This invention relates to liquid treatment of continuously moving shaped structures and more particularly to the liquid treatment of films and continuous filaments, singly or in combination.

In the continuous production of shaped structures such as filaments, yarns, tows and films, it frequently is necessary to bring such structures into intimate contact with a treating liquid for a variety of reasons. One case in point may have the objective to saturate a water-wet tow comprising continuous filaments with a topical finish or lubricant; thorough coating of all filaments requires displacement of the water by the finish solution. Extraction of a solvent from a filamentary tow or film is more complex since multiple complete displacements of the adherent film of extraction liquor are required for efficient, continuous processing. Even the simple process of stretch-orientation of a filamentary or film structure in a hot liquid bath will operate more efficiently if the shaped structure is frequently stripped of the adherent layer of liquid to permit an approach toward equalization with the bath's temperature.

Efforts toward the objective of improved contact efficiency with a treatment bath have taken a number of forms. It is common practice to employ multiple baths of treating liquids, in which liquid flows counter-current to the direction of the shaped structure when extraction of, for example, a residual solvent is an objective. To minimize carryover of solvent-rich extraction liquor to subsequent baths, quench rolls are frequently employed on the rolls which guide the shaped structure between baths. Such a roll-stringer effect is not completely satisfactory. Liquor is pumped through the nip between yarn ends; the quench roll tends to form filaments wraps, which require equipment shut-down at remove; and product damage can result from the mechanical pressure. Devices which mechanically scrape off the adherent film of water are almost always unsuitable for use on fibers and films due to the high level of damage they impose. The same obstacle is found in fluid-striping devices which employ countercurrent jets of steam or air. An additional objection to the fluid jets is found in their high cost of operation.

This invention provides means for efficient removal of liquid from continuous, moving shaped structures. It further provides means for removal of liquids from continuous, moving shaped structures without damaging mechanical contact therewith.

These and other advantages are provided in this invention by an improvement in apparatus and process of contacting with a liquid treating agent moving shaped structures of the class consisting of filaments, aggregations thereof such as yarns and tows, and films, said improvement comprising the use of at least one liquid-stripper bar oriented adjacent and substantially perpendicular to the path of travel of said shaped structure, said stripper bar having at least one convex curvature in its cross-sectional contour, the degree of convexity increasing sharply in the vicinity of and extending downstream of the point of closest proximity to said path of travel, said cross section further having a second, substantially straight contour contiguous with said convex curvature and extending upstream from the point of closest proximity of said path of travel, said stripper bar having the effect of removing with good efficiency any adherent layer of liquid treating agent from the moving shaped structure.

The section of convex curvature preferably extends through an angle of at least about 15 degrees, and the straight contoured portion preferably extends for a distance of at least about 0.25 inch (6.35 centimeters) or farther. The straight contoured portion should have a disposition relative to the path of travel ranging from parallel, continuous contact, to divergent by about 10 degrees.

This invention will be more readily understood by reference to the following discussion taken with the figures in which:

FIGURE 1 is an overall schematic view of a multiple-bath, extraction-drawing apparatus representing one embodiment of this invention;

FIGURE 2 is a cross-sectional view taken along line 2-2 of FIGURE 1;

FIGURE 3 is an enlarged detail of the liquid-stripper bar employed in the process of this embodiment;

FIGURES 6 to 9 illustrate some alternative shapes which may be employed for the liquid-stripper bars; and

FIGURES 4 and 5 are schematic representations of the apparatus employed in conjunction with the apparatus of FIGURE 1 to determine the degree of liquid carryover with and without the liquid-stripper bars of this invention.

With reference to FIGURE 1, continuous filamentary yarn 1 (from a source not shown) passes over rolls 2 and into baths 3 in which are located rolls 4. The yarn passes over rolls 4 and upwardly to subsequent rolls 2 successively in each of the several extraction-draw tanks. Fresh extraction liquid is supplied at 5 (from a source not shown) and flows counter-currently, relative to the direction of yarn travel, to the first tank 3 from which it is pumped (by means not shown) for recovery of the solvent it contains. The rolls are profiled in speed to provide the desired amount of orienting stretch. Yarn emerging at 6 from the final extraction-draw bath is forwarded (by means not shown) to subsequent stages of processing involving drying, optionally cutting to staple, packaging and so forth. As yarn 1 rises from the baths, it contacts grooved guides 7 which serve to maintain proper distribution of the yarn ends across the length of rolls 2 and 4. Liquid-stripper bars 8 are oriented tangential to the path of the yarn just above grooved guide 7 and are illustrated in greater detail in FIGURE 3. As can be seen in FIGURE 2, both the aggregation of grooved guides 7 and the liquid-stripper bars 8 in this embodiment extend over the full width of the sheet of yarns. With reference to FIGURES 6 to 9 it is seen that a variety of cross-sectional shapes are satisfactory for the liquid-stripper bar, the only requirements of this embodiment being that a relatively flat surface be oriented to approach the sheet at a small angle to the upwardly inclined path of the shaped structure and that the bar, after tangential approach to the sheet, be contoured such that its upper surface proceeds in an upwardly and outwardly direction. A stripper bar with these minimum characteristics provides means for directing away from the yarn path the liquid which has been stripped therefrom. The lower convexity, or in this case, flat-surfaced approach to the sheet assures adequate engagement of the liquid film by the stripper bar. A drain plate 11 may advantageously be added to the stripper bar 8 to prevent the removed liquid from rejoining the yarn again beneath the bar.

The amount of liquor entrained by a warp of individual yarn ends rising out of a bath is strongly dependent on yarn speed and spacing. Differences in entrainment rate are apparent in a change in the elevation of the liquid ridge oriented along the line of emergence of the yarn
ends from the liquid and as a change in the amount of spray projected from rolls 2. A further effect of a speed increase is the entrainment of a film of liquid between running ends which can result in merging of two or more individual ends of yarn. Guiding means such as grooved guides prevent further loss of liquid-contact efficiency and straying of individual filaments which would otherwise occur.

As is illustrated in Figure 5 and the following example, it sometimes is advantageous to use two or more such stripper bars after addition of treating liquid to the moving shaped structure.

FIGURES 4 and 5 schematically represent liquid collection devices employed to measure the amount of easily separable, entrained liquid under various process conditions. Shaped structure 1 is diverted from its normal downward path to wrap around rolls 9 and 10. Spray collectors L1, L2, and L3 are installed in such a way as to collect the liquid from the moving shaped structure as it breaks over rolls 2, 9, and 10. The following example illustrates this invention in comparison with prior art. Liquid collected at L3 is separately tabulated, but it will be recognized that differences between the totals of all three collections of liquid are representative of the improvements afforded by this invention.

Example

A warp sheet comprising 4 ends of 100 filament, 8.8 denier-per-filament yarns is produced by dry-spinning a solution comprising 20% poly(meta-phenylene isophthalate) (PMDA) and 80% of 1.5 inherent viscosity and about 9% CaCl2 in dimethylacetamide (DMAC) by means available in the art. As wound in parallel on a beam, the yarn contains 33.3% polymer, 20% DMAC, 6.7% CaCl2 and 40% water (added as a cooling agent as the filament emerges from the heated cell), the bulk of the solvent having been evaporated during passage through the cell. The warp sheet is threaded through an extraction-draw machine such as schematically depicted in Figure 1 and introduced continuously at 100 yards per minute. During passage through the first seven tanks, the sheet is drawn to 415% of its original length. Thus as it emerges from the seventh bath it is traveling at 415 yards per minute. A grooved guide having an outside diameter of about 1.5 inches (3.81 cm.) and a groove-seat diameter of approximately 1 inch (2.54 cm.) is provided in each tank for each end of yarn. The center-line of the guides is positioned 8 inches (20 cm.) above the static level of liquid in the tank and one-half inch (1.27 cm.) outside the normal path of the emerging yarn so that each end of yarn makes brushing contact with the smaller external diameter of one guide. A liquid-stripper bar having a long dimension somewhat longer than the width of the warp sheet and cross-sectional dimensions of 1/2 x 1 inch (1.11 x 2.54 cm.) and being machined at the top edge to a 0.25 inch (0.63 cm.) radius of curvature is, in some experiments, positioned in a generally horizontal but slightly tilted attitude such that a line within, but near the beginning of, the curvature makes brushing contact with the warp sheet 3% inches (0.92 cm.) above the centerline of the grooved guides. In additional experiments, additional liquid-stripper bars are mounted to similarly contact the yarn at 2.5 inches (6.3 cm.) intervals to a maximum of three such bars.

Table 1 summarizes the results of the tests. L1, L2 and L3 represent the weight of liquid removed per unit weight of yarn. The significance of these designations will be perceived by reference to Figures 4 and 5.

Table I

<table>
<thead>
<tr>
<th>Number of Liquid Stripper Bars</th>
<th>L1</th>
<th>L1+L2</th>
<th>L1+L2+L3</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7.34</td>
<td>0.84</td>
<td>8.17</td>
</tr>
<tr>
<td>1</td>
<td>0.13</td>
<td>0.49</td>
<td>0.62</td>
</tr>
<tr>
<td>2</td>
<td>0.32</td>
<td>0.42</td>
<td>0.44</td>
</tr>
</tbody>
</table>

The large reduction in strip-paddle carry-over is clearly apparent, even with only one stripper bar. It will be apparent that substantial variation from the specific embodiment employed may be undertaken without departing from the spirit and scope of the invention which, therefore, is to be considered limited only by the following claims.

What is claimed is:

1. In apparatus for contacting moving shaped structures with a liquid treating agent, the improvement comprising at least one liquid-stripper bar oriented adjacent and extending substantially perpendicular to the path of travel of said shaped structure after contact with said treating agent, said stripper bar having at least one convex curvature in its cross-sectional contour, the degree of convexity increasing sharply in the vicinity of and extending downstream of the point of closest proximity to said path of travel, said cross-section further having a second, substantially straight portion contiguous with said convex curvature extending upstream from the point of closest proximity to said path of travel.

2. Claim 1 wherein said substantially straight portion has a disposition relative to said path of travel from substantially parallel, continuous contact to divergent by at least about 10 degrees.

3. Claim 1 wherein said convex curvature continues through an angle of at least about 15 degrees.

4. Claim 1 wherein at least two stripper bars are located along the path of travel.

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