COMPUTER ANALYSIS DISTRIBUTION OF THE YARN LINEAR DENSITY FROM OPEN END SPINNING MACHINE

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Abstract:

Basing on a detailed kinematics scheme of the R1 Rieter rotor spinning machine, calculation of spectral characteristics of yarn made on the spinning machine was done. The calculations served to create a computer programme facilitating the qualitative evaluation of the spinning process on the R1 spinning machine. It also allows a rapid localising of mechanical damages and technological errors in the machine. The calculations make it possible to detect the sources of periodical faults and damages of yarn which follow from: the non-centred work of elements of the spinning machine or from their being damaged, from damaged pulleys, gear wheels, driving belts, from dirt or damages of the elements driving the roller etc.

Key words:

Spectral analysis, evenness of mass, spinning machine

1. Introduction

Every rotor spinning machine, even the most modern ones require a strict control of the spinning process. Various software may be indispensable to facilitate the control of yarn unevenness and they can protect against the faults in the yarn and their results in the ready-made goods. The reason of faults appearing in the fibres stream is not always the work of broken elements touching the fibre. They could be the damages of driving belts, bearings non-centred elements in the drivers etc. Detection of such faults in the machinery is often difficult.

2. The object of analysis

The object of the analysis was the R1 Rieter rotor spinning machine working in the Department of Spinning Technology at the Technical University in Lodz. This is an experimental machine endowed with one 20 SC points' spinning section.

The machine possesses two moving automatic carts - one for each side of the spinning machine with one automatic bobbin loader placed before the driving head. Each working set of the R1 machine is driven with a separate motor. It facilitates and hastens a quick computer correction of working parameters of the machine, even during its work. Steering of the spinning machine is effected with the help of an integrated computer connected to the operating monitor.

Basing on the detailed kinematics schematic diagrams of the machine, diagrams of the drivers of particular machine working elements and on the measurements made directly on the machine, the calculations of the spectral characteristics of the R1 spinning machine were conducted. These calculations made it possible to detect the reasons of the periodical faults and damages of yarn, which occur on the R1 spinning machine, resulting from non-centred and damaged working elements of the machine, pulleys, gear wheels, damaged driving belts, dirty and damaged elements of rollers' drivers etc. All the possible reasons enumerated above can affect the whole spinning process and the quality of the received yarn. The aim of the work was to effect the full spectral analysis of the linear density distribution of yarn from the R1 Rieter rotor spinning machine.

Basing on the calculations (combined into a complex characteristics) a computer programme was created which allows the quality evaluation of the spinning process on the R1 spinning machine and allows localising mechanical damages and technological errors in the machine very quickly. The programme algorithm can constitute the basis for improvement of the production and decision making processes in a cotton spinning mill.

3. Methods of analysis

Drivers of the spinning machine elements were analysed, which affect the yarn quality: rotor drive, opening roller, feeding roller and, delivering roller drives. Remaining additional drivers, such as those of the generator of ventilators or of the elements of beams transport do not affect the delivered yarn amplitudes spectrum to a great extent. A detailed analysis of particular elements and of their impact on the delivered stream of fibres was done. The length of the harmonic components of the waves generated in the stream of fibres as the result of a fault or damage of the mechanical parts of the machine was fixed.

Rotating elements placed on the common axis would induce the same λ length in the stream of fibres. Detection of the damaged element is possible only directly at the machine. The following equations have been applied for the calculating analysis of the λ of periodical oscillations, leading to the detection of the places of mechanical disturbances in the spinning process:

$$\lambda = \pi \cdot d_w \cdot R \qquad \lambda = \frac{V_{wyd}}{n_w} \rightarrow n_w = \frac{V_{wyd}}{\lambda}$$

$$\lambda = \frac{V_{wyd}}{V_p / l_p} = \frac{V_{wyd} \cdot l_p}{V_p} = \frac{V_{wyd} \cdot l_p}{\pi \cdot d_w \cdot n_w}$$

where:

λ - wave length in the fibres stream,

d_w and n_w - diameter and rotating speed of the damaged roller,

R - a draw between the damaged element and the delivering roller,

V_{wyd} - the speed of the stream of fibres delivered from the machine,

V_p and l_p - speed and length of the damaged driving belt.

4. Spectral analysis

Mechanical faults

When analysing the length or the component of the harmonic waves generated by the driving elements (in case when they were damaged) the following parameters of the machine work were taken into account:

- linear velocity of delivering V_{wyd}=50÷200 m/min
- linear velocity of feeding V_{zas}=0,125÷5 m/min
- rotary velocity of rotors n_R=45000÷130000 rot/min
- rotary velocity of the opening rollers n_{Br}=6500÷8500 rot/min
- rotors diameter d_R=30÷56 mm
- total draft R_c=40÷400.

On each side of the machine, the rotors are driven by separate motors. Depending on the distribution of trash on the rotor perimeter, the course of the periodical oscillation of the mass distribution in yarn changes and the shapes of the harmonic components are different and this fault will repeat after each rotation of the rotor.

For instance, for the rotor of the d_R = 30 mm diameter, the λ length = 9,5 cm of the wave generated in yarn, and its submultiples are: λ/2 = 4,8 cm; λ/3 = 3,2 cm; λ/4 = 2,4 cm.

Damage of the remaining elements of the rotor may cause the occurrence of the harmonic component in the stream of fibres of the λ wave length, depending on the speed of machine delivering (V=50÷200 m/min), λ=1,6÷147,8 cm.

On each side of the machine, the opening rollers receive the drive from separate motors. The drive has been projected for the number of rotations of the opening rollers being 6500 - 7000 - 7500 - 8000 - 8500 rot/min. Damage of the sheath or any other element in the drive of the opening rollers will generate a defined harmonic component in the distribution of the linear density of yarn. The most often reason of improper work of the opening roller may be a mechanical damage of the sheath or depositing of trash on the roller's sheath.

Depending on the linear velocity of the rotor and on the linear velocity of the opening roller, the λ length of the wave of the periodical error in the stream of fibres (if it is to damage the opening roller), may take the values in the interval of λ=93 cm÷190 cm. Damages of the opening roller in several places may cause in the stream of fibres the occurrence of the periodical component of different wave length; nevertheless, it will always be smaller than λ_{max} = 1,9 m. Analogical waves may appear in the stream of fibres due to the particles of trash stuck in the roller's sheath.

Damages of the remaining elements of the roller drive may cause in the stream of fibres the appearance of the harmonic component of the λ length depending on the machine delivering speed (V=50÷200 m/min), λ=1,4(10,8 cm.

The feeding rollers of the right and left sides of the machine are propelled by one motor. Damage of any of the elements driving the feeding rollers will generate certain harmonic component in the distribution of the linear density. Damage of the elements driving the feeding rollers can generate occurrence of the harmonic component in the distribution of the linear density λ length of the wave depending on the delivering speed of the machine (V=50÷200 m/min), λ = 3,8 m ÷3 km.

The delivering rollers of the right and left sides of the machine are propelled by one motor. Damage of any of the elements driving the delivering rollers will generate certain harmonic component in the distribution of the linear density. Damage of the elements driving the delivering rollers can generate occurrence of the harmonic component in the distribution of the linear density λ length of the wave independently on the delivering speed of the machine, λ=9,5 cm ÷ 7,4 m.

Technological faults

The main reasons of technological faults on the spinning machine are: a bad composition of the fibres blend (for instance: too big a share of short fibres), too big total draft and partial drafts, damaged or worn out sheath of the roller. Technological faults have their background in the incorrect movement of fibres in the drawing fields or they are caused by other disturbances resulting from their clusters passing through the drawing zones. On the spectrogram, the technological fault is visible as a group of stripes with a greater amplitude.

The length of the technological fault for the spinning machine:

$$\lambda = (2 \div 3) \cdot \bar{l} \cdot R$$

where:

$\bar{l}$ - mean length of the processed fibre,

R - draft between the zone of the incorrect fibre passage and the delivering rollers.

The partial drafts from the following drawing zones were used to effect the analysis of technological faults:

Zone 1: The draft between the feeding roller and the opening roller: R1 = 327 ÷17088.

Zone 2: The draft between the opening roller and the rotor: R2 = 3,71 ÷ 7,5.

Zone 3: The draft between the rotor and the delivering roller: R3 = 0,003÷0,033 which is the ratio of density DR = 1/R = 30,3 ÷333,3.

A mean length of cotton fibre equal to $\bar{l}$ = 22 mm was applied to calculate the technological faults in the particular drawing zones.

a) A fault resulting from the sliver, is the one which arises in the delivering zone of the spinning machine:

$$\lambda_{min} = (2 \div 3) \cdot \bar{l} \cdot R_{C\,min} \cong 1{,}76 \div 2{,}64\ \mathrm{m}$$

$$\lambda_{max} = (2 \div 3) \cdot \bar{l} \cdot R_{C\,max} \cong 17{,}6 \div 26{,}4\ \mathrm{m}$$

Technological faults resulting from the incorrect movement of fibres in the delivering zone of the drawing frame are visible on the spectrogram of the rotor yarn as a row of stripes and their grouping depends on the draft of the drawing frame in the wave length interval of 1,76÷26,4 m.

b) A fault resulting from the feeding zone, is the one that is related to the incorrect movement of fibre between the feeding roller and the opening roller:

$$\lambda_{\min} = (2 \div 3) \cdot \bar{1} \cdot R_{2\min} \cong 16{,}3 \div 24{,}5 \text{ cm}$$

$$\lambda_{\max} = (2 \div 3) \cdot \bar{1} \cdot R_{2\max} \cong 33{,}0 \div 49{,}5 \text{ cm}$$

Technological faults resulting from the incorrect movement of fibre in the feeding zone of the spinning machine are visible on the spectrogram of the rotor yarn as the row of stripes and their grouping depends on the draft on the spinning machine in the wave length interval of 16,3 ÷ 49,5 cm.

c) The fault resulting from the opening zone, is the one resulting from the damage of the roller sheath, for instance:

In case of the sheath damage, the spectrogram shows the drawing wave visible as a row of stripes grouped on the analogical length, as in case of the fault arising in the feeding zone, it is: λ = 16,3 ÷ 49,5 cm. These faults appear on the rotor yarn spectrogram on the wave lengths close to the harmonic components of the drawing wave arising from the mechanical damage of the opening roller.

5. Computer programme

Basing on the detailed spectral analysis of the R1 Rieter spinning machine, a computer programme was designed which after entering the data effects the spectral analysis whose calculations are lengthy and time-consuming. It also points out possible reasons of the faults. The programme detects the sources of the periodical non-uniformity of the linear density of yarns manufactured on the R1 spinning machine which follow not only from the non-centric work of machine elements sticking to fibres, or from their damages, but also from the damages of the driving elements, such as: pulleys, gear wheels, driving belts and so on, as well as from the dirt depositing on these elements. The programme facilitates the quality evaluation of the spinning process on the R1 spinning machine. It also allows a quick localising of mechanical damages and technological faults in the machine. The programme is constructed in such a way that it is useful for fast assessing of the machine's work in production conditions.

Below (Figures 1 and 2) are a sample programme windows with the lengths of component harmonic waves which appear after a damage to an element of zone. In order to obtain correct

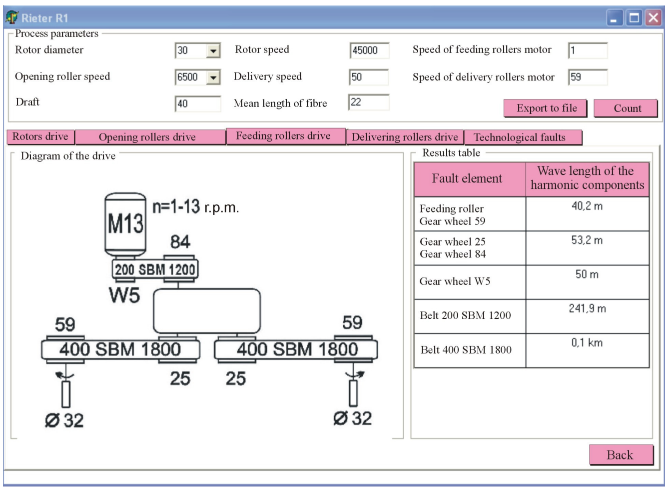

Figure 1. Sample programme window - feeding rollers drive.

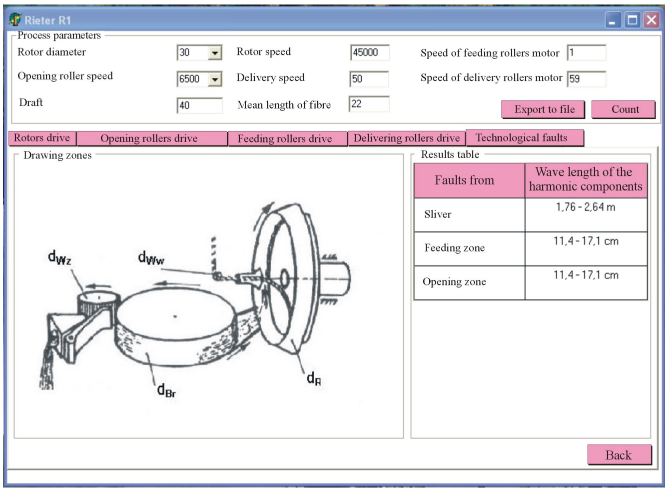

Figure 2. Sample programme window - technological faults.

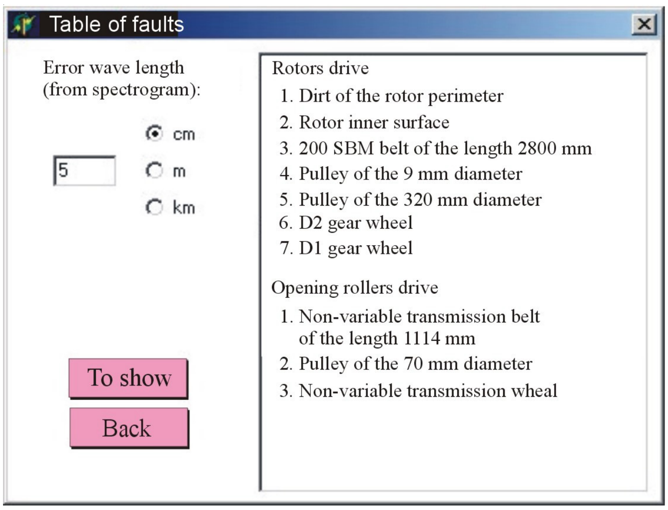

Figure 3. Table of faults, result screen.

results of calculations it is necessary to enter current process parameters and machine data.

"Table of faults" makes it possible to find the cause of the occurring fault for the wave length found in the spectrogram of the yarn. We have both a collective table and the table of faults for individual driving zones of the spinning frame (Figure 3).

6. Summary

1. Irregularity in distribution of mass of the stream of fibers may be caused by a lot of factors, often very difficult to identify. Periodicity of linear density distribution occurring in the stream of fibers may be caused both by the elements having direct contact with the fibers and by the elements transferring power to the working rollers.
2. Preparing a spectral analysis of machines with complex driving systems requires time - and work-consuming calculations, which make it considerably more difficult to quickly find the cause of the detected periodicity in the stream of fibers and to take steps to eliminate the element generating the fault.
3. The proposed computer programme enables fast and precise identification of elements generating periodical error in linear density distribution of yarn. Therefore the time needed to eliminate the cause of periodicity in the stream of fibers can be considerably reduced.

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