Nov. 8, 1966 F. R. CRAMTON 3,283,378

CRIMPED BINDING STRAP AND METHOD OF MAKING SAME

Filed Aug. 7, 1964

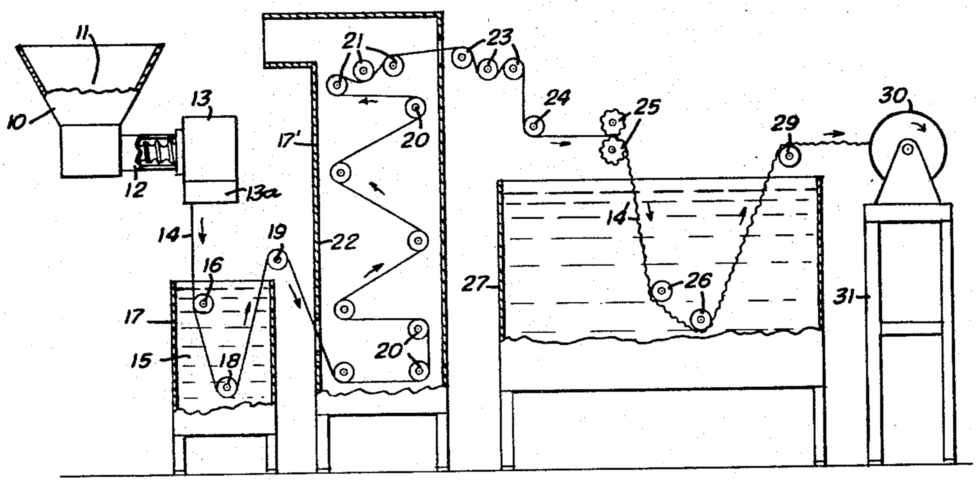

FIG. 1

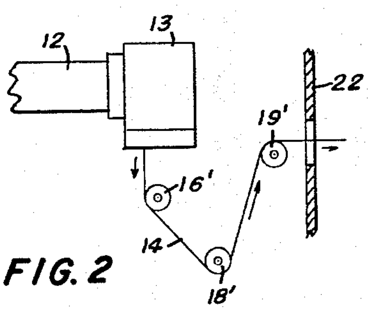

FIG. 2

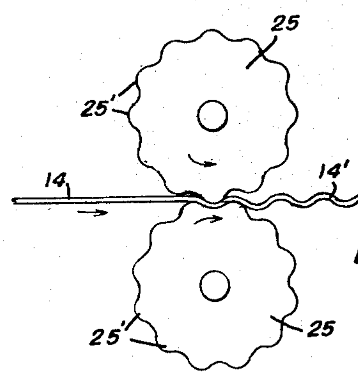

FIG. 3

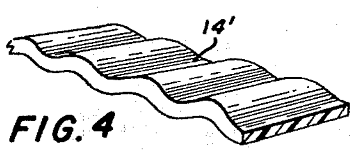

FIG. 4

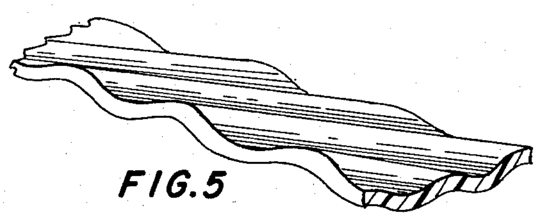

FIG. 5

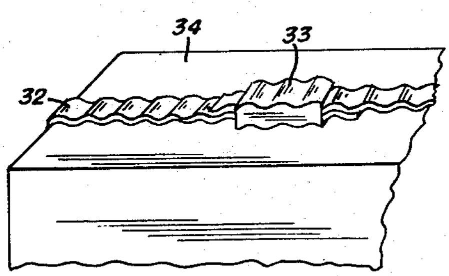

FIG. 6

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United States Patent Office

3,283,378

Patented Nov. 8, 1966

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CRIMPED BINDING STRAP AND METHOD OF MAKING SAME

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Filed Aug. 7, 1964, Ser. No. 388,179
14 Claims. (Cl. 24—16)

This application is a continuation-in-part of my application Serial No. 268,796, filed March 28, 1963, now abandoned.

This invention relates to an improved thermoplastic strap having a novel configuration which increases the strap's energy to break, elongation, and resistance to splitting as well as the ease with which it is adapted to sealing, clamping, or otherwise banding boxes, packages, and the like. More particularly, this invention relates to an improved strap made from an isotactic thermoplastic polymer having a sinusoidal longitudinal configuration.

It is well known that the most widely used strapping material, today, is steel. Steel strapping inherently possesses undesirable features since it tends to rust, it corrodes when exposed to certain chemicals and it is difficult and dangerous to handle. In order to overcome the foregoing problems, a number of non-metallic straps have been introduced. However, these, too, possess certain disadvantages. For instance, the prior art non-metallic straps are unable to maintain a good seal and tend to split longitudinally.

The foregoing described disadvantages are avoided by the practice of this invention which, briefly, involves producing a strap having a crimped sinusoidal longitudinal configuration and comprising a longitudinally oriented isotactic thermoplastic polymer. Preferably, the strap is composed of a thermoplastic composition comprising an admixture of a longitudinally oriented thermoplastic polymer, such as isotactic polypropylene, and a rubbery elastomer, such as polyisobutyluene.

The crimped strap of this invention overcomes the previously mentioned disadvantages in that it is easy to handle and does not corrode or rust. The sinusoidal crimped configuration makes it possible to maintain an excellent frictional seal and, even more significantly, increases its resistance to longitudinal splitting and improves its elongation without loss of ultimate tensile strength. The resistance to longitudinal splitting is increased up to 50% as a result of the crimped sinusoidal configuration. Splits that do occur tend to be limited to a single crimp rather than continuing along the length of the strap. Thus, the strap exhibits resistance to such continued splitting even after a split has started. As previously mentioned, the crimped strap possesses excellent elongation. A level or flat thermoplastic polymer strap generally has an elongation of approximately 10 percent whereas the crimped strap possesses an elongation in the range of from about 30 to about 80%, depending upon the constituents contained in the composition of the strap. This increase in elongation is unexpected since the crimps should theoretically add only about 2% increase in level length per length of crimped strap. The elongation is primarily elastic in nature up to the point where the strap has been pulled and flattened. Such behavior enables the crimped strapping to absorb much greater shock load energy without breaking when packages strapped therewith are dropped or thrown about than when bound with other types of prior art strapping. The energy required to break the strap is known as "energy-to-break."

The crimped strap of the present invention is produced by preparing a melt of the thermoplastic polymer composition, melt extruding a flat strap having a previously determined cross-sectional dimension, solidifying the strap, heat softening and longitudinally stretching the strap to orient the molecular structure, subsequently crimping the strap into the form of a longitudinal sinusoid, and cooling to solidify the polymer composition. Prior to the heat softening step, the extruded strap may be quenched in a non-solvent bath such as water. While the strap has a longitudinal configuration resembling that of a sinusoidal curve, the transverse section is maintained at a substantially constant cross-sectional thickness even though the transverse extending portions may form an oblique section.

Thermoplastic polymers which may be used in the practice of this invention include the high molecular weight (i.e., above about 45,000) solid polymers exhibiting a crystalline X-ray diffraction pattern. Polyolefin polymers such as polypropylene and polyethylene may be employed. Polypropylene is preferred. Among the other solid polymers which may be employed are polyesters, polycarbonates, polyamides, acrylic resins and many of the other polymeric materials.

The preferred polypropylene which may be used in the practices of this invention is the isotactic form which has a density of between 0.90 and 0.94, a melt flow of from 2.0 to 3.5, and a melting pint above 320° F. Such a polymer may be prepared by methods now well known in the art as described by G. Natta in the Journal of Polymer Science, volume XVI, pages 143 to 154 (1955) and in U.S. Patents 2,882,263; 2,874,153 and 2,913,442.

In addition to a strap which consists of one of the foregoing thermoplastic polymers such as isotactic polypropylene, the invention contemplates the use of thermoplastic compositions comprising an admixture of said polymer and at least one rubbery elastomer. The term rubbery elastomers encompasses both the natural and synthetic rubbers. Included within this group are the butadiene-styrene, polyurethane, butyl rubber, polyisobutylene, isoprene, polychloroprene and silicone rubbers. The admixture contains from about 1.0% to about 30% by weight of the rubber elastomer, preferably about 10% polyisobutylene.

The crimped strap of this invention is made according to the following process. The polymer or polymer composition is introduced into the heating zone of an extruder to form a melt of the polymer which is then extruded into a flat band or strap like filament. After the strap has been extruded, it may be solidified as by quenching in a non-solvent bath or by air-cooling. The strap is heat softened by some suitable means. This may be accomplished by conducting it through a heating chamber wherein it is supported, preferably, by a plurality of rolls or equivalent supporting members, the peripheral surface of each providing a supporting surface. The strap is heated while in the heating zone by means of a fluid source of heat, either gas or liquid, or by means of independently heated rolls. Alternatively, the supporting rolls may be eliminated from the heating zone and the strap passed directly through a zone which is heated by some fluid source of heat, or by radiant heat, the filament being unsupported by any member providing a supporting surface which is located within the heating zone. The softened strap may be snubbed by means of a suitable device such as a conventional snubbing roll assembly after it leaves the heating chamber but prior to the drawing operation. Alternatively, the strap may also be heated and drawn in the same zone with the snubs placed outside the heating zone. The softened strap is then stretched longitudinally to increase the molecular orientation along the fiber axis. Any amount of stretching will increase the molecular orientation, however, maximum benefits are attained by stretching the strap from about 6 to about 11 or more times of its length. The ratio of 8:1 is preferred.

After the strap is stretch oriented and while still in a softened condition, it is crimped into the form of a longitudinal sinusoid having a substantially constant thickness. The crimped strap may contain from about two to about twelve full waves per inch, depending on the thickness of the material. The amplitude, which is defined as the height of the wave from the top of the crimp through the strap to the bottom of the succeeding crimp including the thickness thereof, may range from about 0.01 inch to about 0.20 inch. The strap so formed is then cooled to fix the molecular orientation and the crimp.

The aspects of this invention which are capable of illustration are shown in the accompanying drawings.

FIG. 1 is a schematic view of a suitable overall arrangement of apparatus for carrying out the method of this invention.

FIG. 2 is a schematic view of a section of a modification of the apparatus shown in FIG. 1.

FIG. 3 is a side view of the wheels which are used to sinusoidally crimp the longitudinally oriented strap.

FIG. 4 is a perspective view of one embodiment of the crimped strap showing constant thickness in the transverse section.

FIG. 5 is a perspective view of another embodiment of the crimped strap showing constant thickness in the oblique section.

FIG. 6 is an enlarged partial perspective view showing an article of manufacture surrounded by the strap of the present invention and means for binding the strap.

In FIG. 1, a hopper **10** contains pellets **11** of an admixture of crystalline isotatic polypropylene and polyisobutylene. The pellets **11** may be preheated in the hopper **10**, if desired. From the hopper **10** the pellets are conveyed through the heated extrusion chamber **12** by means of a screw to a heated extrusion head **13** which contains an extrusion die **13***a*. In the extrusion chamber **12**, the temperature of the mixture is raised to above the melting point of the polypropylene-polyisobutylene composition. It is extruded through suitable shaped orifices in the extrusion die **13***a* into one or more straps **14**. A preferred extrusion temperature for the composition is about 480° F. when the straps **14** are extruded at a linear rate of from about 18 to about 50 feet per minute from the orifices.

In making straps it is advantageous to quench the extruded straps in order to solidify them. This is accomplished, as shown in FIG. 1, by placing a quench bath **15** between the extrusion head **13** and the heating chamber **22**. The extruded straps **14** are immersed in the quench bath **15**, containing a liquid non-solvent for the composition, e.g., water, by a guide roll **16**. The bath **15** is maintained in a suitable tank **17** at a temperature sufficient to cause solidification, for instance 60° F. An immersion time of from about 8 seconds to about 20 seconds of the straps **14** in the bath **15** is generally sufficient. The straps **14** are transported around a stationary pin **18** in the quench bath **15** and then over the roll **19** and into the hot air conditioning oven **22**. In the oven, the extruded straps are transported over a number of rolls **20**, which may be heated, in a sinuous or zig-zag path, as heated air is circulated from overhead. As the straps pass through the heating zone, each succeeding driven roll **20** over which the straps **14** pass is driven at a slightly increased peripheral speed from that of the preceding roll so as to prevent the straps from sagging appreciably.

The primary purpose of the series of driven rolls **20** is to provide a heat exchange relationship between the straps **14** and the heated air in the oven whereby the straps are uniformly softened by heat.

After leaving the last and uppermost driven roll **20**, the filaments are snubbed with a three roll assembly **21**, each roll of which is driven at about the same as or a higher peripheral speed than that of the preceding driven roll **20**. A fast snub roll assembly **23** is provided just outside the oven **22** which is driven at a high peripheral speed and the filaments are stretched to about 6 to 11 times their original length. This increases the molecular

orientation along the fiber axis. The drawn, oriented straps **14** are thereafter guided between a pair of spaced crimping wheels **25**, as are illustrated in FIG. 3, by guide roll **24**. The crimped straps **14'** are transported around rolls **26** located in a suitable bath **27** containing a non-solvent cooling liquid **28**, e.g., water to fix the crimped polymer and then over the roll **29** to be collected on a reel **30**, supported by a frame **31**.

FIG. 2 illustrates a modification of the apparatus shown in FIG. 1 in which extruded straps **14** are solidified by air cooling rather than by quenching. The straps **14** are passed over the rolls **16'** to allow them to solidify prior to being transported into the hot air conditioning oven **22**.

FIG. 3 is an enlarged view of the crimping wheels **25** of FIG. 1. The flat strap **14** is guided between the pair of crimping wheels **25** having rounded projection **25'** to form the crimped sinusoidal binding strap **14'** of the present invention. The crimping wheels **25** contain projections **25'** which may be parallel to the axis of the wheel or which may vary from parallel to helical for making straps containing transverse and oblique crimps as illustrated in FIGS. 4 and 5, respectively.

In FIG. 6, the sinusoidal strap **32** is positioned around an article of manufacture **34** and tightened by any suitable means in a manner similar to that adapted for steel band strapping. The sinusoidal ends of the sinusoidal strap overlap and intermesh to frictionally engage with one another while a metal clamp **33** having a similar configuration serves to maintain or urge the frictional engagement.

The following examples illustrate the best mode contemplated for carrying out this invention.

Example 1

Isotactic polypropylene pellets having an average molecular weigh of about 100,000, a density of 0.90 and a crystalline melting point of 333° F. are fed into a screw extruder of the type shown in FIG. 1 having a 2.0 inch screw diameter. The die plate contains extrusion orifices, each having a rectangular cross section. The jacket is heated to a temperature of about 480° F. and the straps are extruded at a linear rate of 25 feet per minute from the orifices. The cross sections of each of the extruded straps are substantially flat rectangles of constant thickness. The straps are then passed through a quench bath maintained at a temperature of about 60° F. to solidify them. They are then fed into a heating chamber and are transported over a series of rolls. Hot air is circulated through the heating chamber, thereby heating the straps to a temperature of about 300° F. before leaving the heated chamber. After the heating chamber, the straps are stretched to about eight times their original length. The cross sections of the drawn straps are 0.375" x 0.02". The flat straps are then crimped by intermeshing wheels having rounded transverse projections and driven at a slightly lower speed than the draw rolls, to form the longitudinal sinusoid having about 6½ waves per inch and a constant transverse thickness. The crimped straps are solidified in a water bath and collected on a reel.

Example 2

The process of Example 1 is repeated with the sole exception that the dimensions of the drawn strap are 0.5" x 0.02" instead of 0.375" x 0.02" as in Example 1.

The following table lists the results of tests which show the energy to break of crimped polypropylene. Such "energy to break" values are determined by integration or summation of the area under the stress-strain curve for the particular strapping material tested.

Strap Size:	Crimped polypropylene Energy to break (in.-lbs/in.)
0.375 x 0.02	37.5
0.5 x 0.02	49.0

Example 3

The process of Example 2 is repeated with the exception that a mechanical admixture of 10% by weight of polyisobutylene and 90% by weight of isotactic polypropylene having a melt flow of 2.0 at 230° C. as per A.S.T.M. designation D 1238–62T is fed into the screw extruder.

The following table lists the results of tests which compare the crimped strap of Example 3 to a conventional crimped steel strap having substantially the same cross sectional dimensions. As can be seen from this table, the crimped strap of the present invention requires approximately 1.2 to 3.2 times more energy to break than did the crimped steel strap. Both straps have cross sectional dimensions of 0.020 x 0.50 inch and contain a crimp of 3 cycles-in. with an amplitude of 0.03 inch.

CRIMPED POLYPROPYLE-POLYISOBUTYLENE STRAP VS. CRIMPED STEEL STRAP

Strap Composition	Ultimate Percent Elongation	Energy to Break (in.-lbs./in.)
Steel	7.4	44.0
90% Isotactic Polypropylene-10% Polyisobutylene	80	140.0

Having thus described my invention, I claim:

1. A flexible binding strap comprising a longitudinally stretch oriented thermoplastic polymer, said strap having a substantially longitudinal sinusoidal resiliently deformable configuration.

2. A flexible binding strap as set forth in claim 1, wherein said polymer is isotactic polypropylene.

3. A flexible binding strap as set forth in claim 1, wherein the transverse cross-sectional thickness of said strap is substantially constant.

4. A flexible binding strap as set forth in claim 1, wherein the oblique cross-sectional thickness of said strap is substantially constant.

5. A flexible binding strap comprising a longitudinally stretch oriented thermoplastic composition, said composition comprising an admixture of a thermoplastic polymer and at least one rubbery elastomer, said strap having a substantially longitudinal sinusoidal resiliently deformable configuration.

6. A strap as set forth in claim 5 wherein said rubbery elastomer comprises from about 1% to about 30% by weight of said composition.

7. A strap as set forth in claim 6, wherein said rubbery elastomer comprises about 10% by weight polyisobutylene.

8. A strap as set forth in claim 5, wherein said polymer is isotactic polypropylene.

9. A strap as set forth in claim 8, wherein said rubbery elastomer is polyisobutylene.

10. A method of making a crimped flexible strap of the type set forth in claim 1, which comprises forming

a longitudinally stretch oriented strap of said polymer, mechanically crimping said strap along the longitudinal axis thereof to form a resiliently deformable longitudinally oriented sinusoid and solidifying said crimped strap.

11. A method of making a sinusoidally crimped flexible strap for use in binding packages and the like which comprises melt extruding a strap having a substantially constant cross-sectional thickness and comprising isotactic polypropylene, longitudinally stretch orienting said strap when in a softened condition, mechanically crimping said softened strap in the form of a longitudinal sinusoid, and solidifying said crimped strap.

12. A method of making a sinusoidally crimped flexible binding strap which comprises melt extruding a strap comprising an admixture of isotactic polypropylene and at least one rubbery elastomer, longitudinally stretch orienting said strap when in a softened condition, mechanically crimping said softened strap into the form of a longitudinal sinusoid, and solidifying said crimped strap.

13. An article of manufacture surrounded by a crimped flexible binding strap, said strap comprising a longitudinally stretch oriented thermoplastic polymer in the form of a longitudinal resiliently deformable sinusoid, said article being bound by frictionally engaged overlapping end portions of said strap, said end portions being urged into frictional engagement by clamping means.

14. A method of making a sinusoidally crimped flexible binding strap which comprises melt extruding a thermoplastic polymer, longitudinally stretch orienting said strap when in a softened condition, mechanically crimping said softened strap into the form of a longitudinal sinusoid, and solidifying said crimped strap.

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