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Content

Obsah

APPROACH TO PATTERN DESIGN OF MATERNITY WEAR

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Abstract: *Currently, there is an increasing demand for maternity wear; this has created the need for research into its pattern design. The first step in this research is to determine the procedure needed to take measurements of the female body, to record any anatomical changes during pregnancy. The resulting anthropometric data is processed by statistical methods and the correlation between body measurements is analysed. The results are then applied to a metric pattern design for maternity clothes in two ways: to determine a pregnant woman's "types", and to create input parameters for pattern design that anticipate the needs of different body types for different maternity clothes.*
Keywords: *somatometric research, measurement in pregnancy, pattern design, maternity wear.*

1 INTRODUCTION

Pregnancy or in medicine term gravidity takes forty weeks, or three trimesters, or nine calendar months, or ten lunar months [1]. A woman's body begins to change immediately after impregnation, both physically and physiologically. Because a woman is sexually and developmentally an adult during the gestation period, her height will not change; the changes will only be in terms of girth, primarily in a few certain areas: the thoracic area, abdominal area, gluteal area, femoral area, and arm area [1]. The biggest change is typically in the abdominal region [1, 2].

The typological characteristics of the body, according to traditional typology (e.g. Manouverier, Kretschmer, Mathes, Škerleje [3, 4]), remain unchanged before, during, and after pregnancy.

Sohn & Bye [5] analyzed how changes in the female body shape during pregnancy affect patterns for maternity wear. In their study, participants were scanned during each month of their pregnancy by a 3D body scanner. Virtual fit-to-shape patterns were adjusted to fit each body scan using 3D digital draping. The results of this study indicate that pattern changes corresponded to the body changes, but the patterns did not increase proportionally to each other.

An anthropometric study about protective clothing for pregnant women was carried out by Manley [6]. Changes of 28 body measurements and weight were measured in a selected group of 90 pregnant women, with the aim to determine any correlation between them. It was discovered that waist and abdominal extension measurements proved to increase the most during pregnancy (4–5 inches), and that bust, hips and other measurement directly related to the waist and abdominal extension (vertical trunk, crotch length and crotch depth) also increase, and should be taken into consideration when designing protective clothing for pregnant women. Ho's [7] study deals with the evaluation of the comfort (sensory/tactile, thermo-physiological, and movement) of commercially available maternity support garments (belts), in order to ensure their optimal properties and design.

Belleau's [8] research analyzed factors that affect the selection of garments by pregnant employed women. The results of Bellau's study indicated that there are differences among age range groups in their selection of workplace attire, and among educated workers in terms of general fashion appeal, workplace attire, the care required for the garments, and in terms of seasonally-appropriate material. Belleau's study shows that pregnant women want to adapt their wardrobe to their work environment. Different types of jobs require different clothing material, elastic or inelastic. Therefore, fit pattern design for maternity wear has to correspond to both properties of clothing fabric and body shape changes during pregnancy.

Generally, the using of 3D CAD systems is one modern way to ensure a good fit pattern design, especially for individual approach to maternity wear. These systems allow the import or modelling of shapes pregnant body and design 3D patterns; it performs the flattening; analyse the feasibility of a style; creates virtual 3D prototypes and simulates new concepts with a high degree of realism. Nemcokova [9] carried out a practical demonstration of 3D CAD system application for headgear pattern design.

2 EXPERIMENT

2.1 Selection of body measurements for demonstrating changes during pregnancy

The experimental part of this paper deals with the modification of standard pattern design methodologies for the upper part of the body for maternity apparel. This modification for pregnant women is based on the body measurements of 31 women in their third trimester of pregnancy. The resulting body measurements, as shown in Figure 1, were statistically evaluated for use in the modification of analytical relations that define the basic design lines. The selection of body measurements, describing changes during pregnancy, was made according to the ISO standard [10] and based on a methodology described by Musilova [11].

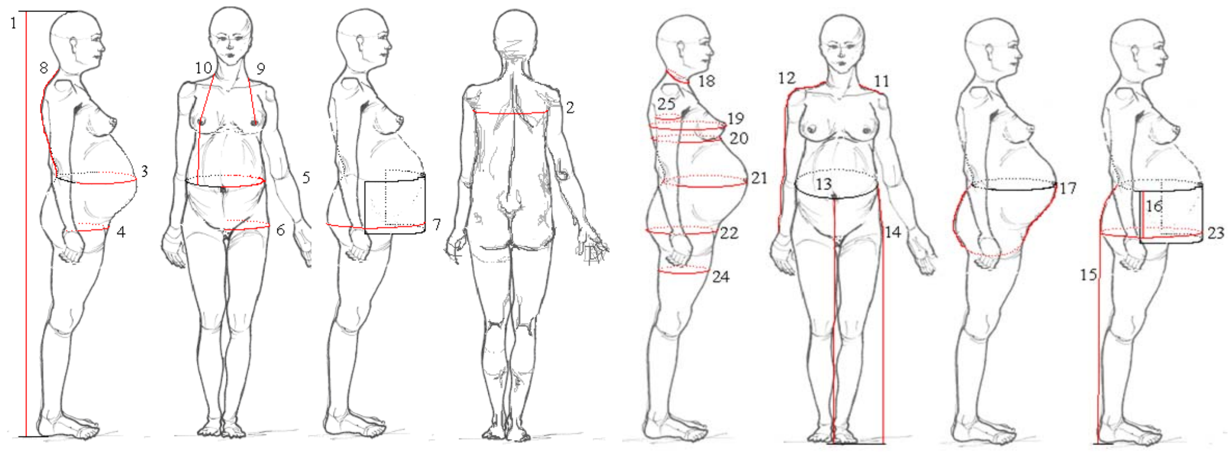


Figure 1 Static body measurements, measured during pregnancy [2]

1. Height
2. Across back
3. Frontal waist width
4. Frontal hip width
5. Profile waist width
6. Profile hip width
7. Profile hip width, including protrusion
8. Nape to waist
9. Frontal length to bust
10. Frontal length to waist
11. Shoulder length
12. Shoulder length plus sleeve length
13. Front leg length
14. Outside leg length
15. Back leg length
16. Crotch depth (standing)
17. Crotch length from back to front
18. Neck girth
19. Bust girth
20. Under bust girth
21. Waist girth
22. Hip girth
23. Hip girth, including protrusion
24. Thigh girth
25. Arm girth

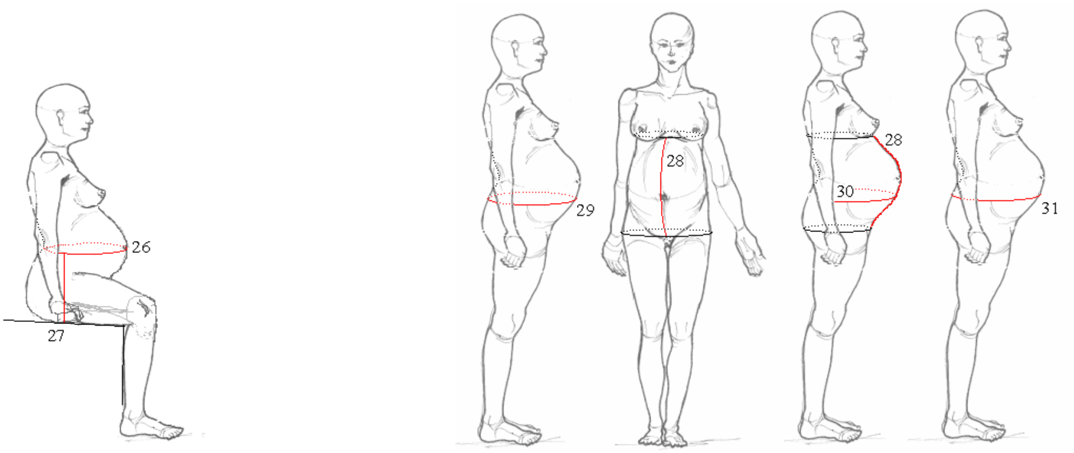


Figure 2 Dynamic body measurements – sitting and other body measurements [2]

26. Waist girth – sitting
27. Crotch depth – sitting
28. Front length of protrusion
29. Girth of biggest protrusion
30. Frontal protrusion
31. Profile protrusion

2.2 Statistical measured data evaluation

An aggregate of 30 women was the basis for the somatometric measurement of the general population of pregnant women. We measured the basic body measurements both before pregnancy and at the end of pregnancy, when the biggest changes of proportions occur. The most important representative part of the whole result file from statistical data evaluation [12] is presented below: specifically, the dependences of body measurements on weight gain, which have a direct influence on trunk block pattern design (see Figures 3–6).

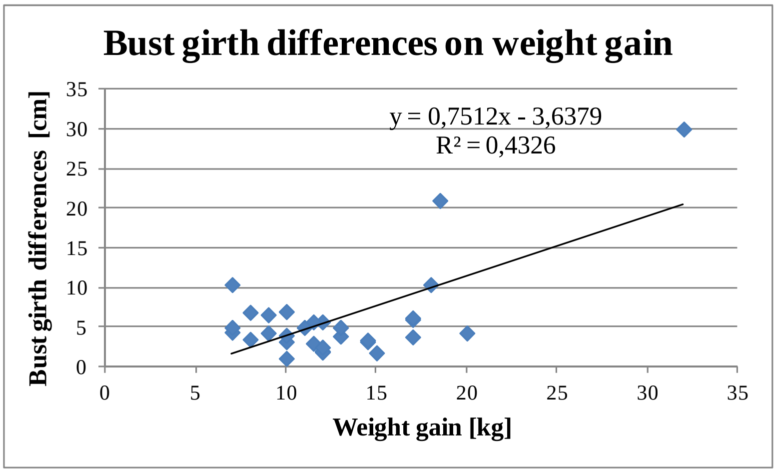


Figure 3 Dependence graph of bust girth difference on weight gain [2]

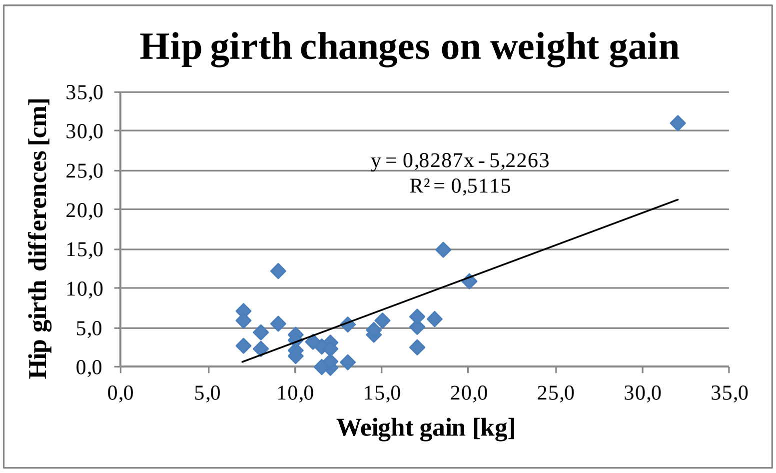


Figure 4 Dependence graph of hip girth difference on weight gain

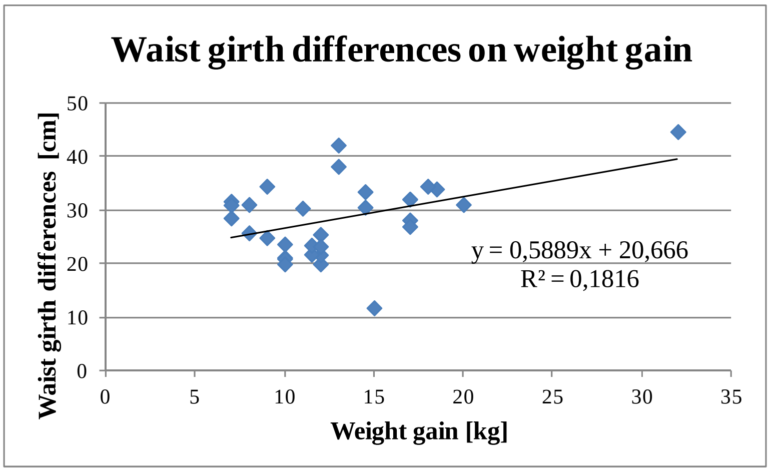


Figure 5 Dependence graph of waist girth difference on weight gain [2]

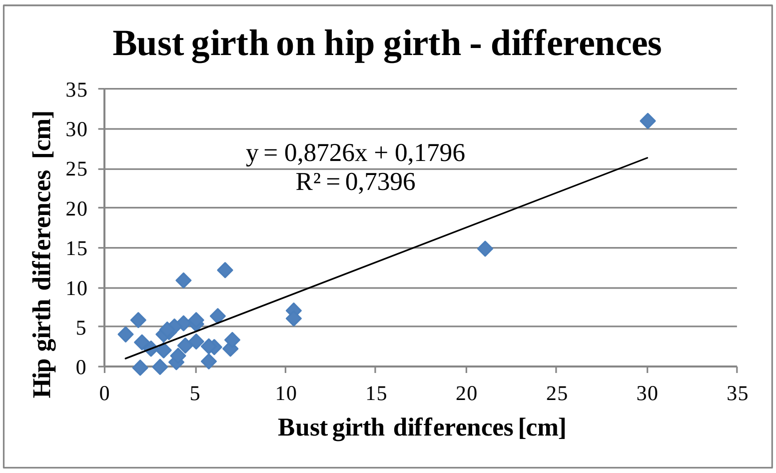


Figure 6 Dependence graph of bust girth difference on hip girth difference

2.3 Proposed typology for pregnant women

The female body changes during pregnancy mainly through weight gain, especially in the abdomen, breasts and buttock regions. On the basis of metric and visual investigation, body types can be divided into two categories according to weight gain; up to 12 kg and over 12 kg (12 kg is medical recommendations for the limit of normal weight gain). In the studied group of women, 48% experienced weight gain of or below 12 kg, and 52% had weight gain over 12 kg. Depending on the amount of weight gain, dress sizes change (see Figure 7).

A variety of pregnant abdomens

The abdomens of pregnant women are different both in profile and in the frontal plane. It is possible to define four abdominal shapes by sight: spherical, broad, and bulged on the sides; spherical, pointed, and bulged in the front; pointed, broad, and bulged on the sides; pointed from both planes and bulged in the front. Abdomen shapes are related to weight gain during pregnancy. The most common shape for weight gain up to 12 kg is a pointed abdomen (81.8%), and for weight gain over 12 kg a spherical abdomen is the most common (94.73%). Figure 8 shows the frequencies of various abdomen shapes.

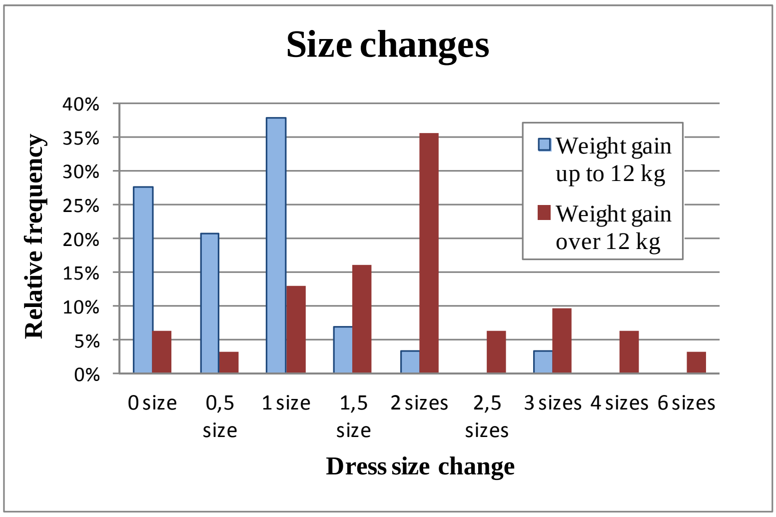


Figure 7 Dress size changes, depending on weight gain

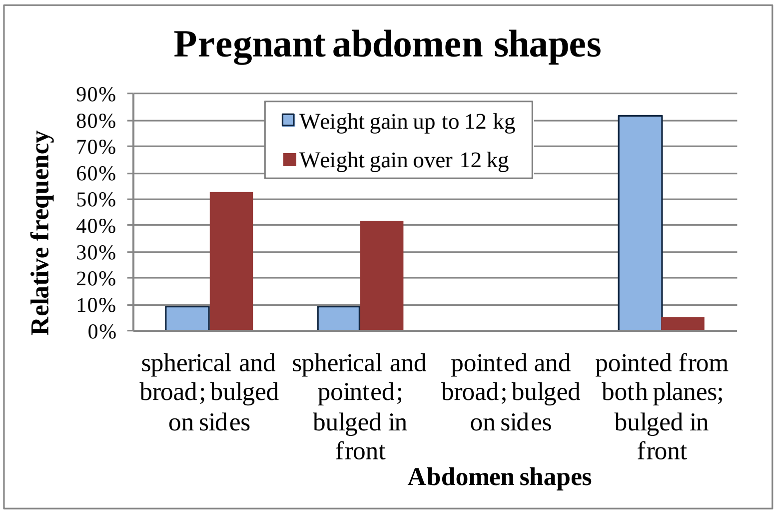


Figure 8 Pregnant abdomen shapes, depending on weight gain

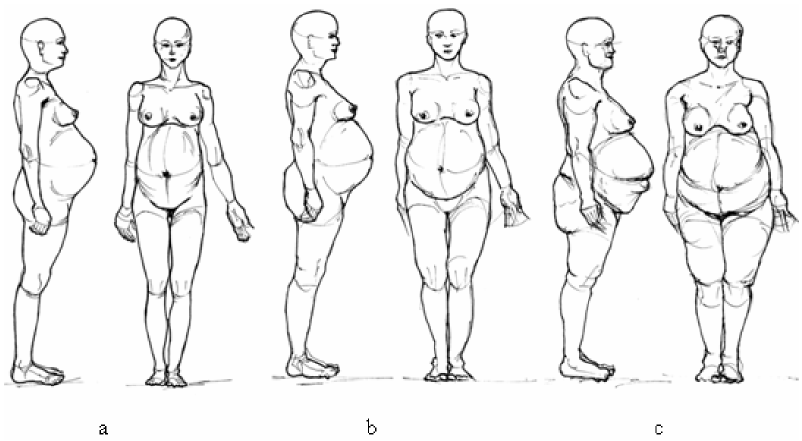


Figure 9 Body types of pregnant women: abdominal (a), overall (b) and invisible (c) [2]

According to these facts, it is possible to design maternity wear three body types of pregnant women: abdominal, overall and invisible type maternity wear can be designed for three main body types: abdominal, overall, and invisible. The “abdominal” body type features changes particularly in the abdomen region, and weight gain of up to 12 kg. The “overall” type has a weight gain over 12 kg, and the body's proportions are changed over the whole body. The “invisible” body type occurs in the case of morbidly obese women when the pregnancy is not seen through the excessive abdomen.

Abdominal body type of pregnant women

The woman may gain up to 12 kg during pregnancy. The change in proportion is determined by the size of the abdomen and, almost always, by the bust size. The shape of the abdomen is rather pointed from the profile plane and pointed, slender bulging in the front when seen from the frontal plane. Other regions are identical with proportions before pregnancy or are changed by just one dress size.

Overall body type of pregnant women

The woman gains over 12 kg during pregnancy. Any change in proportions is across all body regions, and is mostly symmetrical. The dress size is changed by at least one size, or maybe more. This type is almost always determined by the change in size of the bosom. The pregnant abdomen is noticeable from the beginning of pregnancy, and its shape appears spherical from the profile plane and broad and bulged on the sides or pointed and bulged in the front when viewed from the frontal plane.

Invisible body type of pregnant women

In this case, the situation may arise when even weight loss occurs during pregnancy. In the somatometric investigation of this experiment, this invisible type did not occur.

2.4 Implementation of somatometric measurement into pattern design of maternity wear

Based on the above-defined character typology of pregnant women, the pattern design for maternity wear is divided into two groups: weight gain of up to 12 kg, and weight gain of over 12 kg. The pattern design used in this study is based on Müller & Sohn's pattern design method.

Pattern design of blouse for pregnant women with weight gain up to 12 kg

The body measurements of subjects with weight gain of up to 12 kg were used for pattern design. Statistical comparisons of body measurements (bust girth (*bg*) and waist girth (*wg*)), before pregnancy and at the end of pregnancy show their dependence on weight gain. The increase of these body measurements is approximately symmetrical for both types of body: abdominal as well as overall. For this reason, the pattern design is same for both body types.

Clothes for pregnant women must be comfortable in the abdominal region. For this reason, the *dynamic effect of waist girth* (standing vs. sitting position) is very important for pattern design. The average result from our statistical data evaluation is 4.83% in waist girth, and it is possible to use this calculation in pattern design as an allowance for looseness for inelastic textile material. The average dynamic effect in terms of elastic textile material depends on the degree of the material's elasticity.

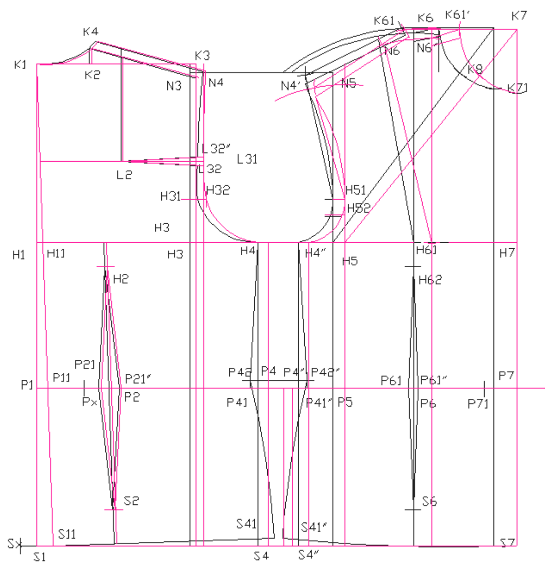
The basic pattern design method must be modified in the case of maternity wear by adding pregnancy allowances. These differences are calculated from selective arithmetical averages taken from the given measurements – specifically, differences in measurements before pregnancy and at the end of pregnancy. The average increase in bust girth (*bg*) is approximately 6.3%. This pregnancy allowance is then added to the total *bg*: 0.063bg (0.063 from bust girth). The average pregnancy allowanced in hip girth (*hg*) is 5.25%, which is then added to the total *hg*, so 0.0525 *hg*.

The average pregnancy allowance in waist girth (*wg*) is 37.04%, but it is not possible to add it to the total waist girth, because the measurement change in the waist line during pregnancy is not symmetrical between the back of the blouse and the front of the blouse; while the change in the back of the blouse is imperceptible, the waist line in the front of the blouse changes a lot. The back of the blouse must remain shaped. The pregnancy allowance is divided into four parts. The first part – 30% – is looseness created by leaving out the front and side darts and by loosening the back centre line (and possibly reducing the back dart), as shown in Figure 10. The second part – 26% – is added to the front centre line. The last two parts – together making up 44% – originate from two design pattern modifications of the front of the blouse: the waist line is widened twice by 22%, as seen in Figure 11.

Below are listed the calculation changes in pattern design: across the back (*ab*), armhole width (*aw*), front part width (*fpw*), and neckline width (*nw*):

½ *ab* is line segment H11H3	$1/2\ ab = 1/8(bg + 0{,}063bg) + 5{,}5$	(1)
aw is line segment H3H4´+ H4´H5	$aw = 1/8\ (bg + 0{,}063bg) – 1{,}5$	(2)
fpw is line segment H5H7	$fpw = 1/4\ (bg + 0{,}063bg) – 4$	(3)
nw is line segment K61´K7	$nw = 1/10$ from $1/2\ (bg + 0{,}063bg) + 2$	(4)

Note: See Figure 10 for marking of line segments



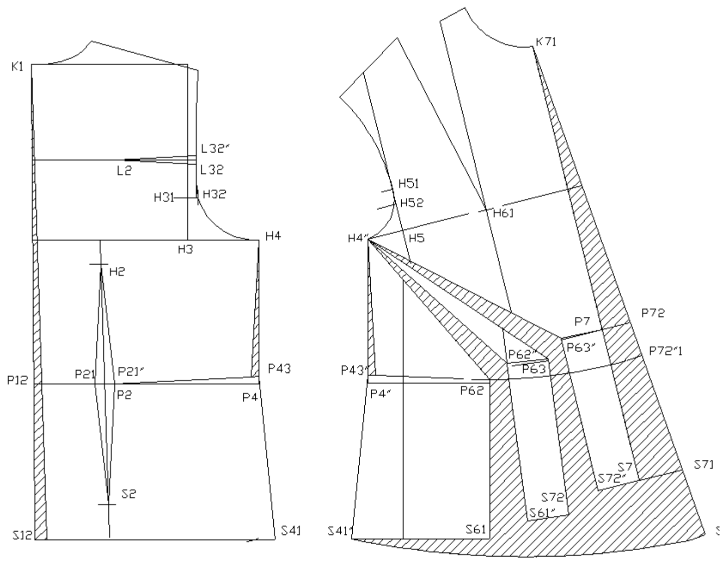


Figure 10 Representation of measurement changes in basic pattern of a woman's blouse (black) and a blouse for pregnant women (grey), including omission of front and side darts

Figure 11 Widening of the waistline in the front of the blouse; design modification of a basic block pattern for pregnant women and final styling modification of blouse pattern for pregnant women [2]

In the next step of pattern design, allowances for looseness are added to the calculated measurements (according to determined rules). This pattern design is intended for inelastic textile material. The next changes in basic pattern design follow from the addition of pregnancy allowances in the position of bust line point H6 and the position of front shoulder point *N4*, demonstrated in Figure 10.

The next modification in pattern design is a change in garment length. The change of garment length is a consequence of changes in abdominal measurements, not only in waist girth but also in length (see Figure 11 for a description of this change in the front length of the protrusion).

Pattern design of sleeves for pregnant women is identical to the original pattern design.

Pattern design of blouse for pregnant women with weight gain over 12 kg

The method of pattern design modification for pregnant women with weight gain over 12 kg is basically the same, but with a few key differences. The difference is in the spreading of pregnancy allowance to the waist line. The front and side darts are removed and the back centre line is loosened as before, but a more significant change is in the reduction of back dart. The next change lies in selection of bigger extension of front centre line according to interval of front length of protrusion.

3 SUMMARY

The principle of pattern design of maternity clothes is to add changes related to pregnancy into the standard method of pattern design. To this aim, a somatometric study and measurement of a pregnant female population were conducted as a foundation for a typology of the pregnant female body. Pregnant women were divided according to their weight gain during pregnancy, according to dress size changes, and according to proportional differences arising during pregnancy. The results led to classification of three different types of pregnant bodies: abdominal, overall, and invisible. A pregnancy allowance was defined for maternity wear; that is, the average difference in body measurements during pregnancy that are needed for pattern design. This pregnancy allowance was included in the pattern design calculation, and added to total body measurements.

Pattern design for pregnant women was split into two categories, according to weight gains and projected typology. The pregnancy allowances were evaluated for each category individually.

This version of pattern design for pregnancy women can be recommended for wider apparel production, because it respects the changes in body proportions during pregnancy.

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PŘÍSPĚVEK KE KONSTRUKCI TĚHOTENSKÉHO OBLEČENÍ

Translation of the article
Approach to pattern design of maternity wear

Současná rostoucí poptávka po těhotenském oblečení generuje potřebu výzkumu v oblasti konstrukce a modelování tohoto typu oděvů. První část této studie je věnována stanovení vhodného postupu zaznamenávání anatomických změn ženského těla během těhotenství. Získaná antropometrická data jsou zpracovávána statistickými metodami a následně jsou analyzovány korelace mezi jednotlivými tělesnými rozměry. Na základě těchto výsledků je definovaná typologie postav těhotných žen a jsou stanoveny vstupní parametry, tělesné a konstrukční rozměry, jsou základem pro konstrukci a vymodelování těhotenského oblečení, které odpovídá požadavkům a potřebám těhotných žen.

IMPLEMENTING MASS CUSTOMIZATION INTO CLOTHING PRODUCTION

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Abstract: *In this paper, we review the concept of mass customization (MC) which integrates a standardized process of mass clothing production with the modern information technology to efficiently produce individually tailored products or services on a large scale. The purpose is to present this concept of generating customized garment patterns that are designed based on individual body measurements that have been scanned with the help of a non-contact measuring system called 'BodyFit 3D'. The first experiment involves transferring the individual anthropometric data into a CAD pattern-making program called 'PDS Tailor XQ' to automatically generate a parametric 2D dress pattern design. The second experiment uses individual body measurements data for the suit jacket pattern which is then altered using made-to-measure (MTM) technology with the help of the CAD system 'InvesMark Futura'.*
Keywords: *mass customization, BodyFit 3D, made-to-measure, dress, suit jacket, pattern design*

1 INTRODUCTION

In recent years, the clothing industry has been undergoing rapid evolutionary changes that have resulted from the digital revolution, globalization, and consumer demands. Consumers want and expect an immediate, personalized service and more variety in the products on offer. To survive in the clothing market companies have increased their competitiveness through mass customization which is a new business strategy for goods and services [1]. According to Joseph Pine, we can define mass customization as "developing, producing, marketing and delivering affordable goods, and services with enough variety and customization that nearly everyone finds exactly what they want." [2]

In order to mass customize clothes, it is essential to create garment patterns based on an individual body shape.

Three-dimensional (3D) body scanning of data provides a wealth of information about the human body dimensions that can be used to create personalized garment patterns for individuals, and in mass customization and size selection operations to identify appropriate sizes for the individual from a range of choices.

Individual posture specifications, deviations from average body measurements, proportions and asymmetries may be taken into consideration in the process of garment design (custom-made garment). Thus, objective and convenient acquisition of a customer’s individual body measurements becomes a part of the technological process (Figure 1). Bearing in mind the advantages of 2D and 3D CAD technology a new procedure for cutting customized patterns according to the individual customer’s body shape was tested (see the scheme in Figure 1).

Within the research activities which are described in this article, the following partial aims were defined:

- To carry out measuring the body of individual customers using non-contact BodyFit 3D scanning technology and evaluate the individual body proportions.
- To find and express suitable options for the 2D pattern making process of customizing individual clothing patterns based on body dimensions scanned with the help of unit BodyFit 3D as the input pattern parameters.

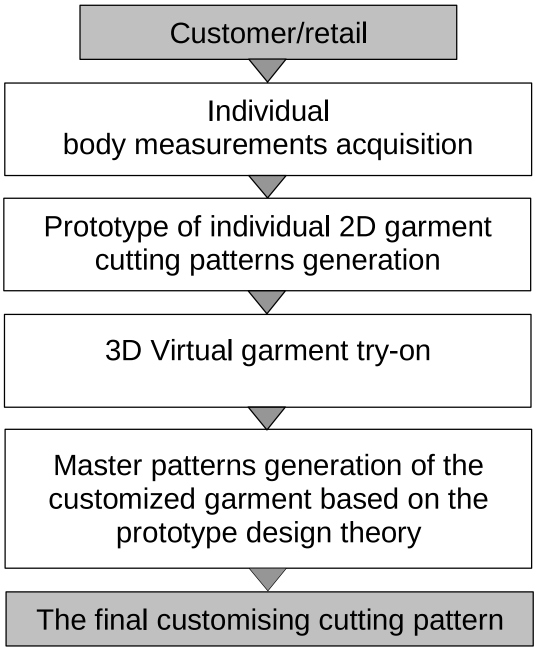

Figure 1 Technological process of producing the customized cutting patterns

2 METHODS

The basic data of every clothing pattern design is the body size which can be gauged using a contact or non-contact method. The number of measurements depends on the methodology of design and the type of designed clothing [3].

2.1 Non-contact determination of body dimensions

The aim of this part of the research is to undertake the first step in measuring the body of an individual customer using non-contact BodyFit 3D scanning technology (Figure 2).
The non-contact measuring unit is built by GFaI (Gesellschaft für angewandte Informatik Berlin) for the innovative reorganization of the textile manufacturing chain by partner companies from trade, textile design, production, logistics and mechanical engineering [4].
The solution automatically acquired more than 30 predefined tailor measurements during a dialog-based measurement procedure of about 1.5 minutes. This interactive procedure is facilitated by upstream online image analysis, detecting and monitoring motions and customer actions inside a measurement space [5].

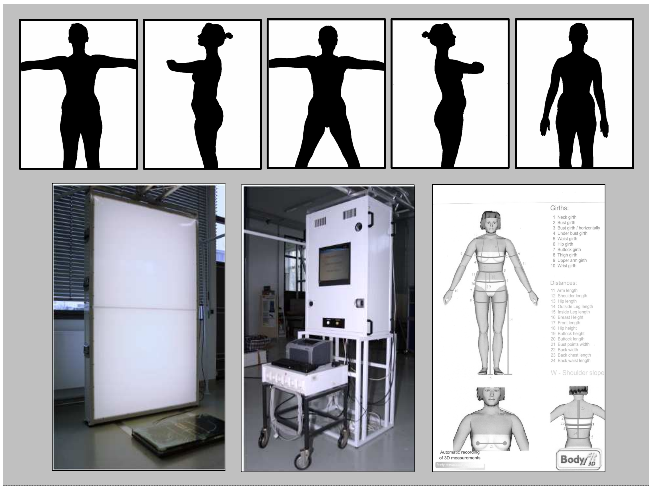

Figure 2 Body scanning system BodyFit 3D

The client arranges his body position (Figure 2) according to unambiguous instructions given by means of acoustic instructions and optical signals (including a graphic display). The system is capable to create additional correcting hints and advice on-line in case of need, depending on the customers behaviour. Differently from alternative solutions, the crucial body measures are taken in fractions of a second, so that clients are not confronted with unreasonable demands for holding a certain position for long [5].
This kind of 3D measurement uses simple white light, so health-related concerns about laser emission, possibly arising from the side of potential users are avoided on principle. The solution is predominantly based on usual standard hardware (digital cameras and DLP projector), what reflects in respectively opportune investment costs. A measurement journal for customers is created and the data are prepared electronically for patterning in cm value with an accuracy of 0.1 cm. The administration of measurements is anonymous [4].
In order to precisely provide somatometric description of 3D complicated shape of individual person to achieve accurate input pattern parameters, the list of the measured

body dimensions was determined: height, bust girth, waist girth, hip girth inside leg length, arm length left and right, average arm length, neck girth, outside leg length left and right, average outside length, back waist length, back width, shoulder angle left and right, shoulder width left and right, average shoulder width, front length, hip height, thigh girth left and right, average thigh girth, buttock girth, breast width, bust points width, breast height, waist to buttock length left and right, average waist to buttock length, buttock height, hip length left and right, back chest length.

2.2 Digital pattern development process for customized apparel

There are two options for the pattern making process that were tested:

The first option develops individual garment patterns based on 2D CAD technology providing a parametric pattern design network. The shape of the pattern cut is created with the help of design parameters computed using regression equations and individual body measurement data (tailor-measured in digital form) as the input design parameters.

The second option involves altering an individual prototype to cutting patterns of a customized garment of given style using a 2D apparel CAD technology called the Made To Measure (MTM) pattern system.

The specific measurements of a customer are used to adapt standard pieces already saved in the CAD system.

Garments can be modified for all the sizes available in a store, so the customer could try on the best fitting size and adjustments would be made to it. The body size of the individual wearer has to be defined and matched to the nearest size on a table of standard sizes. When the order arrives at the garment factory, the pieces are altered, a new marker is created and this is automatically nested if required.

Thus, in a very short time, the new order is ready to be cut and manufactured.

To be able to offer a custom tailored garment at the point of sale, the following are required:

- To define a complete set of size charts with different size ranges for categorized figure types which should provide measurements for the standard sizes.
- To design the patterns for reference garments in the standard sizes which should accurately reflect the characteristics of the categorized figure types and measurements in the corresponding size charts. The design may be created or transformed using suitable CAD pattern generation system.
- To fit the reference markers which will be used as a style in the custom tailoring-ordering process. This task is performed by the marker generation system.

To define the set of modification that may be performed to adapt the garment for each customer e.g. trousers (normal posture; open stance; closed stance; incorrect lengths; incorrect widths). The set of modifications may be defined using the MTM module in the pattern generation system.

3 RESULTS AND DISCUSSIONS

3.1 Study of relationships between individual body dimensions and ready-made sizes

One of the tasks of this research is to evaluate the individual body proportions of the 36 female students at TUL aged 18-29 years old that were scanned by BodyFit 3D. Each body measurements were measured five times with the accuracy of the one tenth cm and mean value of each measurements were used for somatype classification as input parameters for pattern generation process.

The purpose was to classify their figure types based on the statistical analysis of the acquired experimental anthropometric data in relation to the DOB Size Chart (sizing system that is most-commonly used by Czech garment producers).

How is the DOB Size Chart arranged?

Control dimensions are bust girth, height and hip girth. The height remains constant in each size range. Standard sizes are based on a height of 168 cm.

There is a bust girth increase of 4 cm from size to size up to 104 cm. From here onwards the increase is by 6 cm from each size. Short sizes are 8 cm less, long sizes 8 cm more than standard height, but with unchanged bust and hip girths.
The sizes for slim hipped and broad hipped women are 6 cm less or more than the standard hip girth, but with an unchanged bust girth and height.

- Standard range "height and hips: standard"
  Height 168 cm
- Range "height: short, hips: standard"
  Height 160 cm
- Range "height: long, hips: standard"
  Height 176 cm

Each of the female students measured was classified into one of three size subgroups based on the DOB size range control dimensions and the size intervals with those results.

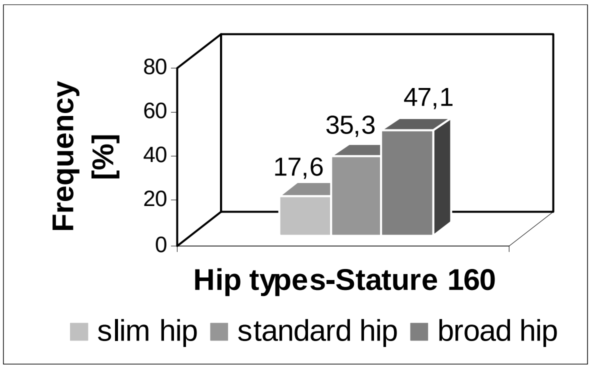

Figure 3 Hip classification-Stature 160 cm

Figure 3 illustrates the hip type distribution for women of stature 160 cm. Slim hipped women make up 17.6% of the sample, 35.3% are standard hipped and 47.1% are broad hipped.
Figure 4 illustrates the hip type distribution for women of stature 168 cm. Slim hipped women make up 22.9%, 34.2% are standard hipped and 42.9% are broad hipped.

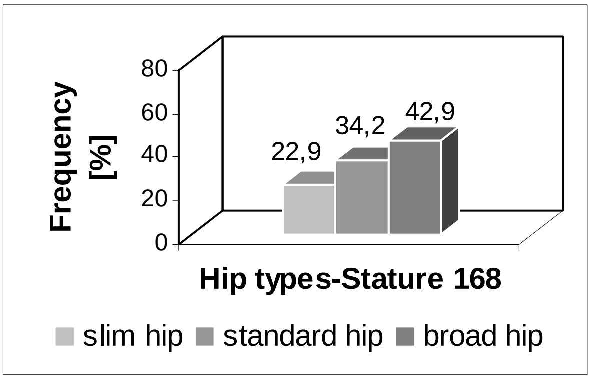

Figure 4 Hip classification-Stature 168 cm

In the case of women with a stature of 176 cm, there are no women classified as slim hipped (Figure 5), but 58.3% are standard hipped and 41.7% broad hipped.

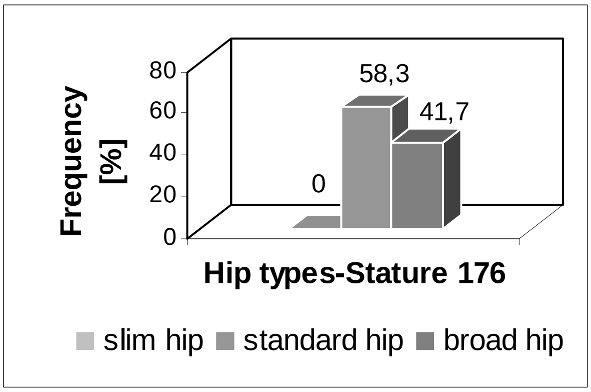

Figure 5 Hip classification-Stature 176 cm

3.2 Automatic 2D digital customized apparel pattern generation

In order to mass-customize clothes 2D pattern generation procedure has been evaluated in frame of the four CAD software applications including products of Lectra, Investronika, Gerber and ClasiCAD. Only one of those methods the CAD system, 'PDS Tailor XQ' of ClassiCAD production is particularly suitable for this experiment due to its special technology.

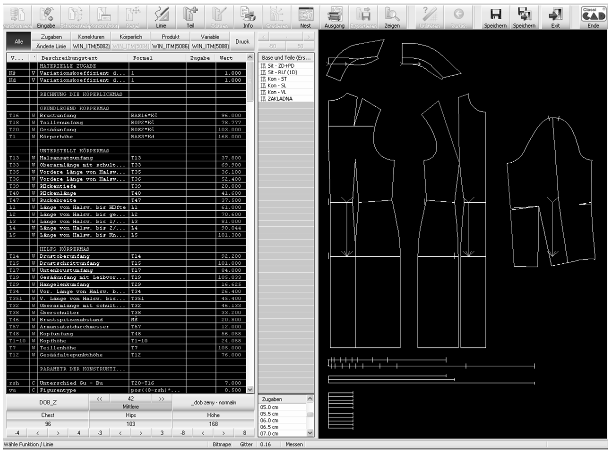

Figure 6 Tailored ladies dress pattern design in PDS Tailor XQ

The distances between the individual design points that correspond with the anatomical body surface points delimit the design line segments, where A and B correspond to specific design points. The dimensions of the design line segments are the sum of the following components of a regression equation (1) of the design curve:

$$AB_i = k_i \times D_i + q_i + e_i \quad (1)$$

AB_i design dimension
k_i regression coefficient
D_i individual body dimension
q_i absolute term
e_i easy allowances

3.3 Virtual garment try-on

The virtual try-on technologies allow individual consumers to try the garment with outline, fabric, color and embellishments on the body using their own measurements and to evaluate clothing fit.

A prototype 2D pattern of a dress was created according to the individual body shapes of each of the 36 female students scanned. Using the pattern design method, 'Unicon+' within program PDS Tailor XQ of the ClassiCAD production final patterns of the prototypes were automatically generated. These 2D pattern prototypes were entered in DXF-AAMA file format into the computer system, 'V-Stitcher SW design solution' from Browswear and were displayed as a prototype-test garment.

Figure 7 3D Virtual garment try-on via system V-Stitcher

The subject tried on the prototype on their 3D avatar and fit modifications were made in any of four areas of the garment as required, based on the subject's preferences such as a tighter fit, looser fit, shorter and longer (Figure 7).

According to the wishes of subject, the prototype model originally created in 2D was modified and subsequently visualized in 3D form. Three prototypes were required to find the perfect fit for the subject. Influence of the woven fabric anisotropy on the drape of areas textiles was considered also. Reference line (warp direction) on pattern pieces was set in relation to the drape value of that fabric which was measured using method of the scanning projection of drape textile [6].

Finally the final customizing cutting patterns were created.

3.4 MTM technology applied to mass customization in a suit jacket production

An experimental test was performed using the MTM procedure on four modifications of men's suit jacket master patterns in CAD system "InvesMark Futura": shortening sleeves, raising shoulders, shortening hems, and waist narrowing. The procedure scheme for the MTM process can be seen in Figure 8.

Custom ordering process of an MTM tailored suit jacket

– *Body and garment measurements required for an MTM tailored suit jacket*

An important aspect custom manufacturing is to accurate define body measurements as well as the product size. In this case, the non-contact body measuring technology BodyFit3D system was used for four male customers in the same nearest clothing size 52 (HAKA sizing system).

– *Making a plan of pattern alterations*

In making an alteration plan by creating a personal measurement alteration chart, the subject's figure types were categorized accurately and the standard graded blocks at the nearest size selected correctly.

The figure and suit jacket fit for pattern alterations was evaluated according to the rules: normal posture; stooping posture; erect posture; incorrect lengths; incorrect shoulder slant; incorrect widths.

– *Creation of suit style*

In the ordering process, subjects created his own suit style with the help of samples of reference garments collected in the catalog of suit details. Sketches of suit components e.g. front part, back part, pocket, sleeve, type of lining, decorations, accessories etc. with codes are displayed in the catalog.

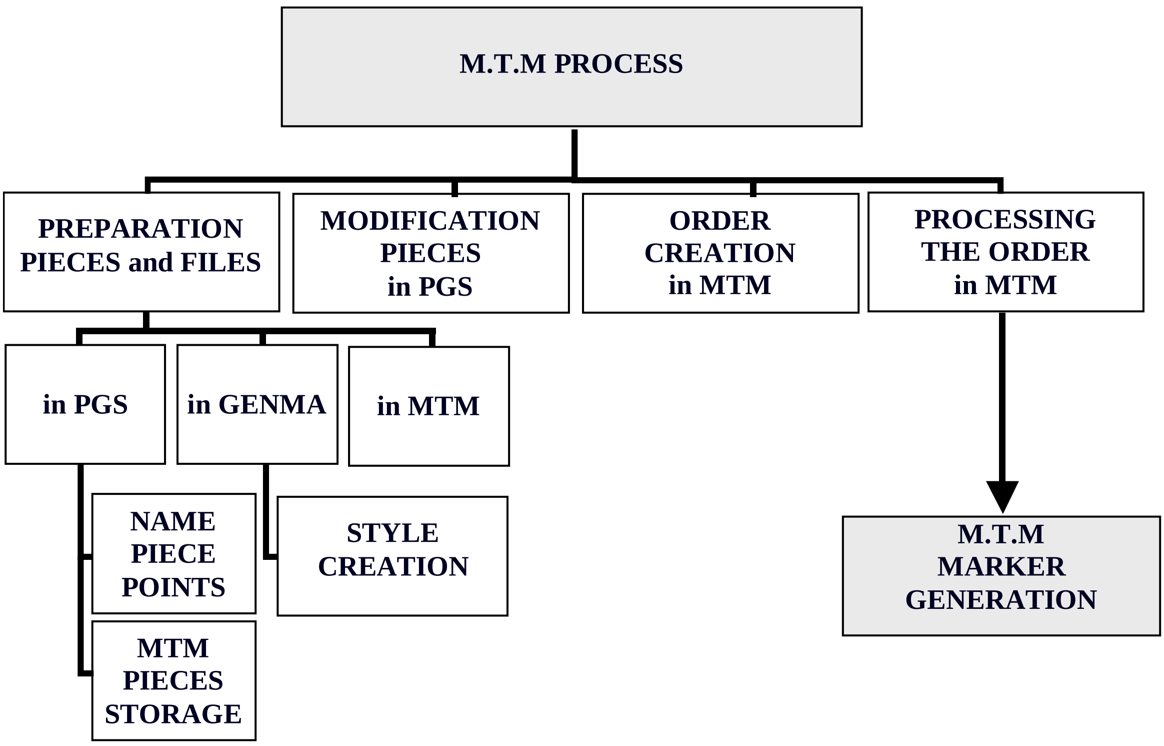

Figure 8 General chart of MTM process of a tailored suit jacket in system "InvesMark Futura"

4 CONCLUSION

Mass customization, as a new paradigm in clothing production, combines the advantage of both mass production and customized production.

The main goal of the research that is described in this paper is to find out suitable computer aided methods of generating 2D clothing patterns based on input design parameters according to customized body dimensions data taken by the BodyFit 3D unit.

In order to mass-customize clothes the CAD system, 'PDS Tailor XQ' of the ClassiCAD production is particularly suitable for 2D pattern generation procedure due to its special technology. The dimension of the design line segments is the sum of the regression equations of the design curve, where variables are individual body dimension.

The second suitable computer aided method the MTM system 'InvesMark Futura' is describe in this paper as suitable for 2D customized pattern generation. Shape of the standard size of the pattern pieces, which are already saved in database and empirically verified are altered.

Due to the proposed procedures which are reviewed in this paper we can design clothing patterns of an individual garment based on individual customized body measurements taken by the BodyFit 3D unit in frame of mass customization.

Acknowledgments: *The authors would like to thank the InCoTex project "Innovation center for customer-oriented, industrial textile products" for their support.*

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IMPLEMENTACE ZPŮSOBU "MASS CUSTOMIZATION" VE VÝROBĚ ODĚVŮ

Translation of the article
Implementing mass customization into clothing production

V současné době je možné vyrábět zakázkové oděvy tak, aby mohly svým zhotovením jednak vyhovět individuálním požadavkům konkrétního zákazníka a zároveň tak, aby byla jejich výroba maximálně automatizovaná s využitím technologií hromadné výroby oděvů. Tímto fenoménem dnešní doby je výrobní koncepce „mass-customization“.
Práce se zabývá studií a testováním mass-customization procesu tvorby střihů oděvních výrobků pomocí počítačové techniky, který integruje standardizovaný proces konfekční výroby a proces výroby zakázkových oděvů podpořený moderními informačními technologiemi.
Hlavním cílem této práce je studie možností automatizované tvorby střihů zakázkových oděvů, které jsou vytvořeny na základě konstrukčních parametrů stanovených dle bezkontaktně změřených tělesných rozměrů pomocí systému BodyFit 3D.
Jako nejvhodnější konstrukční metodika pro automatizovanou tvorbu střihů zakázkových oděvů byl vybrán a ověřen program PDS Tailor XQ od společnosti ClassiCAD pro svoji specifickou technologii. Umožňuje definovat tvary a velikost konstrukčních linií výpočtem dle regresních rovnic, a to dosazením hodnot individuálních tělesných rozměrů zákazníka. Tato vhodná metoda je ověřena na procesu tvorby 2D střihů dámských šatů a ověřena 3D vizualizací v prostředí programu V-Stitcher.
V druhé části experimentu je uplatněna metoda Made To Measure tzv. měřenka. Tvary střihových šablon konfekčního oděvu, které odpovídají nejbližší konfekční velikosti zákazníka, jsou modifikovány podle tělesných rozměrů zákazníka změřených pomocí BodyFit 3D. Dle navrženého MTM postupu v prostředí systému "InvesMark Futura" jsou ověřeny alterace: zkrácení délky saka, zkrácení rukávů, zvýšení ramen a zúžení v pase.

IMPACT OF AMBIENT TEMPERATURE & HUMIDITY ON SEWING NEEDLE TEMPERATURE

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Abstract: *In this article sewing needle heat is measured by the attached thermocouple method which is inserted inside the groove of sewing needle to analyze the impact of ambient factors like room humidity and temperature on the heating of sewing needle. The Lock stitch machine (Brother, DD7100-905) is run without sewing thread and with polyester-polyester core spun (80 Tex) thread at its maximum speed of 4700 RPM with stitch length of 14 SPI for a maximum of 60 seconds. 2/1 twill 100% cotton denim fabric with 257 GSM with two layers were used and it was observed that with the increase of relative humidity there is insignificant difference in sewing needle temperature. Whereas the needle temperature rises with the increase of ambient temperature. Needle temperature increases linearly with the increase of sewing speed whereas the tensile strength of thread has negative strong linear relation with the needle temperature and sewing speed. At sewing floor the ambient temperature must be set carefully to keep the sewing needle temperature low and to decrease the loss in tensile strength of thread.*
Keywords: *needle temperature. ambient humidity and needle temperature, lockstitch sewing.*

1 INTRODUCTION

Industrial sewing is one of the most commonly used manufacturing operations. Its applications can be found in the manufacturing of garments, shoes, furniture, and automobiles. Every day, millions of products ranging from shirts to automotive airbags are sewn. Hence, even a small improvement may result in significant corporate benefits. In heavy industry sewing, such as sewing of automobile seat cushions, backs and airbags. It requires not only high production but also high sewing quality (i.e. good appearance and long-lasting stitches). Typically, the material being sewn includes single and multiple plies of synthetic fabric or leather, and sometimes backed with plastics. These materials are much more difficult to sew compared to ordinary sewing applications. In recent years, in order to increase the sewing production, high speed sewing has been used extensively. Currently, sewing speeds range from 2.000~6.000 rpm. In heavy industrial sewing, typical sewing speeds range from 1.000~3.000 rpm. Needle heating due to the friction between the needle and the fabric is severe. The friction generates heat, part of which is absorbed by the fabric and part by the needle. The heat absorbed by the fabric is spread out along the seam, but the heat absorbed by the needle accumulates. Depending on sewing conditions the maximum needle temperatures range from 100~300°C. This high temperature weakens the thread, since thread tensile strength is a function of temperature [1]. Infrared pyrometer [1, 2] is used to measure the temperature. These experimental methods are accurate and reliable [2, 3]. This heat so can make the loss of needle temper and these faults lead to the decreased production [4]. A various measures of needle temperature have been done, such as measure by infra-red pyrometer, attached thermocouple, separate thermocouple, temperature sensitive waxes, etc. Because the needle is moving very fast under sewing process so it's impossible to measure with thermo cameras. Another problem is that the emissions of the needle changes during sewing as the surface characteristics change [5]. From multiple experiments it was found that thermo cameras cannot be used for measuring of sewing needle temperature at high speed of sewing more than 3000 rpm of machine [7].

2 EXPERIMENTAL PART

To measure the impact of ambient temperature and humidity on the sewing needle temperature following equipments were used.

1. Lock stitch machine (Brother, DD7100-905)
2. Thermocouple by Omega (K type 5SC-TT-(K)-40-(36)) for inserted method
3. Thermocouple end wireless device and receiver (MWTC-D-K-868)
4. Needles (Groz-Becker 100) R- type
5. Denim fabric, 100% cotton, (257 GSM, 2/1 twill)
6. Fan to cool needle (Vortex cooler)
7. Controlled room for humidity and temperature level.

Two layers of denim fabric 2/1 twill with 257 GSM were used for the experiments. The machine was made to run at its maximum speed of 4700 rpm with stitch length of 14 SPI. Temperature was measured by thermocouple (5SC-TT-(K)-36-(36)) inserted inside the groove of needle and measurements were taken at every second of sewing process of 60 seconds [6]. Figures 1 and 2 show the placement of thermocouple to be inserted inside groove of needle. Experiments were done in the controlled condition room where three different relative humidity were set in the condition room, which are 40%, 52% and 65% relative humidity, where as the temperature was kept constant at 26°C with tolerance of 2°C. Secondly the humidity was kept constant at 65% and temperature of controlled room was changed 16°C, 26°C and 36°C.

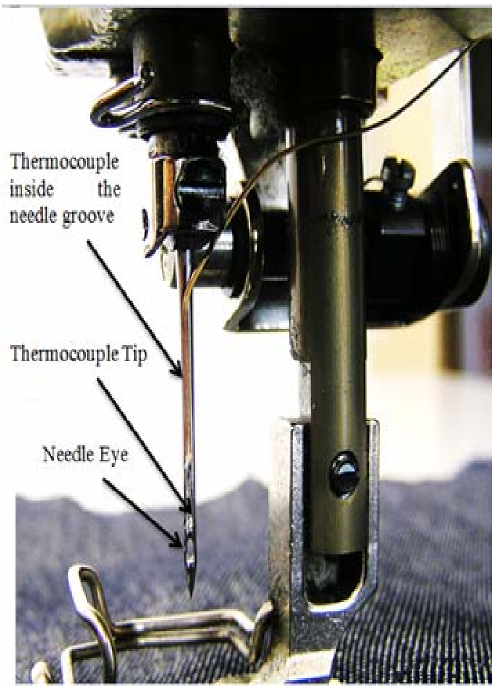

Figure 1 Placemet of inserted thermocouple (figure belongs to author [6])

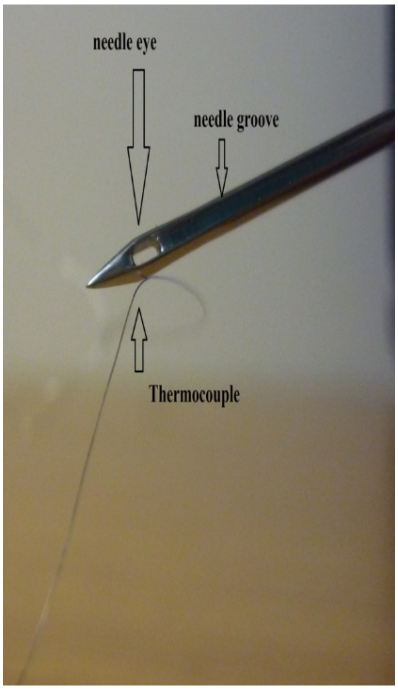

Figure 2 Sewing needle and thermocouple size (figure belongs to author [6])

3 RESULTS

Increase of relative humidity causes the insignificant change of the sewing needle temperature. Tables 1, 2 and 3 show the sewing needle temperature without thread. There is no significant difference caused by the ambient humidity on sewing needle temperature. The humidity level was changed from 40%, 52% to 65% RH. Results show that ambient humidity has minor impact on sewing needle temperature.

Where as the use of cooling device for sewing needle decreases the sewing needle temperature and the impact is more visible when the relative humidity is higher, Figure 3 shows the difference of temperature of needle between sewing with cooling and sewing without cooling at 40% RH. Cooling causes decrease in sewing needle temperature but the decrease is more visible when the RH is higher as shown in Figure 4 where needle temperature is measured at 65% RH

Table 1 Sewing needle temperature at 40%RH, temperature 26°C, 14 SPI and 4700 rpm of sewing machine

Time of sewing [s]	**0**	**10**	**20**	**30**	**60**
Needle temperature[°C]	26	84	86	93	94
S.D [degree C]	0	4	1.7	3	2

Table 2 Sewing needle temperature at 52% RH, temperature 26°C, 14 SPI and 4700 rpm of sewing machine

Time of sewing [s]	**0**	**10**	**20**	**30**	**60**
Needle temperature[°C]	26	83	85	92	94
S.D [degree C]	0	3	1	2	2

Table 3 Sewing needle temperature at 65% RH, temperature 26°C, 14 SPI and 4700 rpm of sewing machine

Time of sewing [s]	**0**	**10**	**20**	**30**	**60**
Needle temperature[°C]	26	82	86	91	93
S.D [degree C]	0	4	2	3	2

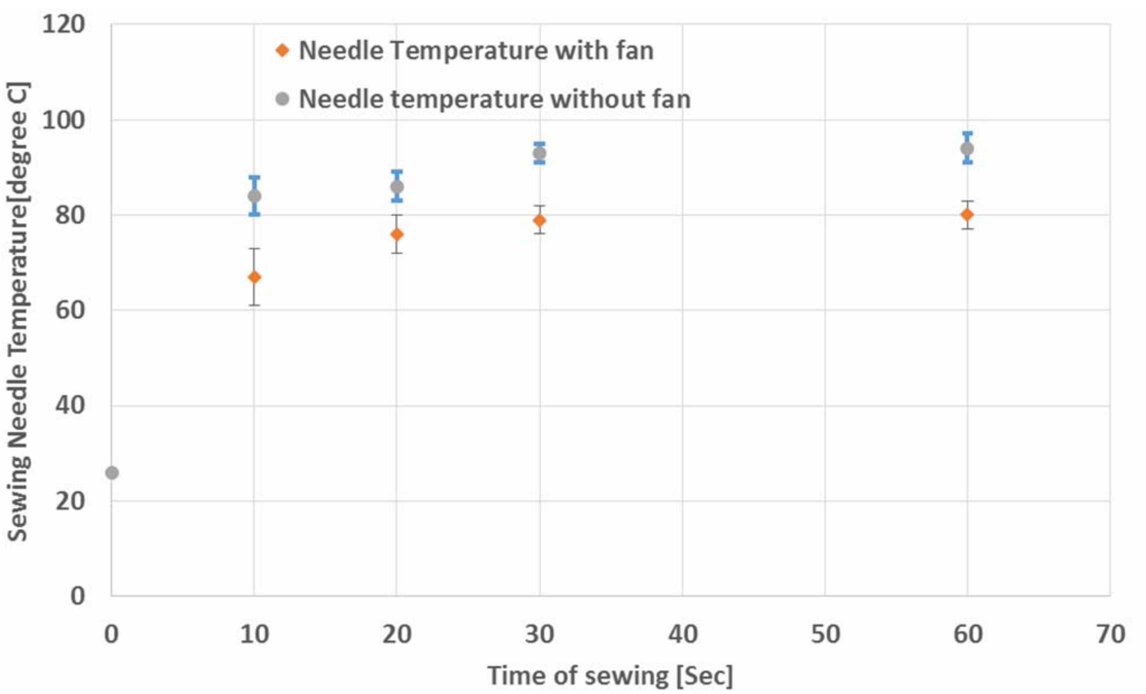

Figure 3 Vortex cooling impact on sewing needle temperature at 40% RH

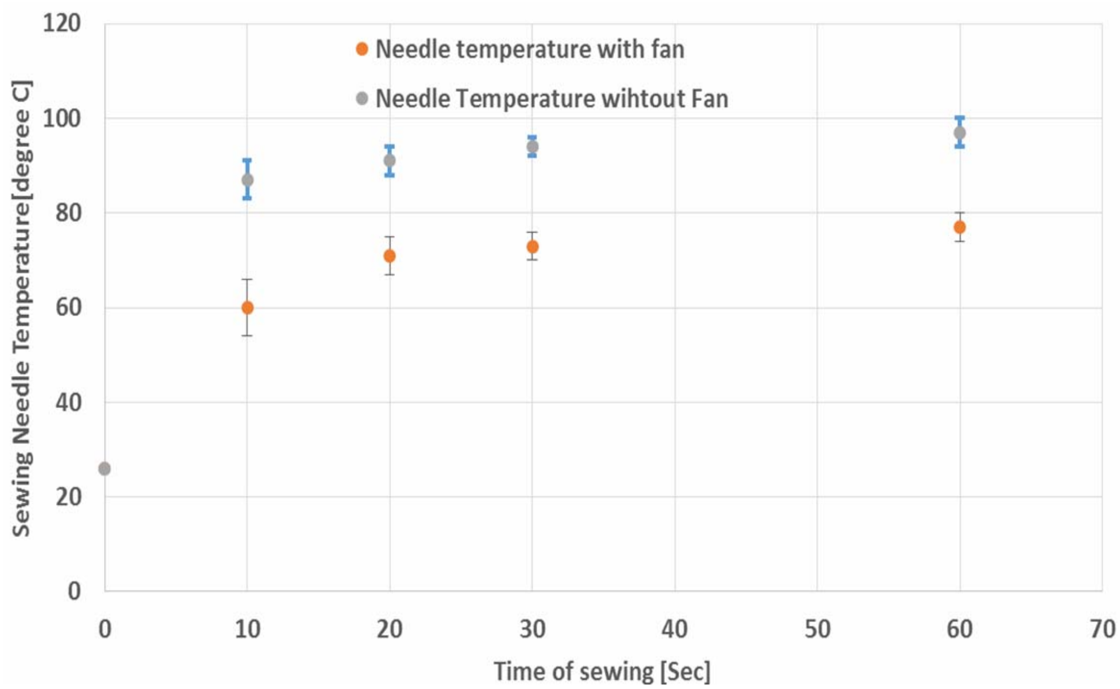

Figure 4 Vortex cooling impact on sewing needle temperature at 65% RH

Sewing machine was operated without thread at three different ambient temperature level of 16°C, 26°C and 36°C and result as shown in Figure 5 that the needle temperature rises with the increase of the ambient temperature. It is highly recommended to keep the ambient temperature as low as possible to minimise needle heat.

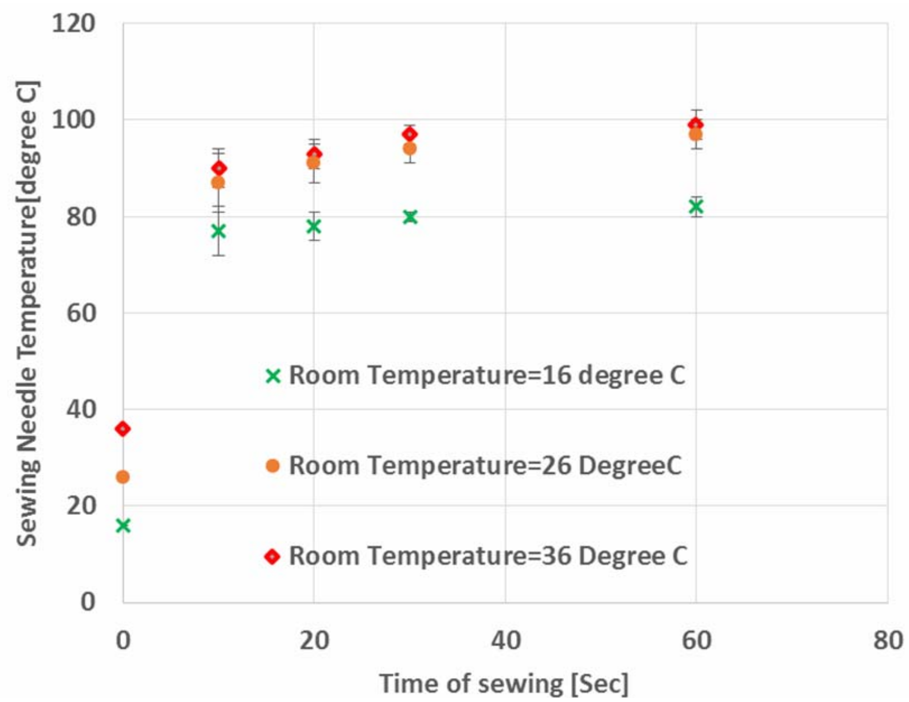

Figure 5 Effect of ambient temperature on sewing needle

Where as Figures 6 and 7 show the decrease of sewing needle temperature with the use of cooling fan, and almost a 100°C difference is observed on average by using cooling for sewing needle.

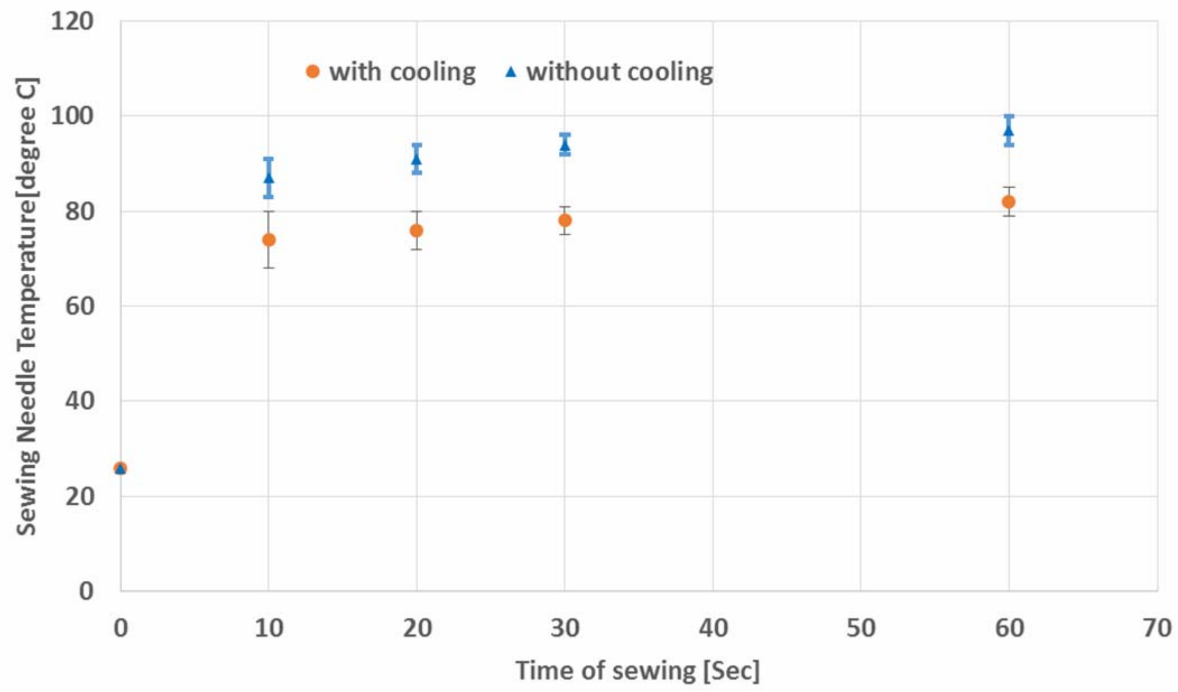

Figure 6 Vortex cooling impact on sewing needle temperature at 26°C and 65% RH

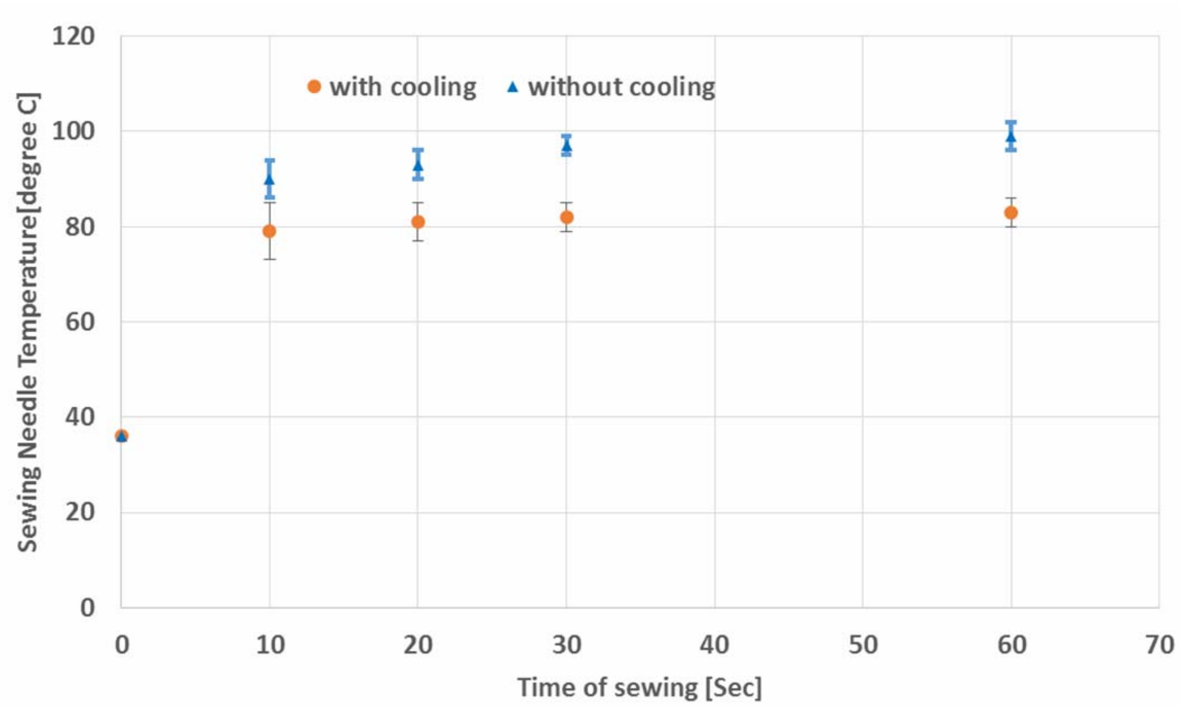

Figure 7 Vortex cooling impact on sewing needle temperature at 36°C and 65% RH

Figure 8 shows the effect of ambient temperature on sewing needle temperature with sewing thread polyester-polyester core spun 80 Tex (40*2) at 4700 rpm of machine needle temperature rises with the increase of ambient temperature and after 30 seconds of sewing the needle temperature rises to 286°C when ambient temperature is 36°C.

Figure 9 shows the effect of ambient humidity on sewing needle temperature with sewing thread polyester-polyester core spun 80 Tex (40*2) at 4700 rpm of machine. There is a minor decrease in sewing needle temperature at higher humidity level.

Figure 10 shows the linear relation between sewing speed and needle temperature and a strong negative linear relation between the needle temperature and tensile strength of the thread. Tensile strength of the parent thread was 50 cN/Tex which decrease to half when the machine speed was 4700 rpm, 30 samples of each at different sewing speed of machine were examined at Instron tensile tester (ISO 2062) where the bobbin thread of seam were carefully cut to obtain the sewing thread.

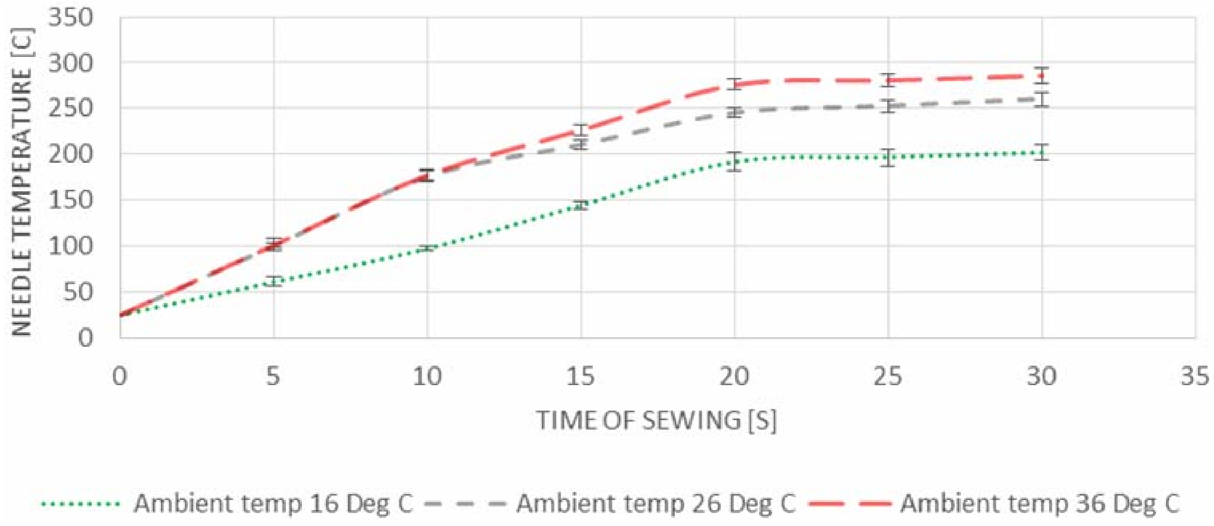

Figure 8 Effect of ambient temperature on needle temperature when sewing with 80 Tex thread

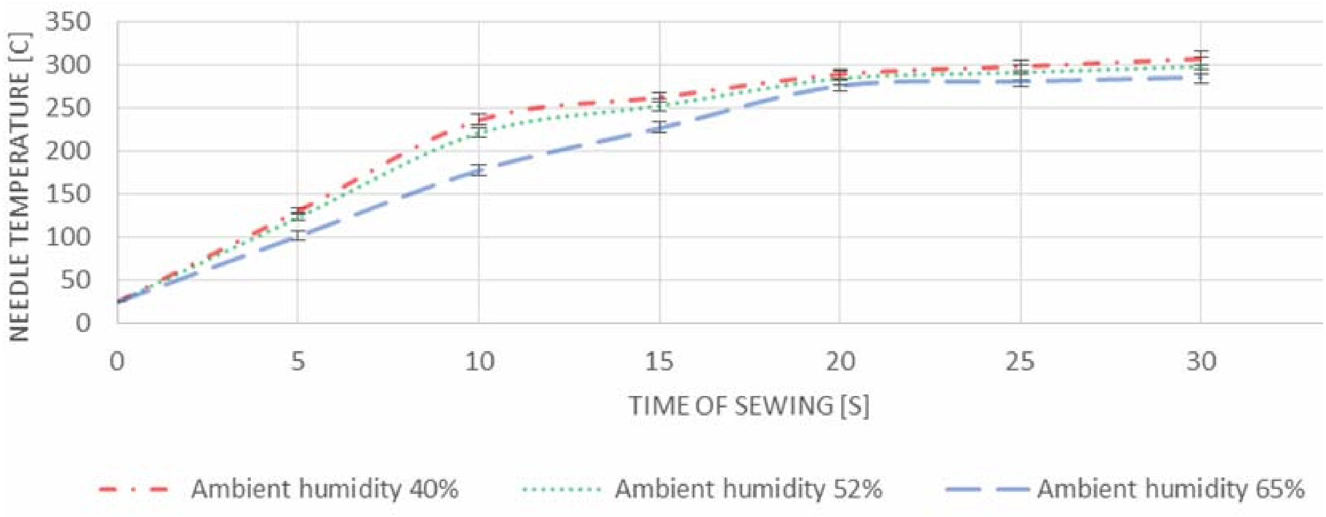

Figure 9 Effect of ambient humidity on needle temperature when sewing with 80 Tex thread

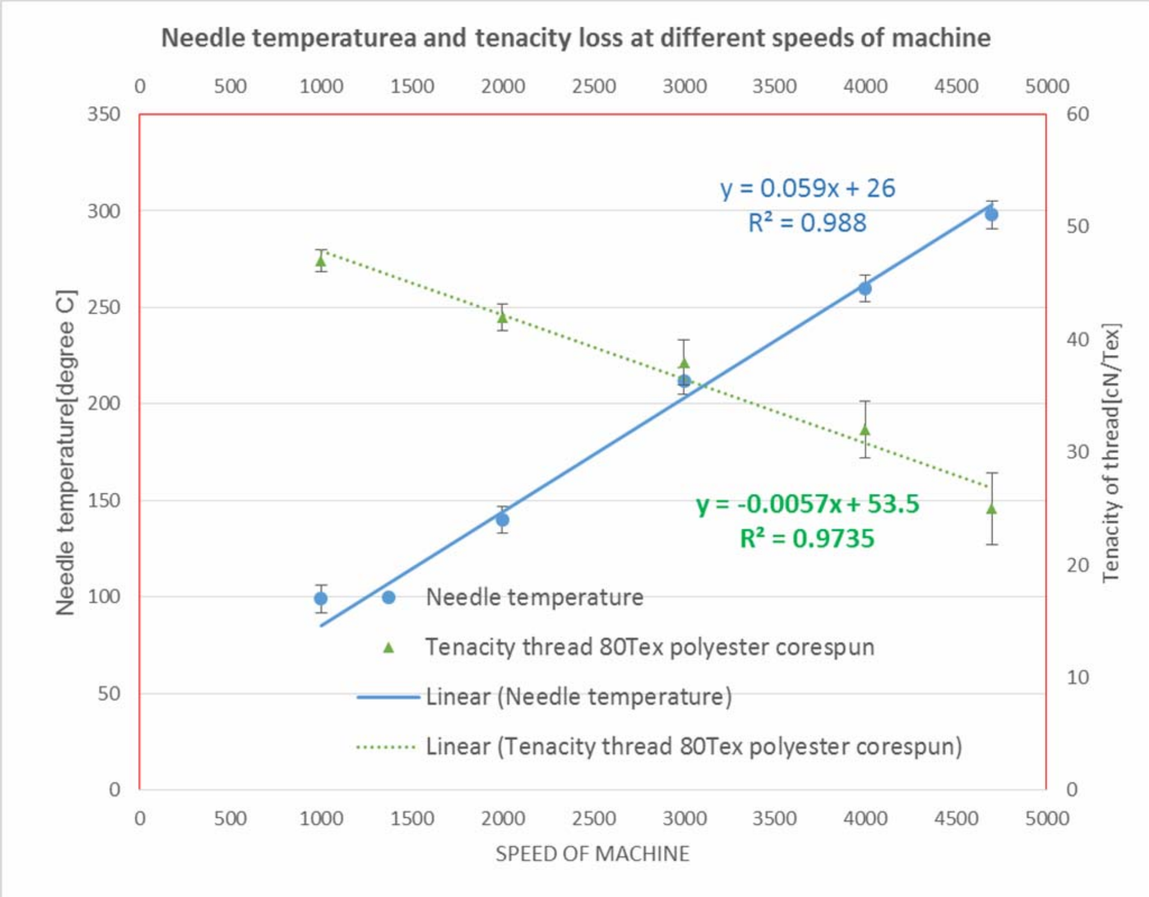

Figure 10 Relation between sewing speed and tensile strength of thread

4 CONCLUSION

The article represents the exact temperature of sewing needle without thread and with thread at different ambient levels of humidity and temperature. Results show that the ambient humidity has almost no influence on sewing needle temperature when used without cooling but with the use of cooling device the higher humidity level shows higher decrease in the sewing needle. Whereas the ambient temperature causes the change in the temperature of sewing needle and higher temperature is noted for needle when the ambient temperature is higher and with the use of cooling device the temperature of needle is decreased to 10°C on average. There is linear relationship between sewing speed and needle temperature and negative linear relationship between thread strength and needle temperature. It is recommended to use the low temperature as much as possible with respect to worker comfort at the sewing rooms, and use of cooling devices can effectively decrease the sewing needle temperature. The results are measured by unique method of thermocouple inserted inside the needle groove.

Acknowledgement: *The research work is part of a bigger research and covered by grant SGS 48001 (ADNAN MAZARI), Czech Republic.*

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VPLYV TEPLOTY OKOLÍ A VLHKOSTI NA TEPLOTU ŠICÍ JEHLY

Translation of the article

Impact of ambient temperature & humidity on sewing needle temperature

V tomto článku je popsána metoda měření teploty jehly pomocí přiloženého termočlánku, který byl vložen uvnitř drážky jehly pro analýzu dopadu faktorů prostředí (teplota, vlhkost) na šicí jehlu. Šicí stroj (Brother, DD7100-905) byl provozován bez šicí nitě a s polyester-polyesterovou jádrovou nití o jemnosti 80 Tex při své maximální pracovní rychlosti 4700 RPM s délkou stehu 14 SPI po dobu maximálně 60 sekund. Šicí proces byl prováděn na tkanině z 2/1 kepru ze 100 % bavlny a z denimu 257 GSM ve dvou vrstvách. Bylo zjištěno, že zvýšení relativní vlhkosti okolí nemá významný vliv na teplotu šicí jehly na rozdíl od vzrůstající teploty v místnosti, kdy teplota jehly stoupa. Teplota jehly se lineárně zvyšuje také s nárůstem rychlosti šití, zatímco na pevnost nití v tahu má silný negativní lineární vztah. Pro šití potahů musí být proto okolní teplota nastavená tak, aby šicí jehla měla nízkou teplotu a nezpůsobovala tak nežádoucí snížení pevnosti nití v tahu.

VÝVOJ NOVEJ ANALYTICKEJ METÓDY PRE NANOTEXTÍLIE S ANTIMIKROBIÁLNYM ÚČINKOM S OBSAHOM STRIEBRA

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Abstrakt: *V príspevku sú stručne charakterizované nanotechnológie a nanomateriály, ich využitie a potenciálne toxické účinky. V súvislosti s rizikami novovyvinutých nanomateriálov je nastolená otázka ich bezpečnosti a potreby vývoja nových metód. Podrobnejšie sú opísané antimikrobiálne textílie s obsahom striebra. V príspevku je prezentovaná navrhnutá a experimentálne odskúšaná metóda stanovenia striebra bez potreby mineralizácie laboratórne pripravených textilných vzoriek s aplikáciou antimikrobiálneho nanosólu s obsahom striebra v dvoch rôznych koncentráciách. V závere je zhodnotený prínos navrhnutej metódy a možnosti jej využitia.*
Kľúčové slová: *nanotechnológie, nanomateriál, nanosóly, antimikrobiálne účinky, analýza celkového striebra*

1 ÚVOD

Nanotechnológie patria k progresívnym typom technológií, ktorých výsledkom je materiál, ktorého jeden alebo viac rozmerov je o veľkosti od 1-100 nm (ISO/TS 27687:2010). Podľa najnovšie navrhovanej definície by sa za nanomateriál mal považovať každý materiál, ktorý obsahuje najmenej 50% častíc s takýmito rozmermi, či už vo forme jednotlivých častíc alebo ich agregátov, resp. aglomerátov vrátane fullerénov, grafénových vločiek a jednostenných uhlíkové nanotrubíc, ktorých rozmery sú často aj pod 1 nm (2011/696/EU) [1].
Pri rozmeroch nanomateriálov prestáva platiť klasická fyzika a k slovu sa dostávajú nezanedbateľné vplyvy kvantovej fyziky. Vzniká úplne nová fyzika, nanofyzika látok [2]. Príčinou, prečo prestávajú platiť pravidlá klasickej fyziky, je zmena veľkosti častíc a s tým súvisiaci ohromný nárast ich povrchu. S nárastom povrchu sa zvyšuje príspevok povrchovej energie k celkovej energii nanočastice, čím sa dramaticky mení správanie materiálu, zvyšuje sa jeho chemická reaktivita [1]. Vplyv enormného nárastu povrchovej energie je úzko spätý aj s procesmi vyparovania a kondenzácie na substráte [2].
Ďalším fyzikálnym parametrom je aj netypicky sa správajúca tepelná vodivosť nanomateriálov než ako sme zvyknutí z makrosveta [2]. Fázové premeny sa v nanosvete riadia inými zákonmi. Objavujú sa fenomény ako sú supravodivosť [2] a supratekutosť v závislosti od veľkostí nanoštruktúry ako aj tvaru objektu (nanočastica, nanovlákno, nanovrstva) [3]. Všetky tieto nové vlastnosti sú predpokladom k ich využitiu, ale súčasne nastoľujú otázky súvisiace s ich potenciálnou rizikovosťou.
S rastom chemickej reaktivity nanomateriálov narastá aj možnosť ich interakcií so živými organizmami (väčšina stavebných prvkov živých buniek má porovnateľnú veľkosť ako nanomateriály). Bola preukázaná schopnosť nanočastíc vstupovať do bunkových štruktúr, kde môžu poškodiť DNA – genotoxický potenciál [1, 4]. K najzávažnejším toxickým účinkom nanomateriálov patria: schopnosť vyvolávať oxidačný stres, pri ktorom dochádza k porušeniu rovnováhy medzi vznikom a odstraňovaním reaktívnych foriem kyslíka, vzniku voľných radikálov, ktoré môžu byť následne príčinami zápalu [1, 5]. Chronický zápal môže byť iniciátorom karcinogenézy [6]. V prípade prieniku nanočastíc do centrálnej nervovej sústavy môže dôjsť k spusteniu neuro-degeneratívnych ochorení (Alzheimerova

choroba, Parkinsonova choroba,...) [1]. Uhlíkové nanotrubice vykazujú vlastnosti podobné azbestovým vláknam (veľkosť a tvar vlákien). Inhalácia azbestových vlákien je považovaná za príčinu pľúcnej fibrózy, vážnych pľúcnych chorôb až mezotheliomu (špecifický druh rakoviny pľúc) [7].
Využitie nanomateriálov je mnohostranné: v elektronike (nové informačné technológie), v medicíne (liečba popálenín, rakoviny, diagnostika, cielená doprava liečiv,...), v kozmetickom priemysle (opaľovacie krémy, súčasť líčidiel,...), v textilnom priemysle (vývoj funkčných textílií, výroba filtrov,...), v potravinárstve (potravinové obaly), povrchové úpravy, atď.
Pri vysokom raste produkcie rastie aj počet osôb vystavených expozícii pri výrobných procesoch, pri úniku nanomateriálov do jednotlivých zložiek životného prostredia, ako aj v súvislosti s ich spotrebiteľským využitím. Nanomateriál sa do ľudského organizmu môže dostať inhaláciou, dermálnou expozíciou, ingesciou tráviacim traktom alebo spojivkovým epitelom [1, 7].
Vzhľadom na predchádzajúce negatívne skúsenosti (napr. DDT, PCB,...) sa apeluje na výrobcov, aby s nanomateriálmi zaobchádzali ako s potenciálne nebezpečnými – tzv. princíp predbežnej opatrnosti [1].
Sledovanie bezpečnosti nanomateriálov v porovnaní s exponenciálnym nárastom počtu aplikácií nanotechnológií výrazne zaostáva. Je potrebné vytváranie metód na meranie, charakterizáciu a hodnotenie rizík nanomateriálov a stanovenie hraničných hodnôt, kedy nanomateriál vykazuje isté špecifické chovanie, ktoré môže mať súvis s jeho potenciálnym toxickým pôsobením. Na charakterizáciu nanomateriálov je potrebné použiť kombináciu rôznych metód s využitím najmodernejších prístrojov. Tieto metódy v mnohých prípadoch vyžadujú modifikáciu a validáciu, nakoľko ich využitie pre nanomateriály ešte nebolo overené. Ako problém sa javí aj nedostatok vhodných štandardov, ktoré by slúžili na validáciu metód [4]. Dôležitým sa stáva aj sledovanie životného cyklu nanomateriálov. Toxicita nanomateriálov pre najjednoduchšie živé organizmy môže byť príčinou porušenia krehkej rovnováhy v prírode [1]. Z uvedených dôvodov narastá význam výskumu aj v oblasti nových metód zameraných na nanomateriály.

2 VYUŽITIE NANOTECHNOLÓGIÍ PRI APLIKÁCIÁCH NA TEXTIL

V nanotechnológiách sa uplatňujú dva základné princípy: princíp miniaturizácie (nazývaný top-down), kedy sa cielene zmenšujú rozmery až pod úroveň do 100 nm a prístup zhlukovania/aglomeračný (nazývaný prístup bottom-up), kedy sa z menších prekurzorov zostavujú a usporadúvajú celky až po nano-úroveň procesom samousporiadania (self-assembly), teda vznik nanoštruktúr cielenou aglomeráciou/agregáciou z atomárnych resp. molekulárnych rozmerov do nanorozmerných aglomerátov/agregátov [2]. Pri vývoji nanotextílií je použitý princíp bottom-up.
Pri nanoštruktúrovaných materiáloch sa stretávame s pozoruhodným javom - fázovým prechodom postupnej kondenzácie nanočastíc z nanosólu do gélu a následným kontrolovaným odparením základného rozpúšťadla za vzniku xerogélov resp. kryogélov. V závislosti od podmienok odparenia základného rozpúšťadla možno dosiahnuť jav samousporiadania resp. samosformovania do nadmolekulových celkov [2]. Tento jav je využívaný pri nanoúpravach textilných materiálov. Najčastejší koncový produkt takéhoto sól-gélového procesu je xerogél, ktorý na textilnom vlákne zanechá nanovrstvu resp. ostrovčeky aglomerátov nanočastíc. V závislosti od vlastností nanášaného nanosólu možno tak dosiahnuť nové a požadované vlastnosti u textilných materiálov ako je napr. hydrofóbnosť, samočistiaci povrch alebo antimikrobiálne vlastnosti.
Nanočastice striebra majú vďaka svojmu antibakteriálnemu účinku rozsiahle spektrum spotrebiteľského využitia: povrch lekárskych nástrojov, endoprotézy, náhrady srdcových chlopní, obväzové materiály, antibakteriálne

textilné materiály,... Sú tiež skvelou pomocou pri vzniku rezistencií na antibiotiká, ku ktorej dochádza pri ich neuváženom používaní.

3 SKÚŠKY TEXTÍLIÍ S ANTIMIKROBIÁLNOU ÚPRAVOU

Antimikrobiálna aktivita je závislá na veľkosti častíc a vzrastá s poklesom ich rozmerov. Pri porovnávaní účinnosti striebra v odlišných formách - Ag^+, koloidné Ag, nanostriebro - existuje korelácia medzi konkrétnou formou aplikovaného striebra a jeho toxicitou pre makroorganizmus (iónová forma je pre makroorganizmy toxickejšia ako nanočastice kovového striebra) [8]. Antimikrobiálna účinnosť stúpa v poradí Ag^+, koloidné Ag a nanostriebro a v rovnakom poradí klesá toxicita pre makroorganizmus, z čoho by vyplývalo, že pre makroorganizmy sa použitím nanočastíc striebra dosiahne najoptimálnejší pomer nízka toxicita/ najvyššia antimikrobiálna účinnosť [9].

Antimikrobiálna účinnosť textílií s aplikáciou nanosólu na báze striebra použitých na experiment bola potvrdená skúšobnou metódou AATCC 100 s použitím gramnegatívnej baktérie *Klebsiella pneumoniae* a grampozitívnej baktérie *Staphylococcus aureus*. Pri príprave textílií s antimikrobiálnou úpravou vznikla požiadavka na monitorovanie skutočného obsahu naneseného striebra v pripravených textíliách. Na stanovenie obsahu striebra sa požívala metóda s mineralizáciou vzorky. Mineralizácia sa realizuje v prostredí zmesi kyseliny chloristej a dusičnej v mineralizačnom prístroji Digesdhal, ktorý ale neumožňuje mineralizáciu viacerých vzoriek naraz. Samotná mineralizácia je časovo náročná, celkový čas mineralizácie je 1 hodina. Proces je limitovaný aj množstvom súčasne mineralizovaných vzoriek, nakoľko mineralizácia prebieha v mineralizačnom zariadení.

Naším cieľom bolo navrhnúť a overiť novú metódu stanovenia celkového striebra bez mineralizácie, zefektívniť postup extrakcie, znížiť náklady, a to nahradením mineralizácie vzorky vytvorením rozpustného komplexu striebra vhodného na následné stanovenie na AAS spektrofotometri.

4 METÓDA STANOVENIA CELKOVÉHO STRIEBRA V TEXTÍLIÁCH S APLIKÁCIOU ANTIMIKROBIÁLNEHO NANOSÓLU BEZ POTREBY MINERALIZÁCIE

4.1 Návrh metódy

Pri návrhu metódy analýzy bez mineralizácie bola pre nás inšpiráciou metóda zoslabovania čierno-bieleho negatívu vo fotografii. Emulzná strana čierno-bieleho negatívneho filmu je vlastne tiež xerogél. Prestup oxidovaného striebra do roztoku vplyvom oxidovadla z nekovalentnej väzby tiosíranom veľmi pripomína situáciu s impregnovanými tkaninami so striebrom inkorporovaným do xerogélu. Zoslabovanie negatívneho filmu je vlastne založené na princípe väzby oxidovaného kovového striebra do pevnej komplexnej väzby – tvorba chelátu [10]. Predmetom nášho záujmu v prípade vývoja metodiky bolo určenia množstva striebra, ktoré je naviazané v rozpustnom komplexe. Takto zastabilizované striebro je vhodné na analýzu atómovou absorpčnou spektrofotometriou.

Chemizmus navrhnutého postupu extrakcie a komplexácie striebra roztokom hexakyanoželezitanu draselného (ako oxidačného činidla) a tiosíranu sodného (ako komplexotvorného činidla) [11] :

$$[Fe(CN)_6]^{3-} + Ag^0 \rightarrow [Fe(CN)_6]^{2-} + Ag^+ \qquad (1)$$

Tvorbu stabilnej rozpustnej formy chelátovaného strieborného iónu možno opísať rovnicami [11]:

$$2Ag^+ + Na_2S_2O_3 \rightarrow Ag_2S_2O_3 \qquad (2)$$

$$Ag_2S_2O_3 + Na_2S_2O_3 \rightarrow 2Na[AgS_2O_3] \qquad (3)$$

$$2Na[AgS_2O_3] + Na_2S_2O_3 \rightarrow Na_4[Ag_2(S_2O_3)] \qquad (4)$$

5 EXPERIMENTÁLNA ČASŤ

Experimentálna časť je zameraná na stanovenie celkového obsahu striebra v textíliách upravených antimikrobiálnym (AMB) nanosólom. Navrhnutá metóda je založená na oxidácii nanostriebra na ión Ag^+ a jeho následnom naviazaní do stabilného a rozpustného komplexu. Keďže vytvorený komplex - chelát s tiosíranom v plameni AAS zhorí, pričom dôjde k atomizácii striebra, je možné stanovenie obsahu Ag priamo metódou AAS.

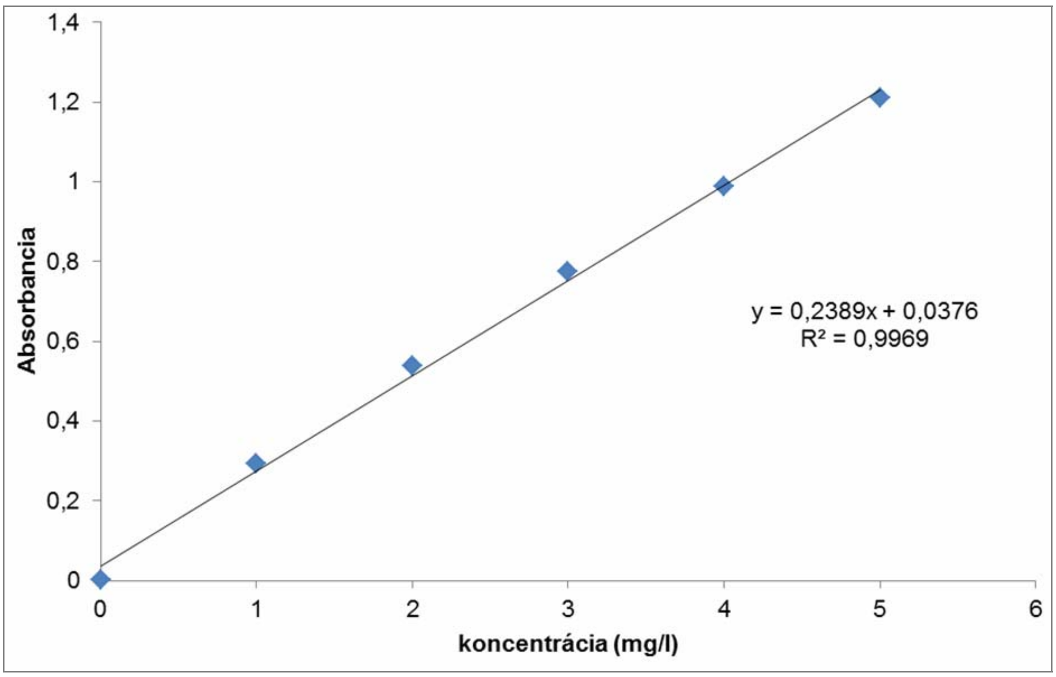
5.1 Použité materiály

Laboratórne pripravené bavlnené textílie s aplikáciou antibakteriálneho nanosólu :
Vzorka č. 1 deklarovaná koncentrácia striebra 15 $mg.kg^{-1}$
Vzorka č. 2 deklarovaná koncentrácia striebra 30 $mg.kg^{-1}$

5.2 Postup skúšky

- odber vzorky textílie s hmotnosťou cca 1 g
- zaliatie vzorky 50 ml čerstvo pripraveného extrakčného roztoku
  (roztok hexakyanoželezitanu draselného $K_3[Fe(CN)_6]$ a tiosíranu sodného $Na_2S_2O_3{\cdot}5H_2O$)
- extrakcia vzorky textílie na trepačke cca 2 hod
- filtrácia extraktu vzorky
- analýza filtrátu metódou atómovej absorpčnej spektrofotometrie.

Na stanovenie obsahu striebra v extrakčnom roztoku metódou AAS sa použil spektrofotometer SpectrAA DUO AA 240 FS - plameňová technika.
Filtrát extraktu neriedenej vzorky (20 ml) bol atomizovaný a analyzovaný v plameni acetylén-vzduch. Na vyhodnotenie obsahu striebra v skúšobnej vzorke bola použitá 6 bodová kalibračná krivka v rozsahu koncentrácií striebra 0-5 $mg.l^{-1}$ (Obr. 1).



Obr. 1 Kalibračná krivka závislosti absorbancie striebra od koncentrácie

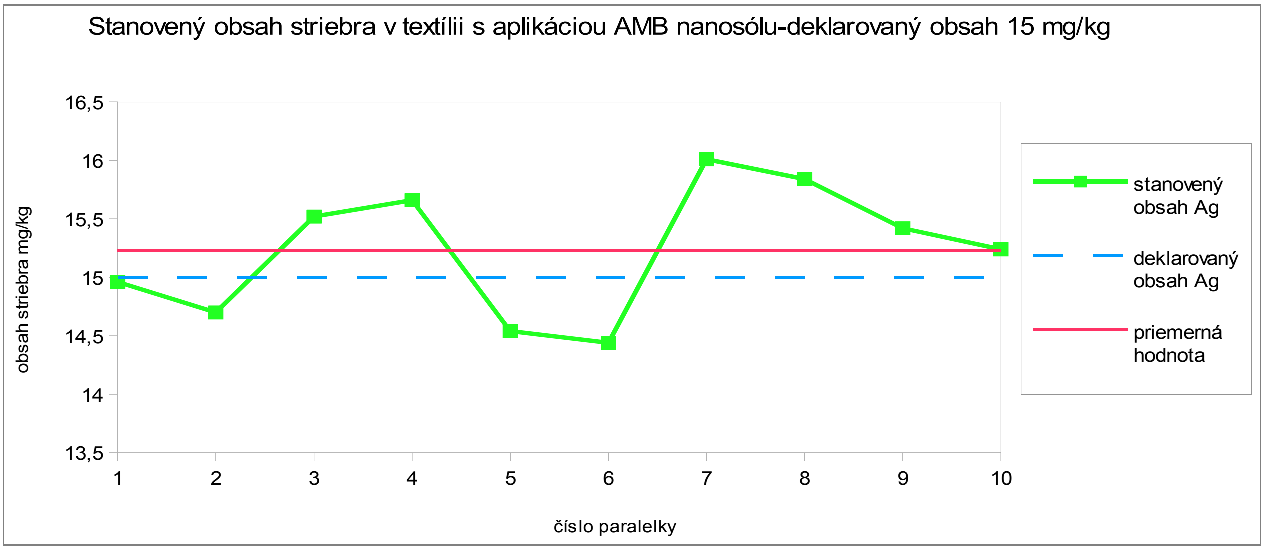
6 VÝSLEDKY A DISKUSIA

Štatistické spracovanie výsledkov analýzy stanovenia celkového obsahu striebra v textíliách vz. č. 1 a vz. č. 2. s aplikáciou antimikrobiálneho nanosólu s použitím metódy bez mineralizácie je uvedené v Tab. 1 a 2 a výsledky sú znázornené aj graficky – Obr. 2 a 3. Medza detekcie (LOD) na prístroji SpectrAA Duo AA 240 FS - plameňová technika pre extrakčný roztok je 0,02 mg.l^{-1}.

Na analýzu boli použité laboratórne pripravené vzorky, na ktorých nebola dosiahnutá dostatočná homogenita antimikrobiálneho nanosólu. Vzhľadom na rozsah kalibračnej krivky pre AAS a deklarovaný obsah striebra sa zvolila navážka cca 1 g, čo v prípade nehomogenity vzorky spôsobuje väčšiu náhodnú chybu. Predpokladáme, že v prípade väčšej homogenity naneseného nanosólu na vzorke by sa dosiahla ešte lepšia porovnateľnosť a menší rozptyl výsledkov.

Tab. 1 Stanovený obsah striebra v extraktoch vzorky č. 1

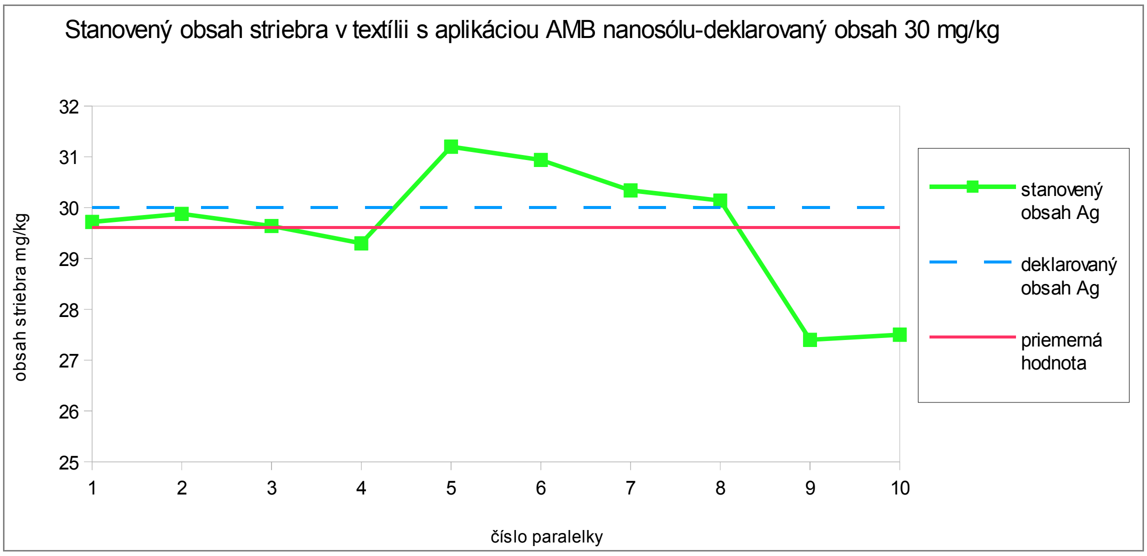
Deklarovaný obsah striebra [mg.kg^{-1}]	15
Počet analýz	10
Stanovený obsah striebra [mg.kg^{-1}] - priemer x_i	15,2
Smerodajná odchýlka	0,5
Relatívna polšírka pre interval spoľahlivosti na hladine Θ = 0,05	1,1



Obr. 2 Porovnanie skutočne stanoveného množstva obsahu striebra v jednotlivých extraktoch textílie s aplikáciou AMB nanosólu v porovnaní s deklarovaným obsahom Ag 15 mg.kg^{-1}

Tab. 2 Stanovený obsah striebra v extraktoch vzorky č. 2

Deklarovaný obsah striebra [mg.kg^{-1}]	30
Počet analýz	10
Stanovený obsah striebra [mg.kg^{-1}] - priemer x_i	29,6
Smerodajná odchýlka	1,3
Relatívna polšírka pre interval spoľahlivosti na hladine Θ = 0,05	2,9



Obr. 3 Porovnanie skutočne stanoveného množstva obsahu striebra v jednotlivých extraktoch textílie s aplikáciou AMB nanosólu v porovnaní s deklarovaným obsahom Ag 30 mg.kg^{-1}

7 ZÁVER

Výhodou inovovanej skúšobnej metódy je jej jednoduchosť, s možnosťou súčasnej prípravy extraktov viacerých vzoriek a z toho vyplývajúca možnosť mať v reálnom čase informácie o skutočnom obsahu striebra a rovnomernosti nánosu strieborných nanočastíc (rozptyl výsledkov stanoveného obsahu striebra odráža nehomogenitu nánosu), čo je dôležité pri kontrole kvality technologického postupu. Pri porovnaní s metódou s použitím mineralizácie je príprava extraktov efektívnejšia a bez potreby špeciálnych zariadení s možnosťou koncovej analýzy na AAS. Nezanedbateľné je aj zníženie spotreby energie pri väčšom počte analýz, zníženie spotreby koncentrovaných kyselín a chemikálií na prípravu extraktov, čo prispieva aj k ochrane životného a pracovného prostredia. Nevýhodou metódy sa javí nestabilita roztoku s rozpusteným strieborným iónom na svetle. Vykonať analýzu na spektrofotometri sa odporúča čo najskôr.

Metóda je vhodná na stanovenie obsahu striebra v rozsahu 5-50 mg.kg^{-1} v textilných materiáloch s aplikáciou antimikrobiálneho nanosólu.

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Podporujeme výskumné aktivity na Slovensku/
Projekt je spolufinancovaný zo zdrojov EÚ

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DEVELOPMENT OF A NEW ANALYTICAL METHOD FOR SILVER CONTAINING NANOTEXTILES WITH ANTIMICROBIAL EFFECT

Translation of the article

Vývoj novej analytickej metódy pre nanotextílie s antimikrobiálnym účinkom s obsahom striebra

Nanotechnologies and nanomaterials, their application and potential toxic effects of the nanomaterials are characterised briefly in the article. Question of their safety and need of development of new methods is raised in connection with the risks of the newly-developed nanomaterials. Silver containing antimicrobial textiles are described in more detail. The authors present a proposed and experimentally verified method for silver determination without need of mineralization of the textile samples prepared under laboratory conditions with application of antimicrobial nanosol containing silver in two various concentrations. Contribution of the proposed method and possibilities of its application are evaluated in conclusion of the article.

INSTRUCTIONS FOR AUTHORS

The journal ,,**Vlákna a textil**" (Fibres and Textiles) is the scientific and professional journal with a view to technology of fibres and textiles, with emphasis to chemical and natural fibres, processes of fibre spinning, finishing and dyeing, to fibrous and textile engineering and oriented polymer films. The original contributions and works of background researches, new physical-analytical methods and papers concerning the development of fibres, textiles and the marketing of these materials as well as review papers are published in the journal.

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