The relative length of the channel section in which complete relaxation of normal stresses on the channel axis \( (L/D \approx 1.5-2) \) is comparable with the length of the spinneret channels which are used in the man-made fibre industry, due to which a residual orientation of the polymer macromolecules at the exit from the spinneret is possible.

**LITERATURE CITED**


**MATHEMATICAL DESCRIPTION OF THE MASS-EXCHANGE PROCESSES IN A VIBRATIONAL APPARATUS FOR WASHING COMPLEX YARNS**

T. G. Suris, A. N. Malyshev, and V. S. Matveev

Demands for the intensification of mass-exchange processes have led to the devising of vibrational apparatus for washing yarns, in which the complex yarn moves separated into elementary filaments in a countercurrent stream of liquid. Experiments on measuring the concentration of solvent at various points in the cross-section of the vibrational apparatus (in the space between elementary filaments of the complex yarn; in the gap between the complex yarn and the channel wall; and in the layer of liquid at the wall) at various distances from the inlet into the apparatus showed that in cross-sections of the stream of wash liquid, the concentration of solvent in it is increased.

In practical calculations of the mass-transfer process in a yarn, one of two models is ordinarily used, which reflect limiting cases of hydrodynamic regions of yarn interaction with the liquid. For the first model, in assigning boundary conditions it is assumed that the concentration of solvent on the yarn surface is constant along its entire length and is equal to its initial concentration in the liquid. The second model gives a description of the distribution of solvent concentrations both in the yarn and also in the liquid, but...
Fig. 1. Calculated curves for change in mean solvent concentration in wash liquid over the length of the path of yarn movement in a vibrational apparatus at various volume flow rates of liquid (in m³/h): 1) 0.005; 2) 0.025; 3) 0.058; ○ experimental points.

TABLE 1. Results of Calculating the Solvent Content of Yarn and of Wash Liquid

<table>
<thead>
<tr>
<th>Number of elementary filaments in complex yarn</th>
<th>Rate of yarn movement, m/min</th>
<th>Water flow rate, cm³/sec</th>
<th>H₂SO₄ content of liquid at overflow from vibrational apparatus, %</th>
<th>Residual H₂SO₄ content of yarn, % of polymer wt.</th>
</tr>
</thead>
<tbody>
<tr>
<td>800</td>
<td>90</td>
<td>16.11</td>
<td>0.465</td>
<td>0.0860</td>
</tr>
<tr>
<td>800</td>
<td>95</td>
<td>16.11</td>
<td>0.490</td>
<td>0.1140</td>
</tr>
<tr>
<td>800</td>
<td>100</td>
<td>16.11</td>
<td>0.515</td>
<td>0.1480</td>
</tr>
<tr>
<td>800</td>
<td>150</td>
<td>16.11</td>
<td>0.757</td>
<td>0.7590</td>
</tr>
<tr>
<td>1000</td>
<td>85</td>
<td>5.41</td>
<td>1.309</td>
<td>0.0142</td>
</tr>
<tr>
<td>1000</td>
<td>100</td>
<td>6.36</td>
<td>1.310</td>
<td>0.0410</td>
</tr>
<tr>
<td>1000</td>
<td>120</td>
<td>7.62</td>
<td>1.308</td>
<td>0.1140</td>
</tr>
<tr>
<td>1000</td>
<td>150</td>
<td>9.53</td>
<td>1.298</td>
<td>0.3250</td>
</tr>
<tr>
<td>1000</td>
<td>200</td>
<td>12.70</td>
<td>1.272</td>
<td>0.9160</td>
</tr>
</tbody>
</table>

thereupon it is considered that the yarn and liquid are moving with identical velocities in the same direction. It is obvious that neither of these models reflects the real observable picture of mass-exchange in vibro-washing. Therefore, to calculate the mass-transfer process in a vibrational apparatus, a numerical method has been developed, which uses a process model that takes into account the features of hydrodynamic interaction of the yarn with the liquid. The following assumptions have been adopted in setting up the model:

at the entrance to the apparatus, the solvent concentration is identical over the entire section of the elementary filament;

in the course of the time interval \( \Delta t_i = \Delta s_i / v_y = 0 \) (\( \Delta s_i \) and \( v_y \) are the path length of rate of yarn movement, respectively, \( i = 1, n \), where \( n \) is the number of elementary sections of length \( \Delta s_i \) into which the path length of yarn movement in the apparatus is arbitrarily divided) the concentration of solvent on the yarn surface remains constant and equal to the initial solvent concentration in the bulk of liquid \( \Delta V_i = G_1 \cdot \Delta t_i \) (\( G_1 \) is the volume flow rate of wash liquid) with which a section of yarn having the length \( \Delta s_i \) comes into contact during the time \( \Delta t_i \):

the volume flow rate of the liquid phase, \( G_1 \), in the yarn during the washing process is constant and equal to the volume flow rate of solvent in the spinning solution during the spinning stage:

\[
G_{1p} = \frac{v_y T}{1000 C_p} \left( \frac{100}{C_p} - 1 \right)
\]

(1)