TECHNOLOGICAL RELATIONS FOR THE STUDY OF THE TANGENTIAL UNWINDING OF THE WARP ON SEVERAL MACHINES FEEDED BY NARROW WARP ROLLS

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REZUMAT: Unele utilaje textile folosesc mai multe suluri de desfășurare. Viteza de alimentare a firelor de urzeală poate fi diferită, atât pe secvență, cât și de la sul la sul. Relațiile dintre caracteristicile constructive și cele tehnologice permit autoreglarea computerizată a rotației sulurilor în procesele de desfășurare tangențială ale textilelor. În această lucrare sunt prezentate câteva relații specifice pentru concepția tehnologică a programului de reglare automată a rotațiilor secvențiale ale sulurilor cu desfășurare tangențială.

Cuvinte cheie: desfășurare tangențială, urzeală, sul

ABSTRACT: Some textile machines use many unwinding rollers. The feeding speed of the warp yarns may be different, both on the sequence and from the roll to the roll. The relations between the constructive and technological characteristics base the computerized autoregulation of the rolls' revolutions in the tangential processes of the textiles. In this paper are presented some specific relationships for the technological conception of the self-adjusting program of sequential rotations of unwinding tangential rolls.

Keywords: tangential unwinding, warp, roll

1. TECHNOLOGICAL RELATION NECESSARY FOR SELF-REGULATION OF UNWINDING ROLLS SPEEDS ON TEXTILE MACHINES

Some textile machines use many unwinding rollers. The feeding speed of the warp yarns may be different, both on the sequence and from the roll to the roll. The feed rate of the warp on a roll, in a sequence i, is determined by the equation [1], [2]:

$$v_i = l_i\, n\, 10^{-3} \text{ or } v_i = \frac{L_{Ri}}{480}\, n\, 10^{-3} \qquad (1)$$

where: v_i - represents the feeding rate of the warp on a certain roll, in a certain sequence (i) of the knitting process, in m / min;

l_i - the stitch length in the knitting sequence (i) in mm;

n - the rotation speed of the main shaft of the warp knitting machine;

L_{Ri} - length of yarn consumption (length fed from the roll), corresponding to a rack, in mm / rack.

In modern machines, each warp roller is rotated by a self-regulated variable speed motor. Motor is driven by the machine's microprocessor. The turn of the roll changes as the unwinding roll decreases and from one sequence to another. Turn of the roll in any sequence will be:

$$n_{xi} = \frac{v_i}{2\pi R_{xi}} \qquad (2)$$

where: n_{xi} - represents the turn of the unwinding roll in a sequence (i), in rpm;

R_{xi} - the radius of the unwinding roll, in a sequence (i), in m.

The unrolling roller speed of self-regulation command, depending on the unrolling radius R_{xi}, cannot be accepted because it can move from one sequence to the other at the same radius. The roller contact unwinding roller, with electronic sensors, continuously measure the length of the unwinding warp on the roller (L_{dx}), or the length of the warp remained on the roller (L_{rx}). Therefore, the equation between the radius and the lengths will be used, in form [3], [4], [5]:

$$R_x=\sqrt{R_{x0}^2-\frac{(R_{x0}^2-R_t^2)L_{dx}}{L_{x0}}} \quad \text{or}$$

$$R_x=\sqrt{R_t^2+\frac{(R_{x0}^2-R_t^2)(L_{xo}-L_{dx})}{L_{x0}}}, \qquad (3)$$

if L_{dx} is counted.

$$R_x=\sqrt{R_{x0}^2-\frac{(R_{x0}^2-R_t^2)(L_{xo}-L_{rx})}{L_{x0}}} \quad \text{or}$$

$$R_x=\sqrt{R_t^2+\frac{(R_{x0}^2-R_t^2)L_{rx}}{L_{x0}}}, \qquad (4)$$

if L_{rx} is counted

where: R_x - represents the unwinding roll radius;

R_{x0} - initial radius of the full roll (at the beginning of the unwinding roller);

R_t - radius at the end unwinding (roll tube);

L_{xo} - the length of the warp on the full roll at the beginning of the knitting process;

L_{dx} – the unwinding length of the warp from the roller, at a time;

L_{rx} - the remained length of the warp from the roller, after a certain working time.

In warp knitting machines, the roll turn does not change only depending on the unwinding radius, but also from one sequence to another (decreases or increases). Each roll can have a different sequence of feeds (yarn consumption). Each feed sequence has a number of rows of stich, which may vary from roll to roll. The number of rows of stitch after which sequence succession repeats forms a knitting ratio. Knitting ratio is the same for all rolls in work.

For calculating the unwinding radius of each roll, at the beginning and end of each knitting sequence, when changing the roll turn according to the knit structure, other technological relationships are necessary (5)-(22):

$$L_{si}=\frac{L_{Ri}}{480}r_i \qquad (5)$$

$$L_{rs}=\sum_{i=1}^{i=k}L_{si} \qquad (6)$$

$$N_{rs}=\frac{L_{x0}}{L_{rs}} \qquad (7)$$

$$N_{ars}=N_{mrs}^{*} \qquad (8)$$

$$R_{rs}=\sum_{i=1}^{i=k}r_i \qquad (9)$$

$$L_{dioN}=L_{rs}(N-1)+\sum_{i=0}^{i=i_a-1}(L_{si}) \qquad (10)$$

$$L_{difN}=L_{rs}(N-1)+\sum_{i=0}^{i=i_a}(L_{si}) \qquad (11)$$

$$R_{xioN}=\sqrt{R_{x0}^2-\frac{(R_{x0}^2-R_t^2)L_{di0N}}{L_{x0}}} \quad \text{or}$$

$$R_{xi0N}=\sqrt{R_t^2+\frac{(R_{x0}^2-R_t^2)(L_{xo}-L_{dioN})}{L_{x0}}} \qquad (12)$$

$$R_{xifN}=\sqrt{R_{x0}^2-\frac{(R_{x0}^2-R_t^2)L_{difN}}{L_{x0}}} \quad \text{or}$$

$$R_{xifN}=\sqrt{R_t^2+\frac{(R_{x0}^2-R_t^2)(L_{xo}-L_{difN})}{L_{x0}}} \qquad (13)$$

$$n_{xi0N}=\frac{L_{Ri}\,n_{ap}}{960\,\pi\sqrt{R_{xo}^2-\frac{(R_{x0}^2-R_t^2)\left[L_{rs}(N-1)+(\sum_0^{i_a-1}L_{si})\right]}{L_{x0}}}} \qquad (14)$$

$$n_{xifN}=\frac{L_{Ri}\,n_{ap}}{960\,\pi\sqrt{R_{xo}^2-\frac{(R_{x0}^2-R_t^2)\left[L_{rs}(N-1)+(\sum_0^{i_a}L_{si})\right]}{L_{x0}}}} \qquad (15)$$

$$n_{mi0N}=n_{xioN}\,i_{sm} \quad \text{and} \quad n_{mifN}=n_{xifN}\,i_{sm} \qquad (16)$$

$L_{dioN}=L_{tioN}\,P_r\,l_i$,at the beginning of sequence i (17) ;

$L_{difN}=L_{tifN}\,P_r\,l_i$, at the end of sequence i (18)

$$L_{tioN}=\frac{L_{dioN}}{P_r\,l_i}, \quad L_{tioN}=\frac{L_{rs}(N-1)+[\sum_{i=0}^{i=i_a-1}L_{si}]}{P_r\,l_i} \qquad (19)$$

$$L_{tifN}=\frac{L_{difN}}{P_r\,l_i}, \quad L_{tifN}=\frac{L_{rs}(N-1)+[\sum_{i=0}^{i=i_a}L_{si}]}{P_r\,l_i} \qquad (20)$$

$$n_{xi0N}=\frac{L_{Ri}\,n_{ap}}{960\,\pi\sqrt{R_{xo}^2-\frac{(R_{x0}^2-R_t^2)L_{ti0N}\,P_r\,l_i}{L_{x0}}}} \qquad (21)$$

$$n_{xifN}=\frac{L_{Ri}\,n_{ap}}{960\,\pi\sqrt{R_{xo}^2-\frac{(R_{x0}^2-R_t^2)L_{tifN}\,P_r\,l_i}{L_{x0}}}} \qquad (22)$$

The significance of notations used in technological relations (5) – (22) are:

L_{si} - the consumed warp length for the whole sequence (i);

l_i - the consumed yarn length for an stitch in sequence (i), (the length of the warp consumed for a row of stitch in sequence i);

r_i - the number of knit rows in sequence (i);

L_{rs} - the consumed warp length for a complete sequence ratio (for example knitting ratio);

k - the number of sequences in the knitting ratio;

N_{rs} - the calculated number of sequence ratios possible to attain from the length L_{xo} of the warp on the roll, calculated for each roll.

N_{ars} - the adopted number of sequence ratios for all unwinding rollers;

$N_{\_mrs}$*- the minimum integer number of sequence reports resulting from one of the unwinding roller;

R_{rs} - the number of rows of knit from all the ratio sequences;

L_{di0N} - the unwinding warp length up to the beginning of any sequence ($i = i_a$) in the N ratio. N will take all the integers values between 1 and N_{ars}: ($1 \le N \le N_{ars}$);

i_a – the knitting sequence adopted for work;

L_{difN} - the length of the unwinding warp up to the end of any sequence $i = i_a$ in the N ratio.

R_{xi0N} - the radius of unwinding on a roll, at the beginning of the sequence i, from the N-th ratio.

R_{xifN} - the unwinding radius on a roll, at the end of sequence i, from the N-th ratio.

n_{xioN} - the turn of the roll at the beginning of the sequence i in the N-th ratio.

n_{xifN} - the turn of the roll at the end of sequence (i) in the N-th ratio.

n_{miN} - the roll motor's turn in different sequences (i) and knitting ratios (N);

i_{sm} - the kinematic ratio of the roller shaft to that of the stepper motor.

L_{tiN} (L_{tioN} or L_{tifN}) - the length of the knit delivery up to the beginning of the sequence (i_o) or the end (i_f) of the knitting ratio (N);

P_r – number of the stitches (rows of knit);

l_i - the length of the yarn in the knitted stitch.

The latter two relationships (21),(22) allow the use of a single electronic counting meter of the knitted length, which, transmitted to the machine's microprocessor, will automatically adjust the rotational speeds of each roll, at the beginning of each sequence ratio.

2. THE USE OF TECHNOLOGICAL EQUATIONS IN COMPUTER PROGRAMS AND SELF-REGULATION OF UNWINDING ROLLS

In any self-regulation unwinding rolls program, certain constant-technological data, specific to each roll and its sequences, are used. In Table 2, this constant data can be tracked for 3 of the 5 rolls used in a particular item [5].

By using the constant data from Table 2 and the technological relations presented in this paper, the rolls of the necessary technological rolls were obtained, for all the important moments of the knitting technological knitting operation (Table 3). Based on these technological turns, it is also possible to determine the self-regulating speeds of the motors acting on these rolls, in all knitting sequences and throughout the unwinding of the roller.

Table 2. **Constant-technological data in the program**

Beam	No	Symbol and u.m.	Data Name	Constant data values in sequence (i_a) equal to:				
1.	1	i	Sequence succession number	1	2	3	4	5
	2	C_{s0},mm	Circumference of the full roller	686,6				
	3	C_t, mm	Circumference of end unwinding (roll tub)	670				
	4	n_{ap},rev/min	Main shaft speed: 700 ≤nap≤3000	1000				
	5	Pr, cm^{-1}	The knitting density	28				
	6	N_r,rotation	Total number of unwinding rotations	2820,1				
	7	L_{Ri}, mm/rack	The length of the warp consumed on a rack (480 knitted stitch) in the ratio sequence (i)	670	0	0	0	0
	8	r_i, row	Number of rows knit in sequence (i) of ratio	75	0	0	0	0
2.	1	i	Sequence succession number	1	2	3	4	5
	2	C_{s0},mm	Circumference of the full roller	495,3				
	3	C_t, mm	Circumference of end unwinding (roll tub)	346,0				
	4	n_{ap},rev/min	Main shaft speed: 700 ≤nap≤3000	1000				
	5	Pr, cm^{-1}	The knitting density	27				
	6	N_r,rotations	Total number of rotations	11323,8				
	7	L_{Ri}, mm/rack	The length of the warp consumed on a rack (480 knitted stitch) in the ratio sequence (i)	1570	1870	1570	1270	-
	8	r_i, row	Number of rows knit in sequence (i) of ratio	10	30	10	25	-
3.	1	i	Sequence succession number	1	2	3	4	5
	2	C_{s0},mm	Circumference of the full roller	497,3				
	3	C_t, mm	Circumference of end unwinding (roll tub)	346,0				
	4	n_{ap},rev/min	Main shaft speed: 700 ≤nap≤3000	1000				
	5	Pr, cm^{-1}	The knitting density	28				
	6	N_r,rotations	Total number of unwinding rotations	11494,3				
	7	L_{Ri}, mm/rack	The length of the warp consumed on a rack (480 knitted stitch) in the ratio sequence (i)	1870	1570	1270	1570	1870
	8	r_i, row	Number of rows knit in sequence (i) of ratio	15	10	25	10	15

Table 3. **Calculated data useful for the roll rate self-adjustment program**

No.	Symbol and u.m.	Calculated data	No (N) of the ratio	Values calculated in sequens (i_a), equal to :				
				1	2	4	4	5
ROLL 1								
1	R_{x0} , mm	Initial radius unwinding roll (of the full roll)		109.36				
2	R_t , mm	Radius of the end undwinding roll		98,53				
3	L_{x0}, mm	Initial length of the warp		1840889,64				
4	l_i, mm	Length of warp in one knitted stitch, per sequence (i)		1,416	0	0	0	0
5	L_{si}, mm	Length of warp consumed throughout the sequence (i)		106,2	0	0	0	0
6	L_{rs}, mm	The length of warp consumed for the troughout sequence of ratio		106,2				
7	$N_{R,}$ ratio	Calculated number of ratio to be made from the whole warp		17334,177				
8	N_R^*	The integer value of the calculated value N_R		17334				
9	N_{ra},ratio	Number adopted by ratio		17334				
10	$N_{r,}$	Number of rows in a ratio		75				
11	n_{xi0N} , rev/min	The roll spin speed at the beginning of the sequence (i) of the N ratio equal to:	N=1	2,032	0	0	0	0
13			N=17334	2,255	0	0	0	0
14	n_{xifN} , rev/min	The Roll speed at the end of the sequence (i) of N:	N=1	2,0324	0	0	0	0
15			N=10000	2,1527	0	0	0	0
16			N=17334	2,2558	0	0	0	0
ROLL 2								
1	R_{x0},mm	Initial radius unwinding roll (of the full roll)		78,86				
2	R_t , mm	Radius of the end unwinding roll		55,o9				
3	L_{x0}, mm	Initial length of the warp		4762824,25				
4	l_i, mm	Length of warp in one knitted stitch, per sequence (i)		3,27	3,895	3,27	2,645	0
5	L_{si}, mm	Length of warp consumed throughout the sequence (i)		32,7	116,85	32,7	66,128	0
6	L_{rs}, mm	The length of warp consumed for the throughout sequence of ratio		248,375				
7	$N_{R,}$ ratio	Calculated number of ratio to be made from the whole warp		19175,94				
8	N_R^*ratio	The integer value of the calculated value N_R		19175				
9	N_{ra},ratio.	Number adopted by ratio		17334				
10	$N_{r,}$ rows	Number of rows in a ratio		75				
11	n_{xi0N} , rot/min	The roll speed at the beginning of the sequence (i) of the N :	N=1	6.604	7,864	6,604	5,3425	-
13			N=17334	9,01	10,733	9.01	7,289	-
14	n_{xifN} , rot/min	The Roll speed at the end of the sequence (i) of N ratio equal:	N=1	6,6045	7,866	6,6045	5,3426	-
15			N=10000	7,7141	9,1881	7,7141	6,2402	-
16			N=17334	9,011	10,7331	9,011	7,2891	-
ROLL 3								
1	R_{x0} , mm	Initial radius unwinding roll (of the full roll)		78,18				
2	R_t , mm	Radius of the end unwinding roll		55,09				
3	L_{x0}, mm	Initial length of the warp		4846335,5				
4	l_i, mm	Length of warp in one knitted stitch, per sequence (i)		3,895	3,27	2,645	3,27	3,895
5	L_{si}, mm	Length of warp consumed throughout the sequence (i)		58,425	32,7	66,125	32,7	58,425
6	L_{rs}, mm	The length of warp consumed for the throughout sequence of ratio		242,375				
7	$N_{R,}$ ratio	Calculated number of ratio to be made from the whole warp		19995,2				
8	N_R^* ratio	The integer value of the calculated value N_R		19995				
9	N_{ra},ratio.	Number adopted by ratio		17334				
10	$N_{r,}$rows	Number of rows in a ratio		75				
11	n_{xi0N} , rot/min	The roll spin speed at the beginning of the sequence (i) of the N ratio equal to:	N=1	7,834	6,577	5,320	6,577	7,834
13			N=17334	10,421	8,749	7,077	8,749	10,421
14	n_{xifN} , rot/min	The Roll speed at the end of the sequence (i) of N:	N=1	7,835	6,578	5,321	6,577	7,834
15			N=10000	9,052	7,599	6,147	7.605	9,052
16			N=17334	10,421	8,749	7,077	8,749	10,421

The results obtained by using the technological relations for self-regulating of roll turns programs and their rotary motors, allow the following technical observations to be made:

- The unrolling turn of the rolls increases continuously with the increase in the unwinding length on the roller, and the increase in the number of N knitting ratio made (for example in Table 2, Roll 1 and Fig. 1: Roll speed 1 continuously increases from 2,032 rpm to 2.255 rpm, with N increasing from 1 to 173334.
- The turn of each roll, with multiple knitting sequences, changes automatically when switching from one sequence to another, having different values depending on the order number (N) of the ratio in the realization (example in Table 2 and fig.2: the roll 3, a N=1 and at the beginning sequence, are: 7,834, 6,577, 5,320, 6,577 and 7,834 rpm, and at N = 10000 the rolls revolutions are: 9,051 7,599, 6,177, 7,592, 9,052 rpm).
- Rolls-turn variation are more important when switching from one sequence to another, compared to variation of these turns as the radius decreases from one ratio to another and the same sequence

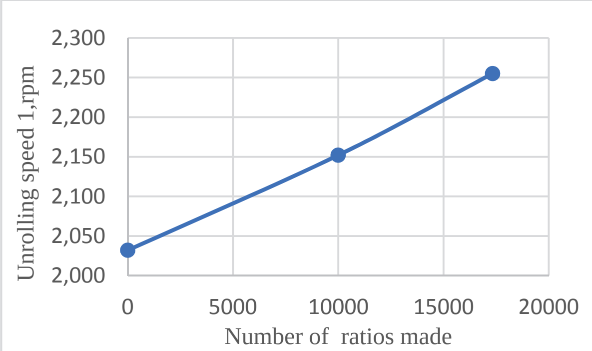

Fig. 1. Variation of roll turn 1 depending on the ratio N achieved.

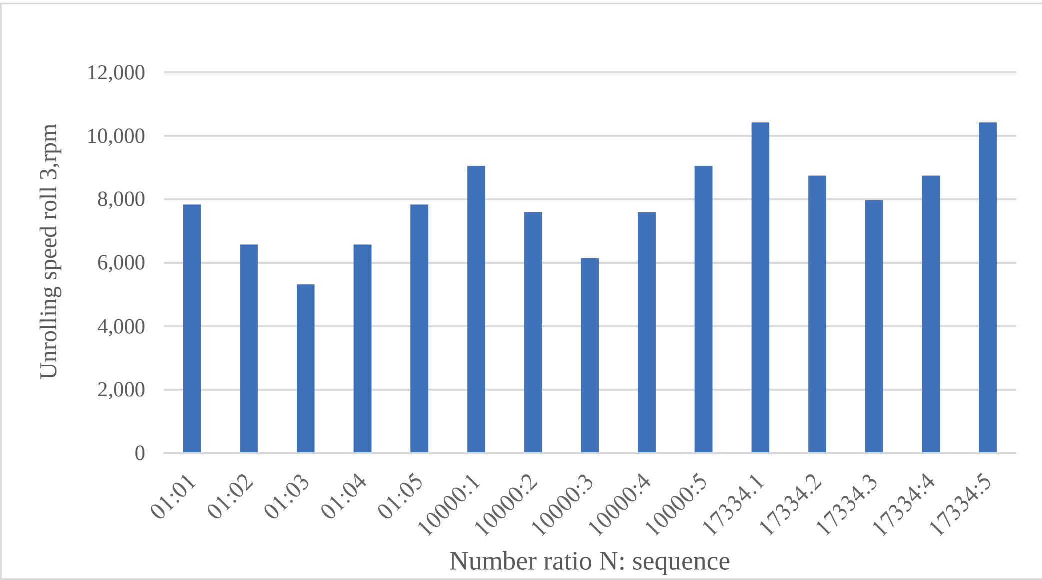

Fig.2 Variation of roll turn according to working ratio and sequence number.

3. TECHNOLOGICAL PROCESSING STAGES OF THE CALCULUS PROGRAM FOR THE SELF-ADJUSTMENT OF THE UNROLLING ROLLS AND THEIR ENGINES (STEPPER MOTOR)

1. Feed all the constructive-technological data (R_{x0} or C_{s0}, R_t or C_{st}), L_{x0}, i, L_{Ri}, etc.in the machine's computer;

2. The determination by the machines' computer of the technological data useful for auto-setting the roller revolutions, at each roller and all the sequences, based on the equations in this paper;

3. When using the electronic counting of the length of the unwinding warp, separated from each roll, the L_{dx} values of these lengths are continuously transmitted to the computer of the machine;

4. The machine's computer can continuously make the L_{dx}/L_{rs} ratio, which is usually a decimal number;

5. The machine's computer will continuously use in the relationships (14) or (15) only the full side (N) of the decimal numbers L_{dx}/L_{rs}, calculated automatically and continuously increasing from 0 to N_{ra}. The computer of the machine can thus provide the basic technological conditions for the self-regulation of the unwinding rolls 'turn, respectively the self-regulation of the roll's turn motor;

6. The technological relationships in this paper allow the renunciation at the quantification of the

unwinding length of each roll of warp, and the use of only the measured length of the knit fed by the machine's cylinders. The following steps can be used:

6.1. On each warp roller, relations (19) and (20) are used to calculate the length of the knit delivered at the beginning of the sequences in each ratio (L_{tioN}), respectively the end of the sequences in each ratio (L_{tifN}); These lengths, calculated for all integer values between 0 and N_{ra}, remain in the machine's computer as constant technological values for each roll;

6.2. During machine operation, only the knitted lengths delivered (L_{tx}) are continuously measured.

6.3. In each roll , when (L_{tx}) equals the (L_{tioN}) and (L_{tifN}) values, the turns (n_{xioN}) and (n_{xifN}) are determined and self - regulated using relations (21) and (22) for rolls. Automatically adjusts the rotation speed of the roll's motor.

4. CONCLUSIONS

1. The relations between the constructive and technological characteristics base the computerized autoregulation of the rolls' revolutions in the tangential processes of the textiles.

2. Structure and technology for making warp knits requires some specific relationships for the technological conception of the self-adjusting program of sequential rotations of unwinding tangential rolls.

3. The basic technological relationships presented in this paper can allow the self-regulation of the sequential rotational speeds of the tangential rolls of the beads, and even the simplification of the metering systems for the self-regulation commands.

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