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YARN TENSION IN THE PROCESS OF ROTOR SPINNING

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Abstract

Yarn tension is a phenomenon of fundamental importance for rotor yarn formation. The problem of dynamic tensions during spinning is of essential importance, as it may result in the possible decrease in yarn quality parameters, such as irregularity of linear density, elongation, tenacity, and the number of faults. We analysed the parameter dependencies which characterise sliver feeding the spinning machine, as well as the dependencies of linear density of the product manufactured on the tension which appears during the process of rotor spinning. This research fragment, on the basis of which the influence of the yarn's linear density on the tension estimated, is discussed in this paper. The measuring method and equipment used is presented.

Key words: *Rotor spinning, rotor yarn, tension, dynamic yarn tension, linear density*

1. Introduction

Yarn tension is a phenomenon inseparably connected with spinning, and is also of fundamental importance during rotor yarn formation. The problem of the occurrence of dynamic yarn tensions is of essential importance, as the possible decrease in yarn quality parameters, such as irregularity of linear density, elongation, tenacity, and the number of faults, may result.

Consideration of real spinning conditions allows us to state that the temporal tension values are more important than the mean values [1]. Investigation into the dynamic forces which act on rotor-spun yarn carried out by Grosberg & Mansour [2] confirmed the occurrence of high-frequency (short-wave) yarn tension oscillations of significant amplitudes, which even exceed the mean value of about 30 %.

Maximum yarn tensions directly influence the number of yarn breakages, which in turn decrease the spinning machine's efficiency and raise yarn manufacturing costs [2].

The distinct influence of yarn tension is visible when analysing the stretching forces of yarn. An increase in yarn tension during spinning causes a decrease in the elongation of yarn over stretching to break. This influence is very substantial, although the yarn tension values constitute only 10% -20% of the yarn's breaking force [3].

Tests carried out hitherto showed that spinning tension is determined by the rotor's rotational velocity and its diameter [1, 2, 3, 9, and 10]. Further experiments and considerations (conducted at the Department of Technology and Structure of Yarns) allowed us to draw the conclusion that the coefficient of variation of yarn tension is well correlated with the coefficient of variation of linear density of the sliver feeding the spinning machine, the coefficient of variation of yarn linear density, and the coefficient of variation of yarn tenacity [4, 5, 6, 7, and 8].

From investigations carried out at the Department of Technology and Structure of Yarns at the Technical University of Łódź [8], it also appears that the mass distribution of the fibre stream feeding the rotor spinning machine has an essential influence on the irregularity of the yarn's linear density, and on the distribution of temporal tensions during spinning. Every mass change in the feeding fibre stream causes an increase or decrease in the irregularity of the yarn's linear density, and these phenomena are reflected by yarn tension changes.

Notwithstanding the numerous investigations and theoretical elaborations carried out, no model which would include all the parameters of the spinning process and would link these parameters with yarn tension has so far been developed.

The models so far elaborated [1, 2] have only considered the influence of the rotor's diameter and velocity and of the yarn's linear density, without considering the quality parameters of the product

which feed the spinning machine. The influence of the sliver's linear density was investigated only by an experiment under real conditions [7].
All these considerations motivated us to undertake an attempt at developing a model which would represent the phenomena occurring during the process of rotor yarn formation as closely as possible. This model should also take into account (in a generalised way) the influence of the following parameters on yarn tension during the process of rotor spinning:

- the rotor's diameter and velocity,
- the linear density of yarn, and
- the quality parameters of sliver feeding the process.

2. Subject of investigation

Within the scope of the investigations carried out, tests were performed which were aimed at estimating the influence of the yarn's linear density on the tension value existing during the spinning process.
Cotton yarns with linear densities of 25, 35, 45, and 55 tex formed with the use of BD 200S rotor spinning machine were used for tests.
The analysis of the quality parameters of the yarns formed was carried out by means of a computer measuring system developed within the scope of the research project [11], and realised at the Department of Technology and Structure of Yarns in co-operation with the Department of Applied Information Technology at the Faculty of Electricity and Electronics (Technical University of Łódź).
A schematic diagram of the testing and measuring stand is presented in Figure 1.

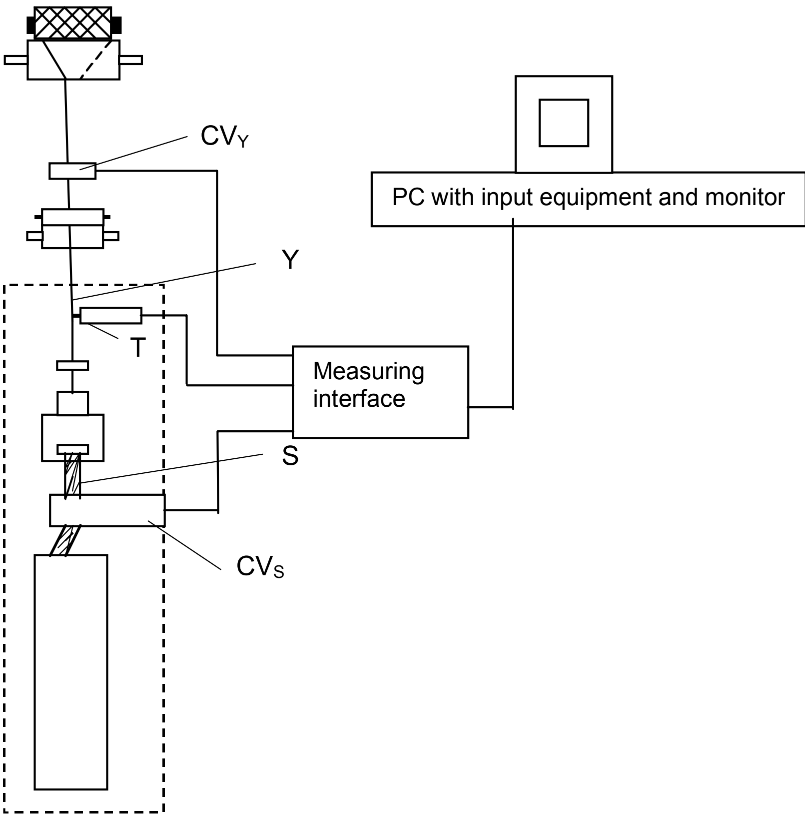

Figure 1. Computer measuring system; T- yarn tension measuring head, CV_Y – yarn linear density measuring head, CV_S – sliver linear density measuring head, Y – yarn, S – sliver

The system allows continual recording of the following fundamental parameters of the spinning process:

- linear density of yarn,
- linear density of sliver,
- yarn tension.

The basic elements of this system are a computer and three measuring heads connected with the computer by means of a measuring interface. The T-measuring head (based on a tensometric gauge) measures yarn tension, whereas the two USTER electro-capacity measuring heads were designated for determining the linear density irregularity.
A block schema of the measuring system is presented in Figure 2.

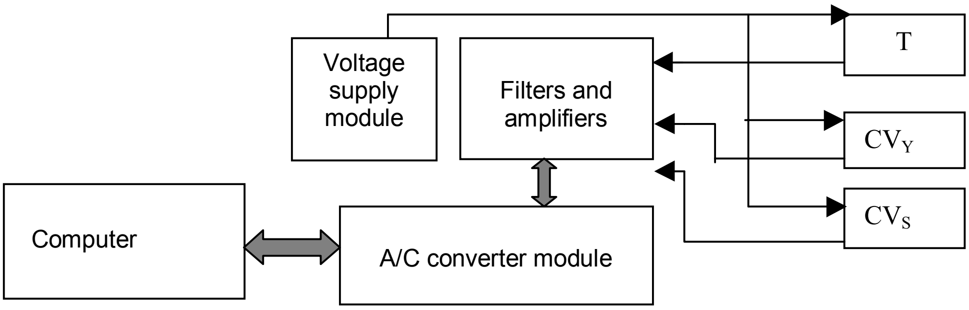

Figure 2. Block schema of the computer measuring system; T- yarn tension measuring head, CV_Y – yarn linear density measuring head, CV_S – sliver linear density measuring head, A/C – analogue-digital converter

The measuring interface consists of an analog-digital converter module, filters, amplifiers, and a voltage supply module. The system is flexible and adaptable to every PC. The software available allows us to control the spinning process, and visualises the parameters measured, as well as conduct data capture, processing and retrieving.
Yarn tension was tested between the rotor and the delivery rollers, whereas sliver linear density was tested before the rotor, and yarn linear density between the delivery rollers and the take-up unit.
The optimum operational parameters of the spinning machine which were accepted for the tests were chosen by experiments, and are specified in Table 1.

Table 1. Working parameters of the spinning machine

Parameters, units	**value**
Rotor rotational velocity, r.p.m.	45 000
Rotational velocity of the opening roller, r.p.m.	7 000
Spinning velocity, m/min.	50 000

Distribution plots of yarn tension temporal values and linear densities of yarn and sliver measured over tests were elaborated in the form of histograms for a predetermined number of specimens by means of a special computer programme.
Independently, the minimum, maximum, and mean tension values, as well as the standard deviations and the irregularity coefficients of yarn tension, were obtained.
The highest coefficient of variation of yarn tension was obtained for yarn with a linear density of 25 tex, whereas the lowest was obtained for the 55 tex yarn.
The phenomenon of dynamic yarn tension fluctuations is more intensive when yarns with low linear density are formed, as these yarns are characterised by a higher mass irregularity than coarse yarn.
This phenomenon is very dangerous as it may cause yarn breakage. The distributions of the measured values obtained by means of the tests performed for the 25-tex yarn are presented in Figures 3, 4, and 5. Figure 6 illustrates the influence of linear density of the yarn formed on the yarn tension value.

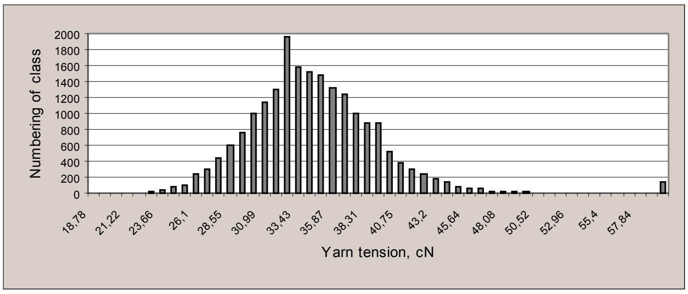

Figure 3. Yarn tension histogram of the 25-tex yarn

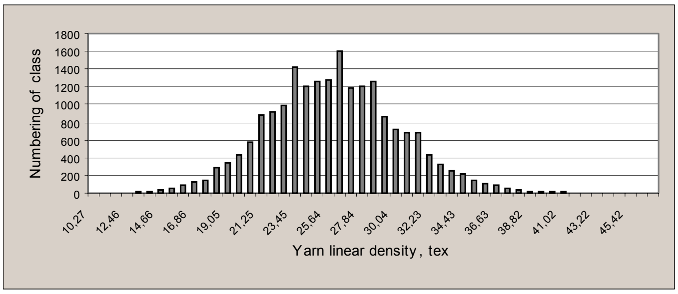

Figure 4. Yarn linear density histogram of the 25-tex yarn

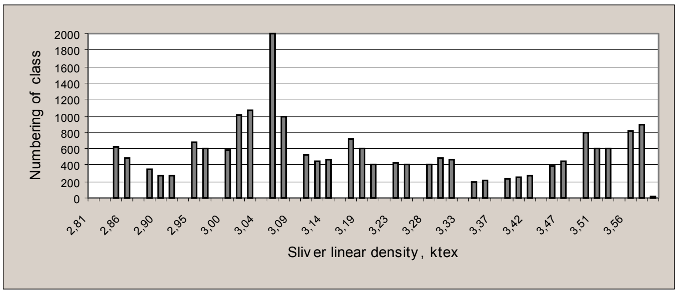

Figure 5. Sliver linear density histogram of the 25-tex yarn

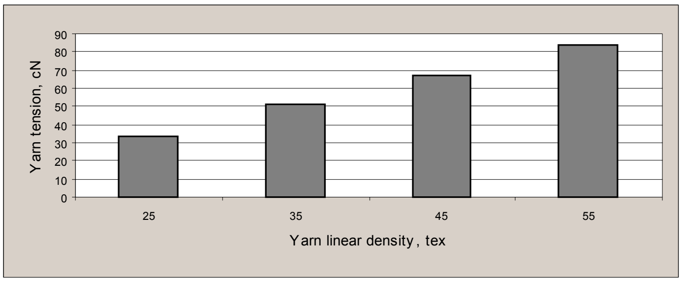

Figure 6. Yarn tension in dependence of yarn linear density

The dependency obtained confirms that the mean value of yarn tension is directly proportional to its linear density, which complies with the Grosberg & Mansour equation [2]:

$$\mathbf{T = 0.72q\omega^2R^2}$$

where:

T – yarn tension in the rotor, cN,

q – linear density of yarn, tex,

ω – rotational velocity of the rotor s-1, and

R – maximum diameter of the rotor, mm.

Investigations into the influence of the quality parameters of sliver (feeding the spinning machine) on yarn tension will be carried out during the next stage of this research project. Then, on the basis of those models which are already known, as well as on experimental research, a model including all the problems of the phenomena which occur in the process of rotor yarn formation will be developed.

3. Conclusions

On the basis of a review of literature, the following conclusions were made :

- spinning tension is determined by the rotor rotational velocity and its diameter; an increase in rotor velocity (at unchanged rotor parameters) causes an increase in yarn tension and a worsening of its quality;
- the coefficient of variation of yarn tension is well correlated with the coefficient of variation of the linear density of the sliver feeding the spinning machine, the coefficient of variation of yarn linear density, and the coefficient of variation of yarn tenacity;

The tests carried out allow us to state the following:

- the phenomenon of changes in the dynamic tension on the spinning process become more intense at yarn formation of low linear density;
- the increase in linear density of the yarn formed significantly influences the increase in yarn tension during spinning.

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