ANALYTICAL GROUNDING OF THE TRANSFORMATION PROCESS OF TRANSFORMABLE GARMENTS

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Introduction

Many consumers are contented with the fast fashion styles, abundant choices, and affordable price. However, other consumers and environmental advocates began to question about this fast fashion system, including the problems of overconsumption and disposable clothing. As a result, many fashion practitioners and scholars have been developing different strategies and methods to minimise the fabric waste, and prolong the product lifespan through innovative design [1]. Transformable design is an emerging design method which growing to be a fashion trend, and hence more fashion brands and designers are willing to invent transformable design.

That is the first of the reasons why transformable garments are so popular nowadays. Transformable clothing occupies a considerable part in the range of clothes. It includes children's wear, working wear, sportswear, clothes for pregnant women etc. The ability to change its function makes transformable clothes very useful when life conditions are changing as fast as nowadays.

There is a lot of different information about the appearance of the transformable clothing in literature, fashion shows, online shops, fashion magazines, online fashion reviews, patents databases. However, there is no any analytical grounding for the actual methods of construction of transformable garments. That is why many researchers investigate the principles of transformable garments design [1, 2, 3, 4].

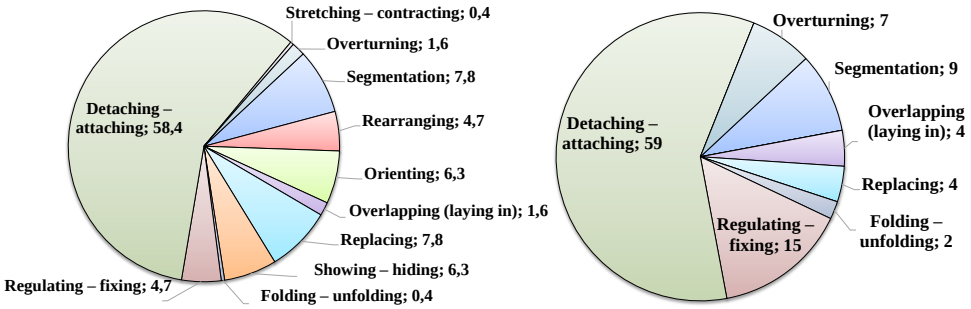
Researchers distinguish different types of clothes transformation: "detaching – attaching", "stretching – contracting", "regulating – fixing", "folding – unfolding", "showing – hiding", "overlapping (laying in) ", "replacing", "orienting", "rearranging", "segmentation", "overturning" [3, 4]. Transformation process might refer to one of mentioned types of transformation as well as to several of them that are used simultaneously. Any of the aforementioned types of transformation provides the ability for the

transformable garment to change its function. Additionally, most of them change their function by the way of attaching or detaching some elements.

The basis of informational and analytical grounding of transformation process is a structural characteristic of transformable segments that are the most essential parts of the transformable garment design. Presence of the transformable segments is the main feature that differentiates transformable garments from the other ones.

In order to investigate the process of transformation the analysis of ready-to-wear transformable clothing was performed. Over 600 transformable garments styles were selected out of online shops catalogues and fashion blogs. The sample size was decreased to 50 garment styles due to the most significant differences between them. The list of differences includes characteristics of garment type, material, silhouette, style seams, collar, pockets, etc.

Analysis shows that among the transformation types, the number of which is 11, only seven of them are used for the outerwear. The most frequently used one is the type "detaching – attaching" (figure1).



a **b**

Fig. 1. Frequency of the transformation types: a) in clothing; b) in the outerwear

According to the statement of [5], clothing sections that were designed as transformable must be classified regarding their purposes and types of transformation that were used to design. Such types of transformation and specific purposes of transformable sections of clothes are provided by specific parts. The main purpose of the specific garment consumes the purposes of separate parts of it. Therefore, a garment might be considered as a set of the sections and their components, which could be functional as well as dysfunctional:

$$V = \{S_i, i = \overline{1,m}\}, \quad (1)$$

where V – garment; S_i – set of garment sections; m – number of sections.

$$S \supseteq KE, \tag{2}$$

where KE – set of design elements.

Design elements such as front, back, sleeve, yoke, collar, cuff, pocket, interfacing, and hood can be considered as garment sections (units) as well as separate cut components [6, 7].

Functional section of garment is a part that consists of several specific components, which are composed into the complete element of garment. It might have one or several different purposes in the same garment and it is considered as complete unit but cannot be severed from the garment.

$$\Phi S = \{S_\phi | \phi \in \Phi\}, \tag{3}$$

where ΦS – set of the functional garment sections such as pockets, collars, etc.;

ϕ – function of the specific section;

Φ – set of functions of garment sections.

Transformable section is functional section, the main function of which is to provide ability to transform.

$$TS \subset \Phi S, \tag{4}$$

where TS – set of transformable sections of transformable garment.

Transformable section includes transformable parts and separate details that are combined with help of means of transformation.

$$TS = \{KE, TE, MT\}, \tag{5}$$

$$TE = \{KE_\phi | \phi \in \Phi_{TP}\}, \tag{6}$$

where TE – set of transformable elements;

MT – means of transformation;

Φ_{TP} – set of functions that provide ability to transform by means of design elements.

Transformable garment has a movable structure that provides an ability to transform. Transformable elements have the same ability. Therefore, they are movable elements that make the form move, and design elements are the constant ones.

$$V \supseteq \{V_O, V_{T_i}, i = \overline{1,n}\}, \tag{7}$$

$$V_O \supseteq \{KE_j, j = \overline{1,m}\} \cup \{TE_j, j = \overline{1,k}\}, \tag{8}$$

$$V_{T_i} \supseteq \left\{KE_{ij}, j=\overline{1,m}, i=\overline{1,n}\right\} \bigcup \left\{TE_{ij}, j=\overline{0,k-i}, i=\overline{1,n}\right\}, \quad (9)$$

$$TB = CP \bigcup MP \bigcup MT, \quad (10)$$

where V –set of the garments that can be obtained within the transformational chain of transformable garment;

V_O –original garment;

V_{T_i} – transformed garment;

n – number of the transformed garments, which can be obtained within the transformational chain of transformable garment;

m – number of design elements;

k – number of transformable elements;

CP (MP) – constant (movable) part of the transformable section.

Summarised function of the transformable section consists of its functions in original and transformed garment as well as function of the transformable section that is providing ability to change one transform into another and vice versa.

$$\Phi_{TS} = \Phi_{TS}^{O} + \Phi_{TS}^{T} + \Phi_{TP}, \quad (11)$$

where Φ_{TS} – summarized function of transformable section;

Φ_{TS}^{O} – function of transformable section in the original garment;

Φ_{TS}^{T} – function of transformable section in the transformed garment;

Φ_{TP} –function of transformability.

As a result of the analysis of design and methods of construction of transformable sections, it was determined that the change of garment length frequently causes the change of garment type (figure 2). Due to the transformation, the internal seam lines of the original garment become to be the hemlines of the transformed garments (figure 3).

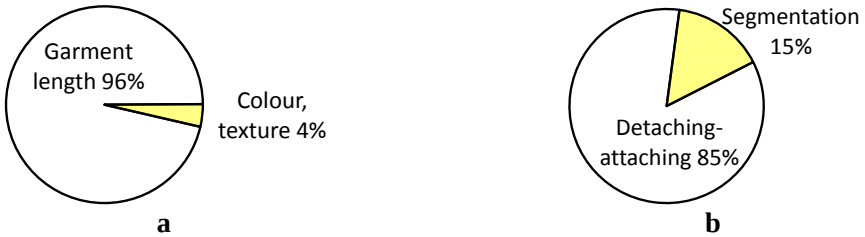


Fig. 2. The frequency of variable parameters (a) and transformation types (b) that cause the change of garment type

Fig. 3. Transformation of the seamlines

Function of seam lines determines the function of the transformable sections constructed on them:

$$\Phi_{TS}^{O} = \Phi_{TS}^{F} + \Phi_{TS}^{S}, \tag{12}$$

where Φ_{TS}^{F} – function of seam line that provide ability to create a form;

Φ_{TS}^{S} – function of seam line that provide ability to create a style.

Transformation of the garment might be performed in two opposite directions: from the original garment to the transformed one and vice versa. Therefore, the function of transformability must belong to the constant part of the transformable section as well as to the movable part.

$$\Phi_{CP} = \Phi_{TS}^{T} + \Phi_{TP}, \qquad \Phi_{MP} = \Phi_{TS}^{O} + \Phi_{TP}, \tag{13}$$

where Φ_{CP} (Φ_{MP}) – function of constant (movable) part.

$$\Phi_{MP} \to KP_{MP},\ KP_{MP} \bigcup MT \to TP_{MP}, \tag{14}$$

$$\Phi_{CP} \to KP_{CP},\ KP_{CP} \bigcup MT \to TP_{CP}, \tag{15}$$

$$\Phi_{TS}^{O} \to KP_{CP} \bigcup KP_{MP}, \tag{16}$$

$$\Phi_{TP} \to MT\,. \tag{17}$$

Selection of the means of transformation depends on form of the seam line and area of transformable elements as well as fabric, which the garment is made of. The transformation type “detaching – attaching” is supposed to use some notions like buttons, zippers, cords and eyelets, etc. Analysis of the transformable sections of garments allows finding out the means of transformation that influence the design of transformable garments. The most frequently used means of transformation is a zipper (figure 4).

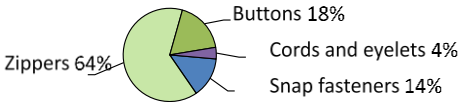


Fig. 4. Frequency of the means of transformation

In addition, when the area of transformable part is large and the seam line is horizontal, then the zipper is a required means of transformation. Otherwise, it would be possible to use anyone of mentioned notions. Besides that, a zipper must be used when the transformational element is made of knitted material that might be overstretched if the means of transformation does not prevent this.

One of the main criteria that determine design and methods of construction of transformable parts is the purpose of means of transformation. In addition, any garment needs a neat finish that is provided by lining. The fact that any transformable garment is supposed to have a lining means that it might interact with a zipper, which is the means of transformation in the case, and interrupt the process of attaching or detaching. Hence, there is a certain necessity to use a facing or something like that as a required component of such a garment part.

Different variants of the design and methods of construction of transformable sections were designed according to the typical assembling techniques of outerwear [6, 8, 9] with taking into account the functions of transformable parts. Ten variants of the techniques out of the total number, which is 26, are shown in the figure 5.

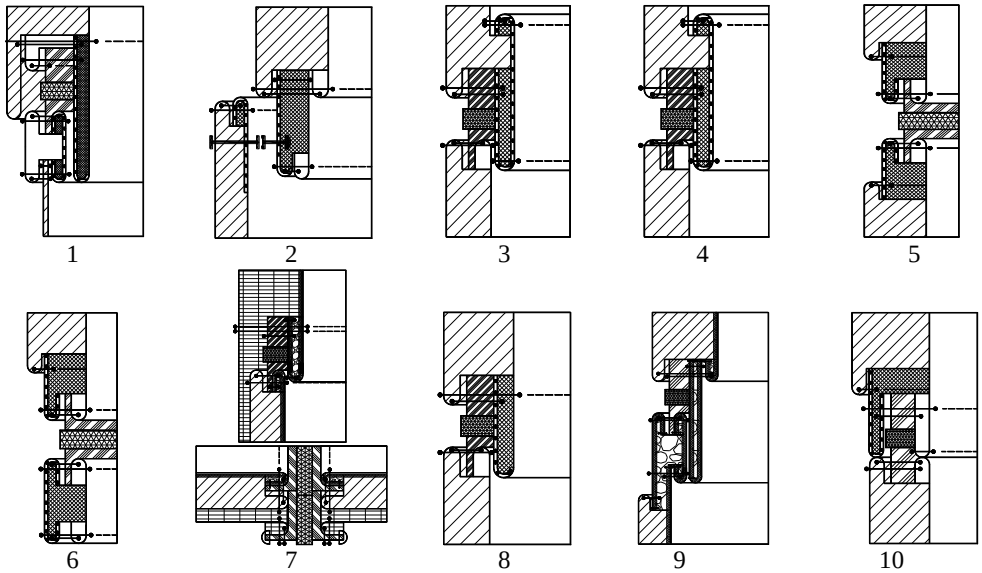


Fig. 5. The variants of assembling methods

Analysis of the modern transformable clothing show that the constant part is usually the upper part of the original garment as well as transformed one. Besides that, it was determined that transformable garment parts consist of basic elements as well as additional ones that are considered as typical for the

transformable garment parts because of their frequently appearance. The most frequently used ones are plackets and additional facing.

As it was mentioned above, transformable garment section consists of the constant and movable parts that are attached to each other with help of the means of transformation. Movable part, unlike the constant one, is a part of the original garment exclusively. Therefore:

$$KTP_{TS} \supset KP_{TS} \bigcup TP_{TS} \bigcup MT, \tag{18}$$

$$KP_{TS} \supset KP_{MP} \bigcup KP_{CP}, \tag{19}$$

where KTP_{TS} – design and method of construction of transformable section;

KP_{TS} – design of transformable section;

TP_{TS} – method of construction of transformable section;

MT – means of transformation of transformable section;

KP_{MP} – design of the movable part of transformable section;

KP_{CP} – design of the constant part of transformable section.

$$TP_{TS} \supset TP_{MP} \bigcup TP_{CP}, \tag{20}$$

where TP_{MP} refers to the method of construction of the movable part of transformable section; and TP_{CP} refers to the method of construction of the constant part of the transformable section.

If the type of transformation is “attaching – detaching”, the basic blocks, which are made of the fashion fabric, form the constant part. Additional components, components of lining and interfacing might be represented with several variants of design solutions or might be absent at all.

$$KP_{MP} \supset BPF \bigcup APF_m^n \bigcup L_l^k \bigcup FI_c^d, \tag{21}$$

$$KP_{CP} \supset BPF \bigcup APF_m^n \bigcup L_l^k \bigcup FI_c^d, \tag{22}$$

where BPF – basic blocks made of fashion fabric;

APF – additional components made of fashion fabric;

L – components of lining;

FI – components of fusible interfacing;

$n=0…m$, $k=1…l$, $d=0…c$ – number of the alternative components that are used in the part;

$m,l,c \in N$ – number of the alternative components that presumably can be used in the part.

General form of equation, which describes design and method of construction of the basic transformable part, is as follows:

$$KTP_{TS_i}^{bas} \subset \left\{ KTP_{TS_i} \middle| \Phi_{TS_i} = \Phi, i = \overline{1,n} \right\}, \tag{23}$$

where $KTP_{TS_i}^{bas}$ refers to design and method of construction of the basic transformable part; Φ_{TS_i} refers to function of the transformable part; and Φ refers to function that provides certain type of transformation.

Basic garment parts consist of minimal numbers of components that are needed in order to form the transformable garment part:

$$\begin{gathered} KTP_{TS}^{bas} \supset KP_{TS}^{bas} = \{BPF, APF, L, FI\}, \\ BPF = \left\{ BPF \middle| K_{BPF} = min_{BPF} \right\}, \quad APF = \left\{ APF \middle| K_{APF} = min_{APF} \right\}, \\ L = \left\{ L \middle| K_L = min_L \right\}, \quad FI = \left\{ FI \middle| K_{FI} = min_{FI} \right\}, \end{gathered} \tag{24}$$

where KP_{TS}^{bas} –design of basic transformable part;

K_{BPF}, K_{APF}, K_L, K_{FI} – number of basic parts made of fashion fabric, additional components made of fashion fabric, components of lining, and components of fusible interfacing respectively.

Then, according to the equation (19), the logical inference will be the follows:

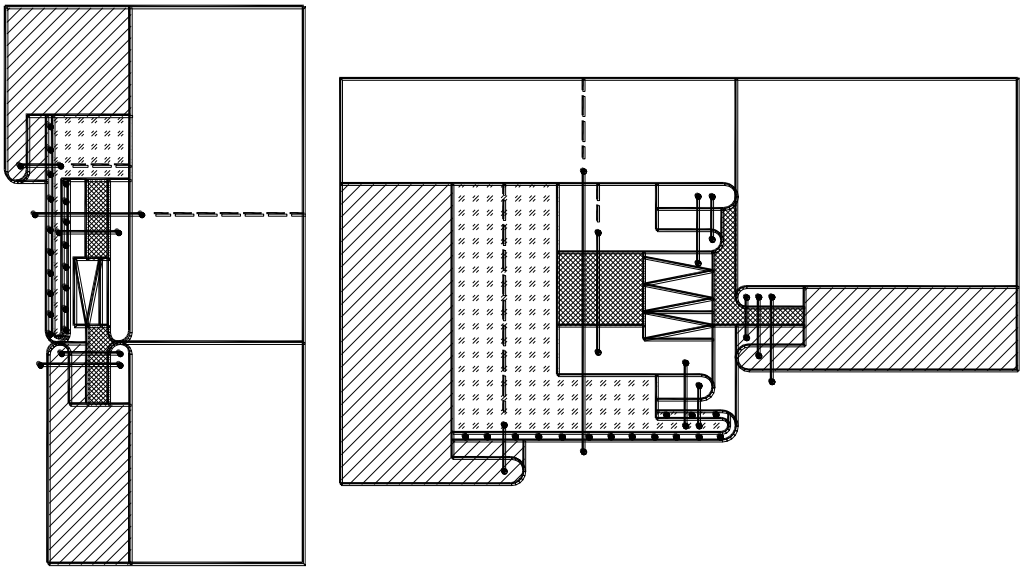
$$KTP_{TS}^{bas} \supset KTP_{MP}^{bas} \bigcup KTP_{CP}^{bas}, \tag{25}$$

where KTP_{MP}^{bas} (KTP_{CP}^{bas}) – design and method of construction of the movable part (constant part) of the basic transformable section.

$$KTP_{TS} \subset KTP_{MP}^{bas} \bigcup KTP_{MP}^{mod} \bigcup KTP_{CP}^{bas} \bigcup KTP_{CP}^{mod}, \tag{26}$$

where KTP_{MP}^{mod} (KTP_{CP}^{mod}) – modification of the design and method of construction of movable (constant) part of the basic transformable section.

The structure of the basic transformable sections for the type of transformation “detaching – attaching” depends on the structure of equation (26). Besides that, the basic design and method of construction depends on whether section is constructed with the straight seam line or the curved one. Therefore, there are two typical variants of the basic methods (figure 6) and several lists of modifications of the constant and movable parts for each method.



a **b**

Fig. 6. The basic methods of construction of transformable sections: a) straight seam line (1); b) curved seam line (2)

The consolidated information about typical transformable sections and their modification as well as developed structures of the sections allow forming the database that is assumed to support clothing design process (figure 7).

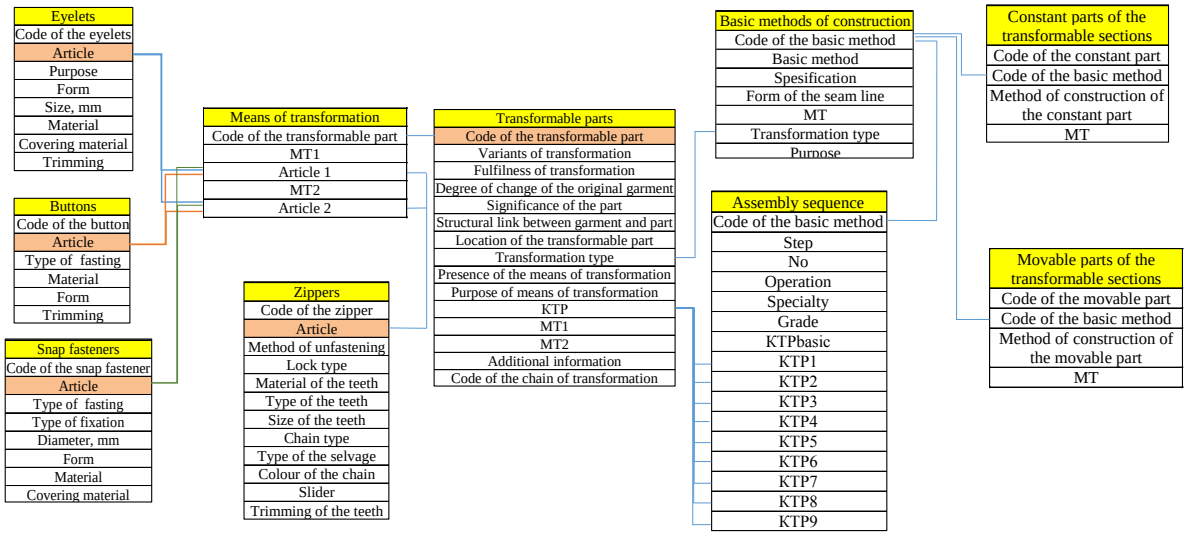
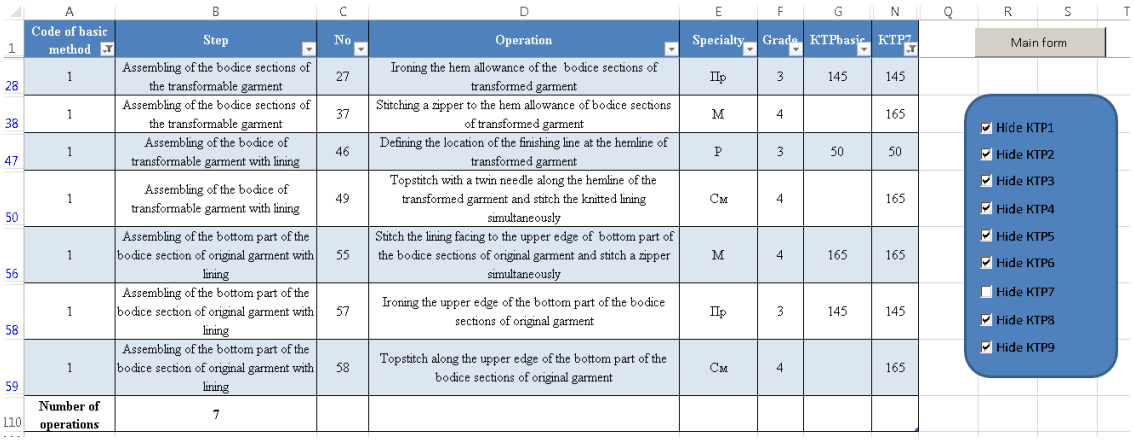


Fig. 7. Fragment of the database structure

Developed structures of the design and methods of construction of the basic transformable parts determine the structures of the general garment assembly sequences that are performed to sew the garment parts.



Code of basic method	Step	No	Operation	Specialty	Grade	KTPbasic	KTP7
1	Assembling of the bodice sections of the transformable garment	27	Ironing the hem allowance of the bodice sections of transformed garment	Пр	3	145	145
1	Assembling of the bodice sections of the transformable garment	37	Stitching a zipper to the hem allowance of bodice sections of transformed garment	М	4		165
1	Assembling of the bodice of transformable garment with lining	46	Defining the location of the finishing line at the hemline of transformed garment	Р	3	50	50
1	Assembling of the bodice of transformable garment with lining	49	Topstitch with a twin needle along the hemline of the transformed garment and stitch the knitted lining simultaneously	См	4		165
1	Assembling of the bottom part of the bodice section of original garment with lining	55	Stitch the lining facing to the upper edge of bottom part of the bodice sections of original garment and stitch a zipper simultaneously	М	4	165	165
1	Assembling of the bottom part of the bodice section of original garment with lining	57	Ironing the upper edge of the bottom part of the bodice sections of original garment	Пр	3	145	145
1	Assembling of the bottom part of the bodice section of original garment with lining	58	Topstitch along the upper edge of the bottom part of the bodice sections of original garment	См	4		165
Number of operations	7						

Fig. 8. The transformable section assembly sequence

Conclusion

As a conclusion, it must be emphasised that although transformable clothing exist mostly in the realm of creativity, developed structure of the database along with theoretical grounding of the transformation process allow using the typical assembling techniques that are standard for the unit method of garment construction.

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