WP T2 – INNOVATION ON TEXTILE WASTE MANAGEMENT

ACTIVITY A.T2.3 PILOT CASES

D.T2.3.3

Pilot Cases Techical Report

Partner:

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CONTENT

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ENTeR – Expert Network on Textile Recycling

ENTeR works in five central European countries that are involved in the textile business, to promote innovative solutions for waste management that will result in a circular economy approach to making textiles.

The project will help to accelerate collaboration among the involved textile territories, promoting a joint offer of innovative services by the main local research centres and business associations ("virtual centre"), involving also public stakeholders in defining a strategic agenda and related action plan, in order to link and drive the circular economy consideration and strategic actions.

The approach of the proposal and the cooperation between the partners is oriented to the management and optimization of waste, in a Life Cycle Design (or Ecodesign) perspective.

1. Pilot case - production of recycled aramid yarn from pre-consumer professional garments

1.1. Introduction

The aim of the present pilot case is to implement a practical excercise of recovery, recycle and reuse in the field of professional flame-retardant workwear, in order to analyse the technical and economical feasibility of the process.

This study covers only a part, though the most significant, of a whole circular supply chain in the specific industrial sector. In fact we have started from pre-consumer (or post-industrial) garments and the final output is the resulting recycled yarn. The upstream supply flow in case of post-consumer apparel (including sanitization) and the downstream flow from yarn to fabric and new garment have not been considered in this pilot case (see Annex 1)

Two different materials sources have been taken into account, with the objective of having different situations in relation with composition and structure of the garments. In particular the aim is to obtain a recycled yarn in original blue color for CASE A and a multicolor (millefiori) yarn for CASE B.

1.2. The starting point

The following garments have been utilized for the pilot case:

1. CASE A: N. 15 complete “non operational” uniforms (jacket+ trousers) of firefighters with the following characteristics:
   a) Composition: 70% meta-aramide – 28 % viscose FR – 2% antistatic
   b) Total weight: 16,7 Kg
   c) Color: navy blue
   d) Simple structure, no linings, limited number of accessories (reflective tapes, zips, buttons, hook and loops, embroideries and labels)

2. CASE B: N. 26 trousers and “salopettes” of forest fireguards with the following characteristics:
   a) Composition:
      i. outer layer: 93% meta-aramide – 5% para-aramide – 2% antistatic
      ii. inner layer: 50% preox – 25% meta-aramide – 25% viscose FR + PU membrane
   b) Total weight: 34,8 Kg
   c) Color: Outer layer orange and blue, inner layers black
   d) Complex structure, with two main layers, waterproof breathable membrane, large number of accessories (elastic tapes, reflective tapes, zips, buttons, hook and loops and labels)

The above garments came from the warehouses of the two suppliers, before being sold to customers and therefore in a pre-consumer status.

1.3. The dismantling phase

The garments have been shipped by courier – no particular precaution needed for pre-consumer apparel – to the selected dismantling platform, a "cooperativa sociale" in Biella area.

Even if not necessary for this operation with pre-consumer garments, this structure is entitled to have the authorization for storage and treatment of waste, including the sanitizing process that they outsource in a specialized plant.

Therefore, the same platform could be exploited in a future case of post-consumer garments.

Before proceeding to the dismantling operation, the selection criteria have been agreed, which means which parts of the garments had to be kept for the recovery and which parts had to be put apart, because not relevant for the purpose of the project. In particular:

- CASE A (qty per uniform):
  - 5 reflective tapes
  - 3 buttons
  - 8 zips
  - 2 woven labels
  - 2 embroideries
  - 36 hook and loops
  - 4 plastic hook

- CASE B (qty per trouser/salopette):
  - 2/6 reflective tapes
  - 4/26 buttons
  - 1/1 woven labels
  - 14/14 hook and loops
  - 1/1 elastic tapes
  - PU membrane

The dismantling and selection has been conducted manually.

As a result of the dismantling phase, we have recorded different situations in terms of yield between CASE A an CASE B, as we could expect by the structure of the respective garments.

A mass balance for both cases is reported in Annex 2.

After a preliminary qualitative check with Filatura di Soprana, the materials for recover have been eventually separated, prepared and shipped to the fraying unit for the second step of the pilot case.

The disregarded material has been put apart and considered as waste to be treated. This is a simplification for the purpose of the pilot case. As a matter of fact a more detailed analysis of potential further recovery is to be considered.

1.4. The fraying

Fraying is a specific mechanical operation in which a fabric or, such as in the present pilot case, part of a garment, is treated and transformed back into fibers and yarns.

The main challenge in the pilot case has been to verify that part of garments, which were not completely unsewn, such as sleeves or trousers legs, could have been treated without a preliminary cutting operation during the dismantling phase. As a matter of fact, no particular issues have been encountered.

For CASE A a lab/pilot fraying machine has been utilized, due to the reduced weight of the input material, while for CASE B the volume to be treated was enough to feed the industrial fraying unit.

As expected, we have recorded a low yield (80%) of the fraying operation because of the limited material quantity. Based on experience, this value could be easily improved up to a standard 94% in case of industrial quantities (> 500 Kg per batch).

The mass balance in Annex 2 highlights the impact of the fraying for both cases.

The fraying operation has been set up in a third part company under the technical control of Filatura di Soprana.

1.5. The garnetting

In case of reclaiming woven fabrics from garments, as it is the case for the present project, fraying operation is not sufficient to prepare a proper material to feed the carding machine and the consequent spinning. An additional treatment is needed to open and equalize the fibers through a garnett machine.

The materials issued from fraying have been consequently prepared and shipped to the garnetting unit for the third step of the pilot case.

As expected, also the garnetting phase has suffered low yield due to the reduced amount of treated material (waste is 32% for CASE A and 37% for CASE B), but, according to the material quality and the industrial experience, a standard yield of 88% could be easily reached in case of standard volumes (> 500 Kg per batch).

The mass balance in Annex 2 highlights the impact of the garnetting for both cases.

The garnetting operation has been set up in a third part company under the technical control of Filatura di Soprana.

1.6. Carding and spinning

The materials issued from garnetting have been consequently prepared and shipped to the spinning unit in Filatura di Soprana for the third step of the pilot case.

Carding and spinning is the core process for the production of a recycled yarn.

A preparation phase is needed, where the raw material coming from the garnetting is blended and homogenized with a targeted quantity of original staple and/or recovered laps in order to assure a regular quality and reliable textile characteristics of the resulting spun yarn.

For both cases of the pilot project a final count of Nm 14/1 has been targeted for the resulting spun yarns. As a consequence, the following blends have been prepared:

CASE A: 50% material from garnetting – 50 % recovered laps, navy blue dyed 100% meta-aramide

CASE B: 70% material from garnetting – 30% original staple fiber 100% meta-aramide greige

In both cases the carding and spinning process has run smoothly, with no significant issues in the machines.

The only remark is once more linked to the small quantities that have led to poor yields, as shown in the mass balance in Annex 2. This situation was however totally expected, and not particularly worrying if we consider an upscale to industrial trial size.

For what concerns CASE A, it has been chosen to blend the recovered raw material with laps in a 50/50% proportion, which means probably a worse case in terms of visual quality of the final spun yarn. An alternative route with a 70/30% blend with original dyed staple fiber should be recommended for a new trial with more significant volume to be handled.

The output from the spinning line is the final product of the pilot case.

We have consequently two yarn types (CASE A and CASE B), whose technical characteristics are reported in Annex 3.

In Annex 4, the final mass balance for both cases are reported, as well as the cost structure by phase and as a whole process.

2. Main deliverables

Positive outcomes:

a. from both cases we have been able to run the different steps of the process

- dismantling and selection
- fraying
- garnetting
- carding and spinning

b. from both cases the resulting recycled yarns have acceptable technical characteristics (TDS will follow in few days) for a re-use as yarn for textile structures (knitting or weft for weaving)

c. from CASE B the output material from garnetting is also suitable for non woven application (felt)

d. despite the limited quantity of material, we are able to make a reasonable estimate of a mass balance of the whole process on larger industrial scale

Negative outcomes:

a. quantity of treated material was too small to get a reliable mass balance for the pilot case itself (but, see above d.)

b. as a consequence, the waste material in each step has been very high with misleading effects on economic outputs of the pilot case itself

c. in particular for CASE A. the quality of the final recycled yarn should definitely be improved by using a “virgin” staple in the blend with recovered fibre instead of laps

3. Conclusion

It has been a very interesting excercise that encourages a further step in the direction of a “circular” supply chain for PPE (Personal Protective Equipment).

There are concrete opportunities to consider the dismissed fire-retardant uniforms as a valuable source for recycling high added value fibres, such as aramids.

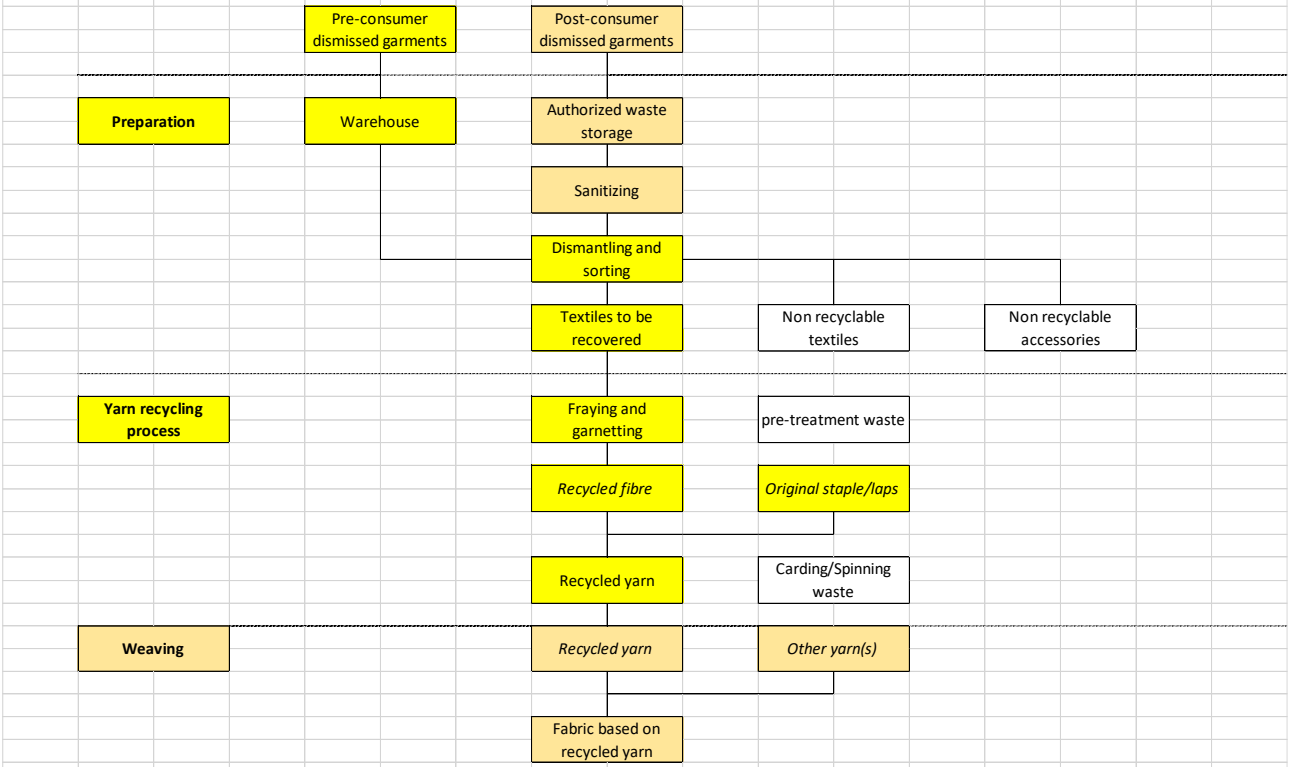
The design of the garments plays a relevant role in terms of economical impact on the recycling process. The higher the number of different components, ingredient materials and garment complexity, the lower is the process yield. It is clear that in this field the technical and protection performance is THE priority, but there should be room for improvement at design stage in order to get more benefits in recovering-recycling-reusing.

4. Annex 1

Annex 1

PILOT CASE - PRODUCTION OF RECYCLED ARAMID YARN FROM PRE-CONSUMER PROFESSIONAL GARMENTS

EXAMPLE OF RECOVER / RECYCLE / REUSE PROCESS



5. Annex 2

Annex 2

PILOT CASE - PRODUCTION OF RECYCLED ARAMID YARN FROM PRE-CONSUMER PROFESSIONAL GARMENTS

MASS BALANCE

		pilot project - real figures				pilot project - estimate industrial scenario			
		CASE A	**% vs. tot.**	**CASE B**	**% vs. tot.**	**CASE A**	**% vs. tot.**	**CASE B**	**% vs. tot.**
		Kg	*%*	Kg	*%*	Kg	*%*	Kg	*%*
	TOTAL INPUT	**16,7**	***100%***	**34,8**	***100%***	**1000**	***100%***	**1000**	***100%***
DISMANTLING AND SELECTION	**outer layer**	**15,2**	***91%***	**8,2**	***24%***	**910**	***91%***	**236**	***24%***
	inner layer			**12,2**	***35%***			**351**	***35%***
	PU membrane			2,9	*8%*			84	*8%*
	accessories (h&l, zips, buttons, labels,...)	1,5	*9%*	11,5	*33%*	90	*9%*	330	*33%*
FRAYING	**input**	**15,2**	***100%***	**20,4**	***100%***	**910**	***100%***	**586**	***100%***
	waste	3	*20%*	4	*20%*	55	*6%*	35	*6%*
	output	**12,2**	***80%***	**16,4**	***80%***	**855**	***94%***	**551**	***94%***
GARNETTING	**input**	**12,2**	***100%***	**16,4**	***100%***	**855**	***100%***	**551**	***100%***
	waste	4,2	*34%*	6	*37%*	100	*12%*	65	*12%*
	output	**8**	***66%***	**10,4**	***63%***	**755**	***88%***	**486**	***88%***
CARDING AND SPINNING	input recycled material	**8**		**10,4**		**755**	***70%***	**486**	***70%***
	input staple/laps	3,5	*30%*	4,5	*30%*	330	*30%*	210	*30%*
	total input blend	**11,5**		**14,9**		**1085**		**696**	
	waste	4,5	*39%*	2,4	*16%*	109	*10%*	70	*10%*
	TOTAL OUTPUT	**7**		**12,5**		**977**		**627**	

6. Annex 3

Annex 3

PILOT CASE - PRODUCTION OF RECYCLED ARAMID YARN FROM PRE-CONSUMER PROFESSIONAL GARMENTS

TECHNICAL SHEETS OF RESULTING RECYCLED YARNS

YARN SPECIFICATION	SOPRANA FILATI E TESSUTI TECNICI
MV161-BL (CASE A)	

ARTICLE
Nm 16/1 , 84% meta-aramid - 10% viscose FR - 2% antistatic - 4% other fibers, blue
COMPOSITION
50% recycled fiber from pre-consumer garments (pompiers marins) 70% meta/28% Vi FR/2% AS navy blue - 50% laps 100% meta-aramide blue dyed

SPECIFICATIONS

	Unit	Standard	Mean value	Notes
Yarn Count	Nm	UNI EN ISO 2060:1997	1/16	
Yarn Count	Tex	UNI EN ISO 2060:1997	63,8	
Twist	t/min		370	
Tenacity	cN/tex	UNI EN ISO 2060:2010	6,4	
Elongation	%	UNI EN ISO 2060:2010	6,5	
.....				
.....				

COMMENTS

The data listed above refer to a pilot production carried out starting from 15 complete uniforms (jacket and trousers) for a total of 16.7 kg initial. The characteristics are to be considered as preliminary and aimed solely at demonstrating the feasibility of a complete production process of regenerated yarn starting from the finished pre-consumer garment. For a definitive validation on the yarn, a test with about 200 kg of fabric (or garments to be dismantled) would be necessary

	Name	Date	Signature
Filatura di Soprana	Catia Pollon	12.01.2021	

YARN SPECIFICATION	SOPRANA FILATI E TESSUTI TECNICI
MV171-MF (CASE B)	

ARTICLE
Nm 17/1 , 66% meta-aramid - 16% cotton - 7% viscose FR - 11% other fibers , multicolor
COMPOSITION
70% recycled fiber from pre-consumer garments (fireguard uniforms) 52% meta/30% preox/15% Vi FR - 30% 100% meta-aramide staple greige

SPECIFICATIONS

	Unit	Standard	Mean value	Notes
Yarn Count	Nm	UNI EN ISO 2060:1997	1/17	
Yarn Count	Tex	UNI EN ISO 2060:1997	58,9	
Twist	t/min		400	
Tenacity	cN/tex	UNI EN ISO 2060:2010	9,3	
Elongation	%	UNI EN ISO 2060:2010	8,4	
.....				
.....				

COMMENTS

The data listed above refer to a pilot production carried out starting from 26 trousers for a total of 34,8 kg initial. The characteristics are to be considered as preliminary and aimed solely at demonstrating the feasibility of a complete production process of regenerated yarn starting from the finished pre-consumer garment. For a definitive validation on the yarn, a test with about 200 kg of fabric (or garments to be dismantled) would be necessary

	Name	Date	Signature
Filatura di Soprana	Catia Pollon	12.01.2021	

7. Annex 4

Annex 4 - Mass balance and cost structure CASE A