UNION OF TEXTILE ENGINEERS AND TECHNICIANS OF SERBIA

tekstilna industrija

1868 - 2020

Naučni i stručni časopis tekstilne industrije UDK 677+687 ISSN 0040-2389 eISSN 2683-5665

Scientific and professional journal of the Union of textile engineers and technicians of Serbia

Godina LXVIII - Broj 4 - Beograd 2020 - Strana 1-96 - Tiraž 100

Izdavač: SAVEZ INŽENJERA I TEHNIČARA TEKSTILACA SRBIJE
11000 Beograd, Kneza Miloša 7a/II, tel: 060 715 0305
e-mail: casopistekstilnaindustrija@gmail.com
Tekući račun: 295-1201293-77 Srpska banka
Štampa: M studio, Stara Pazova

Za izdavača: Prof. dr Snežana Urošević
Predsednik Izdavačkog saveta: Stanko Kiš, dipl. ing.
Redakcioni savet: Prof. dr Snežana Urošević, dr Ana Jelić-Aksentijević, dr Danijela Paunović, dr Gordana Čolović
Glavni i odgovorni urednik: Prof. dr Snežana Urošević
Lektor: Bojana Pejčić, M.Sc.
Tehnički urednik: ing. Aleksandar Sokolović
Dizajn korica: ing. Aleksandar Sokolović

SADRŽAJ

U FINANSIRANJU ČASOPISA UČESTVOVALO MINISTARSTVO PROSVETE, NAUKE I TEHNOLOŠKOG RAZVOJA REPUBLIKE SRBIJE

SAVEZ INŽENJERA I TEHNIČARA TEKSTILACA SRBIJE
UNION OF TEXTILE ENGINEERS AND TECHNICIANS OF SERBIA

tekstilna industrija

1868 - 2020

Naučni i stručni časopis tekstilne industrije UDK 677+687 ISSN 0040-2389 eISSN 2683-5665

Scientific and professional journal of the Union of textile engineers and technicians of Serbia

Volume LXVIII - Number 3 - Beograd 2020 - Page 1-96 - Printing 100
Publisher: Textile Engineers and Technicians Union of the Republic Serbia
Editoral offices: Serbia, 11000 Beograd, Kneza Miloša 7a/II, tel: 060 715 0305
e-mail: casopistekstilnaindustrija@gmail.com

For publisher: Snežana Urošević, Ph.D.
President of the Publishing Council: Stanko Kiš, dip.ing.
Editorial Council: Snežana Urošević, Ph.D., Ana Jelić-Aksentijević, Ph.D., Danijela Paunović, Gordana Čolović, Ph.D.
Editor in Chief: Snežana Urošević, Ph.D
Translation: Bojana Pejčić M.Sc.
Technical Editor: Aleksandar Sokolović, ing.
Cover design: Aleksandar Sokolović, ing.

CONTENT

THE MINISTRY OF EDUCATION, SCIENCE AND TECHNOLOGICAL DEVELOPMENT PARTICIPATED IN FINANCING OF THE JOURNAL

JOURNAL OF THE UNION OF TEXTILE ENGINEERS AND TECHNICIANS OF SERBIA
BEOGRAD, Kneza Miloša 7a/II, Tel: 060 715 0305
e-mail: casopistekstilnaindustrija@gmail.com

REČ UREDNIKA

Završava se još jedna godina uspešnog rada Saveza inženjera i tehničara tekstilaca Srbije ali pod malo drugačijim, težim okolnostima. Zbog novonastale situacije izazvane pandemijom virusa COVID 19, rad svih organizacija u celom svetu je otežan, ali i u ovim vanrednim okolnostima od početka 2020. godine uspeli smo da prevaziđemo sve poteškoće i publikujemo sva četiri broja časopisa "Tekstilna industrija" u predviđenim rokovima sa novim korigovanim dizajnom korica i tiražom od 100 komada. Time je ispunjen plan o redovnosti izlaženja časopisa.

Redakcioni odbor sa glavnim i odgovornim urednikom potrudio se da poboljša kvalitet časopisa te je publikovano ukupno 30 radova, a od toga je 19 radova autora iz inostranstva i na engleskom jeziku. Svi radovi imaju UDC brojeve i karakter rada, DOI broj, imaju apstrakt i ključne reči na srpskom i engleskom jeziku.

Savez inženjera i tehničara tekstilaca Srbije je, kao izdavač časopisa "Tekstilna industrija" u 2020. godinu produžio ugovor sa CEON-om (Centra za evaluaciju u obrazovanju i nauci) o korišćenju naprednog paketa u okviru servis SCIndeks - Srpski citatni indeks. U ovoj godini časopis "Tekstilna industrija" prihvaćen je za indeksiranje u Directory of Open Access Journals - DOAJ.

„Tekstilna industrija" je časopis otvorenog pristupa (OA). Objavljeni članci distribuiraju se u skladu sa licencom Creative Commons Attribution 4.0 International (CC BY). Visoka vidljivost radova objavljenih u časopisu Tekstilna industrija je trajno obezbeđena posredstvom SCIndeksa i dodatno uvećana automatskim reindeksiranjem metapodataka u DOAJ i punog teksta u Google Scholar-u.

Svi brojevi časopisa „Tekstilna industrija" redovno su dostavljeni poštom svim pretplatnicima i autorima, kao i potencijalnim pretplatnicima u cilju promocije časopisa i Saveza inženjera i tehničara tekstilaca Srbije. Isto tako, elektronske verzije časopisa u cilju promocije dostavljaju se potencijalnim pretplatnicima i autorima, članovima redakcionog odbora kao i prijateljima Saveza tekstilaca.

Redovno se ažuriraju i dve FB (Facebook) stranice-Časopis Tekstilna industrija i Magazin Tekstilna industrija, tako da su sve informacije na vreme dostavljene kolegama i javnosti.

Takođe, na sajtu Saveza inženjera i tehničara Srbije, na stranici Saveza inženjera i tehničara tekstilaca Srbije, redovno se objavljuju informacije o publikovanim brojevima časopisa uz objavljivanje impresuma na srpskom i engleskom jeziku.

Redakcioni odbor i glavni i odgovorni urednik pokušavaju da sa boljim sadržajem, kvalitetnim radovima, savremenim tematikama i aktuelnim informacijama i većim brojem radova povećaju broj pretplatnika na časopis. Takođe, ulažu se značajni napori od strane Uredivačkog odbora, a posebno glavnog i odgovornog urednika da se poveća prepoznatljivost časopisa i njegov kvalitet. Čine se svi napori da se dobije bolja kategorizacija časopisa pri Ministarstvu prosvete, nauke i tehnološkog razvoja Republike Srbije za oblast Materijali i hemijske tehnologije, sa sadašnje kategorizacije M52 na M51.

Nadamo se da ćemo u narednoj godini, u 69. godini publikovanja opravdati dato poverenje i nastaviti dugogodišnju tradiciju uspešnog publikovanja časopisa "Tekstilna industrija".

Glavni i odgovorni urednik
Prof. dr Snežana Urošević

TEXTILE WASTE FROM CONFECTION INDUSTRIES AND POSSIBILITIES FOR ITS RECYCLING

Sanja Risteski[1]*, Vineta Srebrenkoska[1]

[1]University "Goce Delčev", Shtip, Faculty of Technology, Shtip,North Macedonia
*e-mail: sanja.risteski@ugd.edu.mk

Professional paper
UDC: 677:628.4:502.174.1
doi: 10.5937/tekstind2004077R

Abstract: *Many of the processes and products associated with modern lifestyles have negative effects on the environment. Among the significant consequences are the rising costs of treating and disposing of excessive amounts of waste. Proper management of the large amounts of waste generated by the confection industry is of high importance to the good of society. Solving the problem of textile waste is of great importance for the garment production facilities in order to increase competitiveness, make additional profits and reduce disposal costs. In this paper were analyzed two confection companies, in order to determine the amount of textile waste that occurs in both companies, and also was made a research for utilization of the generated textile waste through its application as a raw material for the production of composite materials.*

Keywords: textile waste, recycling, utilization, material.

TEKSTILNI OTPAD IZ KONFEKCIJSKE INDUSTRIJE I MOGUĆNOSTI ZA NJEGOVU RECIKLAŽU

Apstrakt: *Mnogi procesi i proizvodi povezani sa modernim načinom života imaju negativne efekte na životnu sredinu. Među značajnim posledicama su sve veći troškovi tretmana i odlaganja prekomernih količina otpada. Pravilno upravljanje velikim količinama otpada koje proizvodi konfekcijska industrija od velike je važnosti za dobrobit društva. Rešavanje problema tekstilnog otpada od velike je važnosti za pogone za proizvodnju odevnih predmeta kako bi se povećala konkurentnost, ostvarila dodatna dobit i smanjili troškovi odlaganja. U ovom radu su analizirane dve konfekcijske kompanije, kako bi se utvrdila količina tekstilnog otpada koja se javlja u obe kompanije, a takođe je izvršeno istraživanje iskorišćenja nastalog tekstilnog otpada kroz njegovu primenu u vidu sirovine za proizvodnju kompozitnih materijala.*

Ključne reči: tekstilni otpad, reciklaža, upotreba, materijal.

1. INTRODUCTION

The environmental and social impacts of manufacturing are becoming very important engineering topics so that in the manufacturing industry, environmental issues are the focus of attention. In this concern, the material life cycle is very important. This cycle consists of stages of extraction, synthesis/processing, product design/production, application and final disposal. Material, energy and environmental interactions/exchanges are important factors for the efficient functioning of the material cycle. The earth is a closed system in which its material and energy resources are limited to a certain extent. Therefore, a number of industries are incorporating new strategies into the design process, known as eco design or environmental design. The purpose of these strategies is: minimizing energy consumption, minimizing material consumption, excluding hazardous substances

and recyclability. Environmental problems include pollution, adverse environmental impacts and waste disposal. Recycling used products and applying green design can improve some of these environmental problems. Many of the processes and products associated with modern lifestyles have negative effects on the environment. Among the significant consequences are the rising costs of treating and disposing of excessive amounts of waste. Proper management of large amounts of waste generated by households, industry and economy is of great importance for the well-being of society.

In the past, poor waste management practices have led to the degradation of ecosystems, as well as the loss of valuable natural resources and potential health risks.

In 21th century, textile and fashion consumption in the world has increased dramatically as a result of various factors such as the growth in world population, overall improvement of living standards and the rapid rise of the fast-fashion. The total volume of textile and fashion production at the global level is estimated to be more than 80 million tons annually [1, 2, 3].

The term *"waste"* is given a different meaning depending on whether it is understood in a narrower or broader sense of the word. As a rule, waste is a collective term that means substances that in households, industry and agriculture at a certain time and place have become unusable or "useless".

Textile waste is composed of natural and synthetic polymeric materials such as: cotton, polyester, nylon, polypropylene and others. The primary source of raw materials for the production of synthetic polymeric materials is oil. Oil is a non-renewable natural resource, and global oil reserves can last for at least several hundred more years at the rate of current consumption. The production of cotton, which is a renewable natural source, requires energy and chemicals, which come from non-renewable resources. The imposed environmental dangers from the over-accumulation of textile waste and from the reduction of natural resources, oil and all raw materials related to the further production of textile materials, have prompted the need to investigate the possibility of re-use of textile waste. The quantities of textile waste that are increasing daily, the pressure and energy during the processes of its disposal or incineration, performed properly or not, impose the need to introduce sustainable ways of textile waste management. Sustainable ways of textile waste management will contribute to reduced waste generation - more efficient use of raw materials and reuse of production flows from production, reduction of disposal costs, which inevitably imposes the need to restructure clothing companies and raise environmental awareness of waste generators [4, 5, 6, 7].

The problem of textile waste can be most economically solved by introducing so-called waste-free or closed-loop technologies. The introduction of new technologies that do not form waste materials in production processes, on the one hand protects the environment, and on the other hand reduces the costs of waste handling or disposal, and also saves on primary raw materials and energy. For the efficient implementation of an integrated textile waste management system that will be cost effective, usually the first step is the modernization of the enterprise. Modernization is associated with technological and process changes accompanied by changes in equipment, operational settings, as well as research into the possibilities of reusing textile waste as a potential raw material. This provides a reduction in landfill costs on the one hand and increases the profitability and competitiveness of the enterprise through the sale or use of the generated waste on the other hand. However, in this transitional period, when a satisfactory level of technical, technological and organizational solutions regarding waste has not yet been achieved, great involvement of all entities is needed, starting from the household, the company, the municipality and the state, in resolving issues related to waste materials [8, 9, 10].

In the frame of this paper will be analyzed the amount of textile waste that is created in clothing companies and the possibilities for its recycling - as one of the procedures for waste management, with the possibility of valorization of this type of waste. Recycling used textiles, instead of disposing them as a waste, is a desirable approach for several reasons. First, the use of recycled textiles eliminates the need to extract raw materials from the ground, thus preserving natural resources and eliminating any environmental impact associated with the extraction phase. Second, the energy needs for refining and recycling recycled textiles are usually lower than those for natural raw materials.

2. EXPERIMENTAL

The focus of efficiency in the clothing industry is to reduce raw material costs, which often reach up to 75% of total production costs. In recent years we have witnessed a continuous increase in the price of textiles, so each percentage of more efficient use of materials directly affects the total production costs. The processes of constructive preparation and the processes of planning, laying and cutting in the cutting department, determine the use of textile materials.

Additionally, in this research the following goals and objectives where set:

- ✓ Determining the amount of solid textile waste generated in clothing companies.
- ✓ Possibility to use textile waste as input raw material in another production process.

In order to determine the amount of textile waste that occurs in the process of cutting by work order, a research was done in two confection companies. Additionally, research was conducted on the utilization of the generated textile waste through its application as a raw material for the production of composite materials. This research was made in other company, which is specialized for composite materials production.

- ✓ Appropriate quantities of textile waste and polymer matrix were measured - accepting the recommendation of the company, and as a result of their experience in the composite production.
- ✓ The quantities of textile waste and polymer matrix were mixed in a universal composite mass mixing machine used by the company for such purposes. Care was taken to ensure that the textile waste was well soaked with the polymer matrix, that there was no presence of dirt from other substances and other impurities. The process was controlled visually.

Table 1: Analyzed confection companies A and B

	Textile company A	Textile company B
Number of employers	220	350
Production orientation	Shirts and pants	Shirts
Cutting layout	Manually	CAD
Cutting equipment	➢ 3 cutting tables, ➢ 2 machines with vertical percussive knife ➢ 2 machines ribbon blade cutting	➢ 4 cutting tables ➢ 3 machines with vertical straight knife
Production capacity	240-250 confection units daily	1300-1500 confection units daily

The two analyzed confection companies (A and B), whose main activity is the production of clothes, differ in terms of organization, number of employees, production capacity, sophistication of the technology used in the technological process of cutting (Table 1).

These two companies were selected in terms of capacity and technology of clothing production in order to determine the possible factors that affect the generation of textile waste. In both companies, the function of processing the work order was analyzed and the real percentage of textile waste that occurs in the tailoring process was defined.

The procedure for obtaining composite material based on textile waste in the company for composite production was as follows:

- ✓ The textile waste generated from the confection companies (from cotton fabric), was with different irregular shapes and dimensions, as well as different impurities. In order to use the waste as an effective reinforcing material, firstly was cleaned of various impurities, and then chopped into more regular shapes.
- ✓ As polymer matrix for the composites production was used the matrix that was in that moment in stock in the company.
- ✓ Composite tiles were produced from the obtained composite mass by compression pressing in a laboratory.
- ✓ The quality of the produced composites was determined only visually because that was not the aim of this paper.

The idea for this research was to make initial research on the possibilities of using textile waste in the production of composites, which is of potential interest for composite producers and clothing production facilities in order to increase competitiveness and make additional profits.

3. RESULTS AND DISCUSSION

From the performed analyzes in the both companies, the solid textile waste that was created in the process of cutting was determined. It is noted that the two companies have different cutting system, namely, the company A performs the manual production of the cutting layouts and manual measurement of their length and width, while the company B does it by computer with the help of US systems for cutting. As a result, there are differences in the cutting process in the two companies, and this generates different amount of textile waste. The approach for making the same cloth-

ing product in both forms was different and the waste generated during its production was different.

The examined article of women's shirt is made of textile material which is made of 90% cotton and 10% elastane. The material is monochromatic and the measured areal weight is 184 g/m². For cutting of 150 confection units, 3 coils were delivered or total 218 m of textile material (Table 3).

The cutting layouts are made directly on the textile material, so the operator repeats this procedure for each (cut) layer. The basic data (length and width of the cutting layout) presented in Table 4 are obtained by their manual measurement.

Material costs are a major component of production costs with 50 - 70% in the total production costs for clothes. Table 5 shows the values for the planned length of textile material for cutting the textile article, according to the cutting plan given in Table 4.

3.1 Losses of textile material due to intermediate loss and quantities of textile waste generated from cuttings

The degree of utilization is not known for the examined work order, due to the manual production of the cutting layouts. Therefore, the textile waste generated during the cutting process of each of the cutting

Table 2: Work order structure for confection article women's shirt

Size	38	40	42	Total
Quantity	80	70	60	150

Table 3: Delivered quantity of textile material

Number of textile coil	Width of textile coil (m)	Length of textile coil (m)
1	1,46	68
2	1,46	70
3	1,46	80
Total:		218

Table 4: Plan for cutting a women's shirt from a work order

Cutting layout	Represented sizes	Number of layers in cut lay	Number of confection units in cut lay	Width of cutting layout	Length of cutting layout
1	40x1; 42x1	7	15	1,44	2,96
2	40x1; 38x1	10	20	1,44	2,95
3	38x1: 38x1	32	65	1,44	2,94
4	38x1;42x1	12	25	1,44	2,94
5	40x1; 40x1	12	25	1,44	2,64
Total		73	150		

Table 5: Planed material length for cutting the confection article-women's shirt

Cutting layout	Number of layers in the cut lay	Length of cutting layout (m)	Leftovers at the ends for cutting (m)	Planned length of the material (m)
1	7	2,96	0,03	20,93
2	10	2,95	0,03	29,80
3	32	2,94	0,03	95,04
4	12	2,94	0,03	35,64
5	12	2,64	0,03	35,64
Total	73			217,05

layers is manually measured. The measured quantities of textile waste generated during the cutting process of a women's shirt are presented in Table 6.

Significant material/fabric losses occur because the length of the material in the textile coil does not always correspond to the integer lengths of the seam. Therefore, it is of great importance to plan the utilization of the length of the textile coils in relation to the length of the different cut layers. Research conducted in the clothing company has shown that the planning of textile coils for cutting was not applied here.

Table 7 shows that the total losses due to defects and leftovers at the ends of the textile coils are 5.1 m. In the cutting process of the work order a total of 212.9 m of fabric was used. The total amount of textile waste generated during tailoring of a work order is the sum of the losses of textile material that occur due to the intermediate loss and the losses due to defects and residues at the ends of the textile coils.

Based on the results of the shown researches, in the confection company B the amount of created waste was about 7%. Compared to the results of the research in the clothing company A, the quantities of generated textile waste were significantly reduced. This is primarily due to her many years of experience in the production of shirts and the application of CAD system for efficient interactive planning of cutting layouts. In this company the planning of the order of the textile coils for laying was not used, which affects the waste from coil leftover to range from 1.4 - 1.7%.

Table 6: Quantities of created textile waste from cut lays in the cutting process

Cut Lay	Represented sizes	Number of layers in cut lay	Measured textile waste (kg)
1	40x1; 42x1	7	2
2	40x1; 38x1	10	3
3	38x1: 38x1	32	9
4	38x1;42x1	12	3,5
5	40x1; 40x1	12	3,5
Total:		73	21

Table 7: Report for textile coils realization without planning

Length of textile coil (m)	Consumed material/fabric in the cut lay (m)	Coil leftover (m)
68	66,8	1,2
70	69,2	0,8
80	76,9	3,1
Total: 218	212,9	5,1

From Table 8 it is visible that when cutting an article of women's shirt, 12% of the total amount of used textile is converted into textile waste.

Table 8: The total amount of textile waste by cutting the article of women's shirt (company A)

Work order Women's shirt	Total used fabric	Amount of textile waste in cut lay	Amount of textile waste from coil leftover	Total amount of textile waste
	58,56 kg	5,64 kg	1,37 kg	7,01 kg
		9,6 %	2,3%	12 %

Table 9: Total amount of textile waste caused in the cutting process of women's shirt (company B)

Work order Women's shirt	Total used fabric	Total amount of textile waste
	58,56 kg	3,87 kg
		6,6 %

3.2 Examination of the possibility for textile waste application in the production of composite materials

Composites were produced by compression molding of the composite mixture based on textile waste as a reinforcement and epoxy resin as polymer matrix. The conditions for the compression molding and obtaining of the composite plates were made based on the experience of the company.

As a result, were obtained composite plates that visually had final dimensions, mass and volume. The obtained positive results are an introduction to further more extensive and comprehensive researches on the use of textile waste in this type of applications. Also, it is necessary to make analyzes of those composite plates that would be compared with some conventional composites, and their comparison will classify them into composite materials that will be competitively priced and applicable for given purposes.

Considering the fact that large quantities of textile waste are generated within the garment industry, this research is very important, because it provides positive initial assumptions about the possibility of using textile waste as a potential raw material. In addition, the use of textile waste in the production of industrial products will reduce the costs of textile waste disposal and at the same time will contribute to increasing the profitability and competitiveness of clothing companies.

4. CONCLUSION

From the obtained results can be concluded that:

- ✓ Different quantities of textile waste are produced in the analysed confection companies. In general, a larger amount of textile waste is generated in the clothing company A. One of the main reasons for the variation in the percentage of waste in companies that produce similar items is the difference in the level of technological equipment. The confection company A, as a result of ineffective planning and lack of CAD system, the quantities of textile waste range from about 12%. In contrast to this at the clothing company B, as a result of many years of experience in the production of a standard product and the efficient interactive planning of the cutting layouts with the application of CAD system, the quantities of textile waste range from about 7%.
- ✓ In both companies, planning of the textile coils for cutting was not applied, which contributes to the increase of the percentage of waste, as a result of defects and coil leftovers.
- ✓ Solving the problem of textile waste is of great importance for the garment production facilities in order to increase competitiveness, achieve additional profits and reduce disposal costs. Within this paper, was tried for re-use of the generated textile waste.
- ✓ With method of compression moulding are produced composite materials from polymer matrix and textile waste as a reinforcement.
- ✓ Composite materials that visually had good quality, indicated the possibility of successful use of textile waste in the production of composites, and at the same time provide a good basis for further researches in this area.

REFERENCES

[1] [1] Lu, J. J., Hamouda, H. (2014). Current Status of Fiber Waste Recycling and its Future. *Advanced Materials Research*. 878, 122-31.

[2] Weber, S., Lynes, J., Young, S. B. (2017). Fashion interest as a driver for consumer textile waste management: reuse, recycle or disposal. *International Journal of Consumer Studies*, 41(2), 207-215.

[3] Young, C., Jirousek, C., Ashdown, S. (2004). Undersigned: A study in sustainable design of apparel using post-consumer recycled clothing. *Clothing and Textiles Research Journal*, 22(1-2), 61-68.

[4] Reno, J., (2018). What is Waste? Worldwide Waste. *Journal of Interdisciplinary Studies*, 1(1).

[5] Reno, J. (2014). Towards a New Theory of Waste: from 'Matter out of Place' to Signs of Life. *Theory, Culture & Society*, 31(6), 3–27.

[6] Ebikapade, A, Baird J. (2016). The Concept of Waste and Waste Management. *Journal of Management and Sustainability*, 6(4), 88.

[7] Pongráczre, E. (2002). *Defining the concepts of waste and waste management evolving the theory of waste management*. Department of process and environmental engineering, University of Oulu.

[8] Ütebay, B., Çelik, P., Çay, A. (2020). *Textile Wastes: Status and Perspectives, Waste in Textile and Leather Sectors*, Ayşegül Körlü, IntechOpen.

[9] Tojo, N., Kogg, B., Kiørboe, N., Kjær, B., Aalto, K. (2012). *Prevention of Textile Waste Material flows of textiles in three Nordic countries and suggestions on policy instruments*. Nordic Council of Ministers.

[10] Sandin, G., Peters, G.M. (2018). Environmental impact of textile reuse and recycling – A review. *Journal of cleaner production*, 184, 353-365.

Rad primljen: 02.11.2020.
Rad prihvaćen: 18.11.2020.