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METHOD AND APPARATUS FOR THERMALLY TREATING TAPE.

Proprietor : NATIONAL RESEARCH DEVELOPMENT CORPORATION
101 Newington Causeway
London SE1 6BU (GB)

Inventor : RUDDELL, James, Nelson
Laurelmount 41 Kilvergan Road
Lurgan County Armagh, BT66 6LF (GB)

Representative : Neville, Peter Warwick
Patent Department National Research Development Corporation 101 Newington Causeway
London SE1 6BU (GB)

References cited :
DE-A- 1 704 969
DE-A- 1 779 155
DE-A- 2 047 640
DE-A- 2 446 136
DE-A- 2 706 927
FR-A- 2 451 418
GB-A- 1 400 552

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Description

This invention relates to a method and to apparatus for thermally treating long flexible material such as tape or items such as wire, yarn (e.g. monofilament, continuous filament or spun), fabrics (whether woven or non-woven), continuous tow, thread and fibres and filaments generally (particularly for textiles). The treatment will normally be heating, but cooling would also be possible.

One application is to synthetic (e.g. polypropylene) tape, in which heating treatment is conventionally applied at two stages, firstly to draw out the as-extruded tape, and secondly to anneal the drawn-out tape. Previously, in one known method, tape has been heated by passing is through a hot-air oven. The oven is typically several metres long and, consuming perhaps 40 kW, is costly to heat. Moreover, uniform temperature control is difficult, and temperature variations within the oven are common.

Hot-air ovens depend upon the transfer of heat through a boundary layer of air on the surface of the material being treated. To achieve this transfer at an acceptable rate the circulating air temperature must be raised well above that required in the material. In addition, temperature variations within the mass of circulating air cause product inconsistency. With lighter-weight filamentary materials, air turbulence may cause any broken ends to become entangled in neighbouring material. Hot-air ovens also leak hot air to the surroundings and lose heat by conduction through and radiating from the oven structure. Hot-air ovens also occupy considerable floor area.

A second known heating method is infra-red radiant heating.

Infra-red radiation equipment, though simpler in design and cheaper than hot-air ovens, imposes a high energy demand. The radiant heat passes to all protrusions within the equipment itself and not just to the material being treated. Performance of the radiating elements falls off with age, and this introduces difficult control problems. How well material being treated absorbs radiant energy also varies considerably from one polymer batch formulation to another and even within any one batch: this results in still more variability in product physical properties.

A third known method is to pass the tape over heated rollers or hot rotating drums. These may require complicated bearings, rotating seals for any heating oil circuitry present and careful temperature control, and thus can be expensive. The use of a number of heated cylinders, usually running at progressively higher surface speeds, gives generally good temperature distribution and a consistent product, but incurs considerable energy loss from surface radiation all round the cylinders, only a limited portion of the surface acts to heat the material itself.

A fourth known method is to draw the tape under tension over a convex ("hog's back") heated metal surface, the tape remaining in uninterrupted contact with the surface for a distance of typically 2-3 m, (which it covers in about 1 second). Since the non-contacting surface of the tape is visible throughout, its dimensional changes during its drawing can be readily observed. However, heat transfer in this method can only be from one side, and this will result in uneven heat treatment as between bottom and top of the tape. The tape may accordingly relax with a slight lateral curl, which is inconvenient when (as is usual) a flat tape is in fact wanted. An improvement on this method is disclosed in West German laid-open patent application DE-A-1 704 989 which describes a method and an apparatus of the type indicated in the first part of independent claims 1 and 16. In this document, two heated convex "hog's back" surfaces are arranged one after the other in the direction of tape drawing but in opposite orientations, forming an S-shaped tape route, such that the tape is heated on one side by sliding contact over the first heated convex surface, and then heated on the other side by sliding contact over the second heated convex surface. However, a disadvantage is the high sliding friction, which can lead to tape breakages, which are very disruptive to production. In addition, though tapes may be closely spaced side-by-side as they first come onto the first surface, after they have "necked" (been strained by the heat and tension) they open up gaps between them; in this way, the heated metal surface suffers considerable losses of heat by radiation and convection.

Thus all these four methods of heat treatment suffer from poor energy utilisation and other disadvantages.

According to the present invention, a method of thermally treating long flexible material comprises passing it between two opposed profiled heated or cooled members, wherein the profile of the members comprises a ridge running generally transversely to the direction of passage of the material, the spacing between the members being sufficiently close that the material contacts each member, the method being characterised in that the profile of the members is ridges and valleys, the ridges of one member facing the valleys of the opposing member, the material contacting each member at a plurality of locations yet the spacing between the members being sufficiently large that the material can pass between them without being constrained to deflect from coplanarity by more than its own thickness.

Also according to the invention, apparatus for thermally treating long flexible material such as tape comprises two opposed profiled members between which material may be passed, wherein the profile of the members comprises a ridge running generally transversely to the direction of passage of the material, the members being spaced sufficiently closely that material passing between them would touch each member, and means for heating or cooling the members, the apparatus being characterised in that the profile of the members is ridges and valleys, the ridges of one member facing the valleys of the opposing
member, the spacing between the members being sufficiently close that the material would touch each member at a plurality of locations yet being sufficiently large that the material can pass between them without being constrained to deflect from coplanarity by more than its own thickness.

«Transversely» is intended to include any substantially non-zero angle, although angles in the region of 90° are best. Preferably the spacing between the members is sufficiently large that the material can pass between them without being constrained to deflect from coplanarity by more than 1/4 or its thickness. Usually, the ridges where contacting the material are generally smooth, and may be flat plateaux or domed; sharp edges contacting the material could snag or tear it.

Preferably, each member has at least ten ridges for contacting the material. Preferably, the residence time of any point on the material between the members is 0.01 to 0.2 seconds, more preferably 0.02 to 0.1 seconds.

The material may be synthetic (e.g. polyester or polyolefin) tape.

For polyolefin tape, preferably the members are heated to 125 to 145 °C, and for drawing out the tape, the ration (speed leaving the members) : (speed entering the members) is preferably from 2 : 1 to 30 : 1, more preferably from 4 : 1 to 20 : 1, most preferably from 5 : 1 to 10 : 1. For relaxing (annealing) the polyolefin tape, the members may be heated to 135 to 155 °C and the ratio (speed leaving the members) : (speed entering the members) is preferably from 0.85 : 1 to 0.97 : 1. For sequential drawing and relaxing, the temperature of the relaxing members may be 5 to 20 °C more than the drawing members.

Optionally several tapes are treated by the method side-by-side, the tapes possibly being formed by sitting a wide film or sheet before the drawing step. As another possibility, several monofilaments, possibly from the same spinneret, are treated by the method side-by-side, and the monofilaments may be twisted together after the relaxing step. For bulking the resulting yarn as mentioned later, a different temperature may be applied during the drawing (i.e. before the twisting) to some of the monofilaments.

The ridges of the members may be parallel but need not be. The ridges may be of constant or varying pitch and height. The two members may be mounted such that the spacing between them can be adjusted, preferably between a setting wherein the plane defining the outer extent of that portion of one member coincides with the plane defining the outer extent of the profiling of the opposing member and: a wider setting, and preferably adjustable independently at the entry and exit ends. The members may be substantially of metal e.g. ferrous metal such as mild steel or spheroidal graphite iron and are equipped with cooling and/or heating means, such as drillings for flow of thermal liquid, or heaters, desirably with thermostats, settable at a temperature to suit the material, such as (for example for polypropylene) from 125 °C to 155 °C. The members may have a (usually convex) chamfered edge parallel to the tape transport direction, to make for ease of rethreading.

Usually, the apparatus will further comprise means for material transport generally in line with the gap between the members and generally transverse to the ridges. Usually the means of the transport can pull material out of the members at a speed of 0.85 to 30 times the speed at which it feeds the material into them, and to perform the method set forth above, preferably the speeds ratio is in the range (2 to 30) or (4 to 20) or (5 to 10) : 1 or is in the range (0.85 to 0.97) : 1.

In this method and apparatus, suitably adapted as necessary, woven fabric can be treated, even if the fabric incorporates irregularities. The apparatus and method could be used for drying various yarns of fabrics from ribbons to broadloom fabric.

Plant may comprise two sets of such apparatus, the first apparatus operating at a speeds ratio of 2 to 30 : 1 and the second apparatus operating at a speeds ratio of 0.85 to 0.97 : 1, for sequential drawing and relaxing as already mentioned. For further integration, the plant also may include an extruder for forming a sheet to be transported into the first apparatus, which may include a sheet splitter (for forming tapes side-by-side) before the material enters the members. Alternatively the plant may have a spinneret for several (e.g. thousands) of separate mono-filaments, which may be wound for sale and use directly, or the plant may twist together (usually in groups) the monofilaments passing out of the second apparatus, with an optional transversely segmented member for applying a different temperature to some of the monofilaments to impart differential reheating shrinkage whereby, on subsequent reheating, to bulk the yarn.

Thus the method and apparatus and plant set forth may draw and/or relax (anneal) tape, yarn, filament or fibre and/or the heat-treatment may heat-set fabric and yarns e.g. air-textured tow and/or may be used in the production of for example high-bulk hand-knitting yarns by providing means for imparting differential shrinkage of differently treated tow to bulk it up.

The method and apparatus may be adapted for multistage drawing, multistage relaxing or other multistage heat treatment.

The invention will now be described by way of example with reference to the accompanying drawings, of which:

- Figure 1 shows the method according to the invention being performed by apparatus (of which part is removed for clarity) according to the invention,
- Figure 2 is a cross-section of a part of a machined block (alternative to that described hereinafter in relation to Figure 1) in apparatus according to the invention, and
- Figure 3 is a schematic view of plant according to the invention.

In Figure 1, two identical mild steel cast and machined blocks 1 and 2 are fixed opposing each other,
i.e. face to face, but not touching. Part of the block 1 is cut away for clarity. Chamfers 1a and 2a on the blocks 1 and 2 respectively form a groove leading to the gap between the blocks. Each block has five machined parallel curved ridges 20 semi-circular in cross-section of diameter 1/2 cm, pitch 1 1/2 cm and length 10 cm, and starts with its left-hand edge (facing the ridged face) at the summit of a ridge and its right-hand edge in the valley. The blocks being identical, when they face each other, ridge faces valley and vice versa.

Tape 3 to be heat-treated is introduced between the blocks 1 and 2 sideways down the chamfered groove entry 1a/2a. The blocks are sufficiently close together that the tape has sliding contact over each ridge on each block alternately; frictional drag on the tape may be altered by altering the gap between the blocks.

Four cartridge-type rod electric heaters 4 (only three shown) are inserted in holes drilled in the blocks 1 and 2 and are thermostatically set to 130 C. (They are rated at 130 W each). Polypropylene tape initially 6 mm wide by 0.1 mm thick is drawn out of the apparatus at 100 m/min at a draw ratio (= speed out : speed in) of 6 : 1. While with a hot-air oven, the tape emerges having, as theoretically predictable, a thickness of (original thickness)/V(draw ratio) and a width of (original width)/V(draw ratio), the tape drawn out of this apparatus is relatively wider and thinner.

After the tape is heat-treated and drawn, it is passed through annealing blocks (identical apparatus) at an appropriate higher block temperature and appropriate overfeed (draw ratio of less-than-1 : 1). If a longer annealing duration is required, a longer block may be provided; alternatively it is very easy to add any desired number of pairs of blocks, which, indeed, could be made as an off-the-shelf item. Cooling blocks could also be added if required.

Ridges would normally be machined out of the solid, but may be formed as fixed or rotatable heated tubes or bars attached to mounting blocks. The ridges need not be parallel or evenly spaced or of precisely identical heights, although manufacture is easier if they are. Highly polished or sophisticated sliding surfaces may be provided, but carefully machined mild steel is adequate. The ridges may be fairly flat-topped, i.e. may be plateau, not necessarily having a clearly defined summit.

In this method and apparatus, woven fabric can be treated, even if it incorporates irregularities. The apparatus and method could be used for drying various yarns or fabrics from ribbons to broadloom fabric.

In Figure 2, a pair of mild steel machined blocks 1 and 2 are assembled on the same principle as Figure 1. These blocks are for a larger-scale of operation than Figure 1, being 1 m wide in the direction of the ridges and 250 mm long along the direction of the tape. The ridges 20 have a plateau of about 5 1/2 mm, separated by valleys of about 6 1/2 mm (both measured in the direction of the tape) ; the valley walls are 2 1/2 mm high and occupy 1/4 mm in plan; thus the ridges have a repeat distance of about 5 1/2 + 1/4 + 6 1/2 + 1/4 = 12 mm. The valley walls are radiuset (1/2 mm radius) where they meet the plateaux, which themselves are slightly domed (by about 0.1 mm). After prolonged running under good conditions, the plateaux, out of their 5 1/2 mm in the direction of the tape 3, are seen to be polished by the tape over about 3 mm. Flat-topped plateaux are also satisfactory, provided the aforesaid radiusing is there, or at any rate that no sharp edges are presented to the tape. Thermostatic cartridge heaters (not shown) are inserted at 10 cm intervals in the block, giving a rating of 28 kW/m² ; thus the pair of blocks described is rated at 14 kW but in steady use would be expected to consume about 7-8 kW.

In Figure 3, two pairs of the Figure 2 block are used, as will be described. An extruder 30 produces a continuous sheet or film 31 of polypropylene, 960 mm wide and 0.1 mm thick, which is to be formed into treated tape: The sheet passes through chill rolls 32 and is slit by a slitter (an array of parallel mounted blades) into 160 tapes each 6 mm wide, which then pass over a first speed-regulating godet G1. To maintain separation of the tapes, a spacer 35 has guide pins 50 mounted so as to guide the tapes to spread laterally slightly.

The tapes then enter the one-metre-wide pair 37 of blocks as described in Figure 2. The spacing of the blocks is such that the tapes (held taut) are an easy sliding fit at the entry side; the blocks may be adjusted to be slightly closer at the exit side. The tapes are drawn under tension and become much thinner on their 250 mm journey through the block 37, to an extent determined by the speed of the second godet G2. The temperature of the blocks is typically 135 C. Tests have shown that the tape surface actually reaches 120 C on leaving the blocks 37. To achieve the same result using a conventional hot-air oven and the same speeds for godets G1 (21 m/min) and G2 (150 m/min), the oven air must be heated to over 160 C and the oven must be at least 3 m long. The space saving offered by the very much shorter blocks is very significant. The temperatures of the blocks are chosen by trial and error.

The tapes are then passed through a second pair 38 of blocks, set at 150 C to anneal (relax) the tapes, which are transported by a third godet G3 running at 142 m/min to winders 40. The ratios of the godet speeds will be chosen according to the final product requirements. The blocks 38 are identical to the blocks 37 in this example, but in some cases it may be advantageous for the blocks 38 to be longer than 37 in the direction of tape transport.

More detailed results at various godet speeds are set out hereafter, but a further discussion of block spacing is appropriate with reference to Figure 2. The blocks must not be so close that the plateaux of both blocks intermesh, for then the frictional drag on the tapes is so great that breakages become too frequent. Indeed the planes of the plateaux are preferably just far enough apart that the tape is not forcibly
deviated from linearity as it passes between the blocks. In practice, the blocks may be even slightly further apart, as the tape is seen to flutter to make touching contact with both blocks on several plateaux at any instant. Without such contact, the advantageous heat transfer afforded by the invention cannot be assured, and thus much greater block spacing would not be acceptable. The best block spacing for a given material will be found by trial and error.

In the drawing stage (blocks 37), the location in the blocks of the actual necking of the tape is remarkably consistent near the entry side, Taking at not-air oven as the basis for comparison, being today's (1985) most widely used tape heat treatment means, the location within a hot-air oven where necking occurs is found to wander, leading to variations in tape properties as is demonstrated hereinafter.

There now follow tables showing the results from treating this tape by this method at different draw ratios (= speeds ratio G2 : G1) and input speeds, in terms of breaking stress (tenacity), breaking strain (elongation) and shrinkage (when reheated later to 130 C). The results from a conventional 160 C hot-air oven are shown for comparison. The consistency in both tenacity and breaking strain (which can be measured in terms of a statistical function known as CV, the coefficient of variation) can be seen to be much improved. Additionally, in these examples, this tape has a softer feel and clearer appearance than when treated in a hot-air oven.

All the tests reported were performed using polypropylene containing 3 wt% low-density polyethylene, on the apparatus of Figure 3, or on a conventional 3 m hot-air oven where stated. The annealing in Tables 1-3 was as already described. *Shrinkage* is a measure of the thermal dimensional stability of the tape, low values indicating greater stability. Unless otherwise stated, G2 ran at 160 m/min.

In place of the winders 40, if monofilaments are treated instead of tapes and if the annealing is at different temperatures for some filaments so that they will shrink differentially on later reheating, a spinner may re-unite groups of the filaments to form hand-knitting multifilament yarns which thus have bulk imparted to them. The different temperatures are achieved by segmenting one of the one-metre-wide annealing blocks 38 into five 20 cm blocks side-by-side each set to a different temperature.

(See tables... pages 6-10)
<table>
<thead>
<tr>
<th>Draw ratio (G2:G1)</th>
<th>Temperature of block 37°C</th>
<th>Tenacity (g/den)</th>
<th>CV (g/den)</th>
<th>Shrinkage (%)</th>
<th>Breaking strain (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:1</td>
<td>125°C</td>
<td>972</td>
<td>4.65</td>
<td>2.4</td>
<td>28.80</td>
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<td>7:1</td>
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<td>973</td>
<td>5.75</td>
<td>3.2</td>
<td>16.50</td>
</tr>
<tr>
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<td>125°C</td>
<td>976</td>
<td>6.25</td>
<td>4.1</td>
<td>13.60</td>
</tr>
<tr>
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<td>974</td>
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<td>9.40</td>
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<td>22.60</td>
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<td>982</td>
<td>5.70</td>
<td>3.5</td>
<td>17.10</td>
</tr>
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<td>130°C</td>
<td>974</td>
<td>6.15</td>
<td>5.1</td>
<td>13.00</td>
</tr>
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<td>130°C</td>
<td>977</td>
<td>5.66</td>
<td>4.2</td>
<td>9.80</td>
</tr>
</tbody>
</table>

**Table 1**

<table>
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<tr>
<th>Draw ratio (G2:G1)</th>
<th>Temperature of block 37°C</th>
<th>Tenacity (g/den)</th>
<th>CV (g/den)</th>
<th>Shrinkage (%)</th>
<th>Breaking strain (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:1</td>
<td>137°C</td>
<td>982</td>
<td>4.50</td>
<td>2.8</td>
<td>18.30</td>
</tr>
<tr>
<td>7:1</td>
<td>137°C</td>
<td>976</td>
<td>5.70</td>
<td>3.5</td>
<td>16.80</td>
</tr>
<tr>
<td>8:1</td>
<td>137°C</td>
<td>976</td>
<td>6.30</td>
<td>3.6</td>
<td>13.50</td>
</tr>
<tr>
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<td>5.75</td>
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<td>989</td>
<td>5.80</td>
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<td>6.30</td>
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<td>Draw ratio (G2:G1)</td>
<td>Temperature of blocks (°C)</td>
<td>Tenacity (g/den)</td>
<td>CV</td>
<td>Breaking strain (%)</td>
<td>CV</td>
</tr>
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<td>-------------------</td>
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<td>---------------------</td>
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</tr>
<tr>
<td>6:1</td>
<td>130-133C</td>
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<td>5.30</td>
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<tr>
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<td>130-133C</td>
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<tr>
<td>8:1</td>
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<td>1017</td>
<td>4.40</td>
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<td>6.30</td>
<td>4.9</td>
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<td>9:1</td>
<td>142-145C</td>
<td>142-145C</td>
<td>5.80</td>
<td>8.45</td>
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<td>Draw ratio (C2:G1)</td>
<td>6:1</td>
<td>7:1</td>
<td>8:1</td>
<td>9:1</td>
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<td>Hot-air oven temperature</td>
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<td>160°C</td>
<td>160°C</td>
<td>160°C</td>
<td>170°C</td>
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<tr>
<td>Shrinkage (%)</td>
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<td>5.35</td>
<td>9.97</td>
<td>9.98</td>
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<td>CV (%)</td>
<td>21.10</td>
<td>10.5</td>
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<tr>
<td>CV (%)</td>
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<td>7.8</td>
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Table 3: Hot-air oven - not according to the invention
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Chill Roll 32</th>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>1st Oven Denier (C)</th>
<th>2nd Oven Denier (C)</th>
<th>Shrinkage (%)</th>
<th>Breaking strain (A) CV</th>
<th>Tenacity (g/den) CV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.9</td>
<td>21.4</td>
<td>150</td>
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Hot-air oven - not according to the Invention.
Table 5

According to invention - Figure 3

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Claims

1. A method of thermally treating long flexible material (3), comprising passing it between two opposed profiled heated or cooled members (1, 2), wherein the profile of the members comprises a ridge (20) running generally transversely to the direction of passage of the material, the spacing between the members (1, 2) being sufficiently close that the material (3) contacts each member, the method being characterised in that the profile of the members (1, 2) is ridges (20) and valleys, the ridges (20) of one member (1) facing the valleys of the opposing member (2), the material contacting each member at a plurality of locations yet the spacing between the members being sufficiently large that the material can pass between them without being constrained to deflect from coplanarity by more than its own thickness.

2. A method according to Claim 1, wherein said spacing is sufficiently large that the material (3) can pass between the members (1, 2) without being constrained to deflect from coplanarity by more than 1/4 of its thickness.

3. A method according to either preceding claim, wherein the ridges (20) where contacting the material (3) are generally smooth.

4. A method according to either preceding claim, wherein each member (1, 2) has at least ten ridges (20) for contacting the material.

5. A method according to any preceding claim, wherein the residence time of any point on the material (3) between the members (1, 2) is 0.01 to 0.2 seconds.

6. A method according to Claim 5, wherein said residence time is 0.02 to 0.1 seconds.

7. A method according to any preceding claim, wherein the material (3) is synthetic filament or tape.

8. A method according to Claim 7, wherein the material (3) is polyolefin tape.

9. A method according to Claim 7 or 8, wherein the members (1, 2, 37) are heated to 125 to 145 C. the members (37) : (speed entering the members (37)) is from 2 : 1 to 30 : 1.

10. A method according to Claim 9, wherein the tape is drawn out such that the ratio (speed leaving the members (37)) is from 0.85 : 1 to 0.97 : 1.

11. A method according to Claim 7 or 8, wherein the members (1, 2, 38) are heated to 135 to 155 C.

12. A method according to Claim 11, wherein the filament or tape is relaxed such that the ratio (speed leaving the members (38)) is from 0.85 : 1 to 0.97 : 1.

13. A method according to Claim 11, wherein several filaments or tapes (3) are treated by the method side-by-side, the tapes optionally being forming by slitting (34) a sheet (31) before the drawing step, or the filaments optionally coming from a common spinneret.

14. A method according to Claim 13, wherein the filaments are twisted together after the relaxing step.

15. A method according to Claim 14, wherein a different temperature is applied to some of the filaments.

16. Apparatus for thermally treating long flexible material such as tape, comprising two opposed profiled members (1, 2) between which material (3) may be passed, wherein the profile of the members comprises a ridge (20) running generally transversely to the direction of passage of the material, the members (1, 2) being spaced sufficiently closely that material (3) passing between them would touch each member, and means (4) for heating or cooling the members, the apparatus being characterised in that the profile of the members is ridges (20) and valleys, the ridges (20) of one member (1) facing the valleys of the opposing member (2), the spacing between the members being sufficiently close that the material would touch each member at a plurality of locations yet being sufficiently large that the material can pass between them without being constrained to deflect from coplanarity by more than its own thickness.

17. Apparatus according to Claim 16, wherein the means (4) for heating or cooling the members are passages within the members for flow of thermal fluid.

18. Apparatus according to Claim 16, wherein the means (4) are heaters on or within the members, controlled by thermostats.

19. Apparatus according to Claim 16, 17 or 18, wherein the members (1, 2) are mounted such that the spacing between them can be adjusted between : a setting wherein the plane defining the outer extent of the profiling of one member coincides with the plane defining the outer extent of the profiling of the opposing member and : a wider setting.

20. Apparatus according to Claim 19, wherein the spacing can be adjusted independently at the entry and exit ends.

21. Apparatus according to any of Claims 16 to 20, wherein the members (1, 2) have a chamfered edge (1a, 2a) parallel to the transport direction, to facilitate retreading.

22. Apparatus according to any of Claims 16 to 21, wherein the members (1, 2) are substantially of metal.

23. Apparatus according to Claim 22, wherein the metal is ferrous.

24. Apparatus according to any of Claims 16 to 23, wherein the ridges (20) where intended to contact the material (3) are generally smooth.

25. Apparatus according to any of Claims 16 to 24, wherein each member (1, 2) has at least ten ridges (20) for contacting the material (3).

26. Apparatus according to any of Claims 16 to 25, further comprising means (91, 92, 93) to transport material (3) generally in line with the gap between the members (1, 2, 97, 38) and generally transverse to...
27. Apparatus according to Claim 26, wherein the means of the transport (91, 92, 93) can pull material out of the members (37, 38) at a speed from 0.85 to 30 times the speed at which it feeds the material into them.

28. Apparatus according to Claim 27, wherein the speeds ratio is in the range (2 to 30) : 1 or is in the range (0.85 to 0.97) : 1.

29. Plant comprising two sets in tandem of apparatus according to Claim 26, the first apparatus (91, 37) operating at a speeds ratio of 2 to 30 : 1 and the second apparatus (38, 93) operating at a speeds ratio of 0.85 to 0.97 : 1.

30. Plant according to Claim 28, further comprising and extruder (30) for forming a sheet (31) to be transported into the first apparatus (91, 37), which comprises a slitter (34).

**Patentansprüche**

1. Verfahren zur thermischen Behandlung von langem flexiblem Material (3) durch Hindurchführen zwischen einander gegenüberstehenden mit Profil versehenen geheizten oder gekühlten Teilen (1, 2), worin das Profil der Teile einen im allgemeinen transversal zur Durchführungserichtung des Materials verlaufenden Rücken (20) aufweist und der Abstand zwischen den Teilen (1, 2) hinreichend gering ist, daß das Material (3) jedes Teile berührt, wobei das Verfahren dadurch gekennzeichnet ist, daß das Profil der Teile (1, 2) aus Rücken (20) und Tälern besteht, wobei die Rücken (20) eines jeden Teils (1) den Tälern des gegenüberstehenden Teiles (2) zugekehrt sind, wobei das Material jedes Teile an einer Vielzahl von Orten berührt, aber der Abstand zwischen den Teilen hinreichend groß ist, daß das Material zwischen ihnen durchlaufen kann, ohne zu einer Abweichung von der Koplanarität um mehr als seine eigene Dicke gezwungen zu sein.

2. Verfahren nach Anspruch 1, worin der Abstand hinreichend groß ist, daß das Material (3) zwischen den Teilen (1, 2) hindurchgelangen kann, ohne zu einer Abweichung von der Koplanarität von mehr als 1/4 seiner Dicke gezwungen zu sein.

3. Verfahren nach einem der vorstehenden Ansprüche, worin die Rücken (20) dort, wo sie das Material (3) berühren, im allgemeinen glatt sind.

4. Verfahren nach einem der vorstehenden Ansprüche, worin jedes Teil (1, 2) wenigstens 10 Rücken (20) zur Berührung mit dem Material aufweist.

5. Verfahren nach einem der vorstehenden Ansprüche, worin die Verweildauer eines jeden Punktes auf dem Material (3) zwischen den Gliedern (1, 2) 0,01 bis 0,2 s beträgt.

6. Verfahren nach Anspruch 5, worin die Verweildauer 0,02 bis 0,1 s beträgt.

7. Verfahren nach einem der vorstehenden Ansprüche, worin das Material (3) ein synthetisches Filament oder Band ist.

8. Verfahren nach Anspruch 7, worin das Material (3) ein Polyolefinband ist.

9. Verfahren nach Anspruch 7 oder 8, worin die Teil (1, 2, 37) auf 125 bis 145 °C erhitzt werden.

10. Verfahren nach Anspruch 9, worin das Band so herausgezogen wird, daß das Verhältnis (Geschwindigkeit beim Verlassen der Teile (37)) : (Geschwindigkeit beim Eintreten in die Teile (37)) 2 : 1 beträgt.

11. Verfahren nach Anspruch 7 oder 8, worin die Teil (1, 2, 38) auf 135 bis 155 °C erhitzt werden.

12. Verfahren nach Anspruch 11, worin das Filament oder Band so relaxiert wird, daß das Verhältnis (Geschwindigkeit beim Verlassen der Teile (38)) : (Geschwindigkeit beim Eintreten in die Teile (38)) 0,85 : 1 beträgt.

13. Verfahren nach Anspruch 13, worin mehrere Filamente oder Bänder (3) nach dem Verfahren nebeneinander behandelt werden, wobei die Bänder gegebenenfalls durch Aufschlitzen (34) einer Folie (31) vor dem Verziehungsschritt gebildet werden oder die Filamente gegebenenfalls aus einer herkömmlichen Spinddüse kommen.


15. Verfahren nach Anspruch 14, worin eine unterschiedliche Temperatur auf einige der Filamente angewandt wird.

16. Vorrichtung zur thermischen Behandlung von langem, flexiblen Material, wie Band, welche zwei einander gegenüberstehende mit Profilen versehene Teile (1, 2), zwischen denen Material (3) durchgeführt werden kann, worin das Profil der Teile einen im allgemeinen transversal zur Durchführungserichtung des Materials verlaufenden Rücken (20) umfaßt und die Teile (1, 2) einen so geringen Abstand zueinander haben, daß das zwischen ihnen durchlaufenden Material (3) jedes Teil zu berühren pflegt, sowie Einrichtungen (4) zum Erhitzen oder Kühlern der Teile umfaßt, worin die Vorrichtung dadurch gekennzeichnet ist, daß das Profil der Teile aus Rücken (20) und Tälern besteht, wobei die Rücken (20) eines Teils (1) den Tälern des gegenüberstehenden Teils (2) zugekehrt sind, wobei der Abstand zwischen den Teilen hinreichend gering ist, daß das Material ein jedes Teil an einer Vielzahl von Orten zur berühren pflegt, jedoch hinreichend groß ist, daß das Material zwischen ihnen durchlaufen kann, ohne zu einer Abweichung von der Koplanarität um mehr als seine eigene Dicke gezwungen sein.
17. Vorrichtung nach Anspruch 16, worin die Einrichtungen (4) zum Erhitzen oder Abkühlen der Teile Kanäle innerhalb der Teile zum Durchfluss einer thermischen Flüssigkeit sind.
18. Vorrichtung nach Anspruch 16, worin die Einrichtungen (4) durch Thermostaten gesteuerte Heizelemente auf oder innerhalb des Teils sind.
19. Vorrichtung nach Anspruch 16, 17 oder 18, worin die Teile (1, 2) so angeordnet sind, daß der Zwischenraum zwischen ihnen eingestellt werden kann zwischen einer Einstellung, worin die die äußere Begrenzung des Profils des einen Teils definierende Ebene mit der die äußere Begrenzung des Profils des gegenüberliegenden Teils definierende Ebene zusammenfällt, und einer weiteren Einstellung.
20. Vorrichtung nach Anspruch 19, worin der Abstand unabhängig am Eintritts- und Austrittsseite eingestellt werden kann.
21. Vorrichtung nach einem der Ansprüche 16 bis 20, worin die Teil (1, 2) eine parallel zur Transportrichtung verlaufende abgekrümmte Kante zur Erleichterung des Wiedereinführens aufweist.
22. Vorrichtung nach einem der Ansprüche 16 bis 21, worin die Teile (1, 2) im wesentlichen aus Metall sind.
23. Vorrichtung nach Anspruch 22, worin das Metall ein Einsenmetall ist.
24. Vorrichtung nach einem der Ansprüche 16 bis 23, worin die Rücken (20) dort, wo sie das Material berühren sollen, im allgemeinen glatt sind.
25. Vorrichtung nach einem der Ansprüche 16 bis 24, worin jedes Teil (1, 2) wenigstens 10 Rücken (20) zur Berührung des Materials (3) aufweist.
26. Vorrichtung nach einem der Ansprüche 16 bis 25, welche weiterhin Einrichtungen (G1, G2, G3) zum Transport von Material (3), im allgemeinen auf einer Linie mit der Spalte zwischen den Teilen (1, 2, 37, 38) und im allgemeine transversal zu den Rücken (20) aufweist.
27. Vorrichtung nach Anspruch 26, worin die Transporteintrichtungen (G1, G2, G3) das Material mit 0,85 bis 30-facher Geschwindigkeit aus den Teilen (37, 38) herausziehen können, mit der sie das Material einspeisen.
28. Vorrichtung nach Anspruch 27, worin das Geschwindigkeitsverhältnis im Bereich von 2 bis 30: 1 oder im Bereich von (0,85 bis 0,97) : 1 liegt.
29. Anlage, enthaltend zwei Tandemauflagbauten der Vorrichtung nach Anspruch 26, wobei die erste Vorrichtung (G1, 37) bei einem Geschwindigkeitsverhältnis von 2 bis 30 : 1 betrieben wird und die zweite Vorrichtung (38, G3) bei einem Geschwindigkeitsverhältnis von 0,85 bis 0,97 : 1.
30. Anlage nach Anspruch 29, die ferner einen Extruder (30) zur Bildung von Folien (31) umfaßt, die in die erste Vorrichtung (G1, 37), die eine Zerschneidervorrichtung (34) umfaßt, transportiert wird.

35 Revendications

1. Procédé de traitement thermique d'un matériau souple et long (3), comprenant le passage du matériau entre deux organes profilés opposés chauffés ou refroidis (1, 2), le profil des organes comprenant une crête (20) disposée transversalement à la direction de passage du matériau de façon générale, l'espacement des organes (1, 2) étant suffisamment faible pour que le matériau (3) soit au contact des deux organes, le procédé étant caractérisé en ce que le profil des organes (1, 2) est formé de crêtes (20) et de creux, les crêtes (20) d'un organe (1) étant en face des crêtes de l'organe opposé (2), le matériau étant au contact de chacun des organes à plusieurs emplacements, mais l'espacement des organes est cependant suffisamment grand pour que le matériau puisse passer entre eux sans être obligé de s'écartner d'un plan de plus de sa propre épaisseur.
2. Procédé selon la revendication 1, dans lequel l'espacement est suffisamment grand pour que le matériau (3) puisse passer entre les organes (1, 2) sans être obligé de s'écartner d'un plan de plus du quart de son épaisseur.
3. Procédé selon l'une quelconque des revendications précédentes, dans lequel les crêtes (20), à l'endroit du contact avec le matériau (3), sont lisses de façon générale.
4. Procédé selon l'une quelconque des revendications précédentes, dans lequel chaque organe (1, 2) a au moins six crêtes (20) destinées à être au contact du matériau.
5. Procédé selon l'une quelconque des revendications précédentes, dans lequel le temps de séjour en un point quelconque sur le matériau (3) entre les organes (1, 2) est compris entre 0,01 et 0,2 s.
6. Procédé selon la revendication 5, dans lequel le temps de séjour est compris entre 0,02 et 0,1 s.
7. Procédé selon l'une quelconque des revendications précédentes, dans lequel le matériau (3) est un filament ou ruban synthétique.
8. Procédé selon la revendication 7, dans lequel le matériau (3) est un ruban de polyéthylène.
9. Procédé selon l'une des revendications 7 et 8, dans lequel les organes (1, 2, 37) sont chauffés entre 125 et 145 °C.
10. Procédé selon la revendication 9, dans lequel le ruban est étiré de manière que le rapport (vitesse à la sortie des organes (37)) : (vitesse à l'entrée des organes (37)) est compris entre 2 : 1 et 30 : 1.
11. Procédé selon l'une des revendications 7 et 8, dans lequel les organes (1, 2, 36) sont chauffés entre 135 et 155 °C.
12. Procédé selon la revendication 11, dans lequel le filament ou le ruban est relaxé de manière que
le rapport (vitesse à la sortie des organes (38)) : (vitesse à l'entrée des organes (38)) soit compris entre 0,85 : 1 et 0,97 : 1.

13. Procédé selon la revendication 12, dans lequel plusieurs filaments ou rubans (3) sont traités par le procédé, côte à côte, les rubans étant éventuellement formés par découpe (34) d'une feuille (31) avant l'étape d'étirage, ou des filaments provenant éventuellement d'une filière commune.

14. Procédé selon la revendication 13, dans lequel les filaments sont retournus après l'étape de relaxation.

15. Procédé selon la revendication 14, dans lequel une température différente est appliquée à certains des filaments.

16. Appareil de traitement thermique d’un matériau souple et long tel qu’un ruban, comprenant deux organes profilés opposés (1, 2) entre lesquels le matériau (3) peut passer, tels que le profil des organes comprend une crête (20) disposée transversalement à la direction de passage du matériau de façon générale, les organes (1, 2) étant espacés suffisamment tout en étant proches pour que le matériau (3) passant entre eux touche chacun des organes, et un dispositif (4) de chauffage ou de refroidissement des organes, l’appareil étant caractérisé en ce que le profil des organes comporte des crêtes (20) et des creux, les crêtes (20) d’un premier organe (1) étant en face des creux de l’organe opposé (2), l’espacement des organes étant suffisamment faible pour que le matériau touche chaque organe à plusieurs emplacements tout en étant suffisant pour que le matériau puisse passer entre eux sans être obligé de s’écarter d’un plan de plus de sa propre épaisseur.

17. Appareil selon la revendication 16, dans lequel le dispositif (4) de chauffage ou de refroidissement des organes comporte des passages formés dans les organes afin qu’un fluide thermique y circule.

18. Appareil selon la revendication 16, dans lequel le dispositif (4) est constitué par des organes de chauffage placés sur les organes ou dans ceux-ci et réglés par des thermostats.

19. Appareil selon l’une quelconque des revendications 16, 17 et 18, dans lequel les organes (1, 2) sont montés de manière que la distance les séparant puisse être réglée entre un réglage dans lequel le plan délimitant l’extérieur du profil d’un premier organe coïncide avec le plan délimitant l’extérieur du profil de l’organe en regard, et un réglage de plus grand espacement.

20. Appareil selon la revendication 19, dans lequel l’espacement peut être réglé indépendamment aux extrémités d’entrée et de sortie.

21. Appareil selon l’une quelconque des revendications 16 à 20, dans lequel les organes (1, 2) ont un bord chanfreiné (1a, 2a) parallèle à la direction de transport afin qu’un réenfillement soit facilité.

22. Appareil selon l’une quelconque des revendications 16 à 21, dans lequel les organes (1, 2) sont formés pratiquement de métal.

23. Appareil selon la revendication 22, dans lequel le métal est ferreux.

24. Appareil selon l’une quelconque des revendications 16 à 23, dans lequel les crêtes (20), aux endroits où elles sont destinées à être au contact du matériau (3), sont lisses de façon générale.

25. Appareil selon l’une quelconque des revendications 16 à 24, dans lequel chaque organe (1, 2) a au moins dix crêtes (20) destinées à être au contact du matériau (3).

26. Appareil selon l’une quelconque des revendications 16 à 25, comprenant en outre un dispositif (G1, G2, G3) de transport du matériau (3) de manière générale dans l’alignement de l’espace formé entre les organes (1, 2, 37, 38) et transversalement aux crêtes (20) de façon générale.

27. Appareil selon la revendication 26, dans lequel le dispositif de transport (G1, G2, G3) peut tirer le matériau hors des organes (37, 38) à une vitesse comprise entre 0,85 et 30 fois la vitesse à laquelle il transmet le matériau à ces organes.

28. Appareil selon la revendication 27, dans lequel le rapport des vitesses est compris dans la plage (2 à 30) : 1 ou dans la plage (0,85 à 0,97) : 1.

29. Installation comprenant deux jeux d’appareils selon la revendication 26 montés en tandem, le premier appareil (G1, 37) travaillant avec un rapport de vitesses de (2 à 30) : 1 et le second appareil (38, G3) travaillant avec un rapport de vitesses de (0,85 à 0,97) : 1.

30. Installation selon la revendication 29, comprenant en outre une extrudeuse (30) destinée à former une feuille (31) qui doit être transportée dans le premier appareil (G1, 37) qui comporte une découpeuse (34).