Quality control in technological finishing process of men´s jacket

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This paper aims to describe the implementation of quality control in the technological finishing process of a men´s jacket. The quality control procedure was carried out in real production in the company Varteks in Varaždin on a sample of 100 men's jackets in the process of quality control during production (quality control after technological process of sewing) and final inspection. Different colour control cards are used for marking all defects, depending on their type. Statistical analysis was carried out based on the results of the quality control during production and final inspection of men´s jacket. The results of statistical analysis show that 51% of men's jackets were returned to the sewing process after quality control during production and 65% of the men's jacket are returned to the technological finishing process after final inspection. In addition, the results of statistical analysis have shown that quality control during production and final inspection have a great impact on overall product quality, but also indicate the necessity of implementing organizational measures to reduce the number of defects in the production process. Quality assurance in the Varteks Company is carried out using the so-called additional audit control (random selection method).

Keywords: *quality control, technological process of finishing, men's jacket, quality control during production, final inspection.*

1. Introduction

The technological process of garment finishing is the final but very important part of the garment manufacturing process in which garments get their final appearance. The final appearance of clothing, its fit to the human body and the presentation to the buyers all have a significant effect on sales of a particular model of clothing on the market [1]. The technological finishing process requires the use of high quality machines and equipment to correct any minor defects that appear during the process of clothing manufacturing to ensure the garment fits the 3D body shape and to prepare the final product for packaging [2]. To ensure high quality of technological process of garment finishing, it is necessary to determine optimal parameters for the process of ironing, provide optimal final ironing programs, select the adequate type of cover on the ironing machines and optimize the programs on automata for sewing on buttons and determine the programs for the interphase transport system [3].

Quality control and quality assurance are complex areas in the apparel industry. Quality control in general comprises all processes of quality assessment during and after production; as a result, products are sorted into two categories: acceptable and unacceptable [4]. According to the ISO 9000 standard, quality control (QC) is a part of quality management focused on fulfilling quality require-

ments. Moreover, this process controls the quality of all factors involved in production [5]. Quality is a strategic goal of each company designed to prevent occurrence of low quality products. Quality control in the apparel industry includes preproduction quality control (each component of a garment should be tested – fabric, closures, interlinings, sewing threads, elastic waistband, other design elements), quality control during production (spreading and cutting defects, defects in assembling, defects during pressing and finishing) and final inspection (testing of performance requirements, overall appearance, sizing and fit) [4].

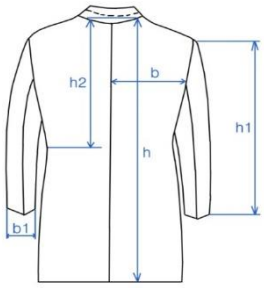
Control planning is a part of quality management system which determines the purpose of the garment, along with other relevant parameters for the garment in question (design, attractive appearance, production quality, comfort, etc.).

Upon establishing the key parameters, the manufacturer should devise plans to ensure continuous increase of quality, conduct the control of default parameters and set quality level standards. These requirements are commonly defined as minimum or maximum acceptable limits or deviations. These limits allow for tolerance and emphasis is placed on achieving quality level that ought to be approximate to the values which are defined in the quality requirements [6]. To ensure quality control achieves its purpose, different control points need to be defined through the whole production process via input, interphase and final inspection [3, 4]. The quality control system should ensure adequate education and staff training, which will train them to use appropriate work methods. In addition, it is necessary to raise awareness of individual responsibility (self-control), because only responsible behaviour and work ethics can ensure the quality level that guarantees the survival of the company on the market [7].

In the phase of final inspection, the correctness or defects on garments are determined by measuring, counting and visual inspection (Fig.1). Supporting technical-technological documentation of garments indicates the manner of carrying out the final inspection. Uniform standards provide a guarantee that the product has the same market value in all countries which are members of the ISO organization [8].

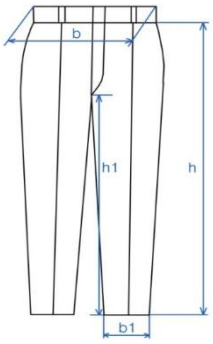
1.1. Types of Quality Control

In order to achieve required standards and requests, the company has to implement the TQM system (Total Quality Management) and the QAS system (Quality Assurance System) into its quality management system. TQM management refers to complete quality



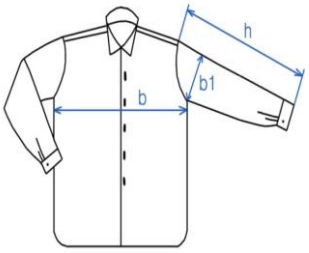
h - length of jacket
h1 - sleeve length
h2 - chest length
b - half width of the back part
b1- half of sleeve circumference

a.

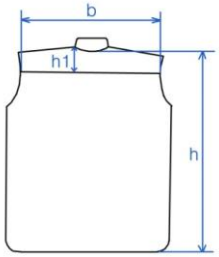


h - length of trousers (without waistband)
h1 - inseam length
b - half of waist circumference
b1 - half of hem circumference

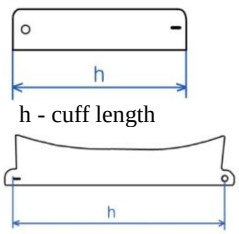
b.



h - sleeve length
b - half of chest circumference
b1 - half of sleeve circumference (upper part)



h - length of men's shirt
h1 - width of yoke
b - width of the back part



h - cuff length
h – collar length

c.

Fig.1 Examples of individual measures during final control on: a. men's jacket, b. men's trousers, c. men's shirt [8]

management; nonconformity or defects are removed as soon as they appear in the production. That demands participation of all employees on all organizational levels, as well as the application of the indispensable JIT (Just in Time) strategy. During the implementation of the QAS system in the textile and clothing industry, the main goals have to be user requirements, while creativity and flexibility are the main advantages of the manufacturer. The system ensures increased productivity by raising quality levels, enabling a timely flow of information, investing in staff training and increasing work motivation [9, 10].

Each company establishes policies and goals of quality, as well as quality plans whose implementation is supervised by the quality management. Four factors which have an impact on the production process of textiles and clothing are as follows:

1. Basic and auxiliary materials,
2. Methods of control in the production process,
3. Machines and working space,
4. Workers whose work, knowledge, education and training contribute to the improvement of quality [10].

Considering the mentioned factors and specifics of fabric and apparel production, various types of quality control have to be carried out in order to achieve complete quality system in the clothing industry.

Quality control during production process

The workplace of quality control during production process (Fig.2) is located between the technological process of sewing and finishing. The goal of this type of control is to find possible defects on garments occurring in the technological process of sewing. The next goal of quality control during production process is to stop the transport of clothing items (men's jacket) with defects from proceeding to the technological process of finishing.

Fig.2 The workplace of quality control during production

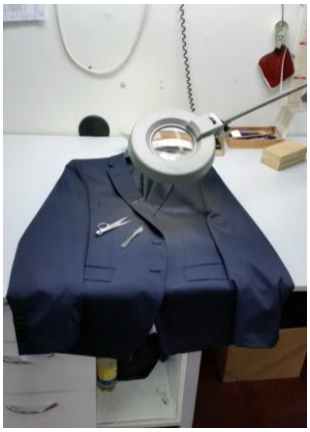
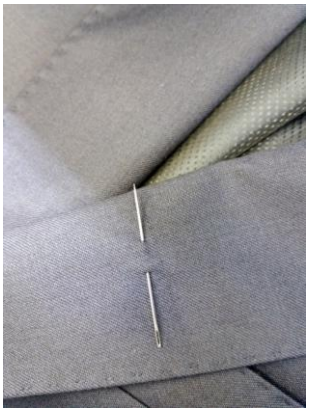


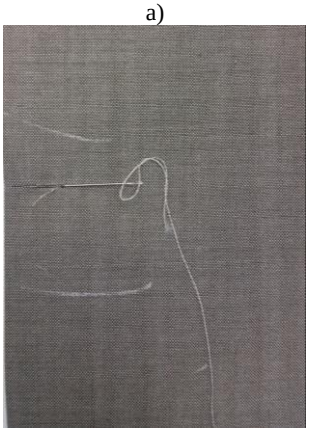
Fig.3 Workplace of piece control

Piece control

The purpose of the workplace of piece control (Figure 3) is elimination of defects that are caused by poor-quality material. Piece control workers must have a properly designed workplace with good lighting, angled (approx. 30°) anti-sliding table equipped with a magnifying glass. The workplace should be equipped with required technical auxiliary tools (nippers, scissors, needle with rounded point) and workers have to be trained how to use them. In addition, the worker has to be educated about the types of fabric, types of weaves (plain, satin and twill weave) as well as the characteristics of warp and weft yarns. In case of a broken, inserted or drawn out weft or warp, or holes on material on larger cutting parts (front, back and side part of clothing, upper and lower part of sleeves, front and back parts of trousers), workers should be trained how to correct the damage by inserting the warp and weft yarn with regard to the rule of a particular weave, using a needle with a rounded point (Fig.4) [11].



a)



b)

c)

Fig.4 Correction of defects caused by poor-quality material: a) needle with a rounded point, b) inserting of drawn out yarn, c) marking defects caused by poor-quality material (drawn out yarn)

The workplace of piece control performs corrections of drawn out yarns and stains removal on the material. If the location of damages on the clothing cannot be corrected, the worker in piece control has to order new cutting parts, which also have to undergo inspection.

Final inspection

The workplace of final inspection is located at the end of the technological process of finishing (Fig.5).

Fig.5 Workplace of final inspection

After the technological process of finishing, clothing items (men's jackets) are transported on clothes hangers by transport stands (racks) to the workplace of final inspection. The workplace of final inspection must have prescribed working conditions that usually Are precisely determined by the buyer. According to the quality manual of the Varteks Company, every workplace of final inspection should satisfy the following conditions:

- luminous intensity that is directed on the clothing has to be 1200 Lx,
- luminous intensity at the workplace of final inspection has to be approx. 750 Lx,
- class of the lighting has to be 1 (according to classification - best quality lighting),
- colour of light has to be white,
- lighting system should be equipped with double tube, reflector and flash protection,
- light should be directed under the angle of approx. 40° on controlled clothing item, at 80 to 90 cm distance from the clothing item at height of 220 to 230 cm behind the worker,
- workplace of the final inspection must not be located near windows to avoid shadow effect due to changes of day and night
- controlled clothing item should be hanged on turns hook, (height of hook has to be adjusted according to the body height of workers).

The workplace of final inspection has to be equipped with two transport stands, one for clothing items which satisfy quality requirements and can proceed to labelling and storage, and the second one for clothing items which will be sent back to production process for repairing (Fig.6). Workplace has to be equipped with a desk and PC for printing and preparing the technical documentation.

The bar code on manufacturer label sewn inside the pocket of men's jacket is scanned and first class quality is confirmed on clothing items without defects. Classified clothing items are sent to packaging and transported to storage. When classifying the types of defects on man's jacket, the worker in final inspection can put one or more coloured control cards, if they determine several different defects (for example, red card for defects which occurred in the technological process of finishing and green card for defects in material).

Audit control or random selection method

Quality assurance in the clothing companies is carried out by conducting additional audit control or random selection method on all garments in a particular size. On men's jacket, audit control is performed on clothing size 48.

Worker in the final inspection and head of control department periodically select a certain amount of men's jackets in technological

a) b) c)

Fig.6 Workplace of final inspection: a) transport stands for male's jackets with defects, b) control card with marked defects, c) PC (working station) for data entry

a) b)

Fig.7 *Audit* control on men's jacket: a) measurement of length; b) measurement of sleeve length

process of production using random sampling method and perform a detailed control of length and circumference of clothing on these samples. The quality of men's jacket is evaluated according to the measurements shown in Fig.7 [11].

Fitting quality control

After audit control of quality (measurement of length of each segment), men's jacket is put on a dress form (dummy) and the fit of jacket is evaluated in all prescribed segments (Fig.8).

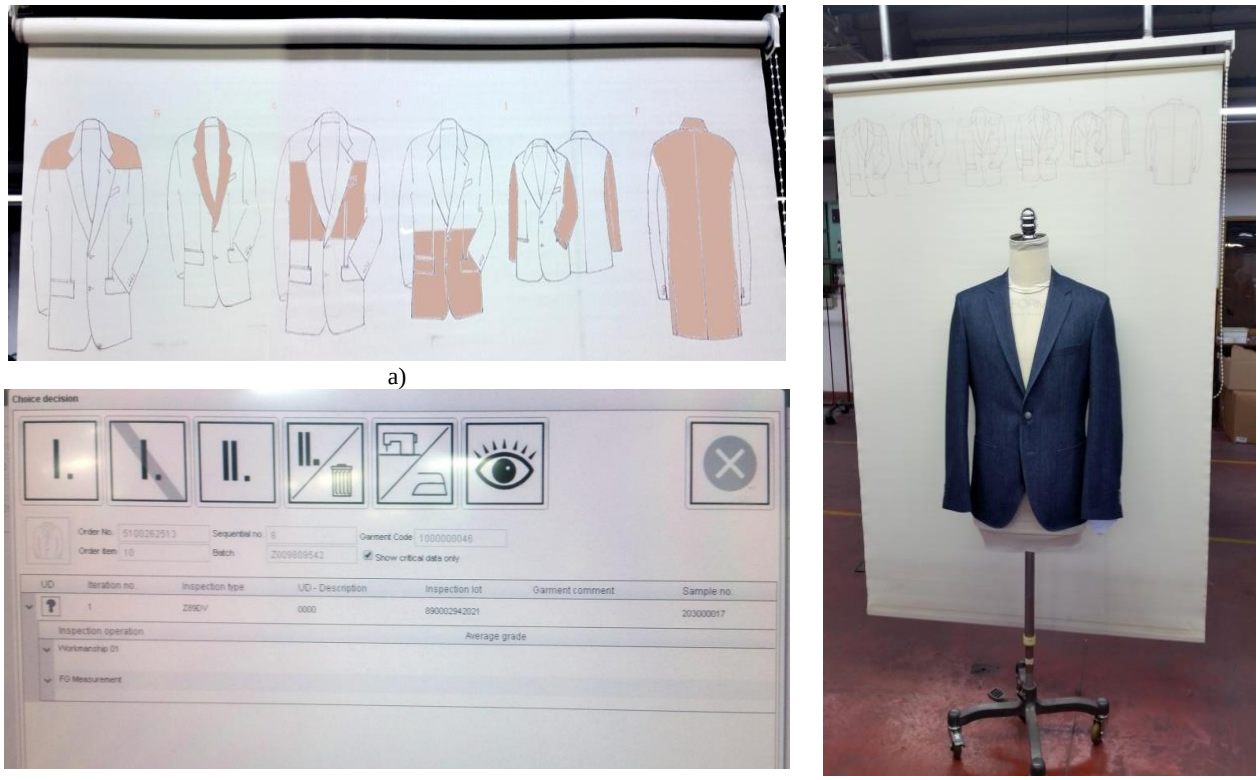
The workplace is equipped with computer program for monitoring, collecting and processing data of fitting quality control. Processed and analysed data of quality are forwarded to the buyer or client.

3. Experimental part

For the purpose of analysis in this article, the procedure of quality control during production and final inspection was carried out on a sample of 100 pieces of men's jacket in real production process in the Varteks Company [12]. A statistical analysis of results was conducted upon collecting the data. The meaning ascribed to control cards in different colours and the manner of marking men's jacket with defects is described in addition to presented results.

3.1. Control cards

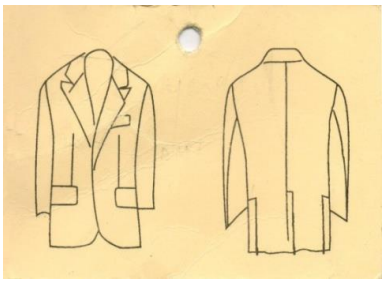
Workplaces in quality control during production and final inspection have the obligation to mark defects using different colour control cards depending on the type of defects. The cards and types of defects are classified as follows:



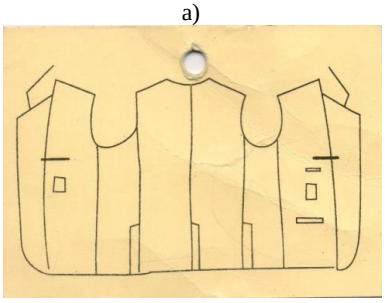
a) c) b)

Fig.8 Implementation of fitting quality control: a) men's jacket segments for fitting quality control; b) dress form (dummy) for fitting quality control

– WHITE – defects made in sewing room (front parts, pocket edges, pockets, front darts)
– ORANGE - defects made in sewing room (inner part – lining and inset labels)
– YELLOW - defects made in sewing room (decorative hand stitching, decorative stitching, seams, vent, pattern, piped seam, bottom part of the collar, length of the jacket, length hem of the jacket)
– BLUE - defects made in sewing room (sewing of sleeves – inner part)
– VIOLET - defects made in sewing room (sewing of sleeves – outer part, buttons, applications on jacket, vent, length and fit of sleeves, side seams, ironing the length of the jacket, back part of the jacket and collar).
– RED - defects made in garment finishing process (ironing and sewing on buttons)
– GREEN – fabric defects [11].



a)



b)

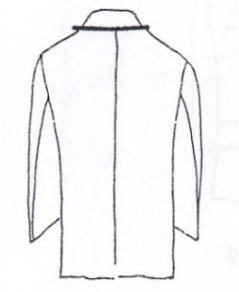
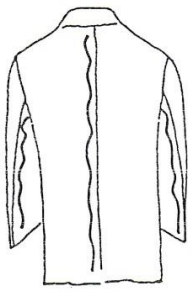
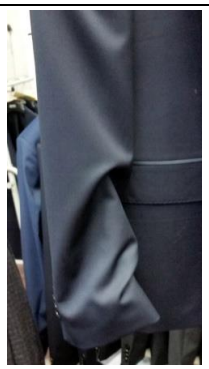
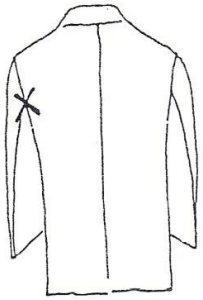
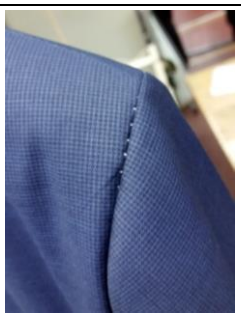
Fig. 9 Cards for marking the defects on men's jacket: a. outer material (fabric); b. inner material (lining)

The appearance of different colour cards for marking the defects on the front and back part of men's jacket, as well as on the inner part (lining) are shown in Fig.9.

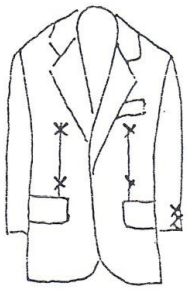
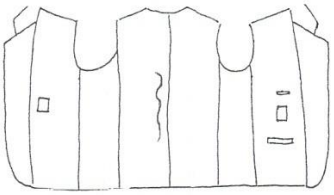
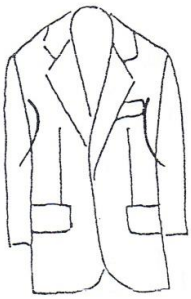
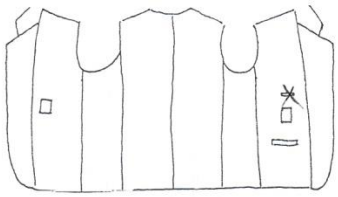
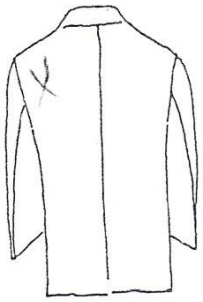
4. Results and discussion

This chapter describes the methods of marking the defects on the control cards in quality control during production and the final inspection of the quality in the finishing process of men's jacket.

Tab.1 Marking defects on men's jacket

Description of the defect	Mark on the control card	Defect on men's jacket
Unequal width of seams or non-matching pattern on the collar		
Improperly sewn sleeve linings		
Insufficient seam resistance		

Tab.1 Marking defects on men's jacket – continuing

Description of the defect	Mark on the control card	Defect on men's jacket
The buttons are not sewn in line with the edge of the vent Position and length of darts		
Unequal edging with lacing		
Unequal ironing of armholes		
Irregularly ironed lining		
Ironing defect (fold on the back part of the men's jacket)		

In Table 1 the type of defect is described in the first column, whereas the second column shows the mark on the control card. An example of defect on men's jacket is shown in the third column.

Table 1 shows the most common errors of quality control during production and final inspection of

men's jacket in Varteks Company, Varaždin, such as:

- unequal width of seams,
- non-matching pattern on the collar,
- improperly sewn sleeve linings,
- insufficient seam resistance,
- the buttons are not sewn in line with the edge of the vent,
- unequal edging with lacing,
- unequal ironing of armholes,
- irregularly ironed lining,
- ironing defect (fold on the back part of the men's jacket).

4.1. Statistical analysis of results of quality control during production

Statistical analysis was conducted on a sample of 100 men's jackets that were controlled during production (quality control after the technological sewing process).

The results of the analysis of quality control during production are shown in Fig.10.

The results of the statistical analysis show that slightly more than half (51) men's jackets are sent to the sewing room for repairing as follows:

- 24 men's jackets in production line no.1 (yellow card – defects made in sewing room: decorative hand stitching, decorative stitching, seams, vent, pattern, piped seam, bottom part of the collar, length of the jacket, hem of length of the jacket)
- 12 men's jackets in production line no. 2 (blue card - defects made in sewing room: sewing sleeves – inner part),
- 4 men's jackets have defects marked on a violet card (defects made in sewing room: sewing sleeves – outer part, buttons, application on jacket, vent, length and fit of sleeves, side seams, ironing the length of the jacket, back part of the jacket and collar)
- 1 men's jacket is marked with an orange card (lining and inset label).
- 10 men's jackets are marked with green cards (material defects).

Statistical analysis clearly demonstrates the effectiveness of quality control during production, but also indicates the need to take organizational measures into account in order to reduce the occurrence of defects.

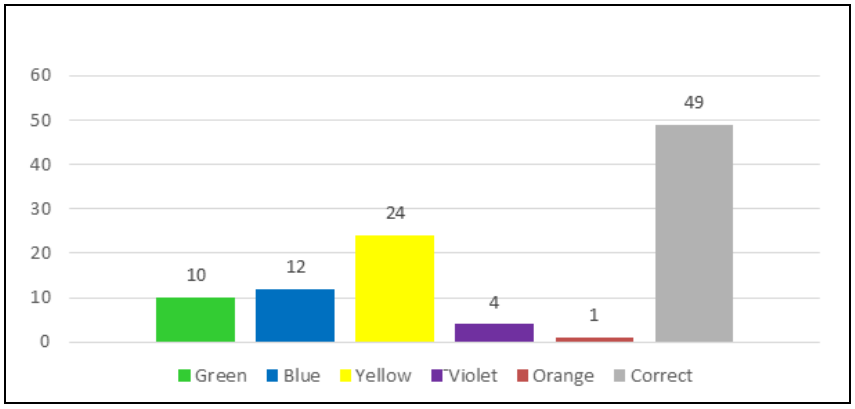


Fig.10 Number of defects per control cards – types of errors

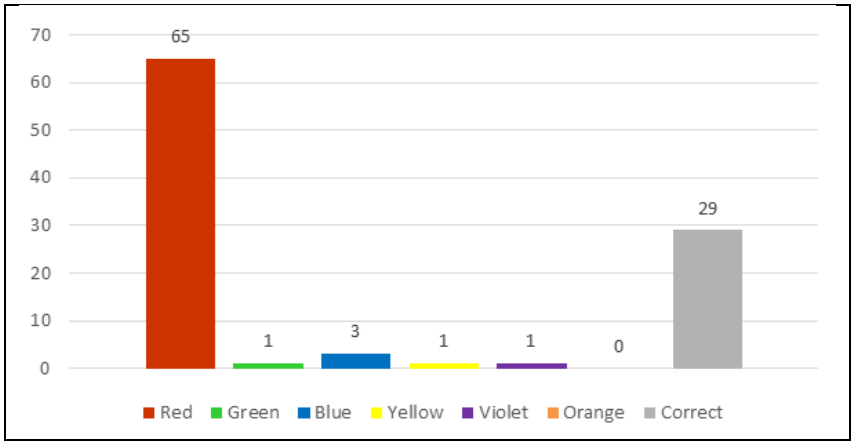


Fig.11 Number of defects per control cards in final inspection

4.2. Statistical analysis of results of final inspection

Statistical data processing was conducted based on the data obtained during final control of 100 men's jackets, during which the work of final controllers was monitored and evaluated for their efficiency. The numbers of defects found are shown in Fig.11.

The statistical analysis found that 65 men's jackets should be returned to the technological finishing process, and only 29 men's jacket were proceeded to final labelling and storage. Beside defects in the technological process of finishing, defects in technological sewing process were found on six men's jackets as follows:

- 3 men's jackets were marked with blue cards (defects made in sewing room: sewing sleeves – inner part),
- 1 men's jacket was marked with a violet card (defects made in sewing room: sewing sleeves – outer part, buttons, application on jacket, vent, length and fit of sleeves, side seams, ironing the length of the jacket, back part of the jacket and collar)
- 1 men's jacket was marked with a yellow card (defects made in sewing room: decorative hand stitching, decorative stitching, seams, vent, pattern, piped

seam, bottom part of the collar, length of the jacket, hem of length of the jacket),
– 1 men's jacket was marked with a green card (fabric defect).

Since there may be more defects on a single garment, each defect has to be removed in the technological phase of the production in which it occurred. Men's jackets on which detected defects have been removed are sent back to the final quality control where the process of quality control is repeated to ensure that the previously detected defects have been repaired. Further control procedure is identical to the first procedure. Men's jackets marked with control cards or defects are returned to the manufacturing process where defects occurred and upon having been removed, they return to the final control. 107 defects were recorded on 100 pieces of men's jacket that passed through repeated quality control (several defects were found on some jackets). The analysis of repeated quality control on men's jackets is shown in Table 2.

Tab.2 Efficiency percentage of repeated control

Red	100
Yellow	5
Violet	1
Blue	1
Red	38
Blue	14
Without defects	48
The efficiency percentage of correction on 100 pieces:	48%
Percentage of defects:	52%

Table 2 shows that 48% of men's jackets without defects are sent to labelling, packaging and storage. The number of blue card defects (making of sleeves - inner part) was increased due to the fact that the marked defects could not be removed in the technological process of finishing; in repeated control, they are classified as types of defects in the technological process of sewing.

Tab.3 Comparison of data collected in quality control during production and final inspection

Type of defect	Quality control during production	Final inspection	Total
	No. pieces	No. pieces	No. pieces
Red	-	65	65
Green	10	1	11
Blue	12	3	15
Yellow	24	1	25
Violet	4	1	5
Orange	1	-	1
Correct	49	29	78
Total	100	100	200
Total without defects	49 + 29 = 78 men's jackets		
Total with defects	200 - 78 = 122 men's jackets		
% Defects	61%		
% Without defects	39%		

Comparison of collected data at workplaces during quality control during process and final inspection of men's jackets on 100 samples is shown in Tab.3.

Based on the statistical analysis of 200 controlled men's jackets, the greatest number of defects was detected in the technological process of garment finishing (red cards indicate defects in the ironing process). The results can be explained from two points of view. Firstly, only men's jackets without defects can be delivered to the customer and in this case the quality control system has its purpose. Secondly, the frequency of defects of 61% represents a high risk for the manufacturer. Therefore, it is necessary to take into account certain organizational measures (detecting the cause of defects, conversation with workers who make a high percentage of mistakes and additional education of workers) that can reduce the number of defects in the production process.

4.3. Computer Quality Monitoring

In the Varteks Company, quality control is monitored by computer programs. After reading a line code for one men's jacket, a sketch of the model with list of measurements of all segments and tolerances are displayed on a monitor screen. The following grades are entered at the end of each quality control:

1 - very good, great,
2 - good,
3 - satisfying, minor defects that can be recognized by an expert,
4 - sufficient, the defects have to be eliminated as soon as possible,
5 - wrong, the possibility of complaint and
6 - insufficient, the jacket is not for sale [11].

The average grade is calculated from the individual grades of the jacket segments, and the results of quality control are sent weekly to the quality assurance department (Fig.12).

Fig.12 Computer program for quality control

The grade of fit depends on the visual impression and deviations from the established boundary values, and their intervals are given in Tab.4.

Based on the control of constructional measurements of men's

jackets, the categorization is as follows:

1. good jacket - grades up to 2.6
2. jacket with minor defects - grades from 2.7 to 3.0,
3. jacket with defects - grades of 3.1 and more.

All defects should be corrected as soon as possible.

Tab.4 Limit values [11]

Interval [cm]	Class
Front part of men's jacket	
0 - ± 1.00 cm	I. Class
± 1.1 – 2.0 cm	I. Class (marginally)
± 2.1 – 3.0 cm	II. Class
± > 3.0 cm	II. Class, not for sale
Back part of men's jacket	
0 - ± 0.5 cm	I. Class
± 0.6 - ± 1.0 cm	I. Class (marginally)
± 1.1- 2.0 cm	II. Class
± > 2.0 cm	II. Class, not for sale
Sleeves	
0 - ± 1.00 cm	I. Class
± 1.1 - ± 2.0 cm	I. Class (marginally)
± 2.1 - ± 3.0 cm	II. Class
± > 3.0 cm	II. Class, not for sale

4. Conclusions

High standards and expectations of customers have set out strict quality requirements that clothing companies have to comply with in order to survive on the market. The production of high quality garments results from applying rigorous standards prescribed by the quality assurance manual containing textual and graphic descriptions of the methods of work and having a clear idea of clients' requirements which implies excellence from all workers involved in the production process. The final goal of any company that produces garments for world-renowned brands is to gravitate towards perfection, to preserve the existing level of quality and to constantly educate their workers and managers in order to remain among leading manufacturers in the apparel industry.

Based on the research and the results obtained at the Varteks Company, the following can be concluded:

– By applying statistical methods in quality control during production, it has been found that 51% of men's jackets were returned to eliminate defects, which means that 49% of them were sent to the technological process of garment finishing.
– In the final inspection, a high percentage (65%) of men's jackets were found to have defects and therefore had to be returned to the technological process of finishing, while only 29% of men's jackets were without defects. The other percentage of defects (6%) refers to defects in the technological process of sewing. Men's jackets with detected and removed defects passed through a repeated quality control procedure, where the same or new defects were determined at a percentage of 52%. Comparing the statistical analysis of quality control in production process and final inspection, defects in the production process were detected on 61% of men's jackets, while only 39% men's jackets were without defects.

Statistical data indicate that workers in final inspection perform their work effectively, tolerances are minimal, and trained controllers are very skilled at detecting defects, whether in fabrics or in the process of sewing or finishing. Based on the obtained data, it can be concluded that certain organizational measures should be taken in the Varteks Company to minimize the percentage of defects detected at all quality control points.

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R e f e r e n c e s :

[1] Ferguson S. MacA.: Garment-finishing techniques, In Garment Manufacturing Technology, Edited by Rajkishore Nayak & Rajiv Padhye, Woodhead publishing, UK, 2015, ISBN 978-1-78242-232-7
[2] Rathinamoorthy R., R. Surjit: Apparel Machinery and Equipments, Woodhead Publishing India Pvt. Ltd., New Delhi, India, 2015, ISBN 978-93-80308-15-9
[3] Rogale, D. i sur.: Procesi proizvodnje odjeće, Sveučilište u Zagrebu, Tekstilno-tehnološki fakultet, Zagreb, 2011., ISBN 978-953-7105-32-7.
[4] Keist, C.N.: Quality contorl and quality assurance in the apparel industry, In Garment Manufacturing Technology, Edited by Rajkishore Nayak & Rajiv Padhye, Woodhead publishing, UK, 2015, ISBN 978-1-78242-232-7
[5] EN ISO 9000:2015 - Quality management systems – Fundamentals and vocabulary
[6] Čunko, R.: Kvaliteta tekstilnih proizvoda, Zrinski d.d., Čakovec 2009, ISBN 953-7105-29-6.
[7] Group of authors: Tekstilni priručnik, Društvo inženjera i tehničara tekstilaca DITT, Maribor, Maribor 1987.
[8] Knez, B.: Tehnološki procesi proizvodnje odjeće, Sveučilište u Zagrebu, Zagreb, 1994., ISBN 953-96183-3-9.

[9] Čunko, R.: Europska standardizacija sustava upravljanja kvalitetom i specifičnosti primjene u tekstilu, Tekstil 41 (1992.) 3, 119-127

[10] Čunko R., E. Pezelj: Kvaliteta tekstilnih i odjevnih proizvoda, Tekstil, 42 (1993.) 1, 17-23

[11] Priručnik o kvaliteti tt. Varteks d.d. Varaždin

[12] Gosarić, I.: Kontrola kvalitete u tehnološkom procesu dorade muškog sakoa, završni rad, Sveučilište u Zagrebu Tekstilno-tehnološki fakultet, Varaždin, 2017.