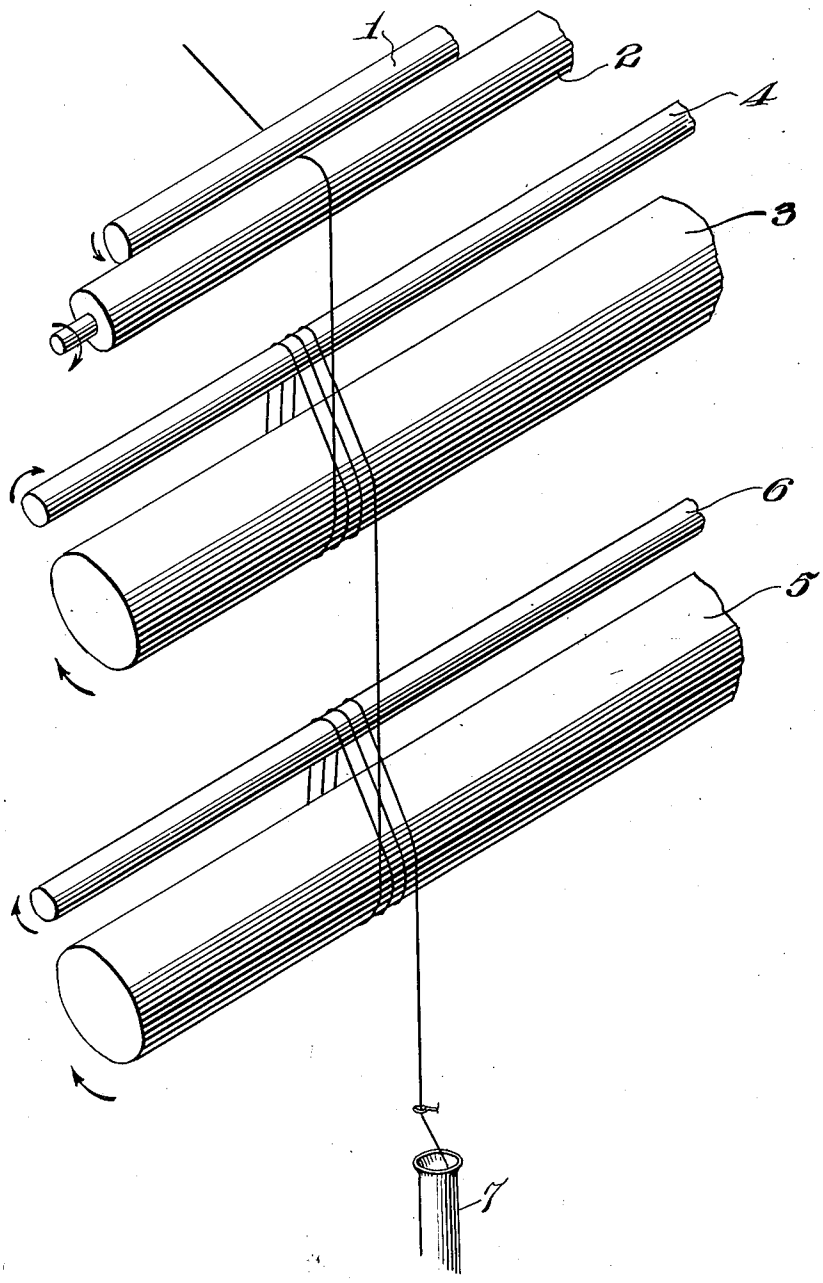
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METHOD AND APPARATUS FOR THE DRAWING OF SYNTHETIC FUNICULAR STRUCTURES

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METHOD AND APPARATUS FOR THE DRAWING OF SYNTHETIC FUNICULAR STRUCTURES

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This invention relates to a new and improved apparatus for drawing funicular structures comprised of synthetic linear polymers.

Recently it has been determined that the physical and chemical characteristics of synthetic linear polyester yarns, such as yarns of polyethylene terephthalate disclosed in detail in Whinfield and Dickson U. S. P. 2,465,319, are greatly enhanced by thermal drawing of the yarn in two stages, cf., the application of Anderson Pace, Jr., Serial No. 763,088, filed July 23, 1947, now Patent No. 2,556,295. The conventional means for drawing yarn between multiple draw rolls when adapted to thermal drawing in two stages has obvious economic and mechanical disadvantages in that moving parts must be heated, and considerable space is required. Furthermore, when multiple heated rolls are used to double-draw, an undesirable amount of quenching occurs between the first (primary) and second (secondary) draws. For example, in double-drawing between rolls, the yarn is drawn from a hot roll to a cold roll to effect the primary draw, and then, for the secondary draw, it is again drawn from a still hotter roll to another cold roll, the cold roll between the two hot rolls effecting an undesirable quenching, i. e., cooling of the yarn. The reason for desiring a minimum degree of quenching lies in the fact that less work is needed to double-draw a yarn that is not quenched between the primary and the secondary stages. Moreover, with quenching kept at a minimum, a much greater part of the heat of drawing from the first stage is used to help raise the temperature of the yarn to that for the second stage of drawing. These factors coupled with the probability that an intermediate quench may well limit the degree of the second stage drawing show the desirability for limiting the degree of quenching.

An object of this invention, therefore, is to provide an improved method and means for the thermal drawing of synthetic linear polymer yarns in two stages.

Another object is to provide compact means for the double-drawing of synthetic linear polymer yarns, said means to comprise a minimum of moving parts.

Still another object is to provide apparatus for the thermal drawing of synthetic linear polymer yarn in two stages, characterized by the advantage that quenching between the first and second draw is eliminated.

A still further object is to provide a simple, economical method and apparatus for the thermal drawing of synthetic linear polymer yarn

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and the subsequent heat treatment of the drawn yarn.

These and other objects will more clearly appear hereinafter.

These objects are realized by this invention which will be hereinafter particularly described with reference to the accompanying drawing wherein the figure illustrates schematically a specific arrangement of elements combined in accordance with the principles of this invention.

Referring to the drawing, the apparatus of this invention, briefly stated, comprises the following arrangement of elements: a pinch roll 1, a positively driven feed roll 2, a positively driven heated draw roll 3 and separator roll 4, a final positively driven draw roll 5 and separator roll 6, and a suitable yarn take-up device 7. The funicular structure to be drawn passes between the pinch roll 1 and the feed roll 2. This prevents slippage and insures the subsequent heating of the yarn at an even rate. The yarn is then passed in one or more wraps around the heated draw roll 3, and separator roll 4. The roll 3 operates at an increased peripheral speed over the speed of the feed roll corresponding to the draw ratio desired. The yarn is then taken to the final draw roll 5 and separator roll 6 about which one or more wraps are also taken to prevent slippage. The final draw roll 5 in turn operates at the desired speed greater, less or the same as that of heated draw roll 3 depending upon whether secondary drawing, relaxation or stabilization of the yarn is desired. The yarn then passes on to a conventional yarn take-up device 7.

A superficial consideration of the apparatus just described would lead one to believe that as far as the yarn is concerned only one temperature is involved. This, however, is not the case, since the yarn as it initially contacts the heated roll is cold and the rate at which it heats up to the temperature of the roll is a function of the heat transfer between the heated roll and the yarn. Therefore, assuming that the heated roll is revolving at some peripheral speed greater than the feed speed of the yarn, it is obvious that primary drawing will occur at that point where the yarn is heated to the degree where minimum tension is necessary to draw the yarn the required ratio. The secondary treating temperature will be, of course, the temperature of the heated roll. It is at this temperature that the further operation of either drawing, relaxing or heat-treating at constant length as determined by the relative speed of the final cold draw roll occurs. The exact point at which this secondary

draw or relaxation occurs is a function of the yarn slippage on the periphery of the hot roll as determined by the coefficient of friction. Since this is a constant value for a given yarn at any one temperature, speed of operation, and roll surface the effect is to tie down the draw point so that uniform yarn results.

With most yarns of synthetic linear polymer it is desirable that both orientation and crystallization or setting occur some time during the manufacturing process to obtain a thermally stable product. For this reason it is preferred when drawing such yarns by the apparatus of this invention that the heated draw roll be heated to a temperature considerably above the minimum temperature necessary for crystallization within a reasonable length of time. In this manner the primary draw in the case of double-drawing for orientation or the total draw in the case of single-stage draw occurs at some lower temperature than the roll temperature just as the yarn initially contacts the heated roll. Then the crystallization or setting operation can occur during the passage of the yarn in its various wraps around the heated roll. In this manner even if no drawing occurs as the yarn leaves the roll, a considerable degree of crystallization is secured. Of course, if the structure is given an additional draw as the yarn leaves the roll an even higher degree of crystallization may be obtained. This latter case, however, is only applicable to yarns which are double-drawn.

The actual draw roll temperature used obviously depends on the material being treated. It is a function of several factors, such as optimum drawing and crystallization temperatures of the individual structure, operability, properties of the desired end product, and many other such variables. Since the reason for using a roll at a rather high temperature is to aid in crystallization and/or relaxation, it is desirable within the limits of the individual material to hasten the desired result by using as high a temperature as possible, keeping in mind, of course, the physical properties of the material and the high degree of operability desired. The hot roll, of course, may be heated in any convenient manner such as steam, vapor, electricity, etc.

The total draw ratio (i. e., the ratio of the length of the yarn in its drawn state to the length of the yarn before drawing) which is governed by the peripheral speeds of both the heated roll and the final cold roll may be varied over a considerable range depending upon the end use of the individual material. Thus, any combination of initial and final draw ratios may be used merely by varying the relative speeds. Or again any ratio of draw followed by relaxation may be easily obtained in the same manner.

In general, it is preferred to have a minimum of two wraps of the yarn around both the heated draw roll and the final draw roll. The reason for doing this is to prevent slippage and insure that the actual draw ratios desired are obtained on the finished material. However, in certain instances it may well be suitable to use one wrap. This is especially true at the higher operating temperatures of the hot roll.

Another variable to take into account is the diameter of the heated roll. It is evident that for larger diameter rolls fewer wraps are needed to give equal yarn contact times. Thus by proper choice of yarn speed and roll diameter yarn treating time can be varied considerably.

The following specific examples of preferred embodiments are further illustrative of the practice and principles of this invention:

Example I

A 300-denier polyethylene terephthalate yarn (Birefringence 0.0012) having 34 filaments is double-drawn by the apparatus shown in the figure. The feed roll delivers yarn at the rate of 50 ft./min. The hot roll is heated electrically by means of an internal electrical heater to 110° C. The peripheral speed of the hot draw roll (2" diameter) is 200 ft./min., giving an initial draw ratio in this case of 4.0. Drawing is observed to take place within ½" after the yarn contacts the periphery of the draw roll. Yarn temperature as measured at this point is between 85° and 90° C. The final draw roll (unheated) rotates at a speed such that the peripheral speed is 1.46 times that of the hot draw roll to give a total draw ratio for the yarn of 5.80. The draw point for the secondary draw is observed to be approximately ½" before the point of last contact with the hot draw roll. The yarn temperature as measured at this point is that of the roll, i. e., 110° C. The yarn obtained in this case is found to have an average tenacity of 6.5 g./d. (grams per denier) and 7.8% elongation.

The above example demonstrates how it is possible to obtain a two-stage drawing operation at two different temperatures using a single heat source. Undrawn yarn is generally not able to withstand high temperatures such as 110° C. The actual drawing occurs at a temperature, however, somewhat lower than the temperature of the draw roll and thus by the time the yarn is heated up to the higher temperature, a partial draw has occurred allowing the yarn to withstand the higher temperature without harm. The final draw, which occurs just prior to the yarn leaving the heated draw roll, is obviously carried out at a yarn temperature which corresponds to that of the draw roll. Care must be taken that the yarn is not held at the increased temperature long enough to induce sufficient crystallization if further draw is expected in the second stage.

The following example shows the use of the apparatus of this invention to draw a yarn in a single-stage to the desired draw ratio at a given temperature followed by a heat-treating or heat-setting operation at a higher temperature at constant length:

Example II

A 450-denier, 34-filament polyethylene terephthalate yarn (Birefringence 0.0011) is drawn 5.80 times using a feed speed of 52 feet per minute and a hot draw roll peripheral speed of 300 feet per minute. The heated draw roll (2" diameter) is maintained at a temperature of 120° C. Five wraps are made about this roll and the separator roll so that an extended time of heat-treatment is possible. The yarn then passes to the final draw roll which has the same peripheral speed as the hot draw roll, thus insuring constant length after the initial drawing occurred. As before, the yarn is taken up on a suitable take-up device. The yarn produced by this treatment has a tenacity of 5.5 g./d. and an elongation of 7.5%. It exhibits extreme stability at elevated temperatures and consequently is extremely useful for high temperature applications involving the use of a textile material.

The next example illustrates the usefulness of the apparatus of this invention for drawing a yarn in a single-stage at one temperature while

allowing the desired degree of relaxation to occur at a higher temperature:

Example III

A 450-denier, 34-filament polyethylene terephthalate yarn (Birefringence 0.0011) is fed at the rate of 55 feet per minute to a heated draw roll with a peripheral speed of 310 feet per minute. The heated draw roll is at a temperature of 180° C. One wrap is made about this 2" draw roll. The yarn is then allowed to relax 6% at the roll temperature of 180° C. by running the final draw roll at a speed of 0.94 times that of the hot draw roll. Yarn temperatures in this case are (1) at point of draw, +95° C., (2) at point where relaxation occurs, +180° C. The yarn obtained in this case exhibits a tenacity of 6.0 g./d. at 15% elongation. It is preferred, especially where relaxation is occurring, to have the hot draw roll and final draw roll no more than 12 to 15" apart with the yarn reasonably shielded from transverse drafts.

While the apparatus of this invention is especially suited for use in the double-drawing process described in the copending application, S. N. 763,088 to Pace, it is obvious, of course, that the invention is not restricted to this one species of yarn, since it may well be used in the drawing of any polymeric material which responds favorably to the treatments hereinabove described, e. g., other polyesters, polyamides, vinyl compounds, etc. In the aforementioned application a primary draw is carried out at a convenient temperature between the second order transition temperature (T_g) and the apparent minimum crystallization temperature (T_l) of a suitable polyester. This is followed by a secondary draw at a much higher temperature to induce crystallization. In a complex process such as that described in Pace, it is evident that an apparatus as simple as that described herein will have many economic advantages.

As described previously it is not only preferred that the heat required to bring a funicular structure to its draw temperature be applied in one step, but that for optimum operability it should be applied continuously in the drawing step to produce double-drawing with no intermediate quench. Thus, the apparatus of this invention involving drawing to and from the same hot roll is admirably suited to meet these conditions.

Economically the most important element of this process is the fact that it requires only one heat source for a diversity of treating operations. This reduces the number of heating installations required and simplifies the drawing process. Moreover, undesirable quenching of the funicular structure is eliminated.

Another advantage that makes this system attractive is the greater degree of flexibility of machine operation as attained with a single-heated surface. This, together with the fact that this apparatus is obviously very useful in connection with a warp sheet process where a plurality of funicular structures may be simultaneously treated, further demonstrates the economic superiority of this apparatus.

I claim:

1. Apparatus for the two stages of drawing and heat-treating heat-stretchable yarns and like structures of synthetic filament-forming material on a single heated roll comprising in combination a positively driven unheated yarn feed roll driven at a predetermined speed, a heated draw roll in the path of travel of yarn from the feed roll and driven at an increased speed sufficient to maintain yarn between said feed roll and said heated draw roll under drawing tension, and a positively driven cold roll in the path of travel of yarn from said heated roll, adapted to maintain yarn between said heated roll and said cold roll at a predetermined tension.

2. Apparatus for drawing heat-stretchable yarns and like structures of synthetic filament-forming material in two stages on a single heated roll comprising in combination a positively unheated driven yarn feed roll driven at a predetermined speed, a positively driven heated draw roll in the path of travel of yarn from the feed roll and driven at an increased speed sufficient to maintain yarn between said feed roll and said heated draw roll under drawing tension, and a positively driven cold draw roll in the path of travel of yarn from said heated draw roll and adapted to maintain yarn between said heated draw roll and said cold draw roll under drawing tension.

3. Apparatus for drawing and thereafter relaxing heat-stretchable yarns and like structures of synthetic filament-forming material in two stages on a single heated roll comprising in combination a positively driven unheated yarn feed roll driven at a predetermined speed, a positively driven heated draw roll in the path of travel of yarn from the feed roll and driven at an increased speed sufficient to maintain yarn between said feed roll and said heated draw roll under drawing tension, and a positively driven cold roll in the path of travel of yarn from said heated draw roll and adapted to maintain yarn between said heated draw roll and said cold roll under relaxing tension thereby obtaining a two-stage treatment on a single heated roll.

4. A method for drawing substantially unoriented heat-stretchable yarns and like structures of synthetic filament-forming material which comprises passing said substantially unoriented structures around an unheated feed roll and thence around a heated roll while maintaining the structures between said rolls at drawing tension, said structures being maintained in contact with said heated roll a sufficient period of time to raise the temperature of said structures to substantially the temperature of said heated roll, and thereafter passing said structures around a second unheated roll while maintaining said structures between said heated roll and said second unheated roll at a predetermined tension.

5. The method of claim 4 wherein the structures between said heated roll and said second unheated roll are maintained at drawing tension.

6. The method of claim 4 wherein the structures between said heated roll and said second unheated roll are maintained at relaxing tension.

7. The method of claim 4 wherein the structures between said heated roll and said second unheated roll are maintained at tension to insure constant length.

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