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STRETCH-STRAIGHTENING OF ORIENTED POLYAMIDE STRAPPING

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ABSTRACT OF THE DISCLOSURE

A process for reducing internal differential strain in elongated highly oriented, crystalline, polyamide strapping which comprises subjecting such strapping to tension at a temperature at least 50° C. below the melting point, according to ASTM method D2117–64, of the polyamide resin.

This invention relates to oriented polyamide strapping and, more particularly, to a process for reducing internal strain in such strapping.

Strapping of oriented plastics is described in British Patent 1,017,175, to E. I. du Pont de Nemours and Company, published Jan. 19, 1966. Such strapping tends to deviate from linearity, especially on storage, due to uneven stress distribution and lack of strain uniformity across said strapping, arising from nonuniform cooling, inaccurate guiding, etc., during manufacture of such strapping.

Internal stresses and strains are manifested by "camber" and "cupping." "Camber" is defined as the maximum deviation from a straight line (while not under tension) of an 8-foot length of strapping when placed on a flat surface so that both ends of the strapping touch said line. A maximum of 4 inches of camber is permissible when such strapping is to be used in automatic packaging machines.

"Cupping" is used with reference to strapping at least several inches wide. Cupping results when the center of the strapping is longer than the edges and is manifested by an arc-shaped cross section in strapping which has been cut transversely to its length. When cupped strapping is slit in half, lengthwise, the two separated halves curve outwards, thus exhibiting a phenomenon analogous to camber. Cupping may be measured quantitatively by slitting such wide strapping lengthwise and measuring the camber thereof. For example, strapping of 3-inch width is slit lengthwise into 3 straps each 1 inch wide, on which camber may be measured as above. A maximum of 4 inches of camber is desired here also.

It has been discovered in accordance with the present invention that the internal stress distribution and strain uniformity of elongated, highly oriented, crystalline, polyamide strapping can be improved by subjecting such strapping to tension while at elevated temperature.

The strapping to be treated according to the present invention are derived by orientation of polyamide billets. The billets can be made by extrusion (i.e., by pressuring molten molding composition from an orifice to form a solid billet at least one-eighth inch wide and 40 mils thick), or by the modified extrusion or molding process and apparatus disclosed in U.S. application Ser. No. 552,191, filed May 23, 1966, by R. T. Fields et al. Orientation of such billet is carried out by passing the billet between at least one part of the orienting rollers as disclosed in British Patent 1,017,175, i.e., the length of the billet is extended at least 4 times while the width of the resultant oriented shape is maintained within 0.7–1.5 times the width of the billet by taking up the extended billet under tension.

According to the present invention, the oriented strapping is then subjected to tension of at least 1000 p.s.i. (stress) at temperatures at least 50° C. below the melting point (as described in ASTM test D2117–64) of the polyamide resin employed. The preferred polyamides of this invention are polyhexamethylene adipamide, polycaprolactam, and a copolymer of 75–85% (by weight) of hexamethylene adipamide units and 15–25% of caprolactam units.

There can optionally be present in the strapping to be subjected to the stretch-straightening process of this invention up to 20% of a plasticizer for the polyamide resin (based on the total weight of polyamide and plasticizer). Suitable plasticizers include those conventionally used to plasticize polyamides, such as N-ethyl toluene sulfonamide, 2-ethyl-hexanediol-1,3, and tetramethylene sulfone.

The process variables in this stretch-straightening process are selected interdependently. The preferred degree of tension varies inversely with temperature.

The method employed to heat the oriented shape according to this invention may be varied. For example, the strapping may be heated by passage through (1) a hot oil bath, (2) heated pull rolls, (3) radiant heaters, or (4) a combination of these methods. Optionally, the strapping to be stretch-straightened can be heated to the desired temperature before the application of tension as described in British Patent 1,017,175.

The following are the preferred process conditions employed with the preferred polyamides of this invention: for polyhexamethylene adipamide, 8,000–20,000 p.s.i. (stress) at 170–225° C., preferably 12,000–16,000 p.s.i. at 190–205° C.; for the above-mentioned copolymers, 3,000–12,000 p.s.i. at 150–170° C.; and for polycaprolactam, 8,000–12,000 p.s.i. at 150–170° C.

Thus, the temperature of the stretch-straightening process generally is at least 50° C. below the melting point of the polyamide (whether or not plasticizer has been added), as measured by ASTM method D2117–64, which measures the disappearance of birefringence in semicrystalline polymers.

The present process improvement can be applied to the strapping as an in-line treatment just after manufacture of the strapping. Alternately, strapping which has been stored can be treated according to this invention just prior to use to remove any camber or cupping which develops in storage.

Stretch-straightening is especially important with a multi-end strapping line where the individual ends must be straight, parallel, and in place. It is also important in making wide oriented strapping such as belting reinforcing tapes for power transmission belts (as disclosed in U.S. Patent 2,999,764).

The following examples are given to illustrate, but not to restrict, the present invention. All percentages and parts are given by weight unless otherwise noted.

EXAMPLE 1

Strapping 0.022 inch by 0.505 inch was made as follows. Billet was extruded and molded according to U.S. application Ser. No. 552,191, filed May 23, 1966, from polyhexamethylene adipamide of relative viscosity 50 (as determined by ASTM method D789). The billet was then oriented in two rolling stages as described in British Patent 1,017,175, to produce strapping.

Five strands of the oriented strapping were then simultaneously pulled, at a rate of 100–120 ft./min., by unheated rolls through a 20-foot long hot oil bath held at 200° C. under a tension of 10,300 p.s.i. (stress).

Each of the 5 strands was found to have camber in the range 0 to ½ inch. By contrast, in the same strapping before the stretch-straightening, camber varied up to about 4 inches, as did camber in strapping which had been stretch-straightened under conditions identical to those of the example except that the tension was only 3,600 p.s.i.

EXAMPLE 2

This example is identical to Example 1, except that the tension to which each strand of strapping was subjected was 14,400 p.s.i. (stress). Camber was found to be in the range 0 to ½ inch.

EXAMPLE 3

Strapping 0.015 inch by 3.0 inches was made as follows. Billet was extruded and molded according to U.S. application Ser. No. 552,191, filed May 23, 1966, from a copolymer of 80% (by weight) hexamethylene adipamide units and 20% caprolactam units (relative viscosity of the copolymer being 50, according to ASTM method D789). The billet was then oriented in two rolling stages as in British Patent 1,017,175, to produce the strapping.

After storage for one month at ambient temperature, the strapping was observed to be severely cupped. Several samples of the strapping were preheated to about 170° C., then passed through an oil bath held at 170° C. at the following line speeds and tensions, respectively:

45 ft./min. and 4,400 p.s.i.;
75 ft./min. and 3,300 p.s.i.;
65 ft./min. and 8,900 p.s.i.;
65 ft./min. and 4,400 p.s.i.; and
62 ft./min. and 7,800 p.s.i.

In no case did strapping which had been stretch-straightened according to this invention exhibit cupping. Cupping is related to camber in that, when the 3-inch strapping is slit into three 1-inch wide straps, none of the 1-inch wide straps exhibit camber greater than 4 inches.

The foregoing detailed description has been given for clearness of understanding. The invention is not limited to the exact details shown and described since obvious modifications will occur to those skilled in the art.

I claim:

1. In a process for forming highly oriented strapping comprising the steps of (1) extruding a composition comprising an intimate mixture of 80–100% by weight of a polyamide resin selected from the class consisting of polyhexamethylene adipamide, polycaprolactam, and a copolymer of 75–85% by weight of hexamethylene adipamide units and 15–25% of caprolactam units and 0–20% by weight complementally of a plasticizer for said composition to form a solid billet at least one-eighth inch wide and 40 mils thick, and (2) passing said billet between at least one pair of rollers to extend the length of said billet at least 4 times while maintaining the width of the resultant oriented strapping within 0.7–1.5 times the width of the billet by taking up the extended billet under tension, the additional step of stretch-straightening the resultant oriented strapping by subjecting it to tension at an elevated temperature at least 50° C. below the melting point, according to ASTM method D2117–64, of said polyamide, whereby, according to said stretch-straightening step, differential internal strain in said oriented strapping is largely eliminated.

2. A process according to claim **1** wherein the said polyamide resin is polyhexamethylene adipamide, and wherein in the stretch-straightening step the resultant strapping is subjected to tension in the range 8,000–20,000 p.s.i. (stress) at a temperature in the range 170–225° C.

3. A process according to claim **2** wherein said tension is in the range 12,000–16,000 p.s.i. (stress) and said temperature is in the range 190–205° C.

4. A process according to claim **1** wherein said polyamide resin is polycaprolactam and wherein in the stretch-straightening step the tension is in the range 8,000–12,000 p.s.i. (stress) at a temperature in the range 150–170° C.

5. A process according to claim **1** wherein the polyamide resin is a copolymer of 75–85% by weight of hexamethylene adipamide units with 15–25% by weight complementally of caprolactam units, and wherein in said stretch-straightening step the tension is 3,000–12,000 p.s.i. (stress) and the temperature is 150–170° C.

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