Processing and products of refined flax and hemp

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2013-10-31
1. Introduction

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1. Introduction

Bast fibers: extracted from the bast of plants, such as flax, hemp (industrial hemp, not drug, with low THC content), ramie, jute, kenaf, and so on; Bast fibers are cellulosic fibers, but with high content gums; Prefer properties of these fibers: high permeability, good water absorption, and better anti-bacterial, easy recycled; Considered as sustainable resource of natural fibers.
1. Introduction

Bast fibers: extracted from the bast of plants, such as flax, hemp (industrial hemp, not drug, with low THC content), ramie, jute, kenaf, and so on; Bast fibers are cellulosic fibers, but with high content gums; Prefer properties of these fibers: high permeability, good water absorption, and better anti-bacterial, easy recycled; Considered as sustainable resource of natural fibers.
Planting of flax
Planting of hemp
These fibers are also characterized with more rigidity, coarser and worse process ability; The traditional textile products made of these fibers are usually restricted to heavier and coarser fabrics.
Linen (products of flax)
Fabric made of hemp
Because of the high content of gums (non-cellulosic materials), we should remove gums before spinning processing to improve the processing ability of the fiber and the performance of the end products.

**Composition of flax and hemp raw materials**

<table>
<thead>
<tr>
<th></th>
<th>cellulose</th>
<th>hemi-cellulose</th>
<th>pectin</th>
<th>lignin</th>
<th>wax</th>
<th>water soluble</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flax</td>
<td>65.0-75.0</td>
<td>12.0-15.0</td>
<td>1.4-5.7</td>
<td>2.5-5.0</td>
<td>1.2-1.8</td>
<td>4.5-9.0</td>
</tr>
<tr>
<td>hemp</td>
<td>51.0-63.0</td>
<td>16.0-18.0</td>
<td>3.8-6.8</td>
<td>6.3-9.3</td>
<td>1.0-1.8</td>
<td>9.0-9.9</td>
</tr>
</tbody>
</table>
As to flax and hemp fiber, because of the short length of their single fiber (10-20mm), we have to remain some gums (not remove all gums) to bind the single fibers together, to form a bundle fiber, which is long (therefore, is thick) enough to be processed.
Decorticate of hemp
Scutched flax and hemp fibers
Traditional processing of flax and hemp

The traditional processing of flax is focused on the long and coarse scutched fiber, with the (bundle) fiber length of 500-700 mm and fineness ranges from 150-300 metric count;

The wet spinning processing of traditional yarn forming processing:
Harvested stalk → retting → scutching → hackling → sliver forming → gilling (5 passages) → roving → boiling (degumming) → wet ring spinning → drying → winding
The procedure of traditional wet spinning processing of flax is more cost and lower efficiency than that of cotton spinning system. In most cases, the hemp, which has the similar property to flax fiber, is also processed as the wet spinning processing.
Because of the more residual gums existing, and because of the wet spinning itself, the resultant flax and hemp yarn is harder and coarser (usually in the range of 14-36 Nm), which cannot meet the requirement of knitting yarns (softer, smooth with high evenness yarn).
Development of flax and hemp application

As the development on the application of fabrics, more and more knitted fabrics are widely used, meanwhile, the soft and fine yarn has more growing potential requirement as the development of knitting, therefore, the dry spinning processing of linen yarn is getting more and more attention.
2. Refining processing of flax and hemp

Refining processing, some times called cottonizing processing, is to treated the flax fiber or hemp fiber before spinning, to improve the property of fibers, make them softer and finer, like cotton fiber, which is easy to be processed and its products have wide application.
Actually, the refining of the fiber is deep degumming before the spinning processing. Chemical treatment is usually employed. Instead of roving boiling, the scutched (flax and hemp) fiber and noil of scutching and hackling is treated with NaOH, H₂O₂, and some other chemicals, to remove more but also not all gums in fibers.
Configuration of fibers before and after degumming
Processing of refining of flax and hemp

• Immersed in acid ($H_2SO_4$) $\rightarrow$ washing $\rightarrow$ Chemical degumming $\rightarrow$ neutralization (washing with acid)$\rightarrow$washing $\rightarrow$ dewater $\rightarrow$ oiling $\rightarrow$ drying $\rightarrow$ opening

• Immersed in acid: $H_2SO_4$ 1-2g/L, 50$^\circ$C, 1-2h, liquor ratio:1:15

• Chemical degumming: boiling with NaOH and $H_2O_2$, some other agents such as stabilizer $Na_2SiO_3$, and penetrant JFC are added.
Effect of Dosage of NaOH on tenacity and fineness (Nm) of degummed flax fiber
Effect of Dosage of $\text{H}_2\text{O}_2$ on tenacity and fineness (Nm) of degummed flax fiber
Effect of boiling temperature on tenacity and fineness (Nm) of degummed flax fiber
Effect of boiling time on tenacity and fineness (Nm) of degummed flax fiber

![Graph 1: Tenacity (cN/dtex) vs. Boiling Time (min)]

![Graph 2: Fineness (Nm) vs. Boiling Time (min)]
Optimum of refining on flax and hemp

Flax
• immersed (dip) in sulphuric-acid: 1g/L, 50°C, 1h;
• boiling: peroxide:6%, NaOH:4%, sodium carbonate: 2%, sodium silicate (stabilizer): 2%, urea: 2%, penetrant JFC:1%, 85°C, 2h.

Hemp
• immersed in acid(H₂SO₄): 2g/L, 50°C, 1h
• Boiling:  H₂O₂ :10%, NaOH:6%, Na₂CO₃:4%, Na₂SiO₃:2%, urea 2%, JFC1%, 85°C, 2h,
or: Boiling only with alkali: Sodium hydroxide:10%, sodium tripolyphosphate: (Na₅P₃O₁₀)2%, urea2%, Sodium silicate2%, 100°C, 3h.
Degummed flax and hemp

After degumming, many gums have been removed, and the fiber are loosen, but still stick together, therefore, mechanical action is need to seperated the sticked fiber further.
Opening of degummed fibers

1. feed plate, 2. feed roller, 3. cylinder, 4. hood, 5. pressure roller, 6. screen cage
Refined flax and hemp fibers

With the reasonable action of opening, fiber can be separated into finer fiber with sufficient length (not single fiber).
Another method is stretch-breaking the degummed fiber, which is more reasonable than the opening with sawteeth cylinder, decreasing the short fiber content during the open action.
Stretch-broken sliver
Stretch-broken sliver

Twin stretch-broken sliver
Comparison of properties of refined and retted flax and hemp fibers

<table>
<thead>
<tr>
<th></th>
<th>flax</th>
<th>hemp</th>
<th>cotton</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>retted</td>
<td>refined</td>
<td>retted</td>
</tr>
<tr>
<td>Fineness(Nm)</td>
<td>150-250</td>
<td>1700-3000</td>
<td>130-250</td>
</tr>
<tr>
<td>Length(mm)</td>
<td>400-1200</td>
<td>25-40</td>
<td>500-2000</td>
</tr>
<tr>
<td>Tenacity(cN/tex)</td>
<td>3.5-4.5</td>
<td>3.2-4.7</td>
<td>2-3-3.5</td>
</tr>
<tr>
<td>Elongation(%)</td>
<td>2-3</td>
<td>2-3</td>
<td>2-3</td>
</tr>
</tbody>
</table>
3. Products of refined fibers

The dry spinning of refined flax and hemp fiber can be processed with the cotton spinning system instead of the wet spinning system:

Opening and cleaning → carding → preparation of combing → combing → drawing (2 passages) → roving → ring spinning
Comparison of regular yarns made by different fibers

<table>
<thead>
<tr>
<th></th>
<th>flax</th>
<th></th>
<th>hemp</th>
<th></th>
<th>cotton</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>retted</td>
<td>refined</td>
<td>retted</td>
<td>refined</td>
<td></td>
</tr>
<tr>
<td>Fineness (Nm)</td>
<td>16-36</td>
<td>30-60</td>
<td>12-32</td>
<td>25-60</td>
<td>20-100</td>
</tr>
<tr>
<td>Irregularity of yarn (CV%)</td>
<td>30-40</td>
<td>14-20</td>
<td>32-45</td>
<td>15-22</td>
<td>10-17</td>
</tr>
<tr>
<td>Tenacity (cN/tex)</td>
<td>18-25</td>
<td>8-12</td>
<td>17-27</td>
<td>8-13</td>
<td>8-11</td>
</tr>
<tr>
<td>CV of tenacity (%)</td>
<td>20-40</td>
<td>15-25</td>
<td>25-40</td>
<td>7-27</td>
<td>10-15</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>2-3</td>
<td>2-5</td>
<td>2-3</td>
<td>2-5</td>
<td>6-9</td>
</tr>
</tbody>
</table>
Quality of pure yarn (27.8tex) and blended yarn (18.5tex)

<table>
<thead>
<tr>
<th></th>
<th>Tenacity (cN/tex)</th>
<th>CV of tenacity (%)</th>
<th>elongation (%)</th>
<th>Irregularity (CV%)</th>
<th>Thins (-50%/km)</th>
<th>Thicks (+50%/km)</th>
<th>Neps (+280%/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pure linen</td>
<td>9.32</td>
<td>23.1%</td>
<td>3.27</td>
<td>24.13</td>
<td>1121</td>
<td>858</td>
<td>924</td>
</tr>
<tr>
<td>Pure hemp</td>
<td>8.95</td>
<td>25.32</td>
<td>3.01</td>
<td>25.06</td>
<td>1325</td>
<td>988</td>
<td>1084</td>
</tr>
<tr>
<td>linen55/cotton45</td>
<td>10.31</td>
<td>17.46</td>
<td>3.44</td>
<td>18.62</td>
<td>831</td>
<td>876</td>
<td>924</td>
</tr>
<tr>
<td>hemp55/cotton45</td>
<td>10.07</td>
<td>18.21</td>
<td>3.52</td>
<td>19.13</td>
<td>822</td>
<td>884</td>
<td>937</td>
</tr>
</tbody>
</table>
Traditional (wet) yarn and refined (dry) yarn
Fabrics made by traditional yarns
Fabric made by refined yarns
Products of refined hemp and flax fibers
4. Conclusion

• With the refining treatment on raw material, the flax and hemp fiber can be finer, softer and shorter, hence be processed in cotton spinning system;

• The yarn of refined fiber is much finer, softer and evener, can be use in more application(such as weaving and knitting)

• The refining of flax and hemp fiber can be expected to decrease the cost of yarn processing because of the short process procedure, high efficiency and better spinning-ability
Thanks!