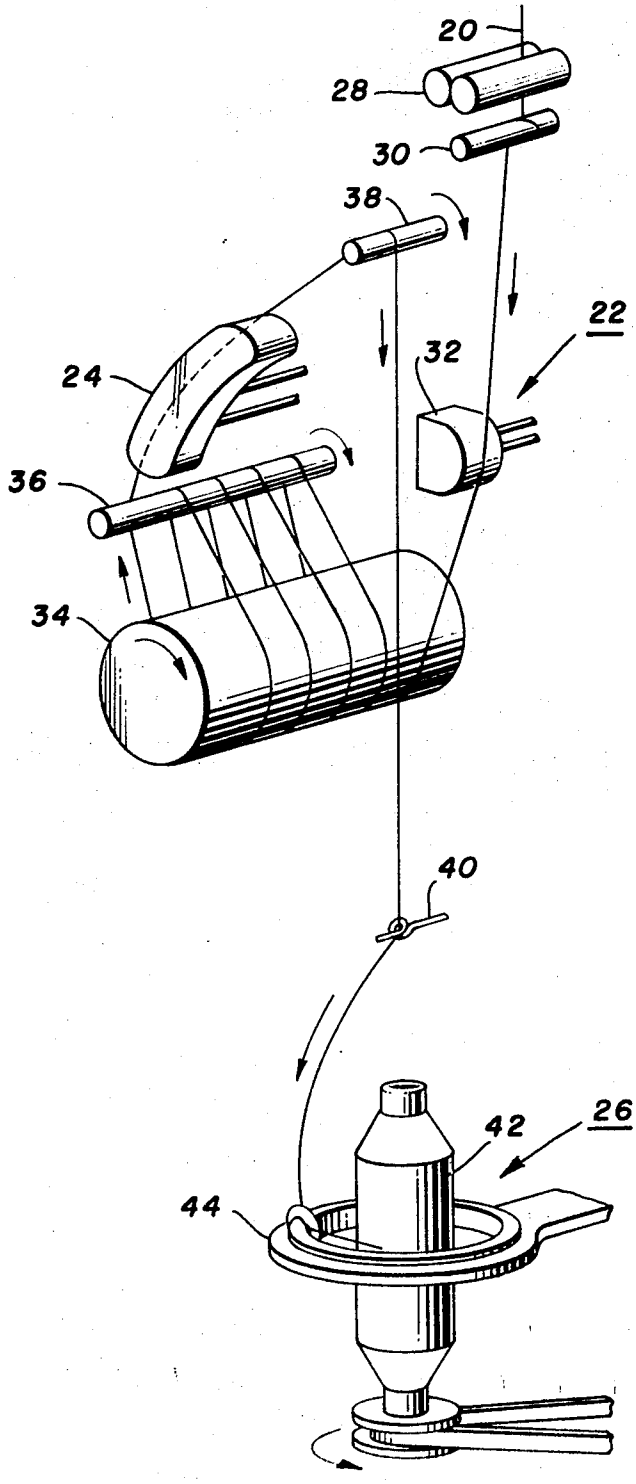
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HIGH-ELONGATION-AND-TENACITY NYLON TIRE YARN

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HIGH-ELONGATION-AND-TENACITY NYLON TIRE YARN

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ABSTRACT OF THE DISCLOSURE

Elongation of high tenacity yarn is increased by heating the yarn to a temperature between 180° and 235° C., while under a tension between 0.05 and 0.35 gram per denier, for a period of 0.003 to 0.15 second.

The invention relates to a high tenacity yarn having a high elongation, and to a process for making such yarn. The yarn is particularly suitable for use in tire construction.

Present known polyamide tire yarns have tenacities of approximately 8.8–9.3 grams per denier and elongations of about 12.1–17.3%, the higher tenacities corresponding generally to lower elongations. A minimum acceptable tenacity is about 8.5 grams per denier. Somewhat higher tenacities can be produced by increasing the draw ratio, but this is at the expense of a corresponding decrease in elongation in the usual process. Tire makers ply-twist the yarn to make tire cord, and then hot stretch or "tensilize" the cord. A high elongation is desirable since it renders the yarn and tire cord more resistant to impact breaks, as well as affording more efficient use of the expensive hot stretching apparatus.

Elongation of a drawn yarn is a measure of the degree to which the yarn can be stretched before it breaks, and is the length by which the yarn can be stretched divided by the original drawn length of the yarn. Thus, if a yarn of unit length can be stretched to a length of 1.20 units before breaking, the elongation is 0.20.

Merely increasing either tenacity or elongation, while suffering a corresponding decrease in the other, does not materially improve the yarn: both properties should have high values. A more useful indication of yarn desirability than either of these properties considered alone is their product. Thus, in a yarn having a tenacity of 9.3 grams and an elongation of 0.17, the product would be 1.58. Substantially improved properties are achieved when the tenacity-elongation product is at least 1.65, and preferably at least 1.70, provided that the tenacity is at least 8.5 grams per denier.

Applicants have discovered that elongation can be substantially increased by subjecting the yarn to a specified temperature range while the yarn is under certain tensions, for specified time lengths, as is more fully disclosed below, and that this increased elongation can be attained with little if any loss in tenacity.

Accordingly a primary object of the invention is to provide a high tenacity yarn having unusually high elongation.

A further object is to provide a yarn of the above character wherein the product of tenacity and elongation values are greater than 1.65, whereby improved yarn properties are achieved.

A further object is to provide processes for producing yarns of the above character.

For a more complete understanding of the nature and objects of the invention, reference should be had to the following detailed description taken in connection with the accompanying drawing, wherein the figure is a simplified perspective view of exemplary yarn drawing apparatus incorporating the invention.

Referring generally to the figure, undrawn yarn **20** is fed to drawing apparatus **22** which draws the yarn and orients the molecules therein. The drawn yarn is next passed over and in thermal contact with a heated element illustrated as plate **24** to increase its elongation, and then is collected in an orderly fashion by means llustrated as a conventional twister takeup mechanism **26** including the usual ring and traveller.

Referring more specifically to the figure, nip rolls **28** feed yarn **20** at a predetermined rate. Yarn **20** next passes in one or more wraps about fixed draw pin **30** and across a fixed heater block **32** positioned below draw pin **30** in the zone of high tension between draw pin **30** and draw roll **34**. Yarn **20** slides across the surface of plate **32** and then in a plurality of wraps about draw roll **34** and its associated freely rotatable separator roll **36**. The peripheral speed of draw roll **34** is selected to draw yarn **20** to a tenacity of at least 8.5 grams per denier. Drawing apparatus **22** as thus far specifically described is conventional.

According to the invention, yarn **20** next contacts hot plate **24** while under reduced tension. Yarn **20** next passes over guide roll **38** and through pigtail guide **40** to apparatus **26** where it is wound on bobbin **42**. The size and temperature of plate **24** are selected in accordance with the speed of yarn **20** so that yarn **20** is exposed to between 180° and 235° C. for a period between 0.003 and 0.15 second, while the yarn is under a tension between 0.05 and 0.35 gram per denier.

As a specific example, the yarn was spun from polyhexamethylene adipamide (nylon 66) polymer having a formic acid relative viscosity of 73, as determined by ASTM method D–789–53T. Using the illustrated apparatus, the relative speeds of nip rolls **28** and draw roll **34** were selected to provide a draw ratio of 5.2 to 1 when roll **34** had a peripheral speed of 280 yards per minute. Block **32** was maintained at 190° C., and was 1.5 inches long in the path contacted by the yarn. Ceramic pin **30** was 0.75 inch in diameter and was heated by yarn friction to about 100° C. Block **24** extended 6.5 inches along the yarn path, and was maintained at 210° C. The yarn tension while contacting block **24** was 0.14 gram per denier, and was substantially the same as the tension between roll **38** and pigtail guide **40**.

Ring **44** was traversed back and forth parallel to the axis of bobbin **42** between limits which converge as a function of time, as generally illustrated in FIG. 9 of U.S. Pat. 2,764,363. Such a package construction is called "warp-wound," and is desirable in providing relatively uniform wind-on tension.

The tension on the yarn contacting block **24** can be maintained at a value within the tension range specified above by selection of traveller weight and shape, and spindle r.p.m. If necessary, the spindle r.p.m. can be decreased as the bobbin diameter increases, to keep the tension within the desired range. In this specific example, spindle r.p.m. is linearly decreased from 3150 r.p.m. at startup to 2700 r.p.m. at doff, maintaining uniform tension of 125 grams on the 840 drawn denier, 140 filament yarn.

Properties of sample yarns produced by the present process as compared to a control yarn made the same process but without block 24 are as follows:

Yarn	Tenacity, g.p.d.	Elongation	Product
Control	9.05	0.157	1.42
A	9.15	0.190	1.74
B	9.10	.193	1.75
C	8.88	.196	1.74
D	9.06	.182	1.65
E	9.90	.181	1.79
F	8.84	.193	1.71
G	8.82	.187	1.65
H	8.73	.204	1.76

The yarns prepared according to the present process have substantially higher impact strength than do yarns such as the control yarn having a tenacity-elongation product of less than about 1.65, and permit more efficient use of the hot-stretching apparatus. Those yarns having a tenacity-elongation product greater than 1.70 are particularly advantageous.

The terms "tenacity" and "elongation" as used in the specification and claims refer to breaking tenacity and breaking elongation as determined by ASTM test method D–2256, using a constant rate of elongation testing machine as set forth therein.

Other drawing apparatus and string-ups can be used to provide the drawn yarn which is fed to hot plate **24**. For example, the undrawn yarn can be supplied directly from the spinning apparatus, or can be wound before being supplied to the drawing apparatus. The spun yarn can be drawn in one or more stages as desired, with or without use of a hot block such as **32** in the draw zone. However, the configuration illustrated in the figure is preferred for its simplicity. Similarly, although the warp wound package is preferred because of its uniformity of winding tension, other package constructions could be used, including packages wound without twisting. Advantageously, nip rolls or a driven roll with cooperating

separator roll could be added between the takeup mechanism **26** and plate **24**, to isolate the yarn contacting plate **24** from tension variations originating in takeup mechanism **26**. The inertia of roll **38** performs this isolation function to a sufficient extent in the illustrated preferred embodiment.

We claim:

1. A process for producing high tenacity yarn having high elongation, said process comprising:

(a) drawing said yarn to a tenacity of at least 8.5 grams per denier,

(b) reducing the tension on said yarn to a level between 0.05 and 0.35 grams per denier,

(c) subjecting said yarn while at said reduced tension level to a temperature between 180° and 235° C. for a period between 0.003 and 0.15 second; and

(d) collecting said yarn in an orderly fashion.

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