FOAMED POLYLACTAM BUOYANT BELT
Filed Aug. 14, 1969, Ser. No. 850,114
Int. Cl. B63e 9/10
U.S. Cl. 9—340
7 Claims

ABSTRACT OF THE DISCLOSURE

A buoyant belt comprising a continuous elongated body of foamed polylactam, said body having a plurality of segments that are attached to one another by integral, flexible, hinge portions, and means for holding the belt around the body of the wearer.

BACKGROUND OF THE INVENTION

This invention relates to a buoyant belt and, more particularly, to a buoyant belt, or safety belt, for use especially by persons participating in water sports. Body-anchoring devices long have been worn by persons participating in water sports. Such devices usually are designated as life jackets, life vests or buoyant belts. Generally life jackets and life vests have been the most effective safety devices but are often considered too bulky and cumbersome to be worn in comfort and freedom of motion desired by persons participating in water sports such as water skiing, aquaplaning or canoeing. Water skiing, particularly, has increased in popularity in recent years, but participants often have feared without benefit of body-anchoring safety devices because of the weight, bulkiness and discomfort associated with the use of life jackets and some life belts or buoyant belts. Recently, improved buoyant belts of foamed plastics have been made that provide greater buoyancy for a given size of belt than is obtained from belts made of buoyant materials used heretofore such as cork, balsa wood or kapok, but these foamed plastic buoyant belts have not been entirely satisfactory. For example, buoyant belts of foamed polystyrene are brittle and have poor qualities of flexibility, thus necessitating enclosing blocks of foamed polystyrene in strong fabric so the belt can be positioned tightly around the body of the wearer. Elongated strips of polyvinyl chloride foam have been used as buoyant belts. However, it is necessary to apply a separate external coating of a polyvinyl chloride plastisol on the foam to provide the buoyant belt with a smooth surface that repels water and is comfortable to the wearer. Belts composed of closed cell polyurethane foams generally lack the degree of flexibility desired in a buoyant belt. Furthermore, all the above-mentioned buoyant belts are not sufficiently strong, i.e., they do not have the high abrasion resistance and high tensile strength that will ensure repeated long satisfactory use. Accordingly, objectives of this invention are to provide buoyant belts that have high tensile strength and toughness; that are not easily torn during use so that they are not separated from their banding or fastening member; that do not require dip coating or enclosing the foamed plastic in fabric; that are not damaged beyond a state of usefulness during long periods of hard use; that provide the desired degree of buoyancy with a minimum of inner weight, that are relatively light and flexible and are comfortable to wear; and that are not adversely affected by hydrocarbon oils and gasoline commonly found as spills or exhaust residues from, for example, motor boats.

SUMMARY OF THE INVENTION

It has now been discovered that a novel buoyant belt made of segmented foamed polylactam of high tensile strength wherein the segments are attached by integral hinges overcomes all the disadvantages noted above. The buoyant belt of the present invention comprises a continuous elongated body of foamed polylactam, said belt being formed from foamed polylactam that is characterized by a tensile strength expressed by the formula \( S_b \geq 20d \) wherein \( S_b \) represents tensile strength in pounds per square inch and \( d \) represents density and has a value of from 1 to 15 pounds per cubic foot, said belt having a plurality of segments, with adjacent segments being attached to one another by integral, flexible hinge portions, and means for holding the belt in place around the body of the wearer. The density represented by \( d \) in the preceding formula, is determined by taking several random representative thin slices, e.g., 15 mils thick, of foamed polylactam cut in a direction parallel to the direction that the polylactam was ejected from the mold cavity and, if possible, each slice being taken from an area substantially equidistant from the surface. The density of each of the selected samples is measured, all of which have densities between 1 and 15 pounds per cubic foot, and the tensile strength determined. The precise tensile strength measurements can be made in an Instron tester where the samples can be stretched at 5 inches per minute. These measurements are taken on the foamed polylactam mass before it is formed into a buoyant belt, i.e., a preform. The buoyant belt of the present invention is remarkably strong and withstands severe impact and strain without tearing. The surface of the buoyant belt is an integral closed cellular skin of polylactam. The closed cellular skin forms an unusually abrasion-resistant covering on the belt and provides a soft smooth surface that makes the buoyant belt especially comfortable to wear. Preferably, the buoyant belt is provided with a plurality of vertically aligned substantially parallel grooves positioned along the inner flat surfaces of the hinged segments, thus giving additional flexibility to the article for ease of wear. Foamed polylactam, particularly plasticized polylactam, used in the buoyant belt are made from lactams having 3 to 12 carbon atoms in the lactam ring, especially caprolactam admixed with lauro lactam or capryl lactam.

DESCRIPTION OF THE DRAWING

In the drawing, illustrating preferred embodiments of the invention, FIG. 1 represents a broken perspective view of the buoyant belt, with parts omitted for clarity; FIG. 2 is a perspective view of a mold-shaped preform of foamed polylactam suitable for forming into a buoyant belt; FIG. 3 represents platens and dies suitable for shaping a mass of foamed polylactam into a buoyant belt.

PREFERRED EMBODIMENTS

With further reference to the drawing, wherein like numbers refer to corresponding parts, a preferred form of the buoyant belt of the present invention is shown in FIG. 1, wherein buoyant belt 1 comprises a continuous, elongated body of foamed polylactam having high tensile strength. The elongated, foamed polylactam buoyant belt contains a plurality of segments 2, preferably substantially pillow-shaped, attached to one another by integral, flexible hinge portions 3. Additional vertically aligned, parallel grooves 4 at right angles to the center line of the belt are formed from the inner weight that are outwardly visible on the surface of the segments of the buoyant belt in order to impart additional flexibility to the belt for ease of wear. Preferably, each of the end segments 2A and 2B is so designed as to have slightly tapered top and bottom walls to give a V-shaped design, as shown in FIG. 1. The foamed polylactam buoyant belt has an integral closed cellular skin 5 of polylactam on the surface of the buoyant belt. The cellular skin in thin, usually less than about 10 mils in.
thickness. The density of the closed cellular skin is about at least one and a half times the average density of the entire polylactam mass before it is formed into the buoyant belt of this invention. A narrow woven polypropylene strap, extends through the central portion of buoyant belt 1 along the horizontal axis of the belt, and metal rings 7 or the like, fasten the two free ends of the strap together to hold the buoyant belt in place around the body of the wearer. Any other means can be used to hold the buoyant belt in place around the body of the wearer such as, for example, snaps or buckles attached to the end segments of the foamed polylactam. However, a flexible web strap is preferred.

Continuous, elongated, foamed polylactam masses suitable for shaping into buoyant belts of this invention are prepared by rapid anion polymerization of monomeric lactam, for example, caprolactam, or mixtures of lactams, especially those containing 3 to 12 carbon atoms in the lactam ring. A process for making the elongated foamed polylactam preform mass comprises adding normally gaseous foaming agent under pressure to melt the lactam containing the lactam in a mold cavity, i.e., an anionic polymerization catalyst; also adding normally gaseous foaming agent under pressure to a separate portion of lactam containing a plasticizer and polymerization promoter, i.e., cocatalyst; then bringing the two portions of lactam together through a mold cavity to a mold cavity, the mold cavity containing a centrally disposed mandrel, and polymerizing the lactam-containing mixture under pressure at least sufficient to maintain the foaming agent in the resulting polylactam. After said lactam is substantially polymerized, the pressure on the polylactam is rapidly reduced by opening an exit port in the mold cavity thus ejecting the shaped substantially solid polylactam containing foaming agent out of the mold cavity into an area of lower pressure where solid-state expansion and foaming occur. The shape of the foamed, expanded polylactam preform, for subsequently forming into a buoyant belt, is, preferably, leaf-shaped, having a space or opening centrally disposed through the long axis of the mass, as shown in FIG. 2. Alternatively, a hollow cylinder or a molded solid cylinder of foamed polylactam can be used to prepare the buoyant belt. In the latter case, the cylinder is slit lengthwise along a radius, a flexible strap is inserted in the slit, and the slit is closed and the surfaces are bonded, e.g., cemented, with epoxy or urethane type adhesive, to hold the slit surfaces about the strap. However, in the preferred case of a leaf-shaped mass, a flexible strap or two ends of a strap are inserted through all or a suitable length of the opening in the foamed polylactam mass and within a period of about 30 to 60 seconds after ejection from the mold, while the temperature of the foamed polylactam mass is at a temperature of about from 120 to 180° C., the preformed mass with the strap in place, is positioned between shaping means comprising upper plates 8 and the lower plate 9 of press 10 as shown in FIG. 3. The platens are equipped with elements 11 which form hinge portions 3 that connect adjacent segments of the buoyant belt. Platens 8 and 9 also, preferably, carry matched metal dies 12, which shape each end 2A and 2B of the foamed polylactam mass to form smoothly contoured tapered end segments. Inserts 13 in lower plate 9 help to form hinges 3 and also form grooves 4 on the bottom substantially flat surfaces of the segments of the buoyant belt when upper plate 8 is brought towards lower plate 9 to a predetermined position. The shaping means or elements thereof can be, but need not be, heated to form the buoyant belt. Alternatively, a metal strap can be inserted into the opening running through the length of the preformed polylactam mass, rather than positioning the flexible strap, or the like, through the polylactam preform at that time, so that when pressure is applied on the polylactam mass in the mold to shape it, i.e., to make a postform, an opening therethrough is maintained for subsequent insertion of flexible strap 6. The interconnected segments of the buoyant belt can have a variety of forms, for example, substantially that of right cylinders, oblate ellipsoids, right triangular prisms, right square prisms and the like, subject to the extent of providing hinged joints between the segments. However, pillow-shaped segments and slightly tapered end segments, as illustrated in the drawing, are preferred. The dimensions of the segments are not critical nor is the number of segments formed in the belt. Generally, about 7 to 11 segments have been found to be most satisfactory for the buoyant belts and, usually, the central segment, that is the one resting on the small of the back of the wearer of the buoyant belt, is usually larger than the other segments, e.g., two times the width of an adjacent segment. Likewise, the numbers of hinges 3, which are governed by the predetermined number of segments 2, and grooves 4 are not critical and are governed by size of the belt and wearing comfort. The dimensions of the hinges can vary but usually they have a width of about ¾" and, during manufacture, are pressed to a thickness of about ⅛", but spring back to a thickness of about ¼" after the press is released, and grooves 4 are about ¾" in width and depth. As indicated above, a sufficient number of segments and hinges, with or without grooves, are provided in the buoyant belt to obtain the desired degree of flexibility in the belt.

Any suitable means for holding the buoyant belt in place around the body of the wearer can be used. Fastening elements such as buckles or snaps can be provided by attaching, e.g., sewing them on integral lips, or other extensions of the end segments of the buoyant belt. Preferably, a narrow flexible webbing strap made of, for example, cotton, polyester, polypropylene or nylon of sufficient strength for the intended use is most satisfactory. The buoyant belt can be held on the wearer by tying or securing the ends together with any conventional strap fastener such as corrosion-resistant metal rings. Although it is preferred to use a single flexible strap that extends along the longitudinal axis and outwardly from opposite ends of the buoyant belt, two separate lengths of webbing strap, one on each end of the buoyant belt, can be used.

Although caprolactam is preferred as the principal lactam in the polymerizable composition to form the polycaprolactam buoyant belt, blends of lactams having 3 to 12 carbon atoms in the lactam ring such as pyrrolidone, butyrolactam, caprolactam, undecylolactam and laurolactam, in amounts of about 1 to 50 parts in combination with about 99 to 50 parts caprolactam are preferred, especially laurolactam or caprolactam. Generally, and preferably, the polymerizable lactam composition contains a plasticizer to impart the flexibility to the buoyant belt. The amount of plasticizer added can vary greatly but amounts of about from 5 to 25 parts, and usually not more than about 10 parts, per 100 parts of lactam are used. Any suitable plasticizer for anionically polymerized polylactam compositions can be incorporated in the composition. Especially suitable plasticizers include, for example, cyclic hydrocarbons such as partially hydrogenated terphenyl, tetramethylethylene sulfone and N-methyl pyrrolidone.

The following examples more fully illustrate the present invention and a method of making the buoyant belt.

**Example 1**

A 100-pound charge of catalyst-containing lactam mixture A comprising 30 pounds of caprolactam, 13 pounds of laurolactam, 5.2 pounds of potassium stearate, 8.6 pounds of tetramethylethylene sulfone and 43.2 pounds of caprolactam containing 3.3% by weight of sodium caprolactamate, 1% mineral oil and 1% hydrogenated terphenyl was formulated under nitrogen, with stirring, at about 125° C. The mixture was saturated with butane gas under a pressure of about 150 p.s.i.g.

A 100-pound charge of promoter-containing lactam mixture B comprising 76 pounds caprolactam, 13.3 pounds laurolactam, 1.1 pounds triphenoxy-s-triazine, 9 pounds
toughness and durability. For example, hinged portions 3 were flexed through an angle of about ±45°, that is a total flex of 90°, for more than one million cycles without showing any signs of weakening, cracking or rupturing.

The total weight of the buoyant belt made in accordance with this example is about 300 grams, as compared with 500 grams for a conventional water ski belt of comparable buoyancy made of polyvinyl chloride. In addition, the buoyant effect of the belt was about from 7 to 9 pounds.

Example 2

The procedure described in Example 1 was repeated except that the mold cavity had a leaf-shaped cross section and contained a T-shaped central insert. The almost completely polymerized mass after ejection from the mold, i.e., the preform, had an elongated leaf shape, as illustrated in FIG. 2. The platens and inserts of the postforming apparatus, were preheated to about 150° C. A metal strap was inserted into the horizontal portion of the T-shaped opening of the leaf-shaped preform before postforming operations were initiated. After the preform was shaped into the desired form of a water ski belt, it was held in the press for about 4 minutes. The resulting shaped mass, or postform, was removed from the press, the metal strap was drawn from the central cavity leaving a lengthwise channel through which a webbing strap was inserted, thus forming the buoyant belt.

1 claim:

1. A buoyant belt comprising a continuous elongated body of formed poly lactam containing poly caprolactam and having an integral closed cellular skin of poly lactam forming the surface of the buoyant belt, said belt formed from foamed poly lactam that is characterized by a tensile strength expressed by the formula $S_t = 20 d^2$, wherein $S_t$ represents tensile strength in pounds per square inch and $d$ represents density and has a value of from 1 to 15 pounds per cubic feet, said belt having a plurality of segments, with adjacent segments being attached to one another by integral, flexible, hinge portions, and a flexible strap positioned along the horizontal axis of the buoyant belt extending outwardly from both ends for holding the belt in place around the body of the wearer.

2. The product of claim 1 wherein the foamed poly lactam is a copoly lactam.

3. The product of claim 2 containing a plurality of vertically aligned substantially parallel grooves positioned along the inner flat surfaces of the hinged segments.

4. The product of claim 2 wherein the foamed poly lactam is a plasticized copolymer.

5. The product of claim 4 wherein the copolymer is formed from lauro lactam.

6. The product of claim 4 wherein the copolymer is formed from capryl lactam.

7. The product of claim 4 wherein the ends of said flexible strap are provided with fastening means.

References Cited

UNITED STATES PATENTS

3,060,135 10/1962 Becke et al. 260--25
3,077,618 2/1963 O'Link 9--337
3,225,369 12/1965 Berwick 9--338 X
3,141,180 7/1964 Pursley et al. 9--340 X

MILTON BUCHLER, Primary Examiner
P. E. SAUERBER, Assistant Examiner