e-ISSN:2319-9849
p-ISSN:2322-00

Research & Reviews: Journal of Chemistry

Research for Accomplishing Multifunctional Textiles for Emergency Shelters and other Applications

Surdu L*, Radulescu IR and Nicula Ghe

The National Research and Development Institute for Textiles and Leather, Lucretiu Patrascanu, Bucharest, Romania

RESEARCH ARTICLE

Received date: 24/09/2015
Accepted date: 21/10/2015
Published date: 23/10/2015

***For Correspondence**

Surdu L, The National Research and Development Institute for Textiles and Leather, Lucretiu Patrascanu, Bucharest, Romania. Tel: 0040213404928

E-mail: lilioara.surdu@certex.ro

Keywords: Woven fabric, Emergency shelters, Tents, Multifunctional textiles.

ABSTRACT

Modern textile technology comprises accomplishing of innovative high-value added textile products with multi-functional character. For materials manufacturing, the textile products have some substantial advantages, like light-weightiness, flexibility and resistance and this is a reason for producing technical textiles. A research is conducted upon a need of the market. The aim of our research was the manufacturing of several types of woven fabrics from cotton and polyester with special treatments and multi-functional character for various types of destinations: emergency shelters, tents for tourism and leisure etc. This type of fabric has special hydrophobic, fire-proof, anti-microbial and resistance properties and was accomplished by a team of INCDTP.

INTRODUCTION

Technical textiles are a field envisaged by the European strategy, and consist of textile materials with technical applications, in fields like: medicine, industry, safety, agriculture etc. This categories of new high-added value textile products ensemble the good properties of textile materials (light-weightiness, flexibility, resistance) and offer adequate solutions for the specific technical purpose [1-8]. Their implementation on the market has to fulfill both customer needs as well as technological possibilities. Textile producers share an intelligent market and have to compete very hard in order to satisfy the consumer. Various marketing trends are used by textile companies in this competition. We would like to focus upon two of them, highlighting the implementation of a research result into production [9-11].

The Major Complementary Marketing Trends Distinguished (Figure 1):

Technology Push

Market Pull

Technology Push is a strategy of a company to propose for the market the latest technology trends, developed inside the company. Market Pull is a strategy of a company to search upon the latest requirements of the market. Research and development is performed as result of an identified need on the market. Both strategies are relevant for an innovating producer, and we have to take into consideration their concurrence in order to implement research results on the market.

The main research result presented in this paper is a technical textile product, performed after identification of a major need: emergency shelters for distressed people. The sheltering of people in emergency situation like floods, fire or other natural disasters is a very important aspect in national security. The accomplishing of a new, modern solution for this type of problem, offers safety and confidence to distressed people [12-15].

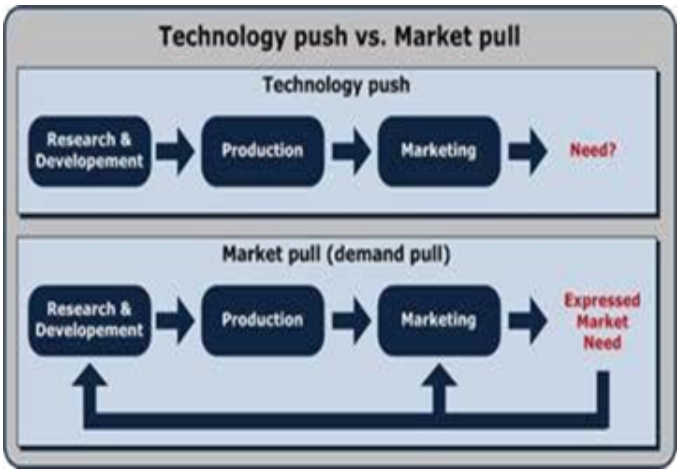

Figure 1. Marketing strategies.

The obtained products consist in a multifunctional woven fabric, having as destination emergency shelters and other applications. The market imposes the following requirements for technical fabrics:

- Fire proof character – for emergency shelters;
- Water proof character – for textile architecture and consumer goods;
- Anti-microbial treatments or combinations of such treatments – for hygienic-sanitary destinations;
- Light coatings – for applications in tourism and leisure.

For this purpose, several woven fabrics, from cotton and polyester have been performed.

The design of the new woven fabrics with destination tents, tarpaulins and textile architectures, aimed reaching the following parameters:

Fabric Mass between

400-450 g/m^2, for cotton fabric;

100-250 g/m^2, for fabrics from Polyester filamentary yarns;

- Breaking force: minimum 300 N;
- Breaking elongation: 20-28%;
- Thickness: 0.3-2.9 mm.

Recommended Finishing: Dyeing Followed By Fire-Proofing Treatment, Hydrophobic Treatment or Coating

The development of equipments and products destined for emergency situations consists in the accomplishing of the following activities:

- Identification of new types of yarns and categories of finishing products, enabling processing by non-conventional weaving;
- Designing and performing of new fabrics destined especially for performing tents for protection in emergency situations, but also for tents with touristic destination;
- Finishing by covering with multi-functional coating, using new generation of finishing products such as NUVA TTC and ethanoic acid [9-13];
- Testing by laboratory investigation of the raw materials, semi-finished materials and finished products.

The production of an innovative technical fabric with multifunctional properties aims to cover a stringent necessity identified in emergency sheltering of distressed people.

EXPERIMENTAL PART

Technological design elements for fabrics structures have been used, multi-functional finishing and treatment (fireproof and hydrophobic), in order to ensure safety elements and comfort for the people in shelters. The technological flow for the accomplishing of new fabrics, destined for tents for sheltering humans, involves the processes in **Figure 2**

The technology flow presented in **Figure 2** is accordingly to the technical possibilities of INCDTP with physical mechanical

parameters specific for tents and shelters. The technical fabrics performed have specific properties destined for satisfying the basic requirements, ensured by raw materials, structure and finishing. Several doubled and twisted yarns from cotton and filamentary yarns from Polyester or Polypropylene have been experimented, on classical and non-conventional weaving machines. The weaving machines used in manufacturing the new types of woven fabrics are the non-conventional weaving machine type SOMET THEMA11 for Polyester yarns and the weaving machine type STB2-216 for cotton yarns **(Figure 3)**.

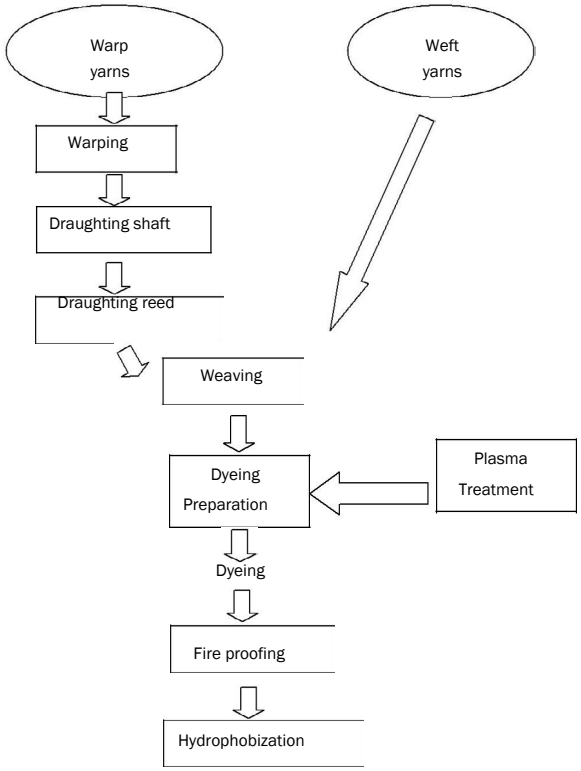

Figure 2. The technology flow for performing fabrics, destined for shelters.

Figure 3. Finishing of the fabrics.

The selected raw materials: cotton twisted yarns Nm20/4 and Nm10/2, processed on the machine STB2-216 and polyester filamentary yarns 80dtex/32f/350z, processed on the machine Somet Thema 11. Three new types of fabrics have been performed within the research activities: woven fabric from 100% twisted cotton yarns (performed on non-conventional weaving machine with micro-shuttle STB 216), woven fabric 100% multi-filamentary Polyester (on the gripper weaving machine SOMET THEMA 11) and a woven fabric from Polypropylene (on a classical weaving machine with shuttle).

The justification for the selection of these raw materials consists in the following specific characteristics.

Cotton Yarns

- Large variety of types and linear density;
- Low cost;
- Good process-ability;
- May be subjected for finishing of the surface by immersion, coating, special finishing;
- Absorption and releasing of humidity, generating the effect of auto-water-proofing in case of the long-drawn contact with water;
- Capable of processing on gripper or shuttle weaving machines, specific for many industrial companies.

Polyester Yarns

- Large variety of types and structures;
- Good tenacity and tear resistance;
- UV resistant;
- Hydrophobic character.

The yarn properties are presented in **Table 1.**

Table 1: Physical-mechanical parameters for Cotton and Polyester yarns.

Yarn type	Nm20/4 Cotton 100%	Nm10/2 Cotton 100%	80dtex/32f/350z PES 100%	167 dtex/144f rotoset PES100%	Standard method
Parameter/measurement unit	V_1 Warp	V_1 Weft	V_2 Warp	V_2 Weft	
Linear density					
dtex (den)	-	-	83.1 (74.8)	168 (151.5)	SR EN ISO 2060/1997
Tex	100.57 × 2	51.4 × 4	-	-	
Nm	9.94/2	19.5/4	-	-	
Breaking force (N)	24.47	30.06	2.64	5.77	SR EN 2062/2010
Breaking elongation (%)	8.31	.	31.96	20.35	SR EN 2062/2010
Twist (tors/m)	339	562	350	-	SR EN ISO 2061/2011
Yarn Twisting (tors/m)	311	306	-	-	SR EN ISO 2061/2011
Diameter (mm)	0.875	0.762	0.25	0.79	SR EN ISO 13152/1993

As consequence of the processing of the raw materials accordingly to the technology flow in **Figure 2**, several types of woven fabrics resulted. In **Table 2**, two of them are described. From the analysis of this data it results that the fabric types obtained within the presents the suitable parameters for performing temporary shelters for emergency situations. A slight increase of the density and compactness with direct effect and the increase of the breaking load can be observed after the finishing process. The decrease of the permeability to minimal values which ensures water-proofing can be also observed.

Table 2. Physical mechanical properties for raw and finished fabrics.

No	Fabric Type		Raw Fabrics		Finished Fabrics	
	Parameter/Measurement Unit		Cotton	Poliéster	Cotton	Poliéster
			100%	100%	100%	100%
			V_1	V_2	V_1	V_2
1	Width (Cm)		130	168.5	121	153
2	Mass On Surface Unit (G/Sqm)		430	130	442	148
3	Density	Warp	105	742	110	808
	No. Yarn /10 Cm	Weft	84	370	96	418
4	Maximal Breaking	Warp	134	973	142	1168
	Force (N)	Weft	129	1145	141	1262
5	Breaking	Warp	28.9	36	31.2	34
	Elongation (%)	Weft	13.59	28.6	17.6	37.8
6	Thickness (Mm)		1.16	0.36	1.21	0.39
7	Air Permeability (L/Sqm/Sec)		400	112	247	95.7

The maintaining of approximately the same values of the finished fabric compared to the raw fabric can be explained by the high level of compactness in the weaving stage. This fact does not permit contraction in wet environment, although the fabric has been finished without tensioning.

The final width of the fabric has been ensured by its free contraction. At the variant performed from polyester fibers, the use of fibers with micro-filamentary yarns has ensured a high level of compactness, stressed by the thermo-fixation operation. The following warping installations have been used for manufacturing the warp **(Table 3)**.

Compactness

Maximal for each linear density of weft yarns used.

The binding chosen is the plain weave for variant (V_1), cotton woven fabric, considered to have the most balanced repartition of the modality for taking over the stresses, the best tear resistance and the best coefficient of filling the blank spaces between

the component yarns. The obtaining of balanced properties on the two directions was envisaged for this variant. The fabrics, presented in **Tables 2** were bleached with bleaching agent "Leucofor E2R" and the fabrics were finished accordingly to technical specification with special finishing agents such as "Nuva TTC and ethanoic acid"

Table 3. Warping installation characteristics.

Type of article Characteristic Raw material	I -130/430	II -150/140
Warp	(V_1) Cotton Nm 10/2	(V_2) PES80dtex/34f/350z
Weft	(V_1) Cotton Nm 20/4	(V_2) PES167/144/rotoset
Number of warp yarns	1260	6375
Draughting	8 shaft. dispersed	right
Draughting order	1. 5. 2. 6. 3. 7. 4. 8	1. 5. 2. 6. 3. 7. 4. 8
Draughting reed	2 yarns	5 yarns
Reed linear density	45 places/10 cm	75 places/10 cm
Binding	Plain weave	Satin

For variant (V_2) from Polyester yarns, the Satin 8/5 binding has been chosen. This fabric has a smooth, glossy aspect and a high capacity for covering the pores. The shiny aspect of the yarns as well as the effect caused by the Satin binding, determines a reduced capacity of water and impurities retention for the front of the fabric, easiness in mounting and plying, reduced volume in the deposition spaces.

This variant is designed especially for the tents of small sizes with especially applications for touristic purposes. The width of the fabric – the fabric has been performed with the width of 140 cm in the reed (V_1) and 170 cm in the reed (V_2). A raw fabric with the width of 130 cm (V_1), which has reached after finishing the width of 120 cm, resulted after weaving. The fabric from Polyester yarns resulted after weaving in of 168 cm (V_2) and reached after finishing the width of 150 cm. These values of the width have been imposed by the width parameter of the machines in the factory (treatments for boiling, dyeing, fireproof finishing, oil repellent finishing) and of matching the confectioning dimensions with minimal losses.

The Technological Parameters used have been chosen accordingly to Physical-Mechanical Properties of the Yarns, as follows:

The warping operation: Both warping variants have been accomplished on the Textima warping machine, by using the following parameters:

- Number of yarns in band: 100; Warping speed: 300 m/min; Warp length: 100 m;
- Cone height: 35 mm;
- Speed for advance: 0,25 mm/rot; Speed for plying: 30 m/min;
- Several specific adjustments regarding the yarn tension and control in the warping process have been performed.

The shaft draughting operation: The preparation of the shaft has been performed manually by verifying and placing on each frame of a number of 1000 lamellar heads with oval orifice.

The order for distributing the yarns was: 1, 5, 2, 6, 3, 7, 4, 8 for V_1 and 1, 2, 3, 4, 5, 6, 7, 8 for V_2, for ensuring a uniform distribution of the stresses.

The reed draughting operation: There was used a manual method and an alternative repartition of 2 yarns in a reed joint (V_1) and 5 yarns in a reed joint (V_2).

This procedure has ensured the desired density. By weaving and contracting as consequence of the finishing treatments, resulted the parameters presented in **Table 2**. For the technological process of weaving, there were used the current devices for mounting the basis warp as well as the devices for controlled tension for the weft yarns. The working parameters of the SOMET weaving machine, such as the order of lifting the healds, the tension in warp and weft, have been introduced on the machine console. At the STB machine there have been performed mechanical adjustments for establishing gauges and replacing changing wheels.

DISCUSSION

After the laboratory tests we have selected the variant named CORTINA, presented in **Table 4.** In order to improve the dyeing fastness and to decrease the temperature of the dyeing bath, the CORTINA fabric was treated with Plasma in the INCDTP laboratory. The laboratory is endowed with a CD Roll-to-roll plasma installation from Euro plasma Belgium. The fabric was treated with Oxygen in order to scour the surface of the cotton material before dyeing and finishing.

Other plasma treatment parameters: Type of gas: Oxygen; Frequency domain: MHz; Power: 50 W; Work pressure: 20 mTorr; Process time: 80 s [1,4,9,10].

For the finishing treatments the fabrics were dyed with specific resistant dyes, specific to both types of raw materials,

followed by coating with Polyurethane. This type of woven fabrics is cleaned after performing of the clothing shelter structure, with water jets and detergents and mechanical or manual brushing.

Table 4. Characteristics of the cotton fabrics type CORTINA.

Characteristics			Value	Reference documents
Mass per unit area		g/m²	430 ± 5	SR EN 12127/2003
Fibrous composition		%	Cotton 100%	SR ISO1833/95
Yarn Density	Warp	(thread/10cm)	350 ± 5	SR EN 1049-2/2000
	Weft		195 ± 3	Method A
Woven fabric thickness		mm	1.24	SR EN ISO 5084/2001
Width		cm	150 ± 3	SR EN 1773/2002
Linear Density of the yarns	Warp	dtex (Nm)	37.4 × 2 (26.7/2)	SR EN ISO 2060:2010
	Weft	dtex (Nm)	50.0 × 3(20/3)	Method B
Breaking force	Warp	N	1235	SR EN ISO 13934-1/2002
	Weft		1270	
Breaking Elongation	Warp	%	16.41	
	Weft		11.67	
Air permeability		(l/m²/s)	97.22	SR EN ISO 9237/1999
Water permeability		%	31.9	SR 9005/1979
Abrasion resistance of fabrics		No. abrasion cycle	49000	SR EN ISO 12947-2/2002
Dimensional modifications to washing 40°C	Warp	%	-3.7	SR EN ISO 5077/2008
	Weft		-3	
Dimensional modifications to hot air 210°C	Warp	%	-3.7	INCDTP METHOD
	Weft		-2.3	
Thermic conductivity		W/mK	0.0414	INCDTP METHOD
Thermic resistance		m² K/W	0.0233	SR EN 31092 (ISO 11092)
Resistance to water vapor		m² Pa/W	4.85	SR EN 31092 (ISO 11092)

The drying is performed by exposure to hot atmospheric air or in hot rooms. In order to obtain a good cleaning effect, the surface of the fabric has to be smooth and flat and the treatments should be compatible with used detergents. Light resistant colorants will be used in the finishing process. Toxic or dangerous products will not be used in the finishing or cleaning process. The fabric was also treated for hydrophobic, fireproofing and anti-microbial properties. The following finishing agents were used for this purpose **(Table 5)**:

Table 5. Special finishing agents.

Special property	Applied finishing agent
Hydrophobic character	Evo Protect FSV
Fireproofing	Flamentin APF
Anti-microbial	Eosy / Unitika

The hydrophobic effect of the multifunctional fabric CORTINA was evidenced by contact angle determination.

We can see in the following pictures the high hydrophobic property of this fabric and the table with contact angles **(Figure 4) (Table 6).**

Figure 4. Contact angle images.

Table 6. Contact Angle values.

	Measurement 1	Measurement 2	Measurement 3	Average
Left Angle	148.60°	139.30°	142.10°	143.33°
Right Angle	147.90°	136.70°	141.40°	142.00°

The average contact angle of 143.33°/142.00° proves a very good hydrophobic character.

CONCLUSIONS

Multifunctional fabrics have been performed within this research activity with destination temporary shelters for emergency

situations and tents for tourism and leisure. Technological elements for designing woven structures, finishing and multifunctional treatment (fire proof, hydrophobic and anti-microbial) have been used with the purpose of ensuring safety and comfort.

Several Aspects have been Complied in order to Manufacture these Fabrics

- The dimensional calculation of the fabric has been performed accordingly to the "mass" parameter.
- The densities have been correlated with the reed linear density of the weaving machine STB 2-216 (45/10) and Somet Thema 11 (75/10) as well as with the apparently diameter of the selected yarns, such as d= 0.875 mm for Nm 10/2, d=0.25 mm for yarn with linear density=80 dtex).
- Before the finishing process the fabric surface have been activated and cleaned in the Plasma installation Roll-to-roll from INCDTP laboratory **(Figure 5).**

Figure 5. Shelter for emergency situations.

Technical fabrics with specific properties destined for satisfying technical and social requirements, have been characterized by the parameters of raw materials, structure and finishing. The finishing ensures water proofing, fire proofing and/or anti-microbial properties.

New technologies have been also experimented: processing of doubled and twisted yarns or of filamentary yarns, by using machines and equipment with high productivity. In consequence, for the diversification of multifunctional technical textiles, the purpose was to produce superior properties regarding tear, proofing and resistance to changing weather conditions. These properties are mandatory for performing of constructions destined for the protection of people.

New possibilities of plasma treatment have been identified: coating, hydrophobic, anti-microbial treatments or combinations, for the durable effect on technical fabrics. After the finishing treatment, the fabrics have been investigated on modern equipment in the INCDTP laboratory and it has been accomplished a shelter for emergency situations. The material has been tested in continuously utilization conditions and no visible degradations of the material has been observed. The parameters obtained in the laboratory investigation do not show significant depreciation of the main physical-mechanical characteristics. A tent as functional model has been exposed to air at atmospheric conditions in Bucharest. Periodically, at an interval of 30 days, the cleaning of the tent has been performed, with water jets and specialized textile detergents.

This textile product is a research result in the field of technical textiles and it covers an important application: sheltering people in emergency situations. For the new characteristics of the fabric a patent request was issued. The new textile product is a consequence of both technology push and market pull. Its benefits have been largely disseminated in the textile industry field.

REFERENCES

1. Surdu L, Rădulescu LR, Ghituleasa C, Cioara L. Research Regarding Multifunctional Textiles Performed With Plasma Nanotechnology. J Chem Chem Eng 2013; 7: 637-642.
2. Sarmadi M. Advantages and Disadvantages of Plasma Treatment of Textile Materials. 21st International Symposium on Plasma Chemistry. Queensland, Australia.
3. Cho K. Cho K, Setsuhara Y. Investigations on Plasma Interactions with Soft Materials for Fabrication of Flexible Devices. Journal of High Temperature Society 2012; 37: 289-297.
4. Surdu L, Cioara L, Ghituleasa C, Rădulescu IR. Research Regarding the Plasma Hydrophobization of Textile Materials for Medical Article. Proceeding of the 14th Romanian Textiles and Leather Conference, Sinaia, Romania.
5. Abdrabboa HM. Treatment of Polylactic Acid Fibre using Low Temperature Plasma and its Effects on Vertical Wicking and Surface Characteristics. Journal of the Textile Institute 2013; 104: 28-34.
6. Shishoo R. Plasma Technologies for Textiles. In the Textile Institute and Woodhead Publishing Limited: Cambridge
7. Wang S, Hou W, Wei L, Jia H, Liu X, et al. Antibacterial activity of nano-SiO_2 antibacterial agent grafted on wool surface. Surface and Coatings Technology 2007; 202: 460-465.

8. Alexander Fridman. Plasma Chemistry. Cambridge University Press, Cambridge 2008; 648-653.

9. Surdu L, Cioara L, Ghituleasa C, Rădulescu IR, et al. Plasma Nanotechnology Finishing Methods for Fabrics used in Barrier Surgical Gowns. Poster 26/6th Aachen-Dresden International Textile Conference, 2012.

10. Surdu L, Cioara L, Ghituleasa C, Rădulescu IR, et al. Research Regarding Plasma Nanotechnology Application for Performing Surgical Gowns. Proceeding of the 5th Textile International Conference, Bucharest, Romania, 2012.

11. Surdu L, Cioara L, Ghituleasa C, Ion Răzvan Rădulescu et al. Comfort Properties of Multi-Layer Textile Materials for Clothing. Industria Textila Nr. 2013; 2: 75-79.

12. Loghin C, Mureşan R, Ursache M, Mureşan, A. Surface Treatments Applied To Textile Materials And Effects In Wet Environment. Industria Textila.

13. Radulescu IR, Surdu L, Cioară L, Ghituleasa C, Gheorghe N, et al. Multifunctional Woven Fabrics For Urgency Shelters. 6th Texteh International Conference 2013, Bucharest, Romania.

14. Subțirică A, Taskoparan F, Dorogan A, Ghițuleasa C, Vameşu M, et al. Evaluation of the Color Fastness Properties of Denim Garments Dyed with Natural Vegetable Dyes" Texteh 6th International Conference 2013, Proceedings, Bucharest, Romania.

15. Radulescu IR, Surdu L, Cioară L, Ghituleasa C, Gheorghe. Controlling Instruments For Companies In The Textile Industry. Technical Textiles Present And Future Symposium 2013, Iasi, Romania.