Rationalisation methods for managing the production processes of textile products from the regulated field

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ABSTRACT – REZUMAT

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One of the essential features of the unified European market is the free movement of many industrial products, thanks to the harmonisation of the laws of the European Union countries. The rigour of safety regulations has led to a constant increase in the supply and volume of personal protective equipment. The EU legislation defines "essential requirements" for personal protective equipment but does not do the same for technical specifications. From this point of view, products can be divided into non-regulated and regulated products. Protective products and toys are manufactured in the regulated sector in the textile sector and require formal certification under European Community directives. Products intended for military use (in the regulated area) are subject to special, sometimes top-secret rules. Fashionable clothing belongs to the non-regulated area and does not require formal certification. The protective equipment must ensure compliance with EU regulations, such as absolute individual protection against specific risks; durable protective functions; psychological comfort while wearing it; ease of maintenance.
The production of textile garments in the regulated sector requires flawless execution with the help of qualified personnel, who have created the physical conditions for the optimal execution of the operations to achieve a constant level of quality. A factor that determines the constant quality level is efficient production management. Production management in the textile industry refers to structuring processes, setting time rules and ensuring efficient working conditions for the people performing the work (rational design of the workplace makes it possible to achieve greater efficiency and meet occupational safety requirements). Once the requirements are clearly defined from the customer's point of view, their translation into technical measures is a task for the manufacturing company. With this in mind, the main objective of this paper is to provide an example of streamlining the management of production to facilitate the manufacturing process of a product in a regulated sector that is compliant with European regulations. The case study has been carried out for the manufacturing process of a pistol bag.

Keywords: *personal protective equipment, production management, execution time, Methods time Measurement, garment industry*

Eficientizarea metodelor de management al producției pentru produse din domeniul reglementat

Una dintre caracteristicile esențiale ale pieței europene unificate este libera circulație a multor produse industriale, grație armonizării legilor țărilor Uniunii Europene. Rigoarea reglementărilor de siguranță a dus la o creștere constantă a ofertei și a volumului de echipamente individuale de protecție. Legislația UE definește „cerințe esențiale" pentru echipamentul individual de protecție, dar nu procedează la fel pentru specificațiile tehnice.
Din acest punct de vedere, produsele textile pot fi împărțite în produse care se încadrează în domeniul nereglementat și reglementat. Produsele de protecție și jucăriile sunt produse care se încadrează în domeniul reglementat din sectorul textil și necesită o certificare oficială în conformitate cu directivele Comunității Europene. Produsele textile cu destinație militară (în zona reglementată) sunt supuse unor reguli speciale, uneori extrem de secrete. Produsele de îmbrăcăminte de modă aparțin zonei nereglementate și nu necesită certificare formală. Echipamentele individuale de protecție trebuie să respecte normele și reglementările UE, în ceea ce privește protecția individuală absolută împotriva riscurilor specifice; funcții de protecție durabile; confort psihologic în utilizării produsului; ușurința întreținerii.
Producția de confecții textile în sectorul reglementat necesită condiții speciale de fabricație, un personal executant cu un nivel ridicat de calificare, care să execute operațiile în conformitate cu specificațiile tehnice ale acestuia. Managementul producției în industria textilă se referă la structurarea proceselor, stabilirea normelor de timp și asigurarea unor condiții corespunzătoare de muncă pentru executanți (proiectarea rațională a locului de muncă asigură o eficiență ridicată a activității prestate și permite îndeplinirea cerințelor de securitate specifice). Pe baza cerințelor definite de către client, departamentul tehnic al firmei producătoare elaborează documentația tehnică de fabricație a produsului contractat. Obiectivul principal al lucrării este de a prezenta un studiu de caz, de eficientizare a managementului producției pentru a facilita procesul de fabricație al unui produs în domeniul reglementat, compatibil cu reglementările europene. Studiul de caz a fost realizat pentru o operație necesară execuției unei genți port-pistol.

Cuvinte-cheie*: echipament individual de protecție, managementul producției, timp de execuție, Metode de măsurare a timpului, industria confecțiilor*

INTRODUCTION

From the manufacturer's point of view, innovative technologies, efficient production management methods, and process flows contribute towards obtaining regulated products compatible with the European customers' standards. In this sense, direct, visible signals to consumers are necessary [1–4].

According to the European Community Directive No. 89/656/EEC, companies that manufacture products in the regulated areas of the European market must: establish harmonised European standards applicable to their products:

- draw up technical regulations applicable to the products manufactured by the company and that are compatible with European regulations;
- determine the conformity assessment procedure to be applied;
- ensure that the products comply with the standards and with all the essential requirements of the applicable directives;
- affix the marking CE on the products and/or on the packaging or accompanying documents, as provided. To affix the CE marking, there are European directives and/or regulations that detail the requirements that the products must meet.

Although national and international standards and norms hold products to a certain standard, they are the "invisible" part of consumers. It should be noted that successful companies are distinguished from others by efficient production management methods and process flows [5–7].

In the apparel industry, labour cost is essential, accounting for over 70%. The labour of operators and the level of knowledge and production process management quality determine the difference in profit figures. Many manufacturers have problems with the lack of understanding of the technological process and the blockages in the various stages of the manufacturing process.

The timing rules required to perform specific operations are based on the time measurement method (MTM), which uses the times for basic human movements to define the time for a job to be performed at a given level of performance. In 1883, Frederick Winslow Taylor introduced the chronometer to measure the time required to complete a complicated task accurately. He developed the scientific study of productivity and found out how to coordinate different tasks to avoid wasting time and improve the quality of work [8]. Later, the method of time measurement (MTM) system was defined by Maynard et al. [8] in "Methods Time Measurement" (1940): "the MTM system is a method of breaking down any work process or manual operation into the basic movements required to perform it and assigning to each movement a predetermined normative time that depends on the nature of the movement and the conditions under which it is performed".

This method provides a logical record and critical analysis of how an operation is performed and how it can be improved. In time study, various techniques are used to determine the time required to perform effective physical and mental work to accomplish a specific task [9]. Various repetitive tasks that require physical and mental effort and material flow can be improved through time studies [9]. Among other data, business management relies on time study because it is a tool that provides information about the efficiency and sustainability of the company [9].

In garment companies, the manufacturing process is divided into successive stages. In what concerns products with regulated destinations, a good knowledge of the variability of manufacturing processes requires an analysis whose purpose is to characterise their state and, if necessary, to make operational corrections (to ensure the prescribed accuracy). The characterisation of their normal operating state involves taking real measures to ensure the performance of the ones that actively influence the entire manufacturing process for this type of product [10, 11].

This paper presents a model for streamlining production management to increase the efficiency of manufacturing a product in the regulated sector so that it complies with European regulations. The case study has been developed to assemble the back with support straps (a pistol bag).

DESCRIPTION OF THE WORK METHOD STAGES

To illustrate the application of these measures, the authors have studied the issue of finding solutions to reduce the execution time of an operation or the assembly phase of the back component with support strips and pieces comprising a pocket gun opening [12]. The front and the back are bound by sewing their contours at a 0.2 cm distance and attaching a piece of Velcro that will later fasten the product (figure 1).

In the company where this case study has been made, all the production process steps are carried out by a single worker. This has the following consequences:

- different execution steps and variable phase sequences;
- products with a high degree of variability in terms of quantity and quality.

Fig. 1. The pistol bag

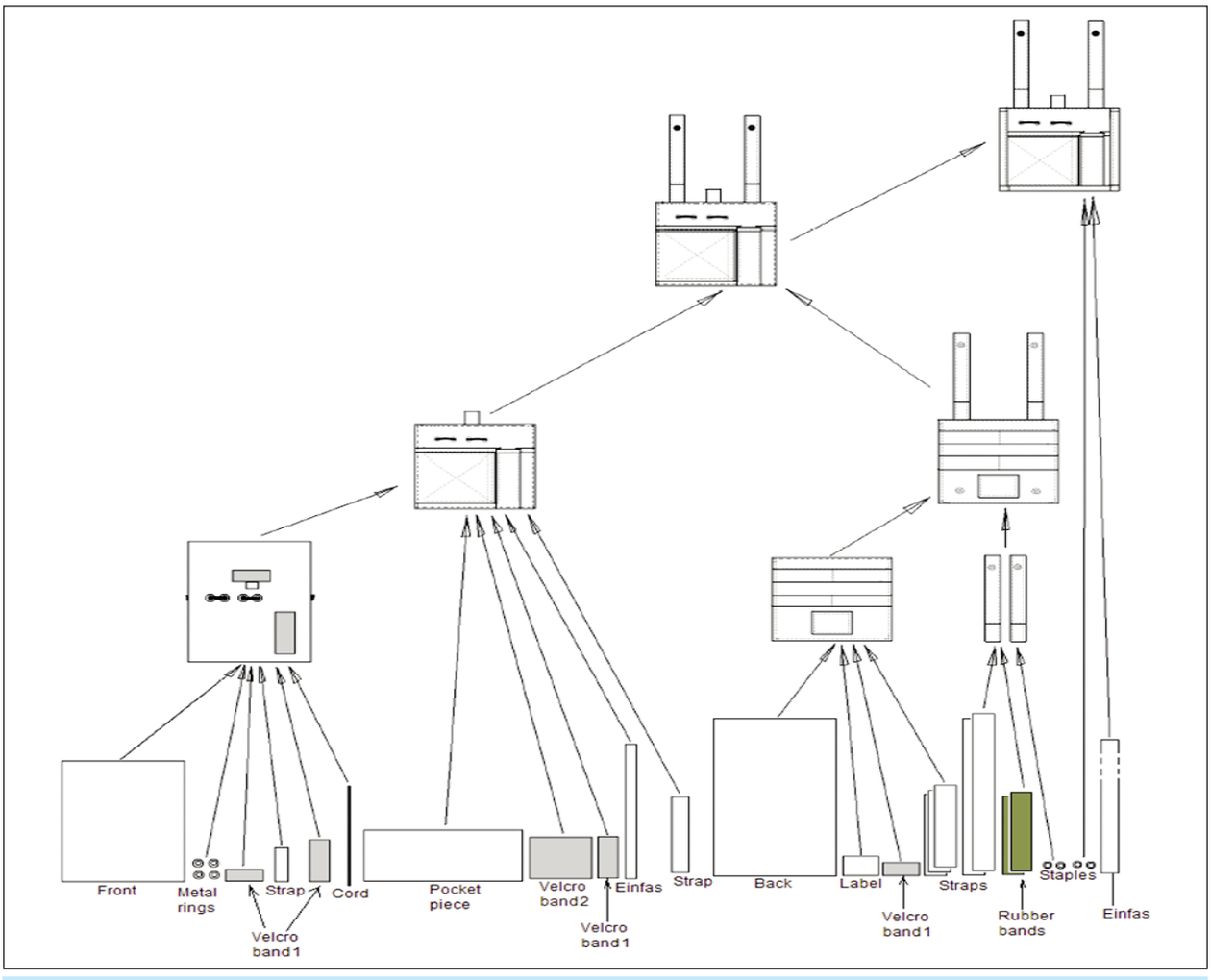

Fig. 2. The hierarchical structure of the pistol bag

To obtain products that meet the European requirements for military items, the following steps have been carried out:

– technological design in the hypothesis of phase work and
– technological redesign of some operations.

The technological design process consists of the realisation of the structure and the elaboration of the technological processes [13] along with the identification of the phases, the types of equipment and the timing of each phase (figure 2).

The tracking of the sewing process in the existing production system, which is necessary to measure the time during the preparation of the process, showed high variability in the duration of the execution of the phases by different workers (the time measurement is based on an average of the time per phase obtained for 4 workers, where the workers are not dependent on the previous and subsequent sewing phase as in the execution of serial products).

The following deductions are:

- the process analysis shows complex handling caused by the rigid structure of the material and the variable number of layers used to make the products, which affects the process and consequently the working times of the same phase;
- was found that the breaking of needles occurs with varying frequency depending on the skill in handling the material (the product has several reinforcements at the beginning and end of the seam).

These findings led to the idea of improving the manufacturing system from a technological point of view [14–17].

This assembly phase of the back component with support straps was chosen because it is essential from a functional point of view since the integrity of the product content depends on the correctness (the attachment of the front of the product to the back is done by edging with a very narrow strip of 1.8 cm supporting all four layers) with an internal reserve of only 3–4 mm.

Moreover, the central component of the product is merged with the rest of it through the edging process, the quality of which is directly influenced by the stage in which the front side and the PVC backside are attached.

The steps that are necessary to improve the workflow from a technological point of view are [18–21]:

a. systematic work description;
b. identification of the structure of the movements specific to the execution of the operation;
c. analysis of the original work method;

d. estimated the time necessary for the execution of the operation according to the original method using the Methods-Time Measurement (MTM) method. MTM analyses an industrial work or manual activity or method into the required basic movements or human movements and assigns a predetermined time standard to each movement: reaching, moving, extending, turning, applying pressure, grasping, positioning, releasing, eye times, body, leg, and foot movements.
e. identification of sources of improvement and proposal of solutions;
f. quantification of the results obtained by applying the proposed solutions.

The improvement method is used to change the working procedures and implicitly redesign the workplace.

The following are the detailed steps:

a. Define the task: "attaching the face and back with support bands" as a working system using the seven necessary elements to identify the characteristics of the factors that may affect the activity performed in this operation.

Table 1 shows the elements that systematically define the analysed work operation.

The activity is summarised in figure 3, *a–f*.

b. The identification of the movements' structure specific to the operation's execution is shown in table 2.

c. Analysis of the initial method of work

The worker uses the sewing piece. The workstation configuration in the original version is shown in figure 4.

The work method for sewing the front and back pieces of the back with the support strips consists of the following steps:

Table 1

ELEMENTS THAT SYSTEMICALLY DEFINE THE ANALYSED OPERATION	
Element	**Description**
WORKING TASK	Aligning the back component of the basic material with the back, sewing the logo, sewing the edges of the doubled back 0.2 cm apart, with the introduction of the 9 cm support strip, sewing a 9 mm narrow strip around, along with the introduction of a 42 mm support tape, sewing in the middle of the 9 cm support tape (3 pieces), cutting the thread, restoring the package.
INPUT	Package containing 50 front components made of base material for the back and a package containing 50 pieces of back components made of the back base material. 9 cm pieces and 42 cm support tape, logo
WORKER	53 years old female worker, 23 years of experience
OUTPUT	Package containing 50 pieces of back components sewn-on edge, sewn logo, 9cm support tape (432 cm length), processed with threads
WORKING MACHINES	JUKI sewing machine (with shuttle) without thread cutter, scissors, power connection (tape) – right, storage box with sewn parts on the left side
ENVIRONMENT	Normal

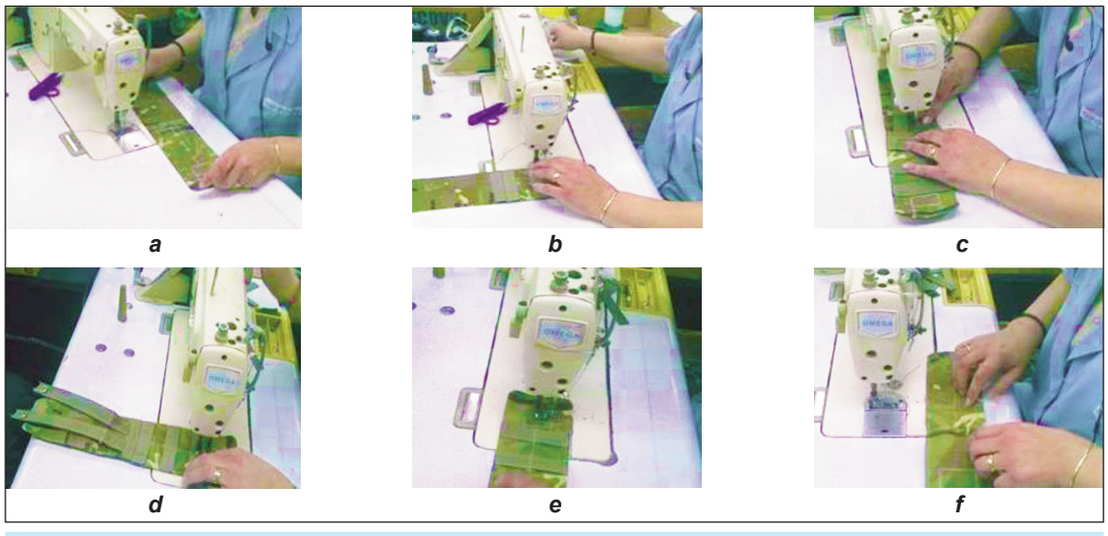

Fig. 3. Analysed work operation: *a* – attaching the front component to the back component; *b* – sewing around the area where the components have been attached with support tape (9 cm); *c* – sewing the two sides of the narrow band together with the 42 cm straps; *d* – sewing the 9 cm wide supporting tape in the middle three times; *e* – sewing the label; *f* – cutting the threads

Table 2

SPECIFIC MOVEMENTS IN THE EXECUTION OF THE ANALYSED OPERATION	
Movement structure	**Description**
1st move	Extend the right hand towards the sewing machine countertop, grab the back rear component, bring the piece and place it on the sewing machine countertop
2nd move	Extend the right hand to the belt, grab the front side of the back component, bring it and release it, and align the ensemble
3rd move	Position the ensemble under the foot at the sign, and arrange the edge pieces
4th move	Extend the right hand and take the narrow support band, bring it into position at the mark, guide the material, extend the right hand and take the 9 cm, support band, bring it into position at the mark, guide the material, extend the right hand and take the 9 cm, support band, bring it into position at the mark, guide the material, extend the right hand and take the 9 cm, support band, bring it into position at the mark, guide the material
5th move	Reposition the material, guide the material, reposition the material, guide the material, reposition the material, guide the material, reposition the material, guide the material, reposition the material, guide the material, reposition the material, guide the material, arrange the ensemble edges, guide the material, reposition the material, guide the material, reposition the material, guide the material, arrange the material, guide the material, reposition the material, guide the material, reposition the material, guide the material, reposition the material, stretch out the left hand, take the scissors, bring the scissors, cut the threads, stretch out the left hand, put the scissors on the left side of the sewing machine countertop, bring the left hand into the sewing area
6th move	Turn the body with the right hand extended, grasp the 42 cm support band (2 pieces), bring it close, release one band, and then the second band, position it on the shield, drive the material, extend the left hand, grasp the second support band 42 cm, bring the left hand close and transfer it to the right hand, position the shield, guide the material, extend the right hand to the reinforcement lever, reinforce, bring the right hand close, guide the material, stretch the right hand, reinforce, bring the right hand, reposition the piece, guide the material, reach for the steering wheel, reposition the landmark, guide the material, reposition the material, guide the material, bring the right hand, guide the material, reach: for the steering wheel, reposition the material, guide the hand, reposition the material, guide the material, reposition the material, guide the material, reposition the material, guide the material, reposition the material, guide the material, reposition the material
7th move	Extend the right hand, seize the logo, bring it, position it on the shield, drive the material, reposition it, drive the material, reposition it, drive the material, reposition it, drive the material, reposition it, drive the material, extend the right hand, seize the scissors, bring them with the transfer to the left hand, cut the threads, extend the left hand with the body back and leave the back mark in the storage box

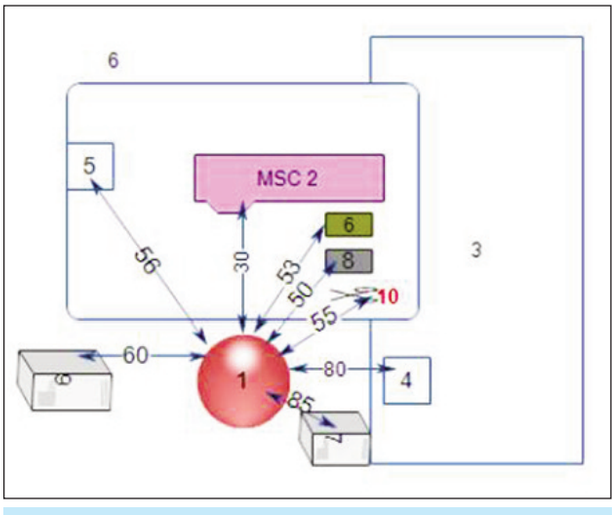

Fig. 4. Initial setup of order: *1* – worker; *2* – simple sewing machine; *3* – band; *4* – back component made of base material; *5* – back cover of the back component made of a base material; *6* – 9 cm support band; *7* – box with support band; *8* – logo; *9* – landmark storage box; *10* – scissors

A. Work preparation

1. Place the back cover of the base material on the right side of the tape.
2. Place the package with the rear pieces of the back of the base material on the left side of the sewing machine countertop.
3. Place the box with the sewn and stitched 42 cm long support tape on the right side of the chair.
4. Place the 9 cm, long support band, on the right side of the sewing machine countertop under the reinforcement lever.
5. Place the logo on the right side, on the sewing machine countertop.
6. Place the scissors on the sewing machine countertop.
7. Place the box for storing the sewn back components on the left side, next to the worker's seat.

B. Procedure

1. Grab the rear part of the back from the base material with the left hand. Place it on the sewing machine countertop in the sewing area.

2. Grab the front part of the back piece from the base material with the left hand. Place it on the rear of the back piece.
3. Check the edges of the components. Place them under the presser foot on the tag.
4. Pick up the 9 cm support tape, mark and sew the edge.
5. Sew the 42 cm support tape and the 9 cm support tape together in the centre with reinforcement.
6. Sew the logo, finish and remove.

d. Estimating the time that is necessary to perform the operation by employing the original procedure using the MTM method.

The necessary time for the processes shown in table 2 is estimated using the MTM method, with a sequence of operation modes shown in table 3.
The unit for Methods-Time Measurement (MTM) is TMU (time measurement unit): 1 TMU = 36 milliseconds (1 TMU = 0.036 seconds) [13–17].
According to the original working method, the time needed to perform the operation is 2.983 minutes.

e. Identify sources of improvement and propose solutions

After the detailed analysis of the existing situation, the following steps can be taken [15–18]:
A. Modifying the work method,
B. Improving the positioning of the front and rear parts on the tabletop.
The results obtained are given below.
A. Changing the work method is done by:
1. Placing the front and back parts of the back at a distance as small as possible;
2. Positioning the package of overlapping front and the back sides of the back components on the top of the sewing machine countertop as close as possible to the sewing area, inside the machine arm;
3. Sewing the chain stitched logo on the newly-formed rear assembly;
4. Sewing the 9 cm support strip with chain stitch;
5. Sewing on the middle of the 9 cm wide support band with chain stitch;
6. Sewing the 42 cm support strip with chain stitch;
7. Keeping the sewn back as close as possible to the worker;
8. Replacing the simple machine without a thread cutter with the simple machine with a thread cutter.

B. Improving the positioning of the front and rear parts on the work surface of the sewing machine countertop.
The following changes have been proposed:
1. The positions of the front and back parts that are going to be attached shall be as close as possible to the sewing area, resulting in an automatic movement when the front and back parts are placed in there (by overlapping and aligning the assembly before sewing).
2. Executing the front and back of the back piece simultaneously and positioning it under the presser foot without replacing the front and back sides of the back component one over the other.
3. Placing the back sewn with the logo or support tape as close as possible to the sewing area to avoid returning the worker's head.

f. Quantifying the results obtained by applying the proposed solutions

As in the analysis of the baseline situation, the following will be carried out to estimate the results of the proposed solutions:
A. Reconfiguring of the workstation where the analysed operation is performed, and
B. Estimating the operational time after the implementation of the proposed solutions.
A. Reconfiguring of the workstation where the analysed operation is performed.
The reconfiguration of the analysed order is shown in figure 5.
B. Estimating the operational time after the implementation of the proposed solutions.
The estimated data are presented sequentially in table 4.
According to the previously described working method, the operating time achieved in performing the operation is 2.15 minutes.

Table 3

ESTIMATION OF THE OPERATIONAL EFFORT FOR THE EXISTING WORKING PROCEDURE BY THE MTM METHOD (FOR FIVE PIECES)

No.	Description	MTM (5 pieces)	TMU	T (min)
1	Extend the right hand to the sewing machine countertop, grab the backside of the back component basic material, bring the back component and position it on the sewing machine countertop	(R56A G1A M56B P1SE) × 5	203.5	0.1221
2	Stretch the right hand out to the band, grab the front side of the back component basic material, brings the components and releases, and arrange the head-straight assembly	(R80AG1A M80B RL1 G4C) × 5	301.5	0.1809
3	Position the set of overlapping front and back sides of the back component base material under the foot at the mark, arrange the edge of the sides	(P2NSD G4C) × 5	197.5	0.1185
.....	.....	.....	.....	.....
		TOTAL	4972	2.983

Table 4

ESTIMATION OF THE OPERATING TIME FOR THE PROPOSED WORKING METHOD ACCORDING TO THE MTM METHOD (FOR FIVE PIECES)

No.	Description	MTM	TMU	T (min)
1	Stretch out the right hand and left hand at the same time, bring to the sewing machine countertop, grab the front sides of the back pieces package of the base material with markings on the top, bring and put on the knee, back sides of the base material with markings below the knee area	R30A G1 M30B (R2A G1A M2C RL1) × 5	44.8	0.0268
2	Stretch the hands out and places the bundle of overlapping parts on the sewing machine countertop and arrange the head straight, release the bundle, stretch the right hand, grab the scissors, grab the overlapped back pieces package, arrange the head straight, put it inside the sewing machine arm, grab the emblem with the left hand	R15B P1SSE RL1 R30A G1B M30B G1B P1SSE M15B P2NSD R5A G1A M15B	97.5	0.057
.....	.....	.....	.....	.....
13	Repack the components, bring the package onto the sewing machine countertop, and bring the 42 cm support band inside the sewing machine arm (12–14 pieces)	G1B P1SSE M15B R79A G1B M79B	68	0.0408
14	Position the backmarker under the presser foot, grab the support band, bring, position to the signs, drive the material, pull the backmarker, cut the threads, redo the package	(P2NSD G1B M15B P2NSD M9B R10B P2SSD M4C) × 5	542.5	0.322
15	Release in the storage box	LR1 × 5	10	0.006
		TOTAL	3595.1	2.15

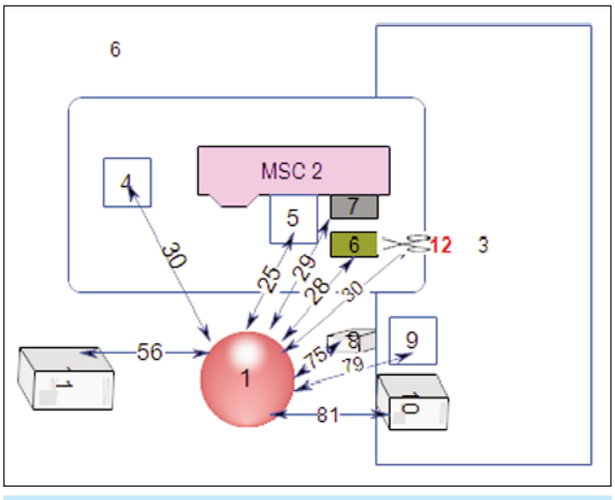

Fig. 5. Reconfiguration of the analysed tasks: *1* – worker; *2* – simple sewing machine; *3* – ribbon; *4* – sewn back a packet with the logo; *5* – overlapped back and front packet; *6* – emblem; *7* – support ribbon; *8* – box with 9 cm long support ribbon; *9* – sewn back a packet with an arrow support ribbon; *10* – box

RESULTS INTERPRETATIONS AND CONCLUSIONS

- Comparing the time obtained with the workers' working method (which had a time of 4972TMU) and the proposed solution, one saves 1376.9 TMU per 5 pieces (0.826 min). Changing the working method described above removes the hands' movements necessary to grab and put down the scissors. This reduces the time that one needs to carry out the sewing stage. By using the improved method, the time can be reduced by 50%. Thus, time is no longer wasted searching for the scissors, and the worker no longer turns their head after taking the scissors and does not force their eyes; the rhythm is constant and even progressive.
- By the changes proposed for the new method, the feeding of the front of the back with the rear of the back on the superimposed knees, and the formation of the head-straight package, their bringing out of the girdle, turning one's body, and stretching one's hands are no longer necessary.
- It shortens the way and the time if, when sewing the emblem, the worker takes over the front and rear parts of the back inside the sewing machine at the same time.
- Stretching one's hands, turning one's head, and straining one's eyes at the stage while picking up the wide supporting band from the right side of the machine's work area is no longer necessary. This is replaced in the improved method by grasping several 20–25 pieces in the right hand and releasing them three at a time. The stretching movements of the right hand to the belt are no longer necessary, and when the worker picks up the 42 cm support tape, they are positioned in the sewing machine arm in a reasonable number.
- By replacing the simple sewing machine without a thread cutter with a simple sewing machine with a thread cutter, one can eliminate the use of scissors, increasing the number of manufactured products per day by 50%.

- If one repositions the package containing the front sides and the backsides as close as possible to the sewing area, their feeding phase will be more efficient.
- Implementing the proposed working method will undoubtedly lead to an increase in the quality level of the next operation, the application of the narrow band on the contour.

Standardisation is one of the pillars of using MTM to define jobs that imply labour. MTM analyses entered into the database with improved definitions of jobs can be shared among users as potential best practices, ensuring a common language and replicability of methods. Such a contribution could facilitate the replication of successful companies on a global scale and contribute to employment and public recognition. A collaborative platform can be developed where skilled technicians can continuously improve remanufacturing processes based on a standardised data set.

The research community can identify optimisation methods for specific products or processes and derive precise requirements for developing new manufacturing technologies.

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