SPINNING SIMULATION – SCIENTIFIC MEANS AND VIEW OF APPLICATIONS

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1. Introduction

An absolutely essential constituent of a scientific and research solution to an optimum spinning process is the representation of a real process with theoretical means. The representation of a real technological process in the form of a model makes research easier. It increases its effectiveness and it reduces the time which is necessary to reach the optimum variant for experimental verification.

The development of scientific and research methods is an important condition of successful solution of new spinning systems and optimization of present technological systems in the spinning mill.

The development of spinning machines of all technological stages is distinguished by a great effort to achieve high productivity. Textile technological processes in these machines proceed under conditions of high operating speed and at the same time it is necessary to guarantee a required quality of the appropriate length textiles and especially of the final yarn in the point of view of significant utility properties as for example mass irregularity, strength. The optimization of a textile technology process and the highest possible degree of utilization of technological reserves of a given spinning system under the above mentioned conditions of high-standard kinematic parameters of the process are conditional on the utilization of new up-to-date methods of theoretical and experimental research. This trend became evident especially in relation to the successful development of rotor spinning machines, which at the same time has brought many stimulatives to the sector of research methods of the processes of textile technology.

Taking into consideration the constantly growing importance of these modern methods and the wider application of them on further spinning machines, we offer you the following outline of these scientific and research problems together with some notes of some significant applications.

2. The kinds of models of technological processes, systems and fibre products

The classification of applied models can be done from various points of view. We will use the classification method issuing from the character of the basic conception of a fibrous product and of the technological environment where the respective process is going on.

With these two basic aspects of the specified research problems, the following possibilities can be stated:

a) the quantities expressing the character or characteristic property of a fibre product, can be
   - determined or
   - random

b) the mechano-physical action defining the character of the technological environment can be characterized as
   - determined or
   - random.

It is evident that altogether it is possible to find 4 combinations with corresponding solution methods

Research method-model	Character of the fibrous product	Character of the technological environment
mechano-physical model	determined	determined
probability model	determined	random
	random	random
dynamic model	random	determined

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In case of the above mentioned models we apply adequate theoretical knowledge, while the theory of random processes (the statistic dynamics) that we apply in connection with the dynamic models is understood as an extension of the probability theory to a description of random variables that can change according to a non-random parameter (time or length).

The solution results of the research problems of the specified technological sphere are the following:

The basic research knowledge:

- clearing up the substance and the laws of the present as well as of quite new spinning processes and systems

- definition of the character of production of the resulting fibre product, of its final structure and properties

The applied research knowledge:

- definition of influential parameters of a spinning system
- evaluation of effectiveness of technological functioning of a spinning system
- optimization of the technological functioning of a spinning system
- projecting new technologies and new technological systems

3. Application of models of technological processes, systems and fibre products

A survey of representative applications of individual models will be presented, together with the basic characteristics of the research problems:

The dynamic model

Research method: Application of selected rules of the random function theory

Principle of the solution procedure: A conception of the technological system as a stationary, linear, dynamic system.
Definition of the auto-correlative function of the mass of short segments in a linear fibre product.

Result of the solution procedure: The modulus of the relative transfer function and its technological analysis, the quadratic mass short-term unevenness of the resulting linear fibre product, the determination of the influence of technological factors on the levelling effectiveness of the specified spinning system, definition of conditions for optimizing the resulting product from the mass short-term unevenness point of view.

General characteristics of the research problems solution:
Transformation of mass unevenness by spinning systems.

Selected technological applications:
- flats card with a drafting mechanism [1] – evaluation of the levelling effectiveness
- a system of successive and combined doubling [2] - levelling effectiveness, the resulting quadratic unevenness, the technological causes of an increased levelling effectiveness, the effect of replacement of spinning rotors with the increasing revolution frequency
- system of cyclic doubling [3] – the resulting quadratic unevenness, the influence of the collecting surface diameter of the spinning rotor, requirements on the fibre flow taken over by the collecting surface
- the separating device of the OE-spinning system [4] – influence on the structure of the mass unevenness of the fiber flow.

The probability model

Research method: Application of selected knowledge of the probability theory

Principle of the solution procedure: A probability description of a process in the transition and other technological spheres, application of the theory of Markov absorption chains and of further probability theory rules.

Result of the solution procedure: The time parameters of the fibre transport through the system (mean value, dispersion ,variance, probability distribution), probabilities of a specified phenomenon (breakage), conditions of the optimum level of the process indicators.

General characteristic of the solved research problems:
Fibre transport and fibre position in complex spinning systems, process failures.

Selected technological applications:
- roller card [5] – relation between the carding process and the resulting sliver structure, blending effectiveness

- air transport channel of a rotor transport system [6] – additional separating effectiveness and optimization of the channel length
- breakage rate of an OE-spinning system [7] – breakage probability in dependence on technological and material quantities.

The mechano-physical model

Research method: Application of the rules of mechanics, particularly of the statics, dynamics, elasticity and strength, with respecting the textile fibre material specificity.
Principle of the solution procedure: Conception of the package body as an elastic isotropic or non-isotropic body using characteristic boundary and deformation conditions.

Result of the solution procedure: Radial trends of the radial, tangential and axial tension in a package body.

Radial trend of the winding force fulfilling the condition of a constant tangential tension in the package body in dependence on the radius, optimization for getting higher uniformity of the deformation properties of the thread package.

General characteristics of the research problem solution:

The mechano-physical influence of a technological device on a fibre material, mechanical effects in package bodies.

Selected technological applications:
- internal mechanical package structure [8] – radial trends of the radial, tangential and axial tensions in a package body

- deformational properties of the wound thread and optimization of the radial course of the winding force [9] – influence of the tangential tension in the package body on the deformational properties of the wound thread and possibilities of influencing the uniformity of the deformational properties.

4. Conclusion

A long-term applying of models of spinning processes, systems and fibre products, together with solutions of concrete technological problems of the spinning technology area, particularly of the OE-rotor spinning sector, enabled us to solve a number of complex research topics.

At the same time, a fairly large complex of research methods has been developed. It is useful to do their systematic classification that would enable an effective choice of appropriate procedures in course of solving of further, new technological problems.
In the above mentioned survey, we are stating only the most important applications that have been also published. It is, of course, an open system that can be further complemented. The selected system starts from technological problems and from the pertaining theoretical natural science knowledge.

We can assume that within the frame of development of new unconventional spinning systems and with the optimization of the existing present spinning systems, a further development of research methods of modeling will also take place. Such methods represent an effective and prospective instrument of research solution of spinning technology problems.

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