smoothly over a length of the variable-diameter core; and
   a woven sheath covering the variable-diameter core.

2. The variable-diameter lanyard of claim 1, wherein the one or more tensile members comprise at least one of Kevlar, xylow, nitinol, and steel.

3. The variable-diameter lanyard of claim 1, wherein the variable-diameter core comprises a first end and a second end, wherein a diameter of the variable-diameter lanyard has a minimum diameter at the first and the second ends and a maximum diameter at a point along the length of the variable-diameter core between the first and second ends.

4. The variable-diameter lanyard of claim 1, wherein the variable-diameter core comprises a closed loop.

5. The variable-diameter lanyard of claim 3, wherein the variable-diameter core further comprises:
   a cured resin that encompasses the one or more tensile members; and
   a bi-component sheath compression molded from two urethane sheets that encompass the cured resin and the one or more tensile members.

6. The variable-diameter lanyard of claim 3, wherein the variable-diameter core further comprises a bi-component sheath compression molded from two silicone sheets that encompass the one or more tensile members.

7. The variable-diameter lanyard of claim 1, wherein the woven sheath comprises at least one of a synthetic fiber, a metallic fiber, and a natural fiber.

8. The variable-diameter lanyard of claim 2, further comprising a device engagement region.

9. The variable-diameter lanyard of claim 8, wherein the device engagement region comprises an overmold member configured to couple together the first end and the second end of the variable-diameter lanyard.

10. The variable-diameter lanyard of claim 9, further comprising a loop coupled to the overmold member.

11. The variable-diameter lanyard of claim 9, further comprising a fastener coupled to the overmold member.

12. The variable-diameter lanyard of claim 1, wherein the variable-diameter core is extruded around the one or more tensile members.

13. The variable-diameter lanyard of claim 1, wherein the variable-diameter core is formed using an injection molding process.

14. The variable-diameter lanyard of claim 4, wherein the woven sheath comprises a first end and a second end, and wherein the first end and the second end of the woven sheath are coupled together.

15. The variable-diameter lanyard of claim 14, wherein the first and second ends of the woven sheath are coupled together with at least one of a splice, a crimp, a sheath overmold, or an adhesive.

16. A method for forming a variable-diameter lanyard, comprising:
   providing a material to an extruder, the extruder comprising a die through which the material is extruded;
   feeding a tensile member through a hypodermal path extending through a portion of the die;
   extruding the material through the die while the tensile member is fed through the hypodermal path, wherein the extruded material surrounds the tensile member to form a variable-diameter core;
   dynamically adjusting system factors of the extruder to change an outer diameter of the variable-diameter core; and
   weaving a sheath over the variable-diameter core.
17. The method of claim 16, wherein the system factors comprise at least one of:
   a line speed;
   heat;
   a screw rotation speed;
   a melt pressure; and
   an air pressure.

18. The method of claim 16, wherein the tensile member comprises at least one of Kevlar, aramid fiber, xylow, nitinol, and steel.

19. The method of claim 16, wherein the outer diameter of the variable-diameter core varies from a minimum at a first end, to a maximum at a point along the variable-diameter core, and back to a minimum at a second end.

20. The method of claim 19, wherein the outer diameter of the variable-diameter core varies smoothly along its length.

21. The method of claim 16, further comprising coupling a first end and a second end of the variable-diameter lanyard together.

22. A method for forming a variable-diameter lanyard, comprising:
   placing one or more tensile members into a variable-diameter mold;
   injecting material into the variable-diameter mold;
   removing the material from the variable-diameter mold, wherein the material and the tensile member form a variable-diameter core; and
   weaving a sheath around the variable-diameter core.

23. The method of claim 22, further comprising:
   placing the one or more tensile members in at least one tube, wherein an inner diameter of the at least one tube is selected based on dimensions of the one or more tensile members;
   placing the at least one tube with the tensile member in a variable-diameter mold, wherein an outer diameter of the at least one tube is selected based on dimensions of the variable-diameter mold; and
   progressively extracting the at least one tube from the variable-diameter mold while leaving the tensile member in the variable-diameter mold.

24. The method of claim 22, wherein the mold comprises a substantially straight section in which the at least one tube can be received.

25. The method of claim 22, wherein injecting material into the mold comprises injecting material into a single location of the mold.

26. The method of claim 22, wherein injecting material into the mold comprises injecting material into a plurality of locations of the mold.

27. The method of claim 22, further comprising placing the tensile member under tension after it is placed in the mold.

28. A method comprising:
   providing a variable-diameter core; and
   weaving a sheath around the variable-diameter core.

29. The method of claim 28, wherein providing the variable-diameter core comprises at least one of a compression molding process, a bump extrusion process, and an injection molding process.

30. The method of claim 28, further comprising providing one or more tensile members in the variable-diameter core.

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