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1868 - 2022
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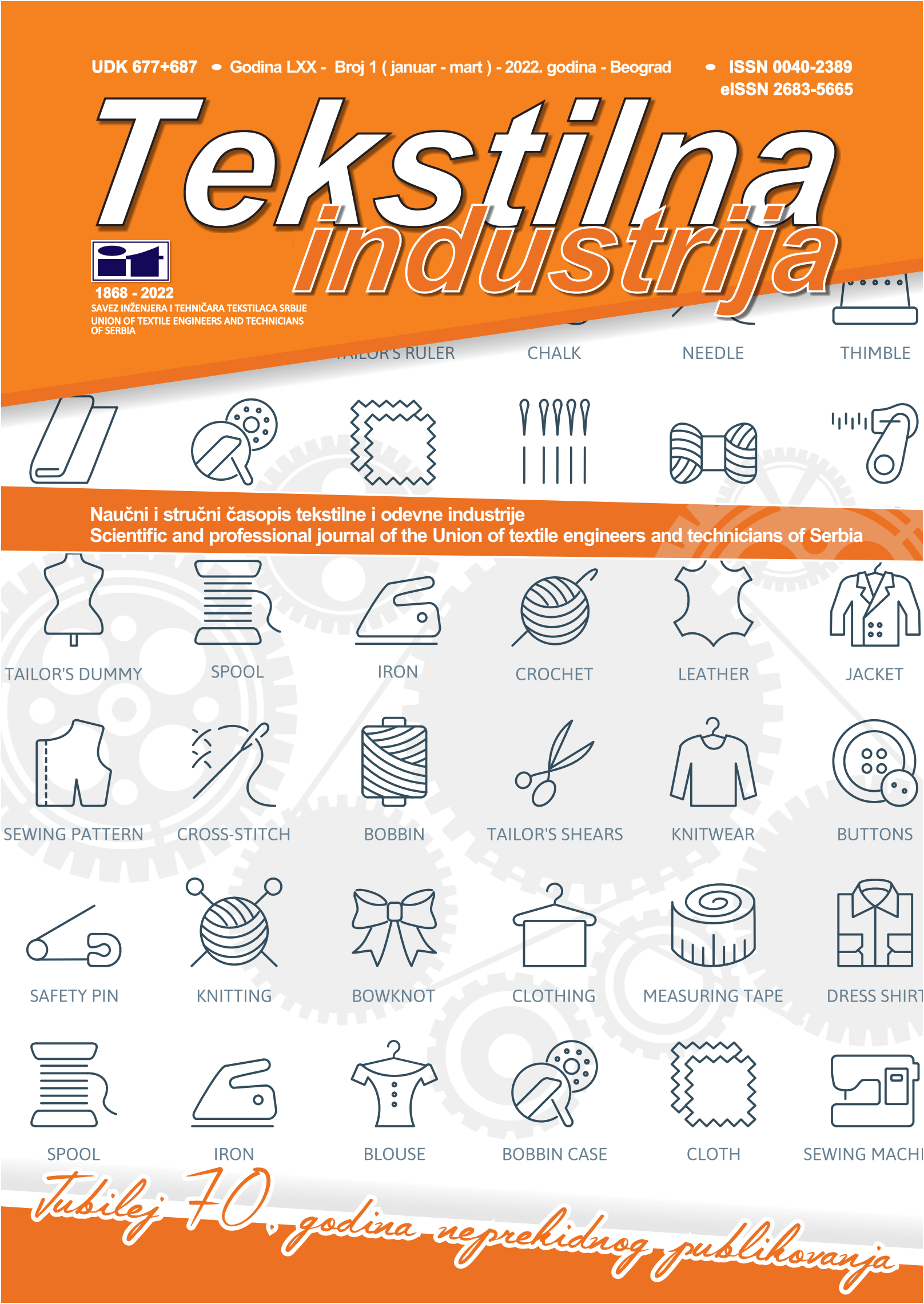
UNION OF TEXTILE ENGINEERS AND TECHNICIANS OF SERBIA



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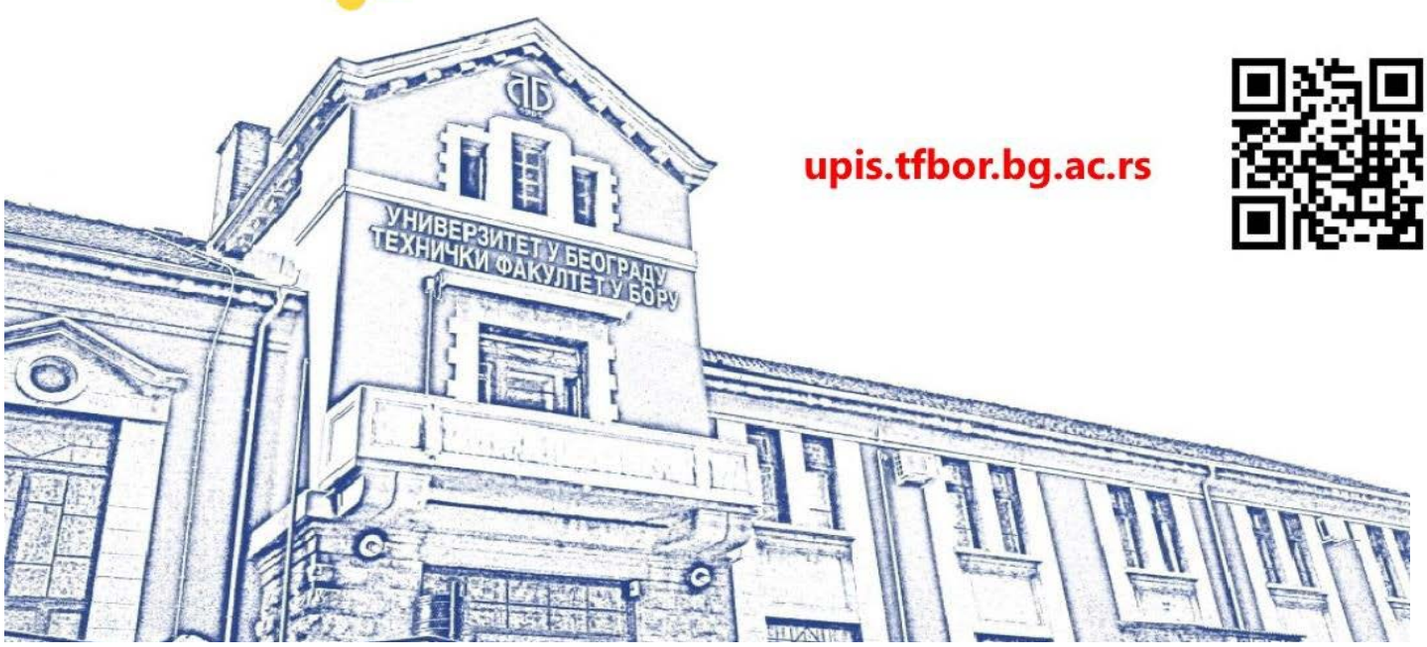

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REČ UREDNIKA

U ime Naučnog odbora i Organizacionog odbora konferencije pozivam Vas da učestvujete na V Međunarodnoj konferenciji "Savremeni trendovi i inovacije u tekstilnoj industriji" CT&ITI 2022 koju zajedno organizuju Savez inženjera i tehničara tekstilaca Srbije, Savez inženjera i tehničara Srbije, Tehnološko-metalurški fakultet u Beogradu, Univerziteta u Beogradu, Tehnološko-tehnički fakultet u Štipu, Univeziteta "Goce Delčev" u Štipu iz Severne Makedonije, Društvo za robotiku Bosne i Hercegovine i Balkansko društvo tekstilnih inženjera-BASTE iz Grčke. Konferencija će se održati po treći put od 15. do 16. septembra 2022. godine u Beogradu, u svečanoj sali Doma inženjera "Nikola Tesla".

Ministarstvo prosvete nauke i tehnološkog razvoja prepoznalo je značaj ove konferencije, te je konferencije podržana od strane Ministarstva prosvete, nauke i tehnološkog razvoja Republike Srbije.

Ovo je prilika koja će okupiti eminentne naučnike i stučnjake sa Balkana i drugih zemalja, zaposlene na fakultetima, visokim tekstilnim strukovnim školama i institutima, kao i sve one stručnjake u zemlji i inostranstvu koji se u okviru svog rada bave problematikom koja je definisana ovim naučno-stručnim skupom.

Konferencija će takođe biti prilika da se uspostavi saradnja visokoškolskih institucija i privrednih subjekata iz sektora tekstilne industrije u Srbiji, kao i da im se pruže nova saznanja o najsavremenijim dostignućima iz oblasti tekstilne i odevne industrije. Analizom stanja u tekstilnoj industriji Srbije ukazaće se na moguća rešenja kroz primere dobre prakse i puteve saradnje univerziteta i privrede kroz plasman inovativnih proizvoda na tržište. S obzirom da tekstilna industrija Srbije ima dugu tradiciju, iskustvo, kvalifikovanu radnu snagu i međunarodni ugled to otvara mogućnost za proširivanje proizvodnih kapaciteta sa dovoljno prostora za unapređenje.

Nadamo se da ćemo u ovoj jubilarnoj godini kada Savez inženjera i tehničara tekstilaca proslavlja 70 godina uspešnog rada i 70 godina neprekidnog publikovanja časopisa „Tekstilna industrija", uspešno organizovati po peti put Međunarodnu organizaciju „Savremeni trendovi i inovacije u tekstilnoj industriji".

Takođe, povodom obeležavanja Jubijela, planira se štampanje publikacije pod naslovom „Tekstilna industrija Srbije-istorija, kulturno nasleđe, razvoj i obrazovanje kadrova". Cilj ove publikacije je da se prikaže istorijat i razvoj tekstilne industrije Srbije u periodu od kraja 19. veka do današnjih dana kroz ekonomske fenomene i pojave, tehnološki razvoj, tržište tekstilne industrije, radnu snagu i obrazovanje stručnih kadrova. Takođe, cilj je da se kroz prikaz tradicionalnih proizvoda koji su okarakterisani kao nematerijalno kulturno nasleđe, čuva istorija, tradicija i kultura, a ujedno da se razvija i tekstilna i modna industrija Srbije.

Pozivam sve čitaoce, autore, kolege, dugogodišnje saradnike i pretplatnike, sponzore i donatore da nam se pridruže u našim aktivnostima kako bi adekvatno obeležili jubilarnu godinu koja je pred nama.

Glavni i odgovorni urednik
Prof. dr Snežana Urošević

METHODOLOGY FOR DETERMINING THE QUANTITY OF TEXTILE WASTE FROM THE CUTTING PROCESS

Stefan Maksimov[1], Sonja Jordeva[1], Silvana Zhezhova[1], Kiro Mojsov[1], Aco Janevski[1]

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Abstract: *The generation of textile waste primarily depends on the volume of clothing production. This waste contributes significantly to the environmental problems because the research shows that in North Macedonia the textile waste management comes down to its disposal in landfills. The analysis of the quantities of textile waste is a necessary precondition for any further initiative for its efficient management, but such a detailed analysis does not exist yet. The aim of this paper is to design a new methodology for determining the amount of textile waste generated from the cutting process. The examination of the practical use of methodology was done in 3 different companies. The results showed that using this methodology, it quickly and easily calculates the amount of waste generated from the cutting process.*

Keywords: textile waste, cutting, methodology, quality and quantity of waste.

METODOLOGIJA ZA ODREĐIVANJE KOLIČINE TEKSTILNOG OTPADA IZ PROCESA KROJENJA

Apstrakt: *Generisanje tekstilnog otpada prvenstveno zavisi od obima proizvodnje odeće. Ovaj otpad značajno doprinosi ekološkim problemima jer istraživanja pokazuju da se u Severnoj Makedoniji upravljanje tekstilnim otpadom svodi na njegovo odlaganje na deponije. Analiza količina i kvalitet nastalog tekstilnog otpada je neophodan preduslov za zvaku dalju inicijativu za njegovo efikasno upravljanje, ali takva detaljna analiza još uvek ne postoji. Svrha ovog rada je dizajniranje nove metodologije za određivanje količine generisanog tekstilnog otpada iz procesa krojenja. Zatim je praktična primena metodologije proverena u 3 kompanije. Rezultati pokazuju da se pomoću ove metodologije brzo i lako izračunava količina otpada iz krojenja.*

Ključne reči: tekstilni otpad, krojenje, metodologija, kvalitet i količina otpada.

1. INTRODUCTION

The apparel manufacturing industry in North Macedonia plays an important role in the overall textile industry. This industry employs about 29 000 people [1] in more than 800 companies, which represents approximately 22% of the total number of employees in the manufacturing sector, or about 5.5% of the total number of employees in the country. This branch of the textile industry is almost 100% export-oriented, which on average annually exports over 15 000 tons of clothes, with an average value of over 400 million euros. This level of clothing production generates a high amount of textile waste from the production processes themselves. The waste from the apparel manufacturing processes consists of fibers, yarns, or streams from the cutting process. This waste, in the enterprises with the closed production process, is returned to production after the various recycling procedures. But, in North Macedonia, textile waste management comes down to its disposal in

landfills. According to the previous research [2] shows that 94.19% of Macedonian textile companies dispose the waste in landfills, while only 3.49% of them hand it over to licensed companies for further processing, despite the fact that total annual corporate costs for custom clearance and disposing the waste of in landfills range up to 1.5 million euros [3].

Textile waste is defined as a problem for many reasons such as: a negative impact on the environment, creation of landfills and costs of their management. The current objectives of the European Union's waste policy are to prevent waste, to promote reuse, recycling and recovery in order to reduce the negative environmental impacts. As a result of this, the EU attitudes on disposing of waste in landfills are becoming ever stricter. The European Parliament resolution on a Thematic strategy on the recycling of waste (2006/2175 (INI)) calls for the quantities of waste for disposal to be reduced to a minimum [4] [5]. The best possible solution for textile waste management is the model of integrated treatment based on the principles of sustainable development. El Hagaar [6] considered that this principle is based on 7 "R": reduce, reuse, recycle, regulations, recovering, rethinking and renovation. Recycling is a key concept in modern waste management. 99% of textile waste can be recycled. From the point of view of energy and raw material preservation, recycling is the most desirable way of waste treatment. The contribution of recycling is reflected in the reduction of environmental pollution and the amount of waste, and the savings of raw materials. Apparel manufacturing companies have a major contribution to recycling through the introduction of a waste sorting process, as only sorted waste can be recycled. Recent research shows that in North Macedonia generally the attitudes of managers regarding the recycling of textile waste are negative. The majority of top managers, 59.3% stated that they would not be willing to sort produced waste [7]. In addition to sorting, the important factors for a successful recycling process are also the quantity and quality of the generated textile waste. The number of studies dealing with the analysis of quantities of textile waste as well as its quality is still small. The latest statistical analysis [8] presents the results for the generated textile waste until 2014. This is a 7-year-old study. Because of this is very important from economic and ecological points of view, more studies are to be carried on this theme. The aim of the research is to develop a simple methodology used in a cutting process for determining the textile waste quantity generated by the companies.

2. EXPERIMENTAL

Employing the industrial practice knowledge about the cutting process flow, a methodology for determining the quantity of generated textile waste was developed through several phases, as follows:

1. Determination of the total length *VDdm* (m) and weight *VKdm* (kg) of the imported fabric. This data is intended to be collected through the analysis of the import documentation.

2. Determination of the real cut length per coil *RSDb (m)*, as the sum of:

$$[(Dks + Ddks) \cdot Bks] + Dod + Onp \quad (1)$$

where: *Dks* - the length of cutting marker (m);
Ddks - the leftovers at the end of cutting layout (m);
Bks - the number of layers in the cut lay (m);
Dod - the length of removed defects (m);
Onp - the length of leftovers at the end of coil which was not used in cut lay (m).

3. Determination of the total real cut length *RSVd (m)*, as the sum of:

$$RSVd = \sum_{i=1}^{n} RSDb \quad (2)$$

Table 1: Example of *Material cut report*

Material cut report								
Order-Nr.				**Order qty.**				
Nr.	Marker name	Length of a coil (m)	Marker length (m)	CAD efficiency (%)	Number of layers in the cut lay	Leftover at the ends of the cut lay (m)	Defects (m)	Coil leftovers (m)

In this phase, a *Material Cut* Report form was designed that aims to keep accurate records of the use of the obtained fabric, and which form will provide the necessary data in the further phases. This form is intended to be applied during the cutting process itself, i.e., by the operators when forming the cutting layers. The form is shown in table 1.

4. The next phase is the determination of:

- the percentage of the cut length *PrSk* (%):

$$PrSk = (RSVd / VDdm) \cdot 100 \quad (3)$$

- the percentage of the removed defects *PrOd* (%):

$$PrOd = (Dod / VDdm) \cdot 100 \quad (4)$$

- the percentage of the coil leftovers *PrOnp* (%):

$$PrOnp = (Onp / VDdm) \cdot 100 \quad (5)$$

5. Then the determination of:

- the gross cut quantity *KBrS* (kg):

$$KBrS = (VKdm / 100) \cdot PrSk \quad (6)$$

- quantity of removed defects *KOd* (kg):

$$KOd = (VKdm / 100) \cdot PrOd \quad (7)$$

- coil leftovers quantity *KOnp* (kg):

$$KOnp = (VKdm / 100) \cdot PrOnp \quad (8)$$

6. In the next phase follows the determination of the net cut quantity *KNeS* (kg):

$$KNeS = (KBrS / 100) \cdot ACADef \quad (9)$$

where: *ACADef* - average efficiency of used cut markers:

$$KBrS = (VKdm / 100) \cdot PrSk \quad (10)$$

$$ACADef = \sum_{i=1}^{n} PCADiKSl \quad (11)$$

where: *PCADiKSl* - efficiency on each of the used cut markers, separately (this data is obtained from the *Material Cut Report* form).

7. Then follows the determination of cutting losses *KMg* (kg):

$$KMg = KBrS - KNeS \quad (12)$$

8. The final phase is a determination of the quantity *VKOk* (kg) and percentage of the generated textile waste from the cutting processes *PrGOk* (%), as follows:

$$VKOk = KMg + Kod + Konp \quad (13)$$

$$PrGOk = VKOk / (KBrS + Kod + Konp) \cdot 100 \quad (14)$$

For examination of the practical use of developed methodology three apparel manufacturing companies producing similar range of garments were selected. The data for the companies A, B and C are shown in table 2.

3. RESULTS AND DISCUSSION

The amount of the generated textile waste from the cutting process depends on several factors: the type of the cut marker, the garment type as well as the frequency of the defects in the fabrics, and the inability to fit them in the cutting loss space i.e., between the pattern pieces in the marker. For fulfilment the orders in company A, 8016 kg woven fabrics were imported from which 3399 kg made of 100% VIS fibers, 2340 kg made of 100% LI, 2020 kg made of 100% Tencel, 157 kg made of 100% CO and 806 kg made of other fiber composition or fiber blends. 1674 kg knit fabrics were used to fulfill the orders with raw composition 95% VIS and 5% EA. In company B, 652.91 kg knit fabrics were imported with raw composition 94% VIS and 6% EA. The total amount of the imported woven fabrics in company B was 4931.01 kg, from which 2045.82 kg made of 100% VIS fibers, 1655.52 kg made of 100% PES, 234.09 kg made of 100% AC, 91.14 kg made of 100% CO and 904.44 kg made of other fiber composition or fiber blends. To fulfil the orders in company C were imported 937,94 kg woven fabric made of 100% VIS, 865.93 kg made of 97% VIS and 3% EA and 256.68 kg made of 100% LI.

During the examination period in company A to fulfill the orders, 9590 kg of fabrics *VKdm* with differ-

Table 2: Details about selected companies

	Company A	Company B	Company C
Number of employees	170	55	30
Production range	Dresses, skirts, and blouses	Dresses, blouses	Blouses
Monthly capacity	30 000	10 000	5 000

ent composition and type were imported. In company B the *VKdm* was 5583.92 kg, while in company C the *VKdm* was 2060.55 kg. Despite the Covid-19 pandemic, during the examination period, the companies worked at full capacity without any downtimes. The results from the analyzed import documentation are presented in table 3, 4 and 5, for each of the companies A, B and C, respectively.

Table 3: Import data, company A

Order	Order quantity	Imported quantity in meters	Imported quantity in kilograms	Type of fabric	Raw composition
A6/1-1	2464	2842	806	Woven	67% Lyocell, 33% Linen
		200	18	Woven	100 % Cotton
A6/1-2	1533	2042.9	613	Woven	100% Tencel
		268	43	Woven	100% Cotton
A6/1-3	3318	2759.3	866	Woven	100% Tencel
A6/2-4	1848	1762.5	541	Woven	100% Tencel
		299	14	Woven	100 % Cotton
A6/2-5	10601	11305	1958	Woven	100% Linen
A6/2-6	2052	2183	382	Woven	100% Linen
A6/3-7	499	806.9	376	Knit	95% Viscose, 5% Elastane
A6/3-8	573	1205	492	Knit	95% Viscose, 5% Elastane
		89	18	Woven	100% Cotton
A6/3-9	505	1026.78	305	Woven	100% Viscose
		131.9	30	Woven	100% Cotton
A6/4-10	764	1271.5	385	Woven	100% Viscose
		192	34	Woven	100% Cotton
A6/4-11	3270	8636.52	1888	Woven	100% Viscose
A6/4-12	3327	5345.22	821	Woven	100% Viscose
Total	**30754**	**42366.52**	**9590**		

The obtained results based on the designed methodology are shown in tables 6, 7 and 8, for each of the companies respectively. In company A the total processed fabric into apparel products was 75.89%, while the total generated textile waste *PrGOk* was 20.14%. The rest of 3.97% is a negative difference between the imported and the real cut quantity of the fabric. The highest percentage of processed fabric into apparel has order A6/1-3, where *PrGOk* was 16.52%, while lowest has order A6/2-4, where *PrGOk* was 46.14%. The large percentage of the generated waste was mostly due to the specificity of the construction parts as well as the fact that the pattern parts were only in one direction in the cutting marker. In company B the percentage of the processed fabric into apparel was 76.13%, while the *PrGOk* was 24.89%. The positive difference of 1.02% is the difference between the real cut quantity and the imported quantity of fabric. The highest percentage of processed fabric into apparel has order B4/4-12, where *PrGOk* was 16.59%, while lowest percentage has order B4/4-10, where *PrGOk* was 47.32%. The large percentage was due to the hand lay up of pattern parts in the cutting lay because of positioning of the print detail of fabric in apparel. In company C the *PrGOk* was 25.84%, the positive difference was 2.51% while in apparel were processed 76.67% of imported fabric. In cutting process of order C5/4-2 the *PrGOk* was 15.7%, while in order C5/1-1 the *PrGOk* was 29%. The highest value of *VKOk* was by company A or 2224.94 kg, while the lowest was by company C where *VKOk* was 477.25 kg. In company B in the examination period the *VKOk* was 1338.37 kg, which corresponds to the size of the company and the monthly production capacity. Most of the waste was generated during the production of order A6/4-11, where *VKOk* was 489.81 kg, while the least at order B4/3-7, where *VKOk* was 15.45kg.

Table 4: Import data, company B

Order	Order quantity	Imported quantity in meters	Imported quantity in kilograms	Type of fabric	Raw composition
B4/1-1	312	520	239.2	Woven	100% Viscose
B4/1-2	1225	2252	900.8	Woven	100% Viscose
B4/1-3	1455	2404.3	841.51	Woven	100% Viscose
B4/2-4	575	984.4	344.54	Woven	100% Polyester
		507.6	202.96	Knit	94% Viscose, 6% Elastane
B4/2-5	780	1020	204	Woven	100% Polyester
		624.71	249.79	Knit	94% Viscose, 6% Elastane
B4/2-6	809	1225	453.25	Woven	69% Cotton, 28% Polyester, 3% Elastane
B4/3-7	397	637	64.31	Woven	100% Viscose
B4/3-8	748	1788	196.68	Woven	77% Viscose, 23% Polyamide
		508.9	234.09	Woven	100% Acetate
B4/3-9	207	350	211.4	Woven	100% Polyester
		110	52.91	Woven	65% Cotton, 32% Polyester, 3% Elastane
		188.5	57	Woven	100% Polyester
		90	14	Woven	100% Cotton
B4/4-10	364	934	63.64	Woven	100% Cotton
B4/4-11	332	740	712.27	Woven	100% Polyester
		335.52	49.19	Woven	100% Polyester
		162.68	13.5	Woven	100% Cotton
B4/4-12	375	720	201.6	Woven	51% Viscose, 49% Cotton
B4/4-13	675	771.2	77.12	Woven	100% Polyester
		500.4	200.16	Knit	94% Viscose, 6% Elastane
Total	**8254**	**17374.21**	**5583.92**		

Table 5: Import data, company C

Order	Order quantity	Imported quantity in meters	Imported quantity in kilograms	Type of fabric	Composition
C5/1-1	4736	1482	256.68	Woven	100% Linen
		2164.82	865.93	Woven	97% Viscose, 3% Elastane
C5/4-2	591	987.3	937.94	Woven	100% Viscose
Total	**5327**	**4634.12**	**2060.55**		

Table 6: Results of the application of the designed methodology in company A

Order	Fabric type/ Raw composition	Net cut quantity (kg)	Defects (kg)	Coil leftovers (kg)	Cutting loss (kg)	Total amount of waste (kg)	Percentage of textile waste (%)
A6/1-1	Woven / 67% CLY, 33% LI	624.35	14.96	20.77	136.59	172.33	21.38
	Woven / 100 % CO	14.16	0	0.36	3.48	3.84	21.35
A6/1-2	Woven / 100% Tencel	503.40	3.53	4.50	101.58	109.60	17.88
	Woven / 100% CO	35.97	0.25	0.56	6.23	7.03	16.35
A6/1-3	Woven / 100% Tencel	722.90	3.67	3.10	136.26	143.07	16.52
A6/2-4	Woven / 100% Tencel	285.72	2.55	10.74	240.76	254.05	46.96
	Woven / 100% CO	11.96	0.04	0.15	1.85	2.04	14.58
A6/2-5	Woven / 100% LI	1481.22	29.79	33.43	403.52	466.74	23.84
A6/2-6	Woven / 100% LI	289.35	3.06	4.20	78.83	86.09	22.54
A6/3-7	Knit / 95% VIS, 5% EA	270.49	16.12	7.46	71.73	95.31	25.35
A6/3-8	Knit / 95% VIS, 5% EA	406.75	8.26	8.35	68.65	85.25	17.33
	Woven / 100% CO	15.70	0.09	0.23	1.98	2.30	12.79
A6/3-9	Woven / 100% VIS	242.10	3.94	6.28	51.89	62.11	20.36
	Woven / 100% CO	25.37	0.23	0.49	3.90	4.62	15.4
A6/4-10	Woven / 100% VIS	300.63	5.72	4.70	65.81	76.23	19.8
	Woven / 100% CO	4.55	0.09	0.04	1.34	1.47	4.32
A6/4-11	Woven / 100% VIS	1390.35	30.94	15.23	443.64	489.81	25.94
A6/4-12	Woven / 100% VIS	652.92	3.89	18.82	140.32	163.03	19.86
Total		**7277.86**	**127.14**	**139.45**	**1958.35**	**2224.94**	**Average: 20.14**

Table 7: Results of the application of the designed methodology in company B

Order	Fabric type/ Raw composition	Net cut quantity (kg)	Defects (kg)	Coil leftovers (kg)	Cutting loss (kg)	Total amount of waste (kg)	Percentage of textile waste (%)
B4/1-1	Woven / 100% VIS	178	2.53	2.82	55.53	60.89	25.46
B4/1-2	Woven / 100% VIS	729.35	8.02	20.72	142.56	171.29	19.02
B4/1-3	Woven / 100% VIS	571.01	18.71	17.48	254.03	290.22	34.49
B4/2-4	Woven / 100% PES	256.57	3.27	3.03	81.24	87.55	25.41
	Knit / 94% VIS, 6% EA	144.90	0	0.61	57.42	58.03	28.59
B4/2-5	Woven / 100% PES	139.97	3.43	5.94	55.45	64.81	31.77
	Knit / 94% VIS, 6% EA	184.89	0	2.72	62.16	64.88	25.97
B4/2-6	Woven / 69% CO, 28% PES, 3% EA	368.18	5.17	9.38	69.92	84.46	18.63
B4/3-7	Woven / 100% VIS	48.04	0.76	0.94	13.75	15.45	24.03
B4/3-8	Woven / 77% VIS, 23% PA	154.96	1.91	5.27	34.04	41.22	20.96
	Woven / 100% AC	200.65	0	2.22	31.18	33.40	14.27
B4/3-9	Woven / 100% PES	159.48	1.33	3.58	46.97	51.87	24.54
	Woven / 65% CO, 32% PES, 3% EA	38.79	0.72	1.38	12.01	14.10	26.65
	Woven / 100% PES	44.24	0	0.36	12.40	12.76	22.39
	Woven / 100% CO	11.21	0	0.23	2.56	2.79	19.93
B4/4-10	Woven / 100% CO	33.51	0.81	1.84	27.47	30.12	47.32
B4/4-11	Woven / 100% PES	583.87	13.74	22.29	90.81	126.85	17.81
	Woven / 100% PES	39.49	0	0.52	9.18	9.70	19.71
	Woven / 100% CO	10.38	0	0.75	2.36	3.12	23.08
B4/4-12	Woven / 51% VIS, 49% CO	168.01	0.35	0.62	32.48	33.45	16.59
B4/4-13	Woven / 100% PES	51.48	3.47	0.60	21.40	25.47	33.02
	Knit / 94% VIS, 6% EA	144.22	0	2.60	53.34	55.94	27.95
Total		**4261.18**	**64.22**	**105.90**	**1168.25**	**1338.37**	**Average: 24.89**

Table 8: Results of the application of the designed methodology in company C

Order	Fabric type/ Raw composition	Net cut quantity (kg)	Defects (kg)	Coil leftovers (kg)	Cutting loss (kg)	Total amount of waste (kg)	Percentage of textile waste (%)
C5/1-1	Woven / 100% LI	168.26	1.73	16.35	66.64	84.73	33
	Woven / 97% VIS, 3% EA	620.93	1.75	6.55	236.95	245.24	28.31
C5/4-2	Woven / 100% VIS	790.58	13.30	25.56	108.42	147.27	15.70
Total		**1579.78**	**16.78**	**48.46**	**412.01**	**477.24**	**Average: 25.84**

The analysis of the practical examination of the methodology showed that a total number of 3681.64 kg textile waste from woven fabric was generated, from which: 1476.5 kg made of 100% VIS; 637.56 kg made of 100% LI; 506.72 kg made of 100% Tencel; 379.33 kg made of 100% PES; 57.33 kg made of 100% CO; 33.40 kg made of 100% AC and 590.8 kg made of other fiber composition or fiber blends. A total of 359.41 kg textile waste from knit fabrics was generated, from which: 180.56 kg was made of 95% VIS and 5% EA and 178.85 kg made of 94% VIS and 6% EA. On average 23.62% of textile waste from cutting processes was generated. The total amount of 4041.05 kg generated waste was disposed into local landfills.

4. CONCLUSION

The examination of the practical use of methodology proved to be successful because the amount of the generated textile waste from the cutting process at the place of its generating was determined in a quick and simple way. The analysis of the results showed that by applying this methodology, in addition to quantity, the quality of the generated textile waste from the cutting process can be determined very easily which is one of the preconditions for its further efficient management. This methodology may be subject to further research due to its improvement or conversion into a software tool that will contribute to better waste accounting and management.

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