MANUFACTURING CONTROL

MONITORING AND CONTROL OF THE PROCESS OF YARN PREPARATION FROM A POLYMER MELT BY ITS TENSION

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According to information and patent materials, there is an adequate stockpile of new methods of monitoring and controlling the process of preparing yarn using indirect nondestructive devices for monitoring its physical parameters — tension, temperature, electrostatic charge, etc. [1]. But the use of these methods in plants of the Man-Made Fiber Branch has not been assigned by any normative documents; therefore, they are used to a very limited extent. In the present article, we examine the possibility of monitoring and controlling the process of preparing polycaproamide yarn from a polymer melt via its tension.

The basic stages in yarn formation which determine yarn quality are the spinning and orientation strengthening (stretching) [2]. In Figs. 1 and 2, we give schemes for spinning and stretching polycaproamide yarn having a linear density of 187 tex, and also yarn-tension diagrams for the indicate schemes. Yarn tension was determined experimentally by using a tension-measuring device of the INN-6 type, serial output of which is being accomplished by the "Khimavtomatika" Barnaul'skii OKBA NPO.

Technical characteristics of INN-6 Instrument

| Linear density of yarn, % | 3—1000 |
| Rate of yarn movement, m/sec | 0.02—20 |
| Range of tension measurement, N | 0—15; 0—50 |
| Allowable basic reduced error, % | ±2.0 |

The instrument is portable, it has an autonomous feed power supply, it has a digital read-out device, and the disposition of the yarn in space can be any. The weight of the sensor does not exceed 0.7 kg; the weight of the measuring block is not over 1.5 kg. The power required is not over 0.1 W.

One can also use instruments of two types to measure yarn tension: the INN-1M, the INN-3U, the stationary yarn-tension sensor SNN-1 (maker, the Barnaul'skoe OKBA), or a mechanical yarn-tension meter of the 583P type of the Zlatoustskii Watch company or of the "Schmidt" company (Germany).

Possibilities of using data on yarn tension for monitoring and controlling the process are indicated by factors which cause a change in yarn tension in spinning and stretching. In spinning, over the course of yarn movement from the spinneret to the take-up package, the yarn tension is increasing. In the section from the spinneret to the lubricating disk, it is possible to measure yarn tension without breaking up the regime only ahead of the lubricating disk. Therefore, tension is usually determined by calculation [3]:

\[ F_1 = F_s + F_{ki} + F_{kf} + F_x + F_m + F_{tr} \]

where \( F_1 \) is the force necessary to draw off the yarn from the spinning zone; \( F_s \) is the force necessary to overcome surface tension at the melt-medium boundary; \( F_{ki} \) is the force necessary to ensure a definite kinetic energy to the yarn being drawn off; \( F_{kf} \) is the force necessary to communicate to the medium entrained by the yarn a definite kinetic energy; \( F_x \) is the frictional force of the spun yarn against the surrounding medium; \( F_r \) is the force of rheological resistance caused by processes of the pilot jet in a lengthwise velocity gradient field; \( F_m \) is the force of the mass acting on the yarn; and \( F_{tr} \) is the transverse force which makes the yarn deviate caused by motion of the sweeping air.

After the lubricating roll, from the spinning machine which has been given (see Fig. 1), the yarn tension \( F_5 \) before the spinning package will be equal to the following:

\[ F_5 = F_1 + F_{kd} + F_{fd} + F_{fr} + F_{dd} + F_{dc} \]
where $F_{kd}$ is the force necessary to communicate a definite kinetic energy to the lubricant taken off the roll by the yarn; $F_d$ and $F_r$ are forces of yarn friction against the lubricating roll and against the squeeze roll; $F_{dd}$ and $F_{dc}$ are the forces caused by stretching the yarn due to the successive increase in diameters of the spinning rolls and the clutch when their angular velocities are equal.

From analysis of the acting forces on the stand scheme and the tension diagram (Fig. 1), it is evident that controlled yarn tension is really possible at the points $F_1$-$F_5$. Thereupon, the deviation in tension at the point $F_1$ from the assigned value informs about the deviation of the parameters (viscosity, temperature, or flow rate) of the polymer melt and the rate of movement of the sweeping air from regulation values [4, 5]. The quantity $F_{kd}$ is brought about by limitation of a definite kinetic energy to the lubricating liquid which is taken off the roll by the fiber. Hence, $F_{kd}$ is determined by friction of the yarn against the lubricating roll. At a low or constant value of $F_{kd}$ the figure for $F_{kd}$ can be used to estimate the amount of lubricating liquid deposited on the yarn [6]. The value of $F_{fr}$ informs one about the quality of the working surface of the squeeze roll.

Successive increase in the diameter of the spinning rolls causes a slight (<1%) stretching of the yarn, which increases up to 50% the tension ($F_{dd}$) of the yarn at point $F_4$, as compared with point $F_3$. In the known information-patent material, there is no information content about $F_{dd}$ and its connection with yarn properties and process parameters.