Design and Computer Construction of Structural Sleeve Forms for Women's Clothing

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ABSTRACT

The paper presents the research of the development process of a unique women's clothing collection with complex, structural sleeve forms. Using the 2D/3D CAD systems for computer clothing design, 15 models of women's clothing with structural sleeve forms were constructed and modeled. Textile patterns were also computer-designed, as a preparation for digital printing on cutting parts of a particular clothing models. The computer clothing design included all the segments of the computer 3D prototype development, with the purpose of investigating the possibilities of modeling and 3D simulations of complex sleeve structures, which in the real manufacturing process require additional fixation of cutting parts. The influence of 3D simulation parameters, in correlation with the applied physical and mechanical properties of textile material, was investigated in order to achieve complex 3D forms of simulated clothing models. Color and textile patterns variations of computer-designed 3D models were developed with the purpose of achieving a realistic visualization of the designed clothing collection. Original prototypes were made for two selected models from the collection, with computer-designed textile patterns applied on a model using digital printing technology.

KEYWORDS

Sleeves, high fashion, 2D/3D CAD system, computer clothing design, digital print

INTRODUCTION

The sleeve, as an element of clothing, definitely has a special significance in the fashion history. Through the past, sleeves have changed their shape in line with fashion trends that have marked certain historical periods [1,2]. By exploring the history of the sleeves, an insight into a complete picture of very different shapes and sleeves is made, conditioned by technical possibilities and knowledge of the particular historical period and the rules of dressing and decorating within social communities of a certain time [3,4]. In the haute couture, design of sleeves, as well as the design of a complete garment item, can be very complex considering block pattern modeling process and manufacturing technology, with the aesthetic component as primary, while the functionality of the model can be reduced [5]. The role of today's haute couture designers is to generate publicity with its extreme and avantgard and to provide inspiration for simplified,

wearable pret-a-porter. Many contemporary haute couture creations are designed for archive and museum collections and more exist as art, but as a fashion [6].
The use of modern 2D/3D CAD (Computer Aided Design) systems for computer design of garment prototypes is still not sufficiently represented in practice, given that it represents a complex computer development process of garment models and requires a broader high-skilled knowledge and experience. Haute couture in particular is characterized by a large proportion of manual labor, given the models complexity in terms of manufacturing process, but also in the segment of block patterns development where the tailors' dummies and paper pattern modeling directly on the mannequin are still most commonly used. In today's modern times, the way of using the CAD system in construction preparation is changing, due to the new possibilities that CAD systems provide in the area of models prototypes development, and also because of the globalization that creates a connection between the manufacturers, primarily through the development process. Application of complex computer CAD system includes complete process, from idea and style concept (sketch drawings), through complete computer development of block patterns and 2D/3D design of model prototype, to production and sales, with the planning and monitoring of all stages of preparation and production [7,8]. In doing so, CAD systems connect with CAM (Computer Aided Manufacturing) systems to manage and control technological operations in the clothing production, where computer guide and manage a certain technological processes [9].
The research presented in the paper analyzes the possible applications of 2D/3D CAD systems for computer clothing design in the development process of haute couture garment prototypes with complex structural sleeves forms that require more complex pattern modeling and additional reinforcements to achieve complex 3D sleeves forms in the real manufacturing process. The paper describes women's fashion haute couture garment development process, based on the application of 2D/3D CAD systems for computer clothing design and research on textile materials physical and mechanical properties influence on the achievement of complex 3D structural sleeves forms in the 3D simulation process of garments prototypes.

EXPERIMENTAL

Materials and Methods

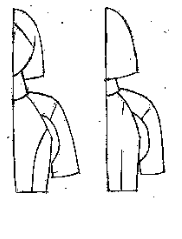
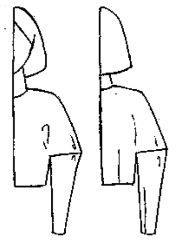
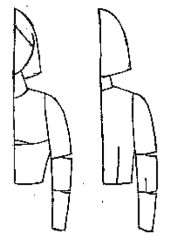
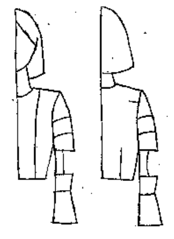
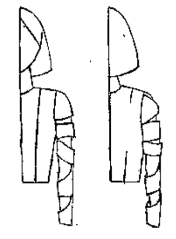
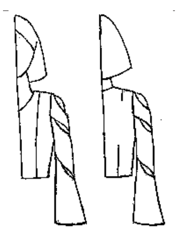
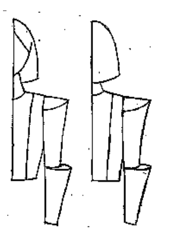
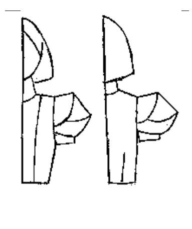
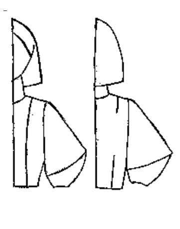
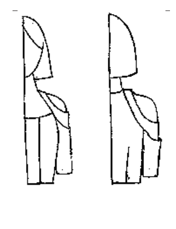
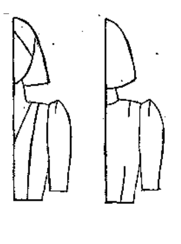
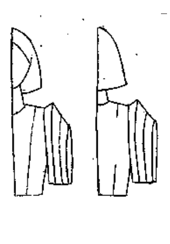
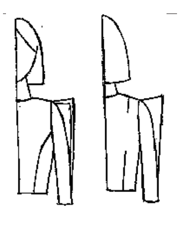
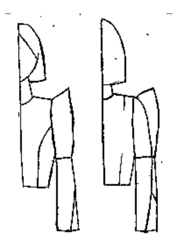
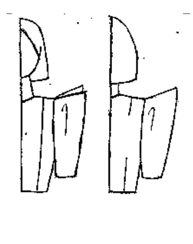
Below are listed the segments of research in the development process of haute couture clothing computer prototypes and the methods and procedures that have been used.

Design development process of women's clothing collection with structural sleeves forms

Drawing or sketch that incorporates new elements are the basis for the design of the clothing art project. Inspiration by which the idea is elaborated, apart from its sketches, the designer finds everything around him, and in order not to be lost in a variety of creativity, he defines the basic points according to which he creates his own art project. At the earliest stage of developing ideas, design sketches should be drawn quickly so that many ideas are created through hand movements. This method is often called brainstorming. The drawings can be presented as flat sketches, i.e. clean lines sketches or flats and technical drawings, to show the exact appearance of the future garment as accurately as possible [10].
After defining ideas and creating sketch drawings, the collection of clothing according to the established rules, in line with fashion trends and appropriate production program of the company is developed through design of art projects, with the aim of satisfying the desire of certain consumers categories and market confirmation through most possible profit [11].

As a basis for the experimental part of the work, the original collection of 15 women's dresses was initially designed, with a focus on a structural sleeves forms. The models are created according to the key guidelines for creating a collection that begins with research, insight into ideas and art projects design of women's dresses with interesting and complex structural sleeves. The characteristics of the haute couture clothing collections are in the application of expensive, high-quality materials, garment models that are more complex in terms of design and pattern construction and manufacturing technologies which enable achievement of specific, often complex garment forms. Tab. 1. Presents the technical drawings of designed models with 15 different sleeve forms as original women's clothing collection. First six models (MODEL 1 to MODEL 6) are based on different, mostly transverse and diagonal sleeve cutting lines. More complex models as MODEL 7 to MODEL 9 intent to achieve characteristic voluminous sleeve form, with expressive structures formed of irregular cutts and significantlly reinforced cutting parts. Irregular sleeve cutts contribute to overall garment dynamics, while regular and precise pattern construction, material selection and garment production need to ensure stability of threedimensional sleeve form. The emphasis is on selection of more firm materials, which, though cut, ensure stable stand-alone form. More elegant models with round cut lines and raised seams (MODEL 10 to MODEL 15) also require selection of more firm materials and additional reinforcement of parts in order to achieve desired structural forms designed within collection.

Table 1. Techical drawings of structural sleeves forms for women's clothing collection

				
MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
				
MODEL 6	MODEL 7	MODEL 8	MODEL 9	MODEL 10
				
MODEL 11	MODEL 12	MODEL 13	MODEL 14	MODEL 15

Computer modeling of women's dresses with structural sleeves forms

Basic block pattern of women's dress size 38 was used as a basis for pattern modeling of designed clothing collection. Basic pattern construction and complex development of cutting parts for all 15 models was performed using CAD system Optitex [12]. Considering the complexity of the sleeves forms, the modeling of cutting parts for each sleeve pattern required a carefully defined methodology, whereby the required experience in the development of more complex garment became apparent. Since the focus of the whole collection is on sleeves, minimal modifications in terms of length change, A form or dart adjustment were performed regarding basic block pattern on front and back part of women's dress. Fig. 1 presents modeling of sleeve for MODEL 12.

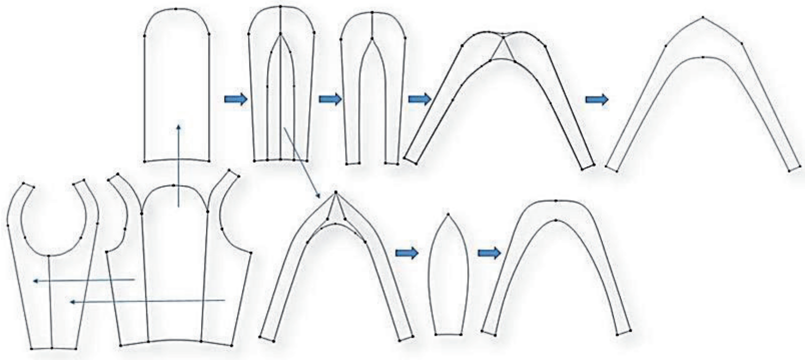


Figure 1. Sleeves modeling - MODEL 12

Determination of mechanical and physical fabric properties

From an aesthetic standpoint, the appearance of clothing is evaluated with the level of manufactured garment quality, garment drape and fit or visual garment forms, and it depends directly on the type and properties of the used fabric, cut construction and production quality [13]. All models of sleeves in the collection require application of firm, non-elastic, low weight material, which can be achieved with adhesive interlining. Basic characteristics of fabric selected for simulation are presented in tab. 2.

Table 2. Basic characteristics of fabrics used

Designation / Fabric type	Raw material composition	Type of fabric weave	Weaving density [cm-1]		Fabric thickness h [mm]	Mass per unit area m [g m-2]
			Warp	Weft		
F1 – fabric	63 % polyester fibre 33 % viscose 4 % elastan fibre	Twill 2/1	35	28	0.90	28,61

Table 3. Parameters of physical and mechanical fabric properties determined by the KES evaluation system

Type of parameter		Abbr.	Unit	Measured value
Sample length			cm	5
Tensile properties	max. elongation at warp direcion	EMT - X	%	21,540
	max. elongation at weft direcion	EMT - Y	%	22,050
Bending properties	bending rigidity at warp direction	B - X	cN cm^{-2} cm^{-1}	0,0297
	bending rigidity at weft direction	B - Y	cN cm^{-2} cm^{-1}	0,0240
Shear properties	shear rigidity	G	cN cm^{-2} $(degree)^{-1}$	0,610
Weight	mass per area unit	W	g cm^{-2}	2,861
Compression properties	thickness	T0	mm	0,900

Objective evaluation of selected fabric was performed using system for objective evaluation KES-FB [13], whereby seven parameters of physical and mechanical properties were measured and evaluated, tab. 3. For the simulation process, It is necessary to convert the results of determining mechanical properties using the KES-FB evaluation system into the units that are supported by the CAD system and program for 3D simulation, for which the converter Fabric Editor Optitex was used [12].

Defining parameters of cutting parts and parameters of 3D simulation in CAD system for 3D design

As a preparation for research on 3D simulation possibilities of model prototypes with structural sleeves forms from the original collection, it is necessary to define the properties of the parametric body model and to adjust it according to body measures for the clothing size 38. 3D simulation enables computer, three-dimensional visualization of desired garment model on the customized 3D body model, before the model is manufactured [14-16]. That way, it is possible to evaluate garment design, test the pattern construction and modeling, predict behaviour of textile material of ceratin physical and mechanical properties, test the tension and stretch of garment on body, in whole to completely verify prototype of garment model [17]. In order to performe a sucessful simulation, it is neccessary to define list of cutting parts parameters and set parameters for 3D simulation, as well as investigate the influence of physical and mechanical parameters adjustment, for the purpose of simulation of reinforced cutting parts.

Parameters of cutting parts include defining information on cutting parts such as name, quantity, pair parts, fold lines and so on. In order to ensure regular joining of cutting parts in the 3D simulation process, it is neccessary to define properties of joining segments, fig. 2, and to properly position cutting parts against the body model, before starting the simulation. It is neccessary to investigate influence of polygon mesh density, that is simulating 3D surface of cutting parts, on realistic folding simulation and visualization of garment. Initial deformation and cylindrical form of cutting parts must also be defined before starting the simulation. Position of every cutting part is defined against the body model as well as garment layers. The appearance of the seams in terms of holding, bending, or stretching the seam, depending on the desired effect, may be affected by changing the values of the seam constrain parameter.

Values of physical and mechanical parameters can be adjusted in CAD system, which affects the visualization of simulated 3D model prototypes. If it is intention that the 3D garment model is presenting real textile material behaviour, than the simulation process includes application of parameters values obtained by the measurement system for objective evaluation of textiles. If the particular cutting parts need to be reinforced to achieve specific form, as for example the use of interlining technology in the manufacturing process, it is neccessary to investigate the influence of adjustment of one or several parameters on desired visualization of simulated 3D prototype.

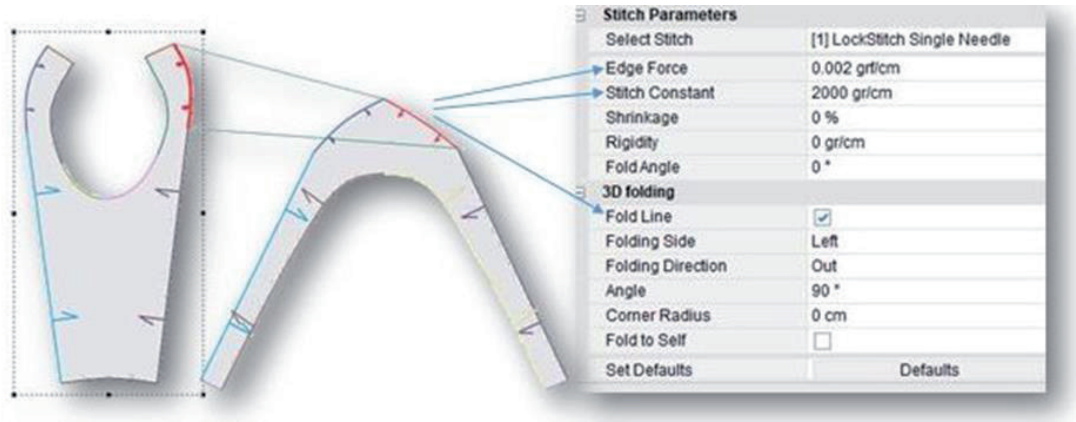


Figure 2. Parameters of joining segments properties

Since the designed dresses collection, for most of the models includes sleeves that are designed as different, manly reinforced structural 3D forms, prior to the simulation process it was neccessary to research the influence of mechanical parameters adjustment regarding bending, shear and tensile properties, and consequent adjustment of weight and fabric thickness as physical properties.

Irregularities during the simulation process can be caused by several reasons: incorrect positioning of cutting parts, incorrect construction and modeling, incorrect parameters of material or joining segments and so on. Simulation process is repeated until the all irregularities are corrected and until appropriate 3D simulation of garment model is obtained.

In the final part, variations of collection models were performed using the application of different colors and fabric patterns, textures, seams, elements like stripes and buttons on simulated 3D models. Fabric patterns and prints are designed using the CAD system for textile design.

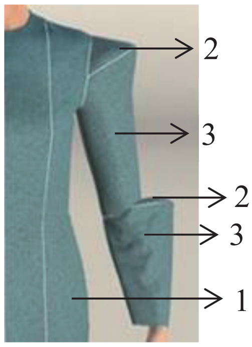
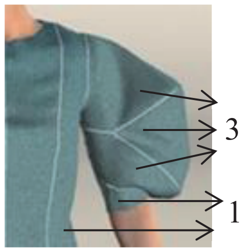
Digital printing on cutting parts

In addition to the garments design, fabric pattern that is applied on sleeves cutting parts by textile InkJet printing technology was also created. Digital printing was performed using the digital printing machine Azon Tex Pro with micro-piezo writing head and water-based pigment printing ink. Before the printing, the textile material was pretreated by applying an acrylic polymer base. In the printing process, the surface of the textile material intend to be printed with multicolored pattern is printed with a white pigment, forming a substrate that covers the dyeing of the textile material and prevents the interaction between substrate color and the color of the pattern. The pigment inks are transparent and do not have appropriate coverage property, so on the darker colored textiles substrate has the strong influence on reproduction of printed pattern. In order to achieve desired brilliant color of the pattern, the textile material is first treated with polymeric binder and during the printing process, a white pigment layer is printed as a substrate for a multicolored sample [18,19].

RESULTS AND DISCUSSION

For each of the 15 designed dress models with different structural sleeves forms, a separate preparation for 3D simulation has been performed, including the adjustment of fabric physical and mechanical parameters values, depending on the desired structural sleeve shape on a particular model. For models in which the design implies a stronger structure and sleeves shape that require additional reinforcement of the cutting parts and seams in the real manufacturing process, the following parameters were adjusted: bending stiffness, shear stiffness and stretching as mechanical properties and weight and thickness as physical properties. Tab. 4 presents values of physical and mechanical properties applied on particular cutting parts, based on the example of two sleeves with specific 3D forms that need additional reinforcement, or parameters adjustment in order to achieve desired look.

Table 4. The physical and mechanical properties parameters and the adjustment of values on the example of two sleeves

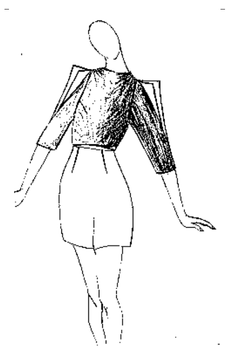
Parameters of physical and mechanical properties / values converted into units recognizable for the CAD system	Basic fabric F1	 MODEL 7	 MODEL 8
		Adjusted values	
	1	2	3
B - X [gfcm]	29,14	6000,00	1000,00
B - Y [gfcm]	23,54	6000,00	1000,00
G [dyn/cm]	34,95	200,00	200,00
EMT - X [%]	430,80	300,00	300,00
EMT - Y [%]	441,00	300,00	300,00
T [cm]	0,09	0,15	0,10
W [g/m^2)	2,86	3,2	3,20

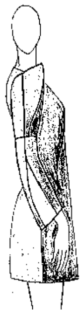
Distinction in the final simulation can be seen on the example of MODEL 7 and MODEL 8, due to the adjustment of mechanical parameters such as bending and shear stiffness or matrial stretch. On MODEL 7, the cutting parts marked as material 2 have significantly increased values of bending and shear stiffness, reduced stretching and increased thickness and weight values. In this way, the effect of the applied interlining is simulated, thus achieving the desired strength of the cutting parts which lie horizontally against the body and define the sleeve shape. On the cutting parts marked as material 3, the value of bending stiffness is less increased, thus achieving the desired shape and conical hang while retaining the minimum fabric softness, tab. 4. In real manufacturing process, such reinforcements can be achieved by applying adhesive interlining of different thicknesses. Material properties measured using the KES evaluation system, whose values are converted into the units of CAD system for garment simulation are applied on the other parts of the dress (Fabric 1). The values of material 3 are also applied to the sleeve cutting parts of MODEL 8, thereby achieving the inflated form of sleeves standing against the body.

In most cases, the parameter values for each cutting part of a single model are different depending on the visual effect that is achieved with it. Certain models within the collection (MODEL 7 - 9 and 12 - 15) have a more complex threedimensional sleeve form that does not fit to the body, but opens to the free space. The higher the values of the bending and shear stiffness, the simulated fabric will be less deformable, while at stretching, the higher the parameters value represents the greater fabric stretching. Additionally, the density of the cutting parts polygon meshs were optimized depending on the applied mechanical properties in order to achieved realistic visualization of the simulated models.

Tab. 5 presents final results of art and computer design of structural sleeves forms for haute couture women's clothing, on a example of four models selected from the collection. Visual verification of simulated 3D prototypes involves evaluation of sleeves 3D forms, fabric drape at the front and back, appearance of folds and fit to the body.

Table 5. Results of art and computer design of structural sleeves forms for haute couture women's colthing on a example of a four models from the collection

Art design	Simulated 3D prototype
	
	MODEL 7
	
	MODEL 9
	
	MODEL 13

	
	MODEL 14

During the research of influence of the adjusted physical and mechanical parameters values, the 3D simulations were repeatedly performed until the 3D model prototype that clearly reflex the designers idea in terms of the shape is achieved for every particular model. Tab. 6 presents the results of models variations in colors and patterns of different textile materials, whereby the applied patterns are previously designed in CAD program and prepared for textile digital printing.

Table 6. Results of the collection models variations using application of different colors and computer designed patterns

				
MODEL 1	MODEL 2	MODEL 3	MODEL 4	MODEL 5
				
MODEL 6	MODEL 7	MODEL 8	MODEL 9	MODEL 10
				
MODEL 11	MODEL 12	MODEL 13	MODEL 14	MODEL 15

After the complete computer verification of the designed 3D models prototypes from the collection, fig. 3, two real models were developed, with design fabric patterns applied using digital printing technology, fig. 4.

Figure 3. 3D prototypes of models with applied fabric patterns, selected for real garment manufacturing

Figure 4. Prototypes of two selected dress models

CONCLUSION

The idea is the starting point in the creation of every garment model. It derives from inspiration shaped in sketches, which are then further elaborated, for the purpose of further work and collection creating. Computer construction and modeling of garment patterns, greatly facilitate and accelerate the process of construction preparation, with more precision compared to the conventional clothing construction method. Complete computer 2D/3D design of model prototype is a demanding process requiring knowledge and expertise in the use of CAD systems, but also the need for wider knowledge and skills in the field of clothing construction and technology, textile materials from the aspect of physical and mechanical properties and application and processing of textile materials for a specific purpose. The 3D simulation of the prototype enables visualization of the actual textile material behavior within a particular garment and can be useful for assessing the applicability of a particular material for a particular garment design. However, the designer can also adjust the values of certain mechanical or physical material properties to achieve visualization of the desired model shape. This can be a basis for further model development and planning of the selection of textile materials and the technological manufacturing process to obtain the desired model shape.

The realistic visualization of simulated 3D models is visualy enhanced with the application of colors and textures, designed in the CAD program for textiles design. In addition, computer-based preparation of pattern design on cutting parts was performed for digital printing on the actual fabric.

The application of colors and textures on virtual garment prototypes opens up the possibilities of evaluating clothing in aesthetic sense, unlike conventional method where model visualization takes place only in the creative mind of the designer and it is necessary to create a real prototype in order to evaluate the design, pattern construction and modeling as well as material selection. In that sense, the use of modern 2D/3D CAD system for computer-aided design allows the fashion designer to investigate all the important parameters on a computer garment prototype, which significantly simplifies and accelerates the design and development of clothing collections. At the same time, it is possible to reduce the producing cost of the test samples, which is also an environmentally friendly way of products development, as it reduces the consumption of materials, energy and waste, resulting from the real process of producing model samples. If all segments of the model prototype computer design have been performed correctly, it is ultimately enough to create one real model sample in the final stage of development process, as verification of all the model elements.

Digital printing on cutting parts contributes to the rapid prototype development, a quick time response to market demands, and enables easier and faster changes and modifications in the process of test samples production. It also contributes to the ecological type of production, since such printing does not pollute the environment, as the conventional textile printing. In the process of digital textile printing there are no phases of template making, which means a significant reduction of wastewater and the wastewater chemicals. From this point of view, we can talk about digital printing as an environmentally friendly technology. In addition, the „Drop on Demand" technology in digital printing enables very precise dosing of printing inks optimized according to the requirements of the pattern and there is no surplus printing paste as in conventional printing technology.

From the aspect of design and reproduction capabilities, the application of digital printing technology into textiles removes all the design limitations that conventional technology has set and allows reproductions of unlimited number of colors and unconstrained imaginative shapes.

REFERENCES

[1] Grau FM. Povijest odijevanja. Zagreb: Jesenski i Turk; 2008.

[2] Boucher F. 20,000 Years of Fashion The History of Costume and Personal Adornment. New York: Harry N. Abrams; 1987.

[3] Tortora PG, Eubank K. Survey of Historic Costume: A History of Western Dress. 5th edition. New York: Fairchild Books; 2011.

[4] Simončić KN. Prilog poznavanju povijesti odijevanja: zakoni protiv raskoši i njihov utjecaj. In: Hošić I. editor. Zbornik radova Pažnja! Odjeća, umjetnost, identitet; 07-08 October 2013; Bihać, Bosnia and Herzegovina. Bihać: Univerzitet u Bihaću, Tehnički fakultet; 2013. p. 13-29.

[5] Zmeškal K, Brlobašić Šajatović B, Petrak S, Šabarić I. Modeliranje rukava ženske odjeće inspiriranih elementima arhitekture. In: Hodžić A, Hodžić, D. editor. Zbornik radova XI međunarodne naučne konferencije o proizvodnom inženjerstvu - RIM 2017; 04-07. October 2017; Sarajevo, Bosnia and Herzegovina. Bihać: Univerzitet u Bihaću, Tehnički fakultet; 2017. p. 489-494.

[6] Bancroft A. Fashion and Psychoanalysis: Styling the Self. London: I.B.Tauris & Co. Ltd; 2012.

[7] Burke S. Fashion Computing: Design Techniques and CAD. UK: Burke Publishing; 2006.

[8] Petrak S, Mahnić M, Rogale D, Ujević D. Computer Design of Textile and Clothing Collection - Assumption of Contemporary Remote Business. In: Adolphe CD. editor. Book of Proceedings of 11th World Textile Conference AUTEX 2011; 08-10 June 2011; Mulhouse, France. Mulhouse: Ecole Nationale Superieure d Ingenieurs Sud-Alace; 2011. p. 1162-1168.

[9] Aldrich W. Metric pattern cutting for women's wear. Oxford: Blackwell publishing; 2008.

[10] Ireland PJ. New Encyclopedia of Fashion Details: Over 1000 Fashion Details. London: Batsford; 2008.

[11] Vinković M. Likovno projektiranje odjeće I. 2. Izdanje. Zagreb: Sveučilište u Zagrebu Tekstilno-tehnološki fakultet; 2014.

[12] Optitex [Internet]. [cited 07. 11. 2018]. Available from: http://www.optitex.com/, Accessed:.

[13] Geršak J. Objektivno vrednovanje plošnih tekstilija i odjeće. Zagreb: Sveučilište u Zagrebu Tekstilno – tehnološki fakultet; 2014.

[14] Goldstein Y. Transforming Clothing Production into a Demand-driven, Knowledge-based, High-tech Industry. London: Springer; 2009. Virtual Prototyping: From Concept to 3D Design and Prototyping in Hours; 95-139 p.

[15] Petrak S et al. Garments Prototype Development Using an Innovative Computer Technology. In: Dragčević Z. editor. Book of Proceedings of the 5th International Textile, Clothing and Design Conference – Magic World of Textiles; 03-06 October 2010; Dubrovnik, Croatia. Zagreb: University of Zagreb Faculty of Textile Technology; 2010. p. 488-493.

[16] Wu YY et al. An investigation on the validity of 3D clothing simulation for garment fit evaluation. In: Concheri G, Meneghello R, Savio G. editors. Proceedings of the IMProVe - International conference on Innovative Methods in Product Design. 15-17 June 2011; Venice, Italy. Padova: Libreria Internazionale Cortina Padova; 2011. p. 463-468.

[17] Petrak S et al. Research of the Motorcycle Trousers Functionality Depending of Construction Parameters of Cutting Parts. In: Dragčević Z, Hursa Šajatović A, Vujasinović E. editors. Book of Proceedings of the 8th International Textile, Clothing & Design Conference 2016 – Magic World of Textiles. 02-05 October 2016; Dubrovnik, Croatia. Zagreb: University of Zagreb Faculty of Textile Technology; 2016. p. 260-265.

[18] Dawson T. InkJet Printing of Textiles Under Microscope. Journal of the Society of Dyers and Colourists. 2006 June;116(2):52-59.

[19] Glogar MI et al. Some Aspects of Ink Jet Printing on Dark Garment. In: Dragčević Z, Hursa Šajatović A, Vujasinović E. editors. Book of Proceedings of the 8th International Textile, Clothing & Design Conference 2016 – Magic World of Textiles. 02-05 October 2016; Dubrovnik, Croatia. Zagreb: University of Zagreb Faculty of Textile Technology; 2016. p. 165-171.