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METHODOLOGY OF IMPLEMENTATION OF CONTROL MEASUREMENTS OF WOMEN'S DRESSES INTO THE TECHNICAL DOCUMENTATION OF PRODUCTION

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Abstract: *The aim of the study was to develop a methodology for indexing the control measurements of models of women's dresses by implanting a prototype design. To study the variance of deviations of control measurements of trade brand models, 10 variants of technical documentation for the manufacture of women's dresses were included based on the «customer-manufacturer» partnership. Using the method of induction analysis, the expediency of implementation the design of the prototype in the nomenclature of control measurements has been confirmed. Based on the calculation of mathematical models of splitting the set of control measurements, a method for differentiating clusters to control the quality of the finished product is proposed. Composite synchronization of control measurements of a series of dress models with the prototype design model was checked by the index of constructive homogeneity. The graphical method of normalizing the basis of deviations of 10 control measurements of the first group confirmed the linearization of deviations in anthropometric standards. Anthropometric implementation of control measurements was verified by cross-nostrification of dimensional codes.*
Keywords: *Control measurements, technical documentation, design implementation*.

1. INTRODUCTION

The application and study of the intellectual level of production in the field of textiles and clothing based on smart technologies is actual now. Product competitiveness is determined by responding to customer needs and its rapid bringing new products to market quickly through e-commerce platforms based on «customer-manufacturer» partnerships.
The relevance of smart clothing is often considered from the standpoint of integration of electronic parts into the technical characteristics of finished clothing [1]. However, issues of functionality, care, health risks from electromagnetic radiation do not explain to the consumer the ergonomic comfort of clothing design [2, 3]. Therefore, manufacturers need to determine what functionality or technology should be used in clothing [4, 5], while ensuring fashionable style and size availability.
The adaptation of the fashion industry to the concept of digital in the function of intelligent monitoring is aimed at the quality of customer service and retention. The principle of universality of anthropometric service differentiation in modern CAD «Clothes» allows to automatically changing the dimensional grid of the product by the algorithm of mass adjustment in parametric grading of industrial patterns. The technology of engineering design using smart technologies in the dialog window of the control measurement system provides a block-modular approach to clustering the evaluation of the finished product by indicators of convenience and design.

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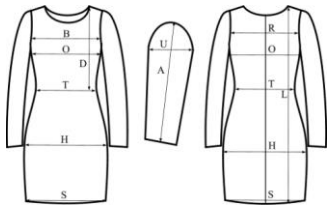
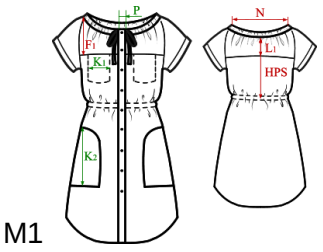
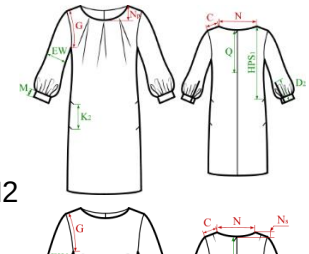
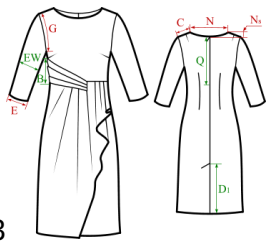
2. METHODS

A consolidated approach to the choice of interactive prototype design provides an analytical method of studying empirical factographic data in industrial collections of commercial brands [6]. The main indicators of the model sample are presented in the forms of technical documentation [7, 8], the number of which and characteristics should reflect the standardized requirements for the integration of the prototype design into the block of graphic information of model designs.

Table 1. Sketch of industrial models of women's dresses for verification of control measurements of the prototype design

Name of the place of control measurement	symbols	scheme of control measurement
1st cluster (set G1) – mandatory for all models		
1. The length of the back from the shoulder	L	
2. The width of the product at armhole depth	O	
3. Width at the waist	T	
4. Width along the line of the thighs	H	
5. Length to the waist in front	D	
6. Width along the bottom line	S	
7. Sleeve width under the biceps	U	
8. Sleeve length	A	
9. Back width	R	
10. Width in front	B	
Together:	10	
2nd cluster (set G_2) – model-constructive measurements of functional divisions		 M1
1. Front basque length	F_1	
2. The length of the yoke back	L_1	
3. The length of the back to the horizontal division	HPS	
4. Shoulder width	C	
5. Sleeve width at the bottom	E	
6. Depth of armhole	G	
7. Backrest neck width	N	
8. Depth of the neck in front	N_p	
9. Depth of the neck backrest	N_s	
Together:	9	
3rd cluster (set G_3) – measurements for decorative parts		 M2
1. Sleeve width at the elbow	EW	
2. Slot in the seams of the product	D_1	
3. Slot in the sleeve	D_2	
4. Length to pocket	HPS_1	
5. Cuff width	M	
6. Clasp length	Q	
7. Clasp width	P	
8. Width of insertion, waistband	B	
9. Pocket dimensions	K	
Together:	9	 M3

Using the method of linearization of anthropometric measurements in dimensional standards simplifies the quality control of measurements at all stages of the product life cycle «design - production - realization – operation» [9, 10].
The aim of the study is to develop a methodology for indexing the control measurements of models of women's dresses by implanting a prototype design. To achieve the goals set, the following main tasks were solved: 1) the controlling function of the quasi metric assessment of the empirical trends of the assortment in the selection of the interactive design of the prototype of the trade brand models was determined; 2) a method for verifying clusters of control of anthropometric information in the ergonomic system «body-product» has been developed; 3) analytically substantiated the methodology for the implementation of control measurements of the prototype design in the interactive modernization of brand models.
In the technical documentation of the customer firm, a sketch of the appearance of the model, as a rule, is accompanied by the designation of measurement areas [11].
There are three clusters of control measurements (Table 1). 1st cluster (set G1) – obligatory main places of anthropometric proportionality measurements for control of constructive balance. 2nd cluster (set G2) – additional model-constructive places of measurements of functional divisions of details for control of compression balance of a silhouette. 3rd cluster (set G3) – additional measuring places for decorative parts to control the compositional balance of the product.
The law of equilibrium describes the tectonics of a product in the form of an ordering of constraint rules.

3. EXPERIMENTAL

To formulate the optimization problem of minimizing the set of linear measurements, a linear objective function and the system of constraints in the allowed solutions of the set of measurement names G_{man} = 45; G_{stand} = 36; G_{prod} = 28:

$$f = \sum_{i=1}^{n} c_j x_j (\min); . \quad (1)$$

$$\sum_{j=1}^{n} a_{ij} x_j \; J \; b_i, i \; OG \setminus I; . \quad (2)$$

where c_j – group set of dimensions of the j-th cluster of sets G(j=1, 2, 3), x_j – linear measurement j-th cluster ($x_j \in G$); a_{ij} – minimized resource of measurements, b_i – involved measurement resource; i – number of linear measurements j-th cluster.
The condition for minimizing the set of measurements f'(y)≤ f(y) in the three clusters of measurements of the anthropometric framework is met: $G_{pord} \leq G_{stand} \leq G_{man} = 28 \leq 36 \leq 45$.
The array of tabular data of measurements of 10 models of women's dresses, taking into account the model of the prototype design contains 201 measurements for 28 names. Accordingly, for the design of the prototype – 19 measurements, for 10 models of the industrial collection – 182 measurements. The arithmetic mean is determined for each measurement $\overline{X}$.
The list of measuring places includes min – 18, max – 23 names.
The set G_1 includes 10 basic (anthropometric) measurements and the frequency of repetition is as close as possible to the standardized list of measurements of the finished product for Ukrainian manufacturers. The set G_2 includes 9 additional control measurements of the model-structural elements of the second cluster. The set G_3 characterizes 9 control measurements of the original elements of the third cluster.

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To study the dispersion of the spread of deviations of control measurements, it is advisable to take into account the interactivity of parameters in measurement clusters.

The application of three clustering methods, hierarchical according to the priority of anthropometric application – $\overline{X_1}$, identified in the prototype design – $\overline{X_2}$ and sorted by the technological rationality of the product model – $\overline{X_3}$ allows us to form a ranking matrix of deviations of the mean values of $\overline{X_1}$, $\overline{X_2}$, $\overline{X_3}$ (Table 2).

Table 2. Ranking matrix of the deviation of the arithmetic mean values $\overline{X_1}$, $\overline{X_2}$, $\overline{X_3}$ of the control measurements of the models of the trade brand with the design of the prototype (DP)

Control measurements, cm	conditional model code			deviation		X_3 ($\overline{X_1}$ + $\overline{X_2}$)	$D\overline{X_3}$ ($\overline{X_3}$ - *DP*)	admission to TD ±, cm
	DP	$\overline{X_1}$	$\overline{X_2}$	$D\overline{X_2}$ |DP-X_1|	$D\overline{X_1}$ |DP-X_2|			
L	95.0	95.4	96.3	0.4	1.3	95.3	0.3	2.0
O	106.0	99.4	104.1	6.6	1.9	101.75	4.2	2.0
T	102.0	94.0	97.7	8.0	4.3	98.0	4.0	2.0
H	113.0	109.6	108.7	3.4	4.3	109.15	3.85	2.0
D	62.0	60.5	64.3	1.5	2.3	62.4	0.4	1.0
S	115.0	113.8	110.2	1.2	4.8	112.0	3.0	2.0
U	38.6	35.7	36.5	2.9	2.1	36.1	2.5	1.0
A	58.0	60.0	61.1	2.0	3.1	60.55	2.55	1.0
R	38.0	38.0	39.1	0.0	1.1	38.5	0.5	1.0
B	36.0	37.0	36.2	1.0	0.8	36.6	0.6	1.0

Note: $\overline{X_1}$ – the estimated average model of control measurements of the industrial collection, $\overline{X_2}$ – the estimated average model of control measurements of the industrial series, $\overline{X_3}$ – estimated average scattering model, TD – technical documentation.

The deviation rank diagram $\Delta\overline{X_3}$ characterizes the level of implementation of control measurements to the proportionality indicators of the prototype design (Figure 1).

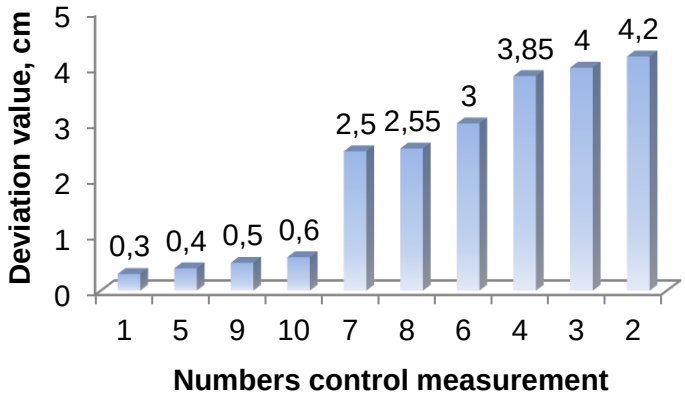

Figure 1.
Diagram of the ranking of control measurements in the implementation of ergonomic design

Deviations of measurements 1, 5, 9, 10 characterize the constructive balance of the supporting section of the dress design. Measurement deviations 2, 3, 4 characterize the compression balance of the modification of the silhouette Si2 into derivative silhouettes Si21, Si23 according to the resolving rules. Measurement deviations 6, 7, 8 testify to the compositional balance of the proportions of the dress.
In Ukraine, the control values of the size of shoulder clothing for women include: 1) height; 2) chest circumference; 3) hips circumference [12]. The European standard icon is supplemented by the control value «waist circumference».
For the cross-nostrification of control measurement tables from the manufacturer's documentation, a waist circumference is additionally included, which is important for marking the sizes of women's clothing.
Synchronization of size codes of women's clothing for the second complete group within the size icon for the average values of control measurements (Germany, Ukraine, international codification) is given in Table 3.

Table 3. Validation of synchronicity of dimensional codes of outerwear in the system of classification of typical figures of women of average height

Size group	European standard (Germany)				OST 17-326-81 (Ukraine)				deviation, cm			international codification
	average height 172 (165-172) cm				central height 164 cm				dimensional codes	circumferences chest and waist		
	circumference, cm			dimensional code	circumference, cm			dimensional code		Germany	Ukraine	
	chest	hips	waist		chest	hips	waist		ΔC	ΔoG	ΔoU	
1st	86-89	94-97	66-69	34	88	96	67.6	44	10	20	20.4	S
	90-93	98-101	70-73	36	92	100	71.8	46	10	20	20.2	S
	94-97	102-104	74-77	38	96	104	76.0	48	10	20	20.0	M
	98-102	105-108	78-81	40	100	108	80.2	50	10	20-21	19.8	M
	103-106	109-112	82-85	42	104	112	84.4	52	10	21	19.6	L
2nd	107-110	113-116	86-90	44	108	116	89.2	54	10	21-20	18.8	XL
	111-114	117-121	91-96	46	112	120	94.0	56	10	20-18	18.0	XL
	115-120	122-126	97-104	48	116	124	98.8	58	10	18-16	17.2	XXL
	121-125	127-132	105-109	50	120	128	103.6	60	10	16	16.4	XXXL
	126-131	133-138	110-115	52	124	132	108.8	62	10	16	15.2	XXXL

The reliability of dimensional codes by the magnitude of the error in the 1st group confirmed their validity with the universal coding scale in the international standardization of size.

4. RESULTS

The method of recognizing the features of the appearance of the model is a hybrid of methods of control measurements and restriction rules in the indexing of the modernization of the silhouette of Si*2* in the prototype design. A sketch of the graphic documents of the prototype model is presented in Table 4.

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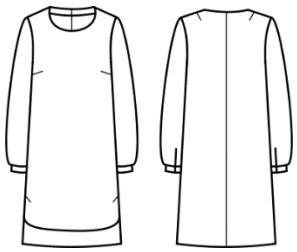
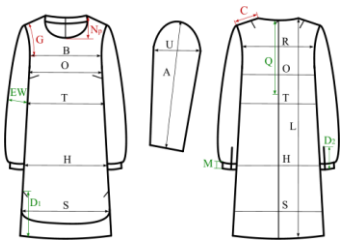
Table 4. Sketch of graphic documents of a prototype model of a woman's dress

Sketch of a prototype model	scheme of control measure-ments of the finished product	photo of the model of the control sample
		

According to the results of the analysis of factographic materials of technical documentation of models of dresses, three groups of the complexity of design-technological preparation of production has been allocated. The first group is subject to the preservation of a design of a prototype of a classical women's dress. The second group contains decorative elements of divisions and proportions of length. The third group - decorative elements of details of technological processing (models.

We assume that all models have the lining, side pockets, the neck is trimmed with welt. On the basis of a typological series, they meet the condition of launching into a typical technological process, it is an industrial series in the number of 3 models.

The control measurements of the G_1 group are 36%, the control measurements of the G_2 group are 32%, and the control measurements of the G_3 group are 32%.

A variant of compositional sorting of control measurements of the set of G_1 models of the industrial series is shown in Table 5:

Table 5. Composite synchronization of the set G_1 control measurements of models of the brand (size 38) with the design of the prototype (size 48)

Control measure ments*, cm	industrial series model number				compositional deviation from DP, ± cm			allowance, + cm	$\overline{X}$	note
	DP	M1	M2	M3	Δ1	Δ2	Δ3			
	Si2	Si21	Si22	Si23						
L	95.0	96.0	96.6	96.6	0	1.0	1.9	2.0	96.4	Proportions of length
O	106.0	106.0	102	104.4	0	4.0	1.6	2.0	104.1	Silhouette shape
T	102.0	102.0	97.0	94.0	0	8.0	8.0	2.0	97.7	Silhouette shape
H	113.0	112.0	106.0	108.2	1.0	7.0	7.0	2.0	108.7	Silhouette shape
D	62.0	61.0	62.0	61.0	1.0	0	0	1.0	66.3	Proportions of length
S	115.0	118.0	106.0	118.0	3.0	9.0	3.0	2.0	110.2	Silhouette shape
U	35.0	36.0	35.0	35.6	0.5	5.5	0.5	1.0	36.5	Silhouette shape
A	58.0	62.0	20.0	60.1	4.0	1.3	1.0	1.0	61.1	Proportions of length
R	38.0	40.5	38.0	37.0	3.5	0	1.0	1.0	39.1	Proportions of width
B	36.0	36.6	35.0	36.0	0.6	2.0	0	1.0	36.2	Proportions of width

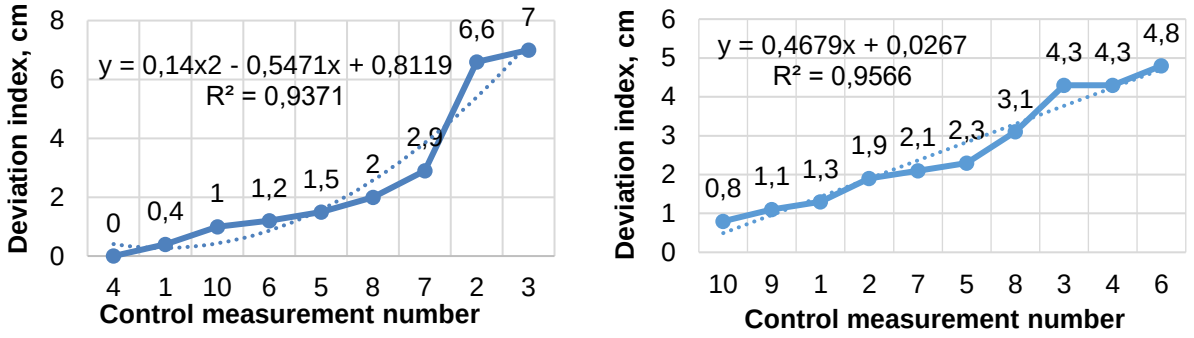
Note: * – the measurement values of the set characterize the perimeter of the measurement area in the technical documentation for the model.

Synchronization of the set G_1 control measurements of industrial series models with the prototype design is confirmed by entering the deviation of the arithmetic mean $\Delta\overline{X}$ of the industrial series into the tolerance of the limit of deviation from the nominal size.

According to the indexation of technological homogeneity, it is necessary to make changes to the formula of many linear measurements in G_2 and G_3 according to the number of permissible impacts and impacts of the noise field relative to the number of factors K = 28, I - the number of impacts of the noise field. , K–I=W – number of permissible effects:

$$G_{prod} = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + a, \quad (3)$$

Then, the set of permissible effects G_2 includes for DP I=19, for M1 I=22, for M2 I=20, for M3 I=22 control measurements. The number of noise effects n=K–I for DP n=28-20=8, for M1 n=28-22=6, for M2: n=28-20=8, for M3 n=28-22=6.
The values of b_0=1 and a=1 – according to the magnitude of the compositional deviations within the tolerance of the silhouette shape of Si2 (see Table 5).
Then $G_{prod.est}$=1+9+6+8+6+1=31 measurements. Therefore, the condition of linearization of the 1st group of basic (anthropometric) control measurements is observed: $G_{prod} \leq G_{prod.est}$=31≤32.
To exclude the fluctuations in deviations of control measurements, a graphical method for determining the basis B vector was used, provided that the number of vectors b_j is equal to k+1 (Figures 4).



a) b)

Figure 4. Graphical method for determining the vector of the basis of deviations of control measurements of industrial collection models: a) $\Delta\overline{X_1}$; b) $\Delta\overline{X_2}$

The value of basis B is calculated by Simpson's formula:

$$B = 1/3[(b_0 + b_{max}) + 4(b_1 + b_3 + ... + b_{n-1}) + 2(b_2 + b_4 + ... + b_{n-2})] \quad (4)$$

where b_0 – coordinates of points lying on the baseline.

For all three graphical models the scattering of deviations $\Delta\overline{X}$ -R^2=0.9272÷0.9566 confirms the high level of reliability of normalization of control measurements. The deviation of the control measurements of the industrial series from the standardized base of control measurements is 2.94%, which is within 5% of the allowable limit for light industry.
In the cooperation of partners of the firm «customer-producer» in the elaboration of technical documentation of the firm-customer agreed standard quality indicators for the main functional purpose; size, full-age group of human; season, the scope of application and operating conditions; confectionary map.

Analysis of the application of the three groups of control measurements in the first cluster of technical documentation on the models of the industrial collection indicates the presence of the prototype design modernization for the entire model range.

5. CONCLUSIONS

The model of typing the cluster groups in the product control measurement system is based on the optimization problem of minimizing the number of control measurements under the condition from the clothing surface to the mannequin surface. It is proved that the minimization condition in the differentiation of the multiplicity of the summary table of measurements $G_{prod}=b_1+G_1+G_2+G_3+a$ the condition of minimization is observed, $G_1=10$; $G_2=9$; $G_3=9$.
The practical significance of applying the analytical method of group implementation of deviations of control measurements is the interactive modernization of the homogeneity of control measurements using the ranking matrix of statistical averages.
Anthropometric indexing of the cluster functionality «mandatory control measurements» in the technical documentation is confirmed by maintaining the model of splitting the set of dimensions into three modules: structural size balance, compression balance of the silhouette shape, the compositional balance of proportions of details.

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