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Optimisation of the Knitting Process on Warp-Knitting Machines in the Aspect of the Feeding Zone Geometry

Abstract
An analysis of the structure of warp-knitting machines shows a great variety of the parameters of the knitting zone geometry, rigidity and attenuation of the tension rail system, a coefficient of friction of the threads against guiding elements and the character of the kinematic input function of loop forming elements. In the process of technical design, the constructors concentrate on the kinematics and dynamics of the components of the machine, the kind and properties of the materials used, optimisation of overall constructional dimensions etc. In many cases the aspects concerning the technology of manufacturing knitted fabrics are ignored at the stage of assumptions and design concepts. A significant element in the modelling of the construction design of a warp-knitting machine is the process of optimisation of the machine feeding parameters, considering the minimum load of the threads being fed. This paper presents a simulation of the feeding zone in order to analyse and optimise its working conditions.

Key words: *knitting process, optimisation, warp-knitting machine, feeding zone.*

Introduction

The process of feeding of the knitting zone with warp threads on warp-knitting machines is determined by the following three groups of parameters: The first group characterises the structure of the feeding device: m – point mass of the tension rail reduced to one thread, k_s – coefficient of the rigidity of the tension rail, reduced to one thread, l_1 – length of the thread from the tension rail to the guide bar, l_2 – length of the thread from the beam to the tension rail, a – angle of the horizontal deviation of the thread "running-on" the tension rail, b – angle of the vertical deviation of the thread "running-of" the tension rail, ρ – angle of wrapping the tension rail with thread, the kind of surface of the tension rail plate determined by the coefficient of friction μ between the tension rail and the thread, n_p, v_p – rotational and linear speed of feeding. The second group refers to the mechanical properties of the threads, treated as a visco-elastic object and includes: *d* the coefficient of thread elasticity k_p and the coefficient of thread attenuation b_p. The third significant group of parameters are the components of the kinematic input function S'(t) which result from the specificity of the process of forming courses of loops on the warp knitted machine. The parameters modelling the changes in the absolute elongation of threads in the feeding zone are the following: Sp(t) – input function for the process of knitting the isotropic structures of the stitches, determined by the following: the dislocation of loop-forming elements in the warp-knitting machine, the process of reversible dislocations of the threads in the knitting zone, the type of stitch, conditions of the take-up of the fabric and the linear speed of the threads unwinding v_p; $\Delta S(t)$ – input function determined by the variation of the gradient of the knitting-in, characteristic of anisotropic warp knitted fabrics only.

A physical model of the constant-length feeding system presents the groups of parameters mentioned above (***Figure 1,*** see page 82). The keynote and aim of this research is to present and analyse the dependencies describing the influence of the first group of geometry parameters of the feeding zone on the character and values of the dynamic loads of the threads.

The practical aim of this research was to optimise the process of knitting on warp knitting machines by outlining the positive and advantageous areas of the input parameters, which will make the technological process a "correct" one with regard to the minimum loads of the threads, without breaking them or, in the extreme situations, damaging the loop-forming elements of the machine. The investigations were carried out with the use of computer simulation based on a mathematical model of the constant-length feeding process on warp knitting machines, which is also empirically verified [1-4].

Mathematical model of the feeding system

The equation of the motion of the tension rail referring to the mechanics of the vibration of the system, with one degree of freedom can take the following form ***Equation 1*** (see page 82), where:

h – relative coefficient of system attenuation,

$$h = \frac{b_{zr}}{2m} \quad (2),$$

w_0 – frequency of the free vibration of the non-attenuated system,

$$\omega_0 = \sqrt{\frac{k_{zr}}{m}} \quad (3),$$

a_i – coefficient describing the geometry of the feeding system,

$$a_i = \frac{\cos\beta - e^{\pm\mu\rho} \cdot \sin\alpha}{l_2 \cdot e^{\pm\mu\rho} + l_1} \quad (4),$$

b_{zri} – coefficient of system attenuation,

$$b_{zri} = b_p(\cos\beta - \sin\alpha) \cdot a_i \quad (5),$$

k_{zri} – coefficient of system elasticity,

$$k_{zri} = k_s + a_i(\cos\beta - \sin\alpha) \cdot k_p \quad (6)$$

The solution of equation (1) fulfilling zero initial conditions takes the following form ***Equation 7*** .

Forces in the threads are determined according to the following dependence ***Equation 8*** (see page 82).

$$\frac{d^2y}{dt^2} + 2h\frac{dy}{dt} + \omega_0^2 y = \frac{a_i}{m} \cdot \left[k_{pi} \cdot S'(t) + b_{pi}\frac{dS'(t)}{dt}\right] \quad (6)$$

Equations 1.

$$y(t)=e^{-ht}\left[y_0\cos(\omega t)+\frac{h\cdot y_0+\dot{y}_0}{\omega}\cdot\sin(\omega t)\right]+\frac{a_i}{m\cdot\omega}\int_0^t\left[k_p\sum_{k=1}^{N_i}S(\tau)_{k(i)}+b_p\sum_{k=1}^{N_i}\frac{dS(\tau)_{k(i)}}{d\tau}\right]\cdot e^{-h(t-\tau)}\cdot\sin[\omega(t-\tau)]d\tau, \quad (7)$$

$$P_1(t)_k=\frac{1}{l_2\cdot e^{\pm\mu\rho}+l_1}\cdot\begin{bmatrix}k_p\cdot S(t)_{k(1)}+b_p\cdot\dfrac{dS(t)_{k(1)}}{dt}-k_p\cdot(\cos\beta-\sin\alpha)\cdot y-\\-b_p\cdot(\cos\beta-\sin\alpha)\cdot\dfrac{dy}{dt}\end{bmatrix}. \quad (8)$$

Equations 7 and 8.

The solution of the mathematical model of the feeding process was based on the numerical and analytical method [1]. The input functions $S(t)_k$, given in a discrete way, are developed into a trigonometric Fourier series. The solution, in the form of dislocations of the tension rail in an analytical way, is an integral of the convolution of the input function and the response to the impulse input function of the system, which was determined by numerical integration using the Gauss method. The results of the calculations are presented in the form of text files of model coefficients a_i, b_{zri}, k_{zri}, h_i, w_{0i} and w_i of the deflection value of the tension rail y(t), the values of forces in the threads $P_1(t)_k$, the derivatives of input function $SS(t)_k$ and the input function $S(t)_k$.

The most important feature of the computer program elaborated, which is used for simulation of the knitting process in the aspect of feeding, is that it supports the process of the technological design of warp-knitted fabrics.

Simulation tests of the knitting process with respect to the diverse parameters of the feeding zone

Characteristic of the feeding zone

The identification of the geometry of the feeding zone conducted for particular warp-knitting machines of the following types: R5NF (E=12), RJSC (E=12), MRSEJ 43/1 (E=18) K2MPS (E20), K13 (E12), RL5NF (E12), made by the K. Mayer company, and Kokett 5223 (E28), made by the Textima company, showed significant diversity in the parameters of the geometry of the feeding zone [5, 6].

The overall length of threads between the beam and guide bar was within the range of 916 to 3249 mm, the partial lengths: l_1 = 591÷2525 mm & l_2 = 220÷1025 mm; the number of elements (barriers) guiding the threads was from 3 to 10, the summary angle of wrapping the barriers γ_c = 96°÷619°, the angle of threads “running-on” the tension rail α = 1°÷62°, the angle of the threads “running-of” the tension rail β = 80°÷-15°.

For each particular type of machine there is a different way of feeding the threads. For example, on an RJSC warp-knitting machine the threads are fed using a constant-tension or constant-length controller, which unwinds the warp threads, made on the basis of a mechanical or electronic control device. On an MRSEJ warp-knitting machine the threads are unwound from the beams, or in the case of the designing wefts, from the creel. On warp-knitting machines of the type MRSEJ and K13, used for producing laces, the classic tension rail in the feeding zone is replaced with individual spring compensators through which the pattern threads are guided.

Characteristic parameters of the structure of tension rail devices include the following: profile, surface finish, the mass of the tension rail plate, and the rigidity of the tension rail springs.

For the most commonly used steel tension rail plates with their surface polished, the coefficient of friction μ depends on the structure of the threads’ surface, which, unwound from the beams, run across the tension rail. Moreover the parameter of the linear mass of the tension rail plate is constant and equals m_{pl} ≈ 85g/m. The individual mass $m=\frac{m_{pl}}{Nu}$, referring to one thread and depending only on the needle gauge of the warp-knitting machine.

The rigidity coefficients of the spring k_{sp} in the warp-knitting machine are selected depending on the elastic properties of the threads, their thickness, the configuration, and the number of springs in the particular length of the tension rail plate. In warp-knitting machines the most commonly used are flat tension rail springs of a rigidity within the range 12-168 cN/mm.

For the synthetic threads which are most commonly processed on warp-knitting machines, with an average needle gauge of k_s = 0,5÷0,6 cN/mm.

In the process of technical (and economic) design, machine construction designers concentrate on the following: the kinetics and dynamics of working machine assemblies, the type and properties of the materials used, optimisation of the constructional overall dimensions of machines, and the safety and ergonomics of machine operation [7].

In many cases, aspects concerning the technology of manufacturing knitted fabrics are ignored at the stage of assumptions and design concepts.

A significant element in the modelling of the construction design of warp-knitting machines is the process of optimisation of the geometry of the feeding zone from the point of view of the minimum loads of the threads being fed.

Identification of the feeding system on warp-knitted machines in the aspect of an analysis of coefficients of the feeding zone geometry and the dynamic loads of the threads.

An analysis of the feeding process with regard to the optimisation of the loads of threads was conducted on the basis of the dependencies between the coefficients of the geometry of feeding a_i and the input parameters of the system, as well as the influence of changes in particular parameters on the forces in the threads. In the description of the process of feeding in warp-knitting machines, coefficient a_i is described by ***Equation (4)***, where coefficients a_1, a_2 and a_3 depend on the three conditions of t movement of the threads on the tension rail plate [1, 8].

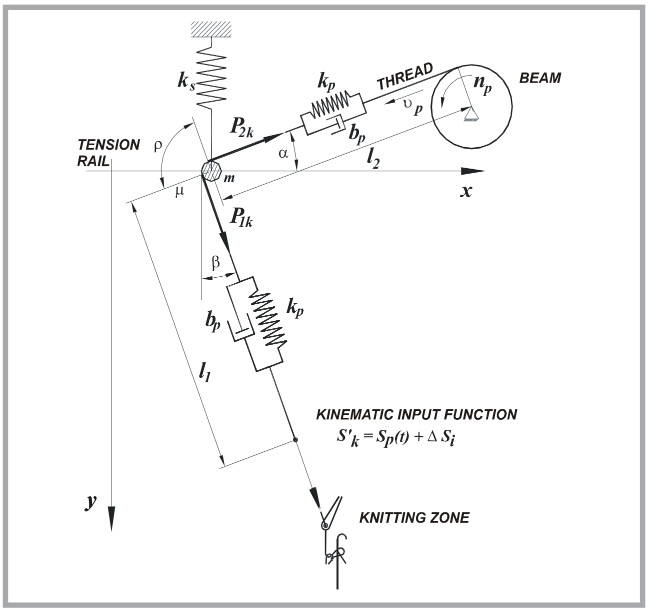

Figure 1. Physical model of a constant-length feeding system for warp knitted machines (P_{1k} and P_{2k} – forces in the threads before and behind the tension rail).

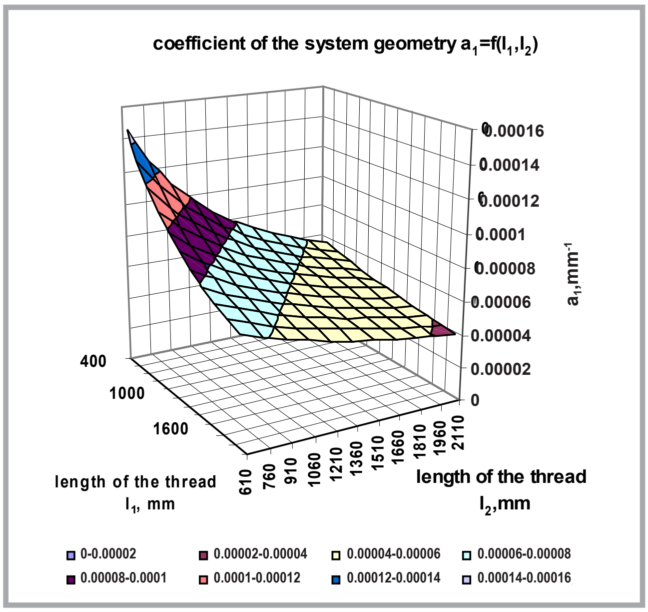

Figure 2. Dependence of the coefficient of geometry a_1 on the l_1 and l_2 lengths of threads (α = 30°, β = 22°, μ = 0,2).

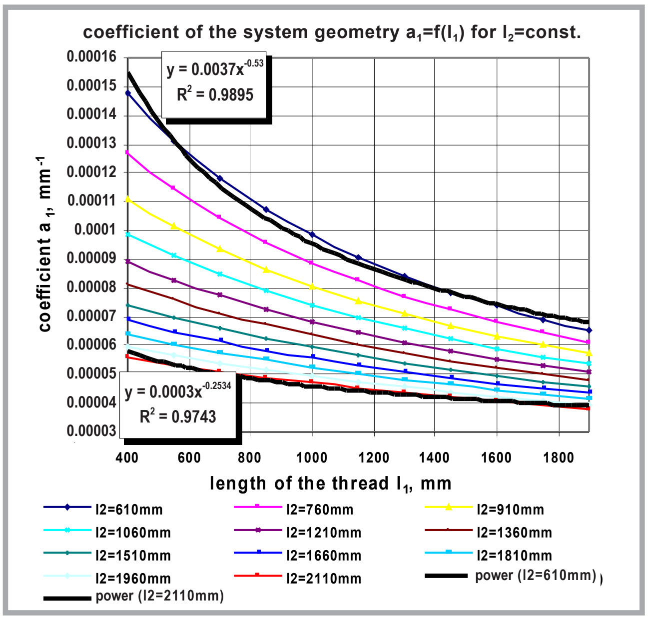

Figure 3. Dependence of the coefficient of geometry a_1 on the length of thread l_1. Coefficient of the system geometry $a_1=f(l_1)$ for l_2=const.

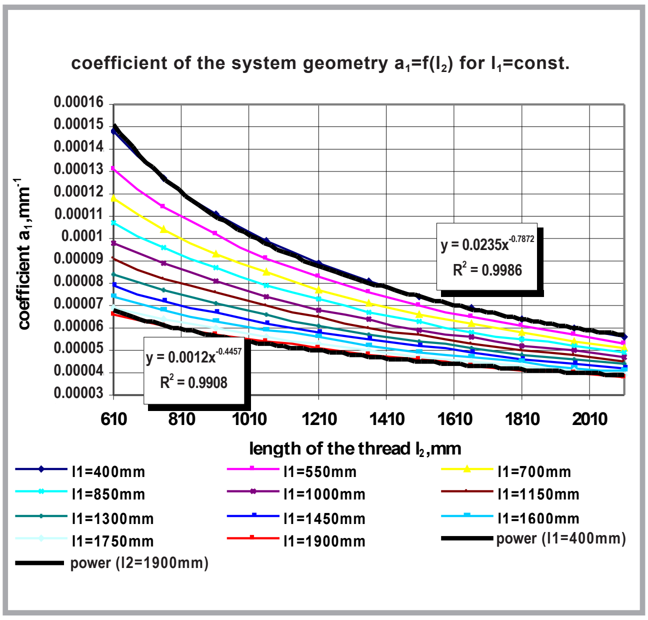

Figure 4. Dependence of the coefficient of geometry a_1 on the length of thread l_2.

Coefficients a_i are functions of the parameters of the feeding zone geometry, including the angles of the threads "running-on" and "running-of" the tension rail plate α and β, the lengths of threads "behind" and "in front" of the tension rail l_1 and l_2 , and the segment e^{mr} determining the friction force, which depends on the coefficient of friction m and the angle of wrapping r. These coefficients are also significant in the modelling of such parameters as the elasticity and attenuation of the feeding system, as well as indicators such as the relative attenuation of the system and the free vibration frequency of the un-attenuated system, in relation to the character of the forces in the warp threads being fed.

In the general form of the differential equation (1) of the dynamics of tension rail movement, coefficients a_i model the level of the input function, depending on the values of S(t) and $\frac{dS(t)}{dt}$. Parameters such as l_1, l_2, m & r presented in the form of a fraction $\frac{1}{l_2 \cdot e^{\pm\mu\rho} + l_1}$ and the values of angles α and β determining the difference (cosβ – sinα) determine the values of forces in the threads $P_i(t)$, calculated according to dependence (8). Coefficients $a_i = f(α, β, l_1, l_2, μ)$ take the form of a composite function describing the elements of both the trigonometric and power functions.

Influence of the l_1 and l_2 lengths of threads on the values of coefficients of the feeding system geometry a_i.

With constant values of α, β & μ, equation (4) $a_i = f(l_i)$ takes the following form:

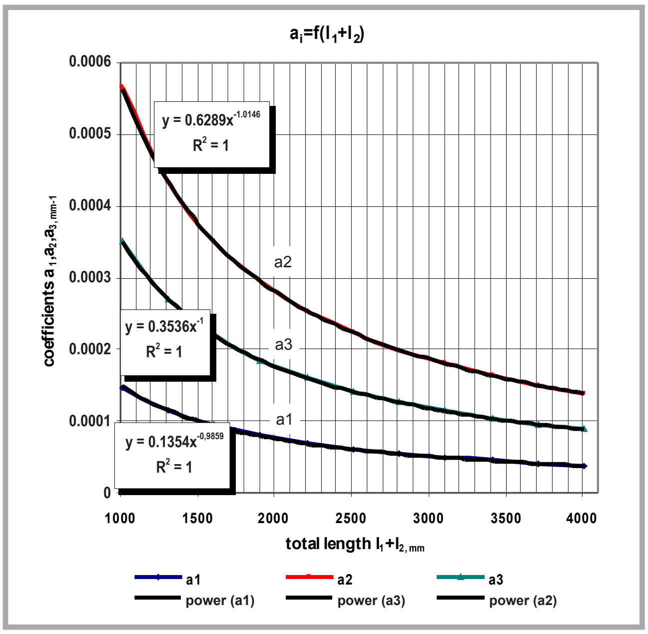

Figure 5. Dependence of the coefficients of geometry a_i on the total length of threads $L_c = l_1 + l_2$.

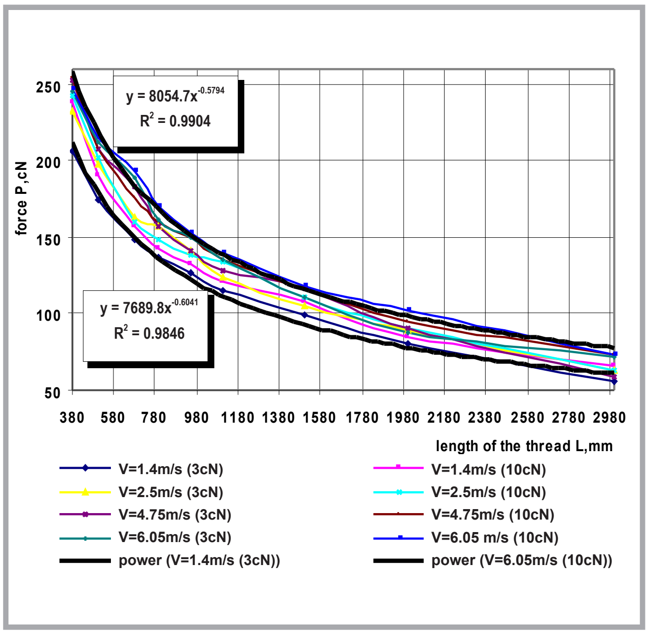

Figure 6. Dependence of force P_{max} on the length of thread being stretched.

$$a_{1,2} = \frac{k_1}{l_2 \cdot k_2 + l_1}, \qquad (9)$$

$$a_3 = \frac{k_3}{l_2 + l_1}, \qquad (10)$$

where:

$k_1 = \cos\beta - e^{\pm\mu\rho} \cdot \sin\alpha,\ k_2 = e^{\pm\mu\rho},$
$k_3 = \cos\beta - \sin\alpha.$

The dependence of a_i on l_i or $\sum l_i$ is a hyperbolic function.

With an increase in the argument of function l_1, l_2 or $L_c = l_1 + l_2$ the value of a_i decreases. The character of changes $a_1 = f(l_1$ and $l_2)$ and dependence $a_i = f(Lc)$ are presented on the graphs in ***Figures 2, 3, 4** & **5***. From a physical point of view of coefficients a_i of the feeding system geometry, it can be stated that with a decrease in a_i and an increase in length of the warp threads, a decrease in the values of forces in the threads can be expected.

Influence of the length of the threads on the character and values of forces in the them

The problem of changes in the loads of forces in the threads, depending on the length of their feeding zone, can be explained by basic research on the process of the dynamic stretching of the threads.
The character of the dependencies of the stretching force on the length of the thread can be determined on the basis of particular solutions of rheological equations of the state of the threads from the point of view of elastic and visco-elastic deformations [9-13].

The dependencies of the stretching force and the length of the thread for the models chosen can be presented in the following form:

- according to Hooke's model:

$$P_H = K_H \cdot l^{-1},$$
$$\text{where: } K_H = \Delta l \cdot E_H \qquad (11)$$

- according to the Voigt – Kelvin model:

$$P_V = K_V \cdot l^{-1},$$
$$\text{where: } K_V = E_V \cdot \Delta l + \eta_V \cdot V_{roz.} \qquad (12)$$

- according to Zener's model:

$$P_Z = K_Z \cdot l^{-1}, \text{ where:}$$
$$K_Z = \eta_Z \cdot V_{roz.}\left[1 - \exp\left(-\frac{E_{Z1} \cdot t}{\eta_Z}\right) + E_{Z2} \cdot \Delta l\right] \qquad (13)$$

where: E_H, E_V, $E_{Z1,2}$ – Young modulus of linear elasticity, η_V, η_Z – coefficients of viscosity, Δl – absolute elongation, $V_{roz.}$ = const – stretching rate.

The dependencies P = f(l) presented are hyperbolic decreasing functions asymptotically approaching P = 0.

The dependencies resulting from the rheological models were confirmed by experimental research of the dynamic stretching of the threads [14, 15].

The characteristics of stretching P = f(E) for the following PET filament yarns: JPE84/f72 dtex, JV167/f40 dtex, and textured JPA 72/2/f17 dtex [15] were determined on a measuring stand specially constructed for the dynamic stretching of the threads with rates V_{roz} within the range of 0-6 m/s and absolute elongation with the possibility of changing within the range of $\Delta l = 0 \div 30$mm.

The threads were stretched at the following rates: V = 1.4, 2.5, 4.75 and 6.0 m/s, corresponding to the input function of the growth in force on the warp-knitting machines n_d = 1200, 2000, 3600 & 4800 rows/min, respectively, for the speeds of knitting.

The investigations showed that with an increase in the length of the thread, the value of forces decreased by about 56% for viscose filament yarns, 71% for polyester filament yarns and 86% for textured polyamide threads.

A mathematical analysis of the characteristics of $P_{max} = f(l)$ showed that the most adequate regression functions describing the dependence between P_{max} and l are the square and power functions (***Figure 6***).

For the length of thread being stretched, limited within the range of l = 400÷1300 mm, the power functions of dependence P = f(l) take a specific form of hyperbolic function $P = a \cdot l^{-1}$ for R^2 = 0,95, which corresponds to the functions of rheological models.
Simulation of the knitting process in the aspect of changes in P = f(L) were carried out taking into account calculations of the real parameters of the process for a Kokett 5223 warp-knitting machine of needle gauge E28. The growth in thread

being fed was changed within the range of 0÷288%.

The results showed a decrease in the values of the average forces of 56%, the minimum forces – 47%, and the maximum forces – 72% (***Figure*** *7*), and the amplitude of change in force DP was 65% (***Figure 8***) within the limits of changes ($l_1 + l_2$) established. The characteristics of the results of P = f(l) obtained were experimentally verified to obtain relative differences between the values calculated and those measured ε P_{max} within the range of 9.8÷19.4%.

Influence of the values of the angles of threads „running-on" and „running-of" the tension rail and the coefficients of friction on the values of the coefficients of feeding a_1 and the forces in the threads

Influence of angles α and β on the values of coefficients of the geometry of feeding a_i.

Dependence (4) describes coefficients a_1 and a_2:

$$a_{1,2} = \frac{\cos\beta - e^{\pm\mu\left(\frac{\pi}{2}+\beta-\alpha\right)} \cdot \sin\alpha}{l_2 \cdot e^{\pm\mu\left(\frac{\pi}{2}+\beta-\alpha\right)} + l_1}, \quad (14)$$

assuming that (l_1, l_2 & μ) = const takes the form of composite function $a_{1,2}$ = f(α, β). The characteristics of a_1 and a_2 are very similar, thus graphs a_1 = f(α, β) are presented in ***Figures 9, 10*** and ***11***. From the graph of a_1 = f(α) for β = const., it results that a decrease in the value of coefficient a_1 can be well described by a linear function, depending on angle α (***Figure 10***) (with the correlation coefficient of the boundary curves $r^2 \geq 0.995$).

The character of function a_1 = f(β) for α = const is described by polynomial equations of the third degree ($r^{23}0.9995$) (***Figure 11***). It can be stated with high probability that function $a_{1,2}$ = f(β) for α > 0 is a symmetric function in relation to the OY axis.

The formula for function a_3 = f(α, β) can be written as follows:

$$a_3 = (\cos\beta - \sin\alpha) \cdot k, \quad \text{where } k = \frac{1}{l_2 + l_1} = const \quad (15)$$

According to the formula above, function a_3 = f(α) for β = const takes the following form: $a_3 = (k_c - \sin\alpha) \cdot k$,

which indicates that the value of a_3 decreases with an increase in angle a on the basis of the character of changes in the sine function.

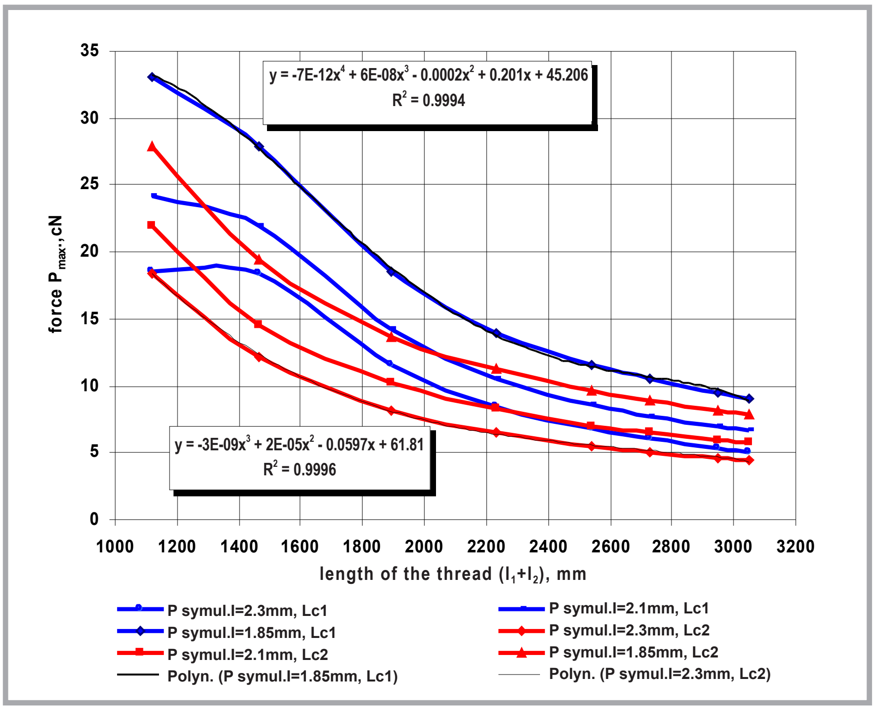

Figure *7. Dependence of force P_{max} on the length of warp thread being fed(data for calculations: N_u = 28, n_d = 600 rows/min, l_1 and l_2, α = 5°, β = 15°, k_s = 0,6 cN·mm^{-1}, $l_{ocz.}$ = 2,3 mm (y_0 = 4mm); 2,1 mm (y_0 = 7mm); 1,85 mm (y_0 = 12mm), μ = 0,2, k_p = 1250 cN, b_p = 100 cN·ms (for JPA 44 dtex), m = 0,185 g, S'(t) dane_t.txt).*

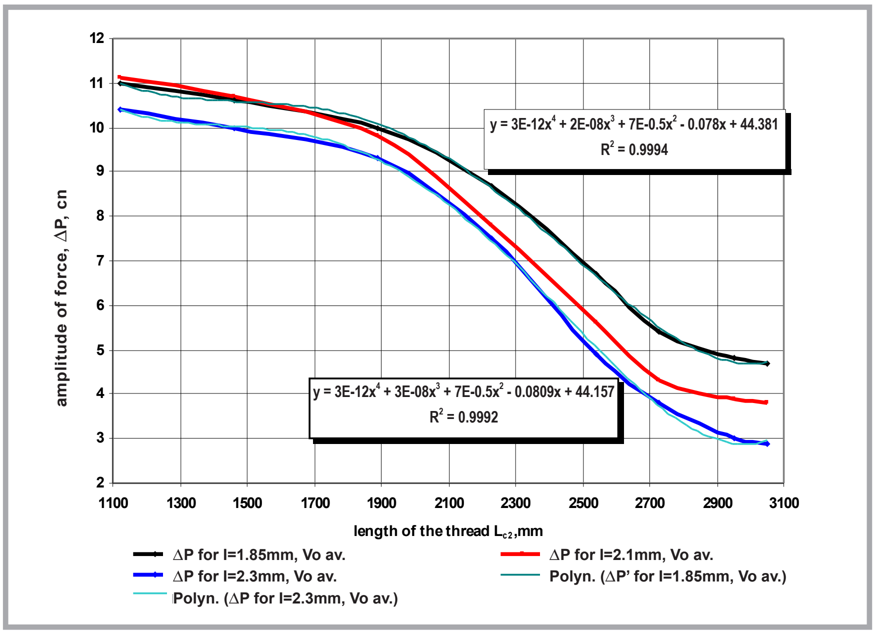

Figure 8. *Dependence of the amplitude of force ΔP_{max} on the length of thread being fed.*

For a_3 = f(β) for α = 0 we obtain $a_3 = (\cos\beta - k_s) \cdot k$, described by the cosine function.

The character of the curves of functions $a_{1,2,3}$ = f(a) analysed is very similar, determining the same tendency of changes in function a_i of angles a. The analogous similarity of the curves can be seen for the dependencies of $a_{1,2,3}$=f(b).

Dependence of coefficients a_i on the friction coefficient m of the thread against the tension rail plate

The dependence of a_i=f(m) concerns coefficients a_1 and a_2, which correspond to the conditions of the dislocation of the threads on the tension rail.

Dependence (4) can be written in the following form:

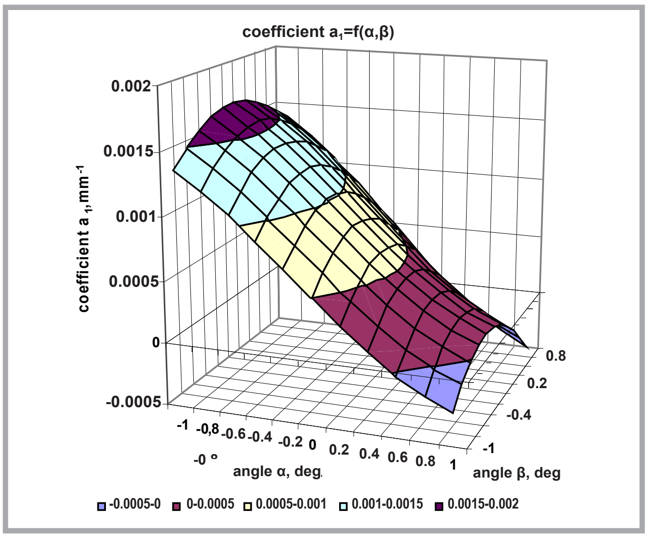

***Figure 9.** Dependence of coefficient a_1 on the angles α of the thread „running-on" and β „running-of" the tension rail plate (l_1 = 400 mm, l_2 = 610 mm, μ = 0,2).*

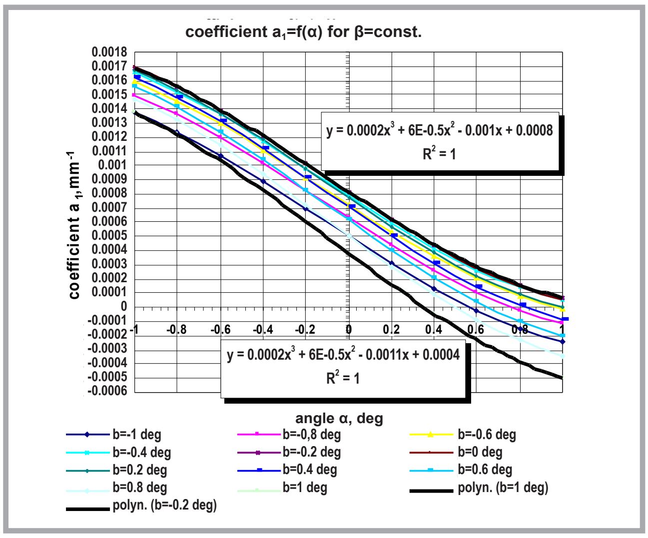

***Figure 10.** Dependence of coefficient a_1 on angle α of the thread „running-on" the tension rail plate.*

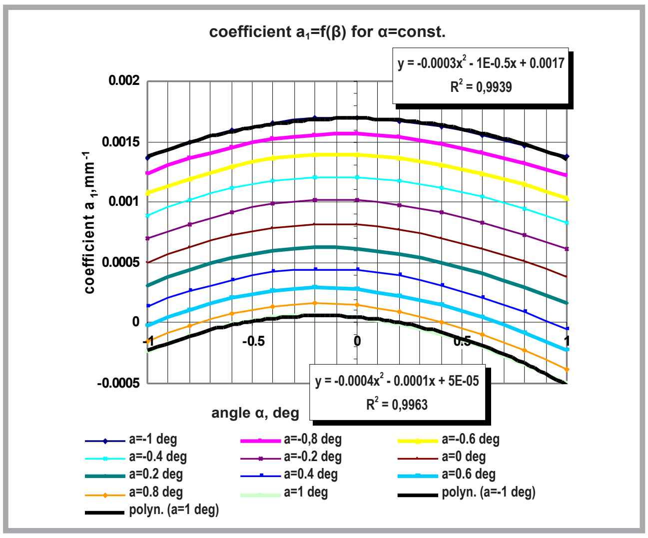

***Figure 11.** Dependence of coefficient a_1 on angle β of the thread „running-of" the tension rail plate.*

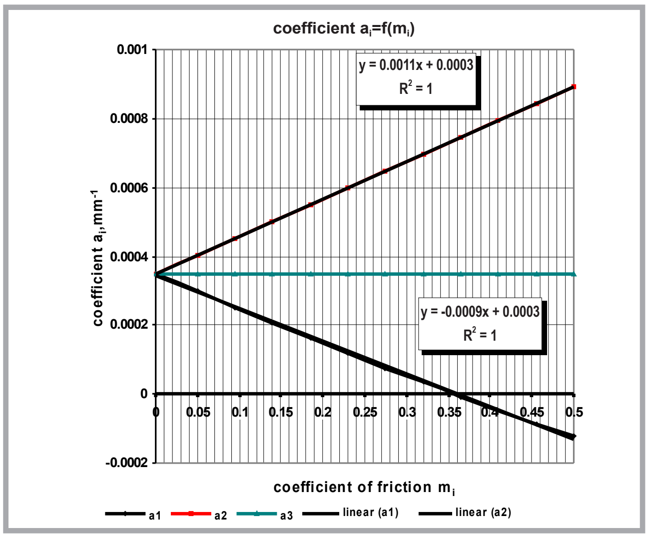

***Figure 12.** Dependence of coefficient a_i on the friction coefficient m of the thread against the tension rail plate (l_1 = 400 mm, l_2 = 610 mm, α = 36°, β = 22°).*

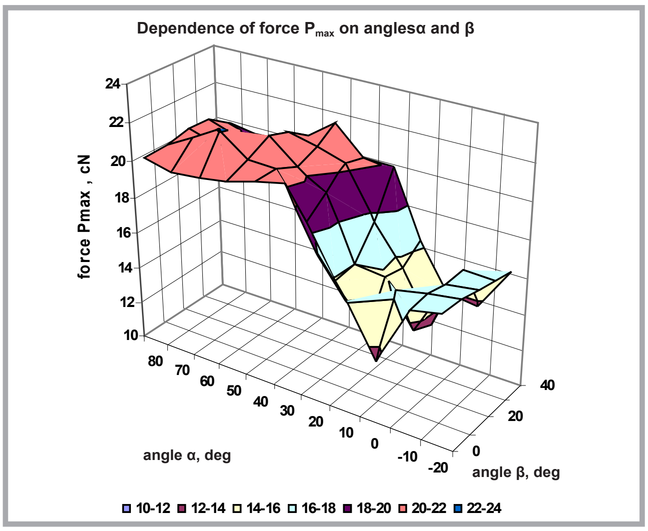

***Figure 13.** Dependence of force P_{max} on angles α and β.*

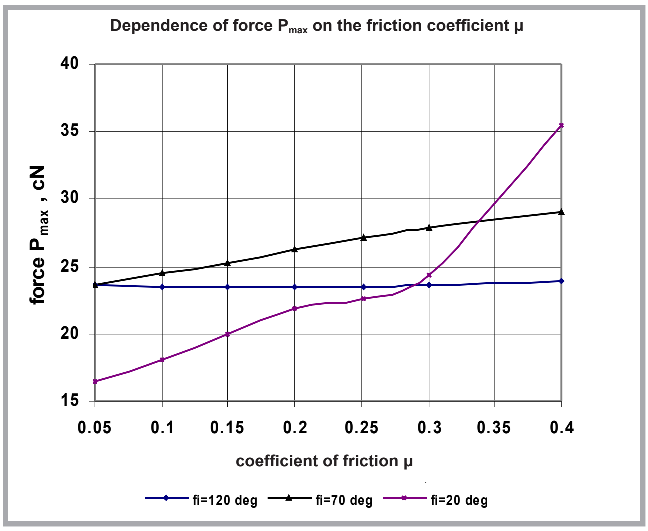

***Figure 14.** Dependence of force P_{max} on the friction coefficient of a thread against the tension rail plate (ρ = 20° for α = 40° and β = -30°, ρ = 70° for α = 40° and β = 20°, ρ = 120° for α = 40° and β = 70°).*

$$a_{1,2} = \frac{k_1 - e^{\pm k_2 \mu} \cdot k_3}{k_4 \cdot e^{\pm k_2 \mu} + k_5} \quad (16)$$

with constant coefficients: $k_1 = \cos\beta$, $k_2 = r$, $k_3 = \sin\alpha$, $k_4 = l_2$ & $k_5 = l_1$ = const.

Fraction $a_{1,2}$ is a quotient of exponential functions. The character of $a_{1,2}$ for a range of m from 0.005 to 0.5 is presented in ***Figure 12***.

With an increase in the argument, the values of function $a_{1,2} = f(m)$ increase for coefficient a_2 and decrease for coefficient a_1. Within the range of m assumed for $r^{23}0{,}999$ with high probability, dependence (16) can be described by a linear function. Straight lines approximating functions $a_{1,2} = f(m)$ are symmetrical to the straight line $a_3 = \frac{k_1 - k_3}{k_4 + k_5}$.

Results of simulations of the dependencies of the force on angles a and b and the friction coefficient m of the thread against the tension rail

For calculations of the forces of the function of angles a of thread „running-on" and b "running-of" the tension rail plate (***Figure 13***), which depend on the angle of wrapping r, the following input data was selected: E 20, n_d = 700 rows/min, l_1 = 400 mm, l_2 = 610 mm, k_s = 0,6 cN·mm^{-1}, $l_{ocz.}$ = 4 mm, k_p = 3150 cN, b_p= 1050 cN·ms (for thread JPE 110/24 f dtex), and y_0=4 mm.

The results of the investigations are presented in ***Figure 13***, which show the following:

- Within the range of angles α = -30÷10° with an initial constant value of the force of around 17 cN, P_{max} decreases by 24% and next within the range of 0°(10°) – 40° the force rapidly increases, reaching 21.5 cN (of 65%) and then it stabilises.
- Function P_{max} = f(b) has a parabolic character ($P_{max} = a\beta^2 + b\beta + c$). The minimum of the function occurs for angle b approaching zero and equals P_{max} = 13.2 ÷ 21.8 cN.

The dependencies mentioned above can help to optimise the parameters of the feeding process from the point of view of the lowest values of force P_{max}.

This way, for α = 30 ÷ 10° and β = -20÷10° the extreme forces P_{max} take the minimum values.

The dependence of the force in the threads on the friction coefficient of a thread against the tension rail plate is presented in ***Figure 14***. Function P_{max} = f(m) has an increasing character, while the value of the angle of wrapping r determines the intensity degree of changes in P_{max} on m. For the linear function of regression (y = ax + b) of P_{max} = f(m) changes, the slopes of the function equal a = 54.9 cN for r = 20°, a = 16.8 cN for r = 70° and a = 4.4 cN for r = 120°.

Summary

1. Simulations of the process of knitting on warp-knitting machines were conducted in order to determine optimal input parameters with regard to the minimum load of threads.
   Analysis of the knitting process was conducted in the aspect of the determination of advantageous areas of an important group of parameters characterising the geometry of the structure of the feeding device, including as follows: the length of warp threads "behind" and "in front of" the tension rail l_1 and l_2, angles α and β of the thread "running-on" and "running-of" the tension rail plate, friction coefficient m of a thread against the tension rail, the mass of the tension rail plate m, and the rigidity of springs supporting the tension rail k_s. Simulations were carried out in both directions, primarily to identify the character of changes in the coefficient of the feeding system geometry a_1. In the mathematical function of the model of the feeding process, the coefficient describes the parameters of the structure of the feeding device mentioned above. The second direction of the analysis, and at the same time the main goal of this research, was to find optimum solutions with regard to limiting the values of forces in the threads, beyond which disadvantageous disturbances in the knitting process can occur, further leading to unfavourable changes in the fabric structure. An algorithm of the mathematical model of the knitting process was elaborated in order to be used as a tool for simulations of the behaviour of the feeding system on warp-knitting machines.

- From the simulations of the knitting process conducted in order to analyse the structural features of warp-knitting machines and to identify optimum parameters of the feeding process with regard to the dynamic load of the threads, it results that:
  - The coefficient of the geometry of the feeding system describing, in a synthetic way, the parameters of the geometry of the structure of the feeding device shows a tendency to decrease with an increase in the length of the threads being fed, which in a physical meaning is characterised by a decrease in the values of forces in the threads. Coefficient a_i is characterised by a decreasing function that depends on the angle a of threads "running-on" the tension rail and is a function of the argument of angle β of the thread "running-of" the tension rail, being of a tendency described by a polynomial equation of the third degree.
  - With an increase in the free length of the threads within a range of 0 – 280%, the forces in the threads decrease by 74%, while the amplitude of force ΔP decreases by 65%. An optimal range of changes ΔL significantly decreasing the values of the maximum forces and amplitude of forces are the increments in length, starting from a value of 100%. The data presented and character of changes in P = f (L) were experimentally verified. The results obtained confirm the experimental investigations of the dynamic stretching of the threads, where the dependence of P = f (L) is a decreasing hyperbolic function asymptotically approaching P = 0.
  - The character of changes in the force, depending on angles α of the threads "running-on" and β "running-of" the tension rail, can be described by hyperbolic tangent and cosine functions, where optimum values of the angles from the point of view of the lowest values of P_{max} equal α = -30°÷10°, β = -20°÷10° and the angle of wrapping ρ = 60°÷110°.
  - The extreme forces in the threads increase in a 'linear' way depending on the coefficient of friction of the thread against the tension rail plate, and the intensity of the increase depends on the angle of wrapping r.

2. A computer simulation of the knitting process in the aspect of the dynamics of feeding is of great importance for the process of designing technological parameters, as well as for the mechanical designer-engineer in the process of designing warp-knitting machines from the point of view of the optimisation of modulus constructional solutions for the machine and also optimisation of the geometry of the feeding zone, and the technical parameters of the machine.

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XVII Seminar and Workshop on 'New Aspects of the Chemistry and Applications of Chitin and its Derivatives'

INVITATION

On behalf of the Board of the Polish Chitin Society I have both a pleasure and an honour to invite you to participate in the **XVII Seminar and Workshop on "New Aspects of the Chemistry and Applications of Chitin and its Derivatives"** which will be held in **Warsaw, Poland, September 21st – 23rd, 2011**.

The aim of the conference is to present the results of recent research, development and applications of chitin and chitosan.

It is also our intention to give the conference participants working in different fields an opportunity to meet and exchange their experiences in a relaxing environment.

Best regards
Dr Malgorzata M. Jaworska

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