A NEW METHOD FOR DETERMINING PRODUCTIVITY OF SECTIONAL WARPING MACHINES

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REZUMAT. Productivitatea maşinilor în ţesătorii este influenţată de un complex de factori printre care se pot enumera: metodele de muncă şi de organizare a muncii în ţesătorii, performanţele maşinilor şi nu în ultimul rând caracteristicile semifabricatelor şi ale materiilor prime utilizate în procesul de muncă. Productivitatea maşinilor este deosebit de importantă deoarece influenţează gradul de încărcare a maşinilor şi în final influenţează performanţele productive ale unităţilor de producţie. În lucrarea de faţă este prezentată o nouă metodă de determinare a productivităţii maşinilor de urzit în benzi, evaluată în baza rezultatelor practice obţinute în cadrul unei ţesătorii de lână.

Cuvinte cheie: productivitate, producția teoretică, producția practică, randament, urzire în benzi, pliere, organizarea muncii, fire, urzeală, țesături.

ABSTRACT. In this paper we present a new method for determining productivity and efficiency of the sectional warping machine based on technological data drawn from the production record sheets of a warping machine.

Keywords: productivity, theoretical production, practical production, efficiency, actual warping, folding, organization of work, threads, warp, fabrics.

1. INTRODUCTION

The productivity of warping machines in a weaver is influenced by the characteristics of the warp threads, by the technical characteristics of warping machines and last, but not least, by the working methods. The production of warping machines can be appreciated in units of length (warp meters) per time unit (minutes, hours) or it can be appreciated [m]ass units (Kg warp) reported per time unit (minutes, hours).

2. MATERIALS AND METHODS

This paper presents research on the determination of theoretical and practical productions of sectional warping machines, of Benninger Ergotech type, through a new method for calculating the production of the sectional warping machine, using technological data drawn from record sheets of the warping production, namely data regarding the warping time and the folding time of the warping batches.

The present research were conducted on several batches warp obtained by the sectional warping machines, of Ergotech Benninger type, that have been used for obtaining the 283 TR weaving fabric article, destined for men suits. The technical characteristics of 283 TR fabric are shown in Table 1. The physic-mechanical properties of the warp yarn of the 283 TR article presented in the analysis reports that accompany yarns are shown in Table 2.

Table 1. **Characteristics of warping threads and fabrics of the 283 TR article**

No.	Characteristic	Values
1	Total number of warping yarns [threads]	4512
2	Number of side yarns [threads]	96
3.	Length of raw fibre [cm]	180
4	Thickness of warped yarn in finished fibre [threads/10 cm]	267
5	Thickness of weft yarn in finished fibre [threads/10cm]	263
6	Tearing strength of the fabric in the warp direction [N]	260
7	Tearing strength of the fabric in the weft direction [N]	249
8	Elongation at tearing of the fabric in warp direction [%]	51,2
9	Elongation at tearing of the fabric in weft direction [%]	49
10	Finished Fabric Weight [g/m^2]	144,7

Table 2. **Physical and mechanical characteristics of warp yarn**

No.	Yarn characteristic		Values
1	Yarn composition		95,1% wool + 4,9% elastane
2	The fineness of the threads, Nm		40
3	Tearing strength of the threads, P [cN]		187,3
4	Tearing toughness, σ [cN/tex]		-
5	Elongation at threads tearing, ε [%]		18
6	Variation coefficient of threads tearing strength, CVP [%]		11,9
7	Variation coefficient of elongation at threads tearing, CVε [%]		31,6
8	Threads torsion, T [t/m]		793
9	Torsion warp direction		S
10	Threads imperfections	Thin:	24
		Thickening:	13
		Neps:	8

The present research was conducted by analysing the technological data drawn from the production record sheet in the warping operation, during the processing of nine batches of warp (L_1, L_9) with a total length of warp 15994 m. In order to determine the theoretical and practical production of sectional warping machines, a new method was used for determining the practical production and efficiency of sectional warping machines [1] using warping time T_u, folding time T_p and stop length of the warping machines.

The length of warping bands, L_b of the "L_i" warp batch is determined by the following relation:

$$L_b = Lu \cdot Z \tag{1}$$

where: L_b is the length of warping bands of L_i warping batches [m]; L_u – warp length of L_i warping batches [m]; Z – no. of bands of L_i warping batches [bands].

The stationary time of the warping machine due to technological reasons, in the actual warping phase, Tsu is determined by the following relation:

$$T_{su} = T_p + T_{sb} + T_{is} + T_{rup} \tag{2}$$

where: T_{su} is the stationary time of the warping machine in the actual warping phase [min]; T_p – preparation time of the warping machine before warping a new warping batch [min]; T_{sb} – stationary time of the machine, during the transition from one band to another [min]; T_{is} – stationary time of the warping machine for introducing separation strings of threads [min]; T_{rup} – time of thread rupture elimination during warping a new warping batch [min].

Stationary times of the warping machine due to technological reasons, in the actual warping phase, are determined by the following relations, according to elementary stationary times of the machine due to different technological reasons:

$$T_{sb} = t_{sb} \cdot Z \tag{3}$$

$$T_{is} = 2 \cdot t_{is} \cdot Z \tag{4}$$

$$T_{rup} = t_{rup} \cdot N_{rup} \tag{5}$$

where: t_{sb} is the stationary time of the warping machine during the transition from one band [min]; t_{is} – stationary time of the warping machine for a joint formation, [min]; t_{rup} – stationary time of the warping machine for rupture elimination of warp thread [min]; N_{rup} – average number of warp thread ruptures during the making of a warp batch, in ruptures.

The warping remaining time, T_{ru} is the time when yarn bands are actually wound around the drum of the warping machine, for the Li warp batch and is determined by the following relation:

$$T_{ru} = T_u - T_{su} \tag{6}$$

where: T_{ru} – warping remaining time [min]; T_u – time of actual warping of a warp batch, time drawn from the production record sheets of a warping machine (winding time of bands on the warping drum) [min].

Rated theoretical production and rated practical production of the sectional warping machine for the actual warping stage is determined by the following relations:

$$P_{tu} = \frac{L_b}{T_{ru}} \tag{7}$$

$$P_{pu} = \frac{L_b}{T_u} \tag{8}$$

where: P_{tu} – theoretical production of a warping machine in the actual warping stage [m/min]; P_{pu} – practical production of a warping machine in the actual warping stage [m/min].

The stationary time due to technological causes of the warping machine, in the folding process is determined by the following relation:

$$T_{sp} = t_{pp} \cdot Z + t_{ss} \tag{9}$$

where: T_{sp} is the stationary time of the warping machine in the folding stage [min]; t_{pp} – stationary time of the warping machine for the preparation of the folding machine [min]; t_{ss} – time for changing the final rollers for folding [min].

Trp, the remaining time for the effective functioning of the warping machine, during the folding stage, is determined by the following relation:

$$T_{rp} = T_p - T_{sp} \tag{10}$$

where: T_{rp} is the remaining time of effective functioning of the warping machine, during the folding stage [min]; T_p – total time of folding, drawn from the record production sheets of the sectional warping machine [min].

The theoretical and practical productions of the warping machine, during the folding stage are determined by the following relations:

$$P_{pp} = \frac{L_u}{T_p} \quad (11)$$

$$P_{tp} = \frac{L_u}{T_{rp}} \quad (12)$$

where: P_{pp} is the practical production of the warping machine in the folding stage [m/min]; P_{tp} – theoretical production of the warping machine in the folding stage [m/min].

The efficiency of the warping machine in both the actual warping stage and in the folding stage are determined by the following relations:

$$\eta_{tu} = \frac{P_{pu}}{P_{tu}} \cdot 100 \quad (13)$$

$$\eta_{tp} = \frac{P_{pp}}{P_{tp}} \cdot 100 \quad (14)$$

where: η_{tu} is the technological efficiency of the warping machine during the actual warping stage [%] ; η_{tp} – technological efficiency of the warping machine during the folding stage [%] ;

The technological efficiency of the sectional warping machine [bands] is determined by the following relation:

$$\eta_t = \eta_{tu} \cdot \frac{T_u}{T} + \eta_{tp} \cdot \frac{T_p}{T} \quad (15)$$

where: η_t is the technological efficiency of the sectional warping machine [%] ; T – total warping time [min]; T_u – actual warping time [min]; T_p – folding time [min].

T, the total warping time, is determined by the following relation:

$$T = T_u + T_p \quad (16)$$

T_u, the actual warping time and Tp, the folding time, are determined by the following relations:

$$T_u = \frac{L_b}{V_u} \quad (17)$$

$$T_p = \frac{L_u}{V_p} \quad (18)$$

where: V_u – actual warping speed [m/min]; V_p – folding speed [m/min].

The practical production of the warping machine is determined by the following relation:

$$P_p = P_{pu} \cdot \frac{T_u}{T} + P_{pp} \cdot \frac{T_p}{T} \quad (19)$$

where: P_p is the practical production of the sectional warping machine [bands] [m/min].

3. RESULTS AND DISCUSSIONS

The characteristics of bands warps used in obtaining the 283 T fabric article, as well as rated theoretical and practical productions of Benninger Ergotech warping machines are shown in the summarizing Table 3. The algorithm presented in this paper was used to determine the rated theoretical and practical productions of the warping machine. After determining the practical and theoretical productions of the warping machine for each warping stage, efficiencies of the sectional warping machine were determined for each batch of warp yarns, both in the warping stage proper and in the folding phase.

As shown in Table 3, using the technological data drawn from the [3] production record sheets, it was found that the number of bands from Li warp batches differ from a warp batch to another and it was adopted based on the warp length and on the dimensional characteristics of coils fuelled in the rack of the warping machine and depending on the number of coils available for each warp batch

Table 3 contains summary data that were used to determine the theoretical and practical productions of the Ergotech Benninger sectional warping machines, corresponding to the warping operation of processing L1, ..., L9 warp batches, warp batches that were used to obtain the 283 TR [3] type of fabric.

Fig. 1. Efficiency of warping machine on warp batches.

Table 3. **Productive achievements of the Benninger Ergotech sectional warping machine [3]**

Characteristic	**Batch L1**	**Batch L2**	**Batch L3**	**Batch L4**	**Batch L5**	**Batch L6**	**Batch L7**	**Batch L8**	**Batch L9**	**Total average values**
Length of warping batch, *Lu* [m]	1984	1984	1364	1364	1240	1240	1860	2480	2480	Ltu = 15994 m
No. of bands in warping batch, *Z*	15	15	15	15	15	8	10	12	12	
Total length of warping bands in the batch, L_b [m]	29760	29760	20460	20460	18600	9920	18600	29760	29760	Lbt = 207080m
Warping time, for the warping batch, T_u [min]	135	145	105	110	95	65	100	130	140	-
Machine stationary time, due to technological causes in the warping stage proper , T_{su} [min]	63,8	71,3	67,6	66	62,3	40,3	42,8	60,4	54,3	-
Practical production of the machine, in the actual warping stage, P_{pu} (V_u) [m/min]	220,4	205,2	194,9	186,0	195,8	152,6	186,0	228,9	212,6	203,9 m/min
Theoretical production of the machine, in the actual warping stage, P_{tu} [m/min]	418,0	403,8	547,1	465,0	568,8	401,6	325,2	427,6	347,3	-
Technological efficiency of the machine, in the actual warping stage, η_{tu} [%]	52,7	50,8	35,6	40,0	34,4	38,0	57,2	53,5	61,2	-
Folding time of warp on roll, T_p [min]	25	25	20	30	20	25	35	40	30	-
Machine stationary time due to technological causes, in the folding stage, T_{sp}, în min	7,5	7,5	7,5	7,5	7,5	4	5	6	6	-
Practical production during folding, P_{pp} (V_p) [m/min]	79,4	79,4	68,2	45,5	62,0	49,6	53,1	62,0	82,7	66,7 m/min
Theoretical production during folding, P_{tp}[m/min]	113,4	113,4	109,1	60,6	99,2	59,0	62,0	72,9	103,3	-
Technological efficiency of the machine during folding, η_{tp} [%]	70,0	70,0	62,5	75,1	62,5	84,1	85,7	85,0	80,1	-
Warping machine rated practical production, P_p [m/min]	198,4	186,7	174,6	155,9	172,5	123,9	151,6	189,7	189,7	175,4 m/min
Technological efficiency of the warping machine, η_t [%]	55,4	53,6	39,9	47,5	39,3	50,8	64,6	60,9	64,5	53%

After analysing the results in Figure 1, the variation of technological efficiency is presented, for the warping and folding stages, as well as the total efficiency of the sectional warping machine. It has been considered in the present research that organizing the production activity is identical throughout the completion of analysed warp batches and that technological times of using the warping machine that were used in the calculation of production and of machine efficiency are the same for all warp batches and it represents average values of stationary times of the warping machine due to technological causes [3].

4. CONCLUSIONS

The method of calculating rated practice production and rated theoretical production of the sectional warping machine presented in this paper uses records of the working time on technological stages of warping and other technological data on the quality characteristics of the warp yarn and their behaviour during the warping operation. The method of calculating production and technological efficiency of the warping machine [1] provides reproducible and versatile results that can be used for the assessment of the production activity and can also be used in programming and launching production on sectional warping machines.

In the present research, rated theoretical and practical production variation and that of the efficiency of the warping machine are determined mainly by the variation in the qualitative characteristics of the warp yarns that were used to make batches of warp (L1,...,L9). Thus we can say that the technological efficiency of the sectional warping machines highlights the importance of the qualitative characteristics of threads on achievements during yarn processing in the sectional warping operation. The present research shows that the number of thread ruptures in the warping operation influences both rated practical and theoretical production machine of the machine, as well as the technological efficiency of the warping machine.

The research presented in this paper has established that practical production of the sectional warping machine can vary within a relatively large interval, during the warping processing of analysed batches. The interval ranges from (123.9 m/min .. ., 198.4 m/min) as it results from the data presented in Table 2. It is thus evident that during the warping of the analysed batches there was a significant variation of up to 60% in the warping machine production, in particular due to the variation of the qualitative characteristics of the warp yarns used to make Li warp batches.

The present research also highlight that technological efficiency of warping machine for (L_1, ..., L_9) warp batches has values in the range (39.3% ... 64.6%) as shown in Figure 1. Higher technology efficiencies from the shown range provide information on the good organization of the production activity in the observation unit, while lower efficiency values are mainly the result of variations in the quality characteristics of the warp yarns used Li warp batches.

REFERENCES

[1] Iacob, I., *Procese şi maşini de preparaţie a firelor*, Vol 2, Editura Performantica, Iaşi, 2010.
[2] Liute, D., Iacob, I., s.a. *Procese şi maşini de prelucrare a firelor – Proiectare tehnologică*, Editura BIT, Iaşi, 1995.
[3] *** *Date tehnologice obţinute din fişe de înregistrare a producţiei.*
[4] *** *Prospecte tehnice ale maşinilor de urzit în benzi Benninger Ergotech.*

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