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APPLYING A STATISTICAL METHOD FOR ESTABLISHING SOME SUBSTANTIAL FACTORS OF A TECHNOLOGICAL PROCESSES

Ass. Prof. Dr. ing. Snezhina Angelova ANDONOVA
South-West University "Neophyt Rilsky"
Bulgaria, 2700 Blagoevgrad, 66 Ivan Mihailov str.
e-mail: sneji_andonova@abv.bg

ABSTRACT
The target of the analysis is the technological process "Humidity and Thermal Process (HTP)" in sewing production.
There are a substantial number of factors which refer to the technological process and all of them should be taken into consideration when carefully examining the qualities of cotton textiles.
In such cases all these factors should be arranged in a scale and according to their influence on the criterion for quality of the goods /for create a mathematical model/.
Thus the process is very complex and slightly examined we take advantage of the statistical method.
The experiments applied are narrowing the scope under question. 11 experts on this field are asked to express their opinion on these criteria, and every one of the experts arranges the factors according to their significance.
The obtained data are processed by implementing a classifying correlation.
Keywords*:* sewing production, Humidity and Thermal Process, statistical method

1. INTRODUCTION
Humidity and Thermal Processing (HTP) is one of the key technological processes in sewing industry. An analysis on research data about HTP in sewing industry shows the necessity of solving important problems by applying steam presses in order to achieve best possible quality indicators and simultaneously save energy and time.
HTP is a complex process where heat and mass transfer in ironing is realised through application of physical processes like convection, radiation, and diffusion. Their joint impact on HTP in steam-presses is not sufficiently revealed. From this point of view we can conclude that our object of investigation appears to be a virgin land, thus the main goals should include application of statistical methods.
Our field of interest is to investigate the HTP of cotton and cotton-like textiles (CT). There appears to be a large number of factors which influence the HTP. According to [4,7,8] all these factors should be ranked appropriately depending on the grade of influence on the factor "Quality". In our case we define "Quality" as a main criterion and it stands for "shrinkage" of cotton and cotton-like textiles after HTP[1,2].
The goal of this paper is to investigate the importance of all the factors influencing the shrinkage of CM after ironing with a steam-press, then to select the most significant factors, and at last to define their influence by arranging them appropriately. To achieve these goals we make use of a specialized statistical method.

2. DISCUSSION AND ANALYSIS

2.1. Conditions to execute the experiment (specialized statistical method)

We have created a special table with 12 factors which influence the shrinkage of CT after ironing with a steam-press (see Table 1).

The significance of all above listed factors and their influence on HTP is investigated in numerous publications. In [1] correlation between **Time** and **Temperature** in HTP of cotton textiles is examined as well the correlation between the ironing surface and the composition of processed materials. [2,3] investigates the correlation between **Continuance of HTP** and the **Number of processed layers**.

In general the significance of all above listed factors (Table 1) is proven. The problem is how to arrange them in accordance to their impact on the fact **"Quality".**

Table 1. Inquiry card

Code of the factor	Factors which influence HTP and the shrinkage of CT after ironing with a steam-press
X_1	**Pressure**
X_2	**Temperature** of steam
X_3	**Quantity** of steam absorbed by the textiles
X_4	**Temperature** of processed textiles
X_5	**Continuance of the 1st stage** – preparing the textiles to be shaped
X_6	**Continuance of the 2nd stage** – Shaping up the textiles
X_7	**Continuance of the 3rd stage** – Part 1: Fixing the final shape - Drying
X_8	**Continuance of the 3rd stage** – Part 2: Fixing the final shape - Cooling
X_9	**Surface area** of processed details
X_{10}	**Number of layers**
X_{11}	**Correlation** between ironing surface area and processed details' surface area (pack of processed details)
X_{12}	**"Sandwich"** – ironing pillows

For this purpose we make use of the inquiry card which was filled in by 11 specialists from the sewing industry and lecturers with the South West University of Blagoevgrad. The ranking matches closely the factors' significance.

The only limitation set is that by filling in the inquiry card there shouldn't be equal evaluations of the different factors.

2.2. Experimental results (of statistical method)

The results are shown in a matrix (table 2.).

The information was evaluated by using Kendall's informational and statistical methods [4,5,6] which deal with the grade of concordance in ranking completed by more than two experts and by using a large number of factors.

Table 2. Ranking matrix

expert \ factor	1	2	...	i	…	N=12
1	X_{11}=9	X_{21}=12	…	X_{i1}=X_{91}=10	…	$X_{12\,1}$=2
2	X_{12}=10	X_{22}=11	...	X_{i2}=X_{92}=9	…	$X_{12\,2}$=1
…	…	…	…	…	…	…
j	X_{1j}=X_{17}=8	X_{2j}=X_{27}=9	…	X_{ij}=X_{97}=12	…	X_{12j}=$X_{12\,7}$=3
…	…	…	…	…	…	…
K=11	X_{1k}=9	X_{2k}=12	…	X_{ik}=X_{9k}=10	…	$X_{12\,k}$=2

For this purpose we should define first Kendal's quotient of concordance:

$$W = \frac{12\sum_{i=1}^{n}\left(C_i - \overline{C}\right)^2}{k^2 n\left(n^2 - 1\right)} \tag{1}$$

To calculate it we should define the sum of each factor evaluated:

$$C_i = \sum_{j=1}^{k} x_{ij} \tag{2}$$

where: k – number of experts; n – number of factors to be ranked; Xij - ranking evaluation;i- factor and by j-th expert (table 2).

The average evaluation sum is defined by (3).

$$\overline{C} = \frac{\sum_{i=1}^{n} C_i}{n} \qquad (3)$$

Table 3. Sum of evaluations

Factor	Sum of evaluations C_i
X_1	101
X_2	120
X_3	119
X_4	85
X_5	83
X_6	66
X_7	56
X_8	16
X_9	115
X_{10}	44
X_{11}	33
X_{12}	21

The value of each factor is stated in Table 3.
The resulting quotient of concordance is **W= 0,9257.**

2.3. Discussion of the experimental results (of statistical method)

The method for a statistical analysis of the quotient W is chosen in accordance with the values "n" and "k".
Subsequently in our case it would be appropriate to use Pearson's criterion for a statistical analysis of W. χ_R^2 is calculated in accordance with (4).

$$\chi_R^2 = k(n-1)W \qquad (4)$$

χ_T^2 is stated by means of statistical tables.

$$\chi_T^2 = f\begin{Bmatrix} f = n-1 \\ P = 0,95 \end{Bmatrix} \qquad (5)$$

where: f - grade of freedom ; P - trustful probability.

χ_R^2 and χ_T^2 are compared, and for the case:

$$\chi_R^2 \triangleright \chi_T^2 \qquad (6)$$

$$(112,004 \triangleright 19,675)$$

Therefore the hypothesis of the statistical significance of the Quotient of Concordance is proven because the value P = 0,95 covers the criteria for a trustful probability. This means that the experts' evaluations match with a trustful probability = 0,95.

3. CONCLUSIONS (RESULTS)

3.1. The factors are ranked in accordance to their significance, as shown in Fig. 1.

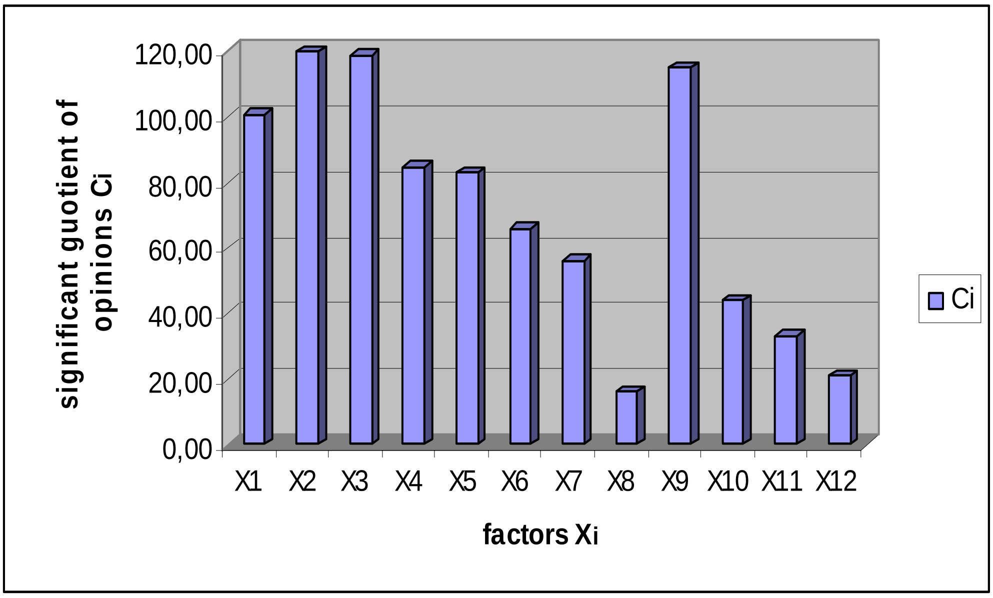

Figure 1. A histogram of experts' opinions

3.2.The factors which significantly affect the shrinkage of CT after HTP with a steam-press are determined:

X_2 - Temperature of steam;
X_3 - Quantity of steam absorbed by the textiles;
X_9 - Surface area of processed details.

3.3. The results show that it is reasonable to reduce the number of controlled factors for the multifactor experiment in order to mathematically model the HTP.

3.4. Considering all above stated we have chosen the factors X2, X3, and X9 to mathematically model the HTP.

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