TEXTILE RECYCLING AT RISE IVF

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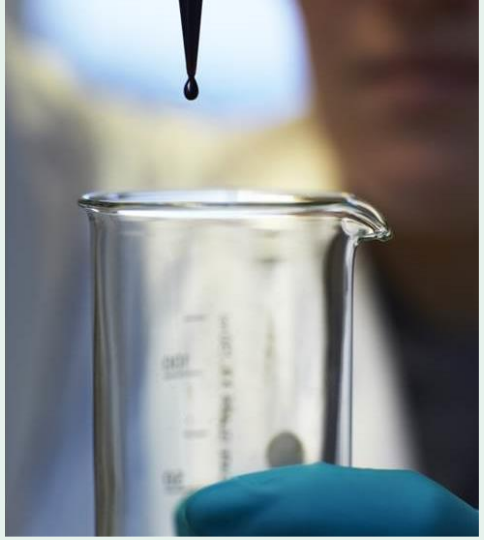
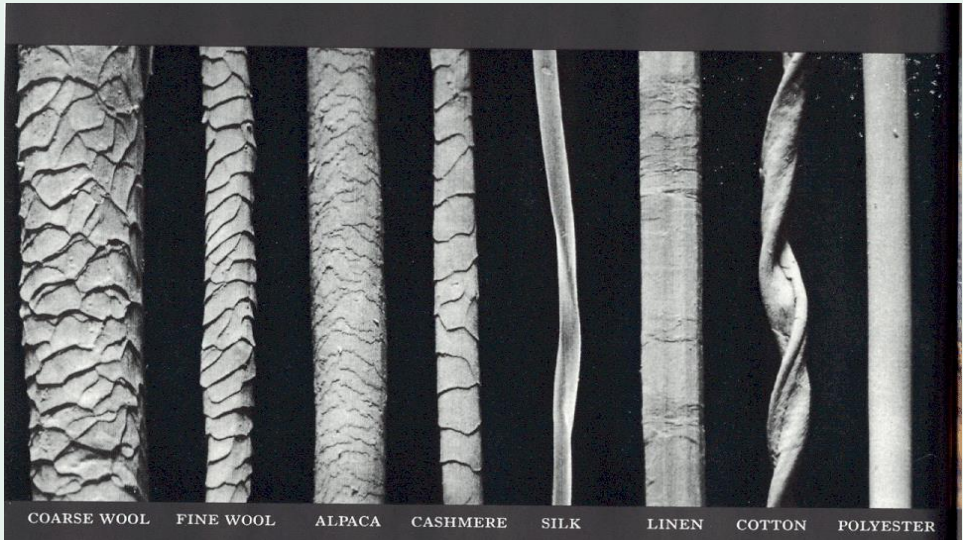
7 november 2019

Research Institutes of Sweden
MATERIAL & PRODUKTION
TEXTIL





RISE in brief

- Research Institute present across the whole of Sweden. And beyond.
- 2,700 employees, 30 % with a PhD.
- Turnover approx. SEK 2.7 billion (2017).
- A large proportion of customers are SME clients, accounting for approx. 30 % industry turnover.
- Runs 100s of test and demonstration facilities, open for industry, SMEs, universities and institutes (RISE is owner and partner in 60 % of all Sweden's T&D facilities).

Large innovation focus on Textile Recycling in Sweden

208 tonnes of textiles discarded daily. More than half of this is estimated to be suitable for reuse or recycling.

First activities addressed technology development for recycling. Now expanded to system development issues.

- Very complex feedstock
- Information needed for efficient recycling
- Chemical content seen as important issue

”

…EPR for textiles will be implemented.

Possible routes to significantly increase reuse and recycling will be sought, involving the textile industry and non-profit organizations”

January-agreement, Swedish Government 2019

Circular Economy Package –
adopted 2018

- Textiles shall be collected separately in all Member States by 2025
- The European Parliament has for years advocated re-use and recycling of textile materials
- By 2024, the EC must consider wether targets for textile re-use and recycling should be introduced

Recent Swedish initiatives

- Re:newcell
- Re:Textile, F/ACT Movement
- Testbed for Textile Recycling
- WargöTex
- SIPTex
- ENTIS
- Classification and risk assessment of textiles for recycling
- Advocacy platforms
- Mistra Future Fashion
- Tex.IT
- Wargön sorting pilot
- Textile & Fashion 2030
- Trash-2-Cash
- Projects on chemicals substitution and micro fibre release

Pure cotton regeneration,
man-made cellulose

PES repolymerisation

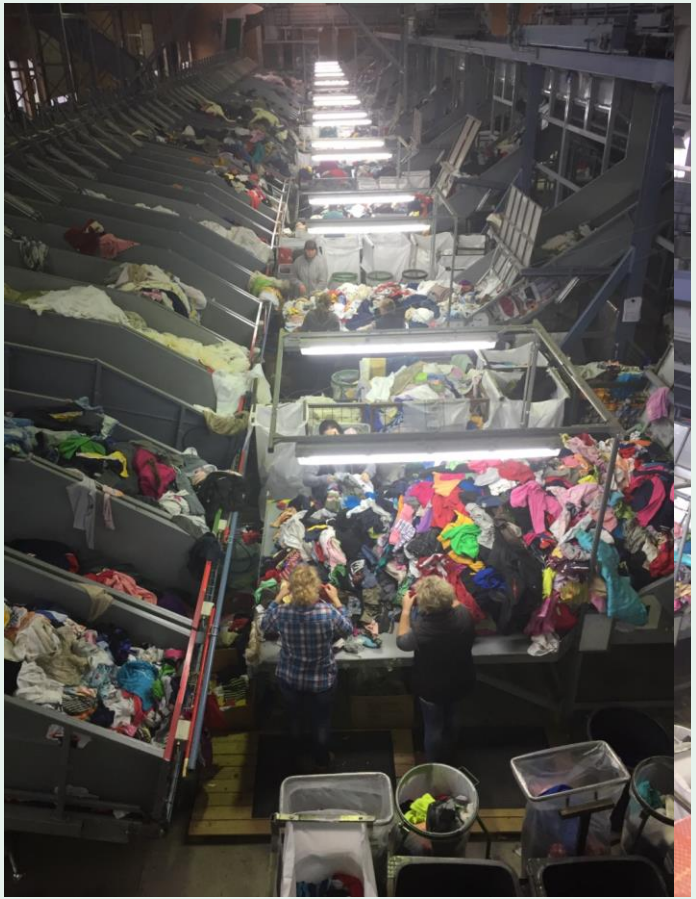
PA repolymerisation
and remelt

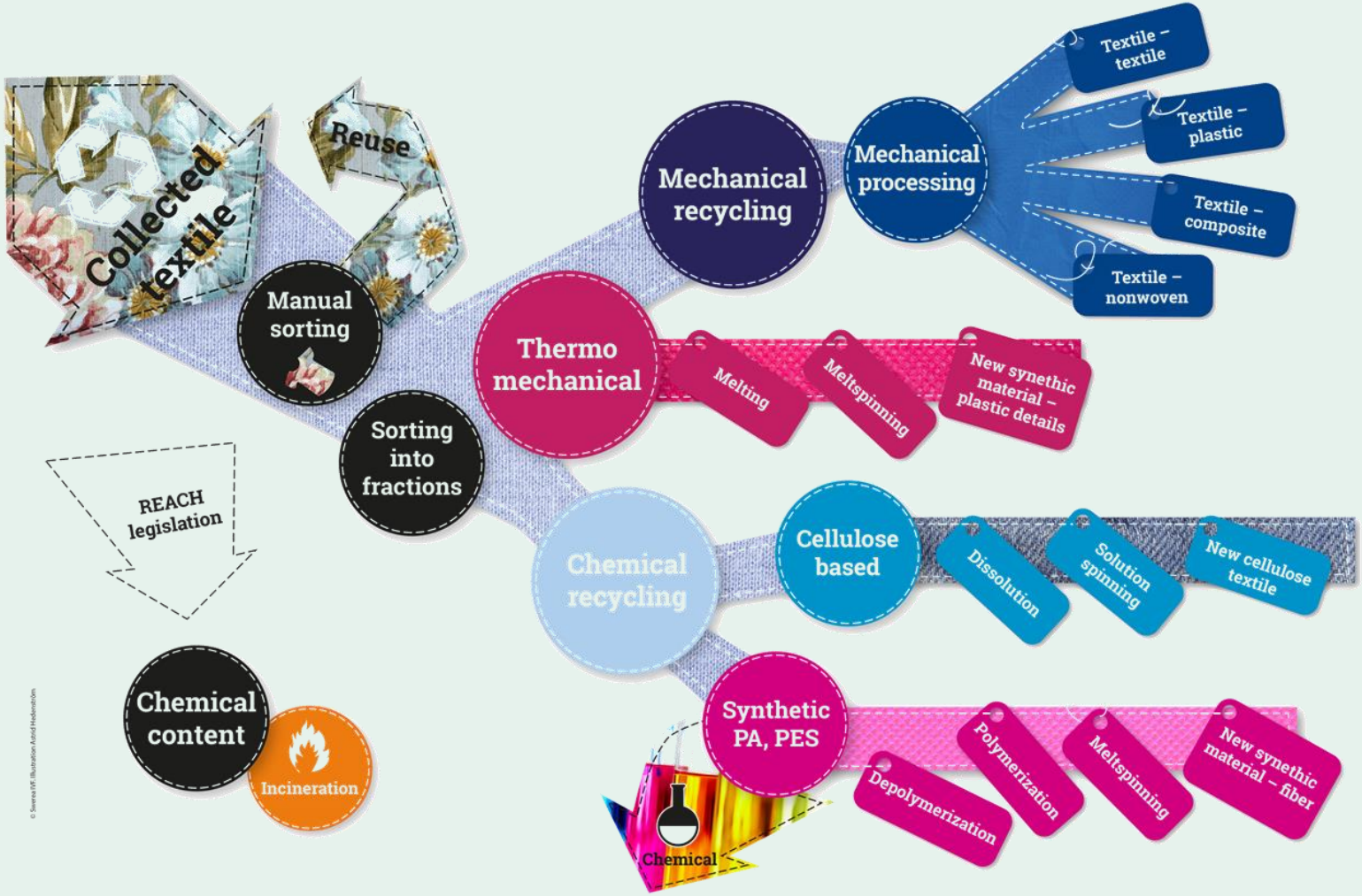
Textile-to-textile
Textile-to-nonwoven
Textile-to-polymer
Textile-to-composite
Textile-to-chemicals

Incineration
- low quality
- chemical content

The reality

This facility handles 50 tonnes daily of textiles collected in several european countries

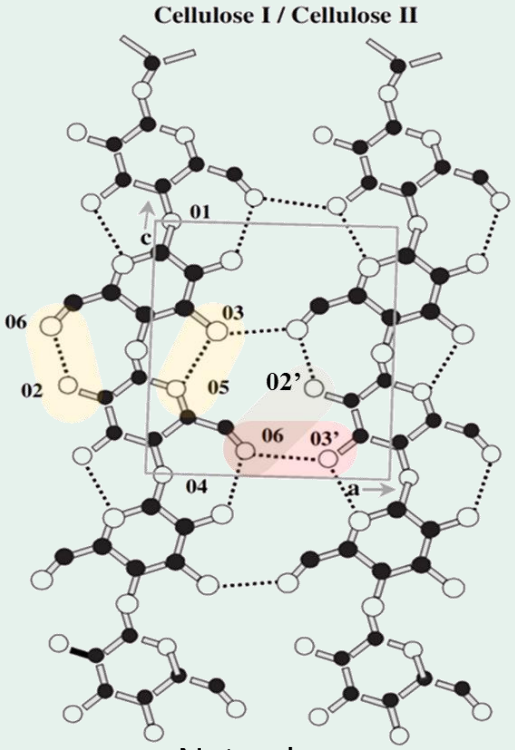



Collected textile
Reuse
Manual sorting
Sorting into fractions
REACH legislation
Chemical content
Incineration
Mechanical recycling
Mechanical processing
Textile – textile
Textile – plastic
Textile – composite
Textile – nonwoven
Thermo mechanical
Melting
Meltspinning
New synethic material – plastic details
Chemical recycling
Cellulose based
Dissolution
Solution spinning
New cellulose textile
Synthetic PA, PES
Chemical
Depolymerization
Polymerization
Meltspinning
New synethic material – fiber

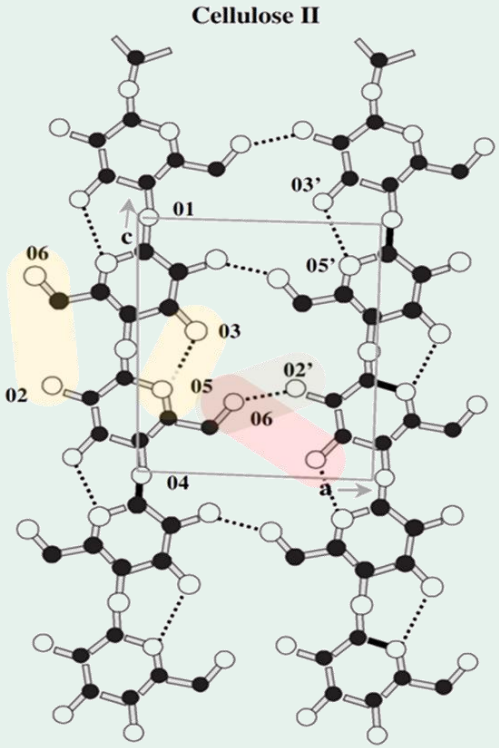
Cotton Recycling

- Only mechanical recycling can retain the fibres as cotton. Chemical recycling yields other fibre types
- Two major processes for regenerated cellulose – viscose process (viscose, modal) and lyocell process (tencel)
- Man made cellulose fibres are today produced from wood (or bamboo). Future potential for recycled feedstock.
- Fast, material specific sorting of collected textiles needed for efficcient recycling

Different crystal structures



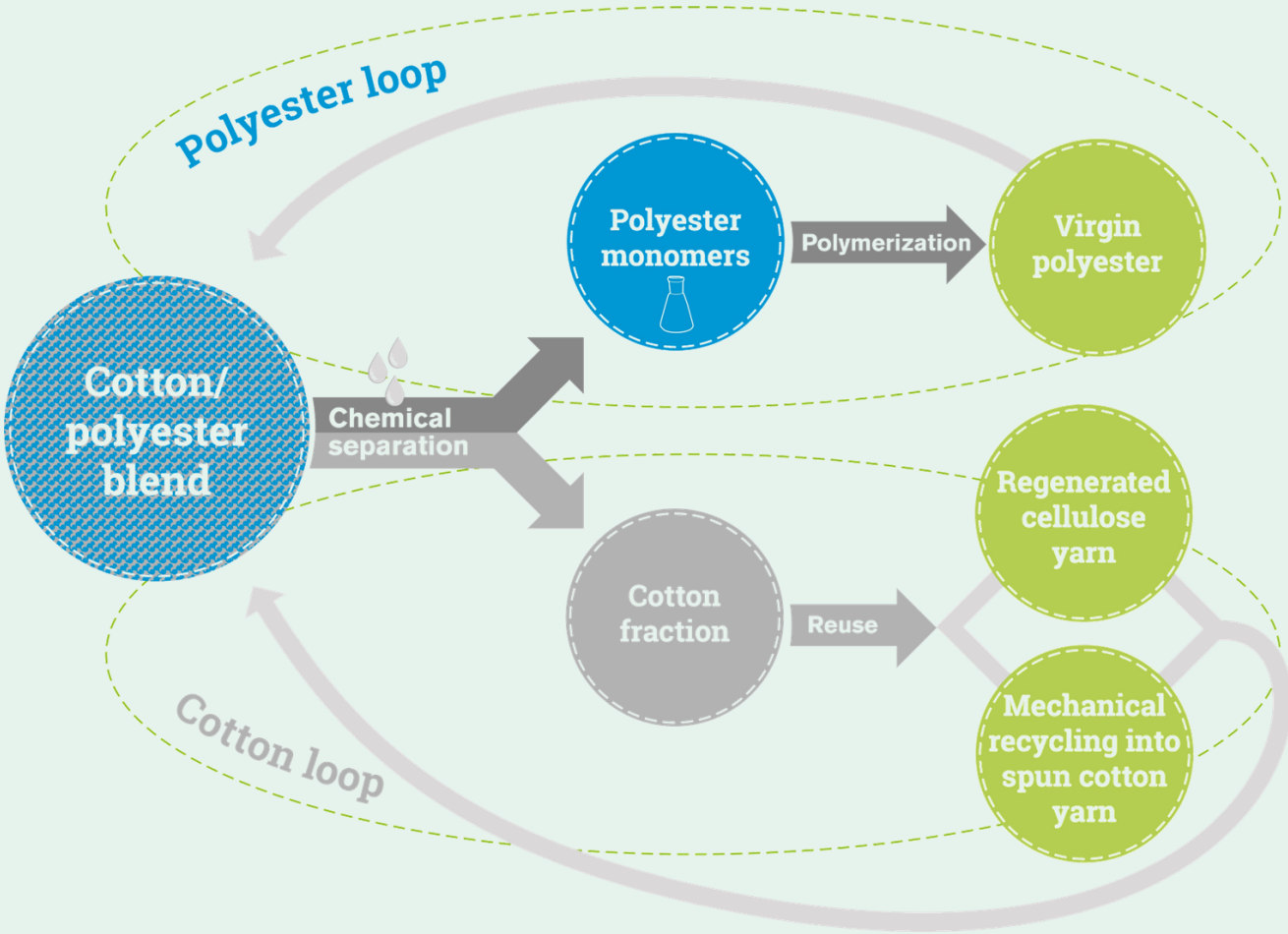
Natural



Regenererated

Mechanical recycling of textiles

- Chemical profile of feedstock
- Fibertype/fibre mix, i.e synthetic vs natural fibre and lycra content
- Construction - woven and knitted materials are very different to process
- Colour!



Global Change Award
AN INNOVATION CHALLENGE BY H&M FOUNDATION
Winner 2018

Influence of chemicals / dyestuff

Dispersive Red 4

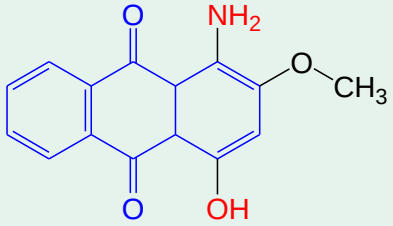
Dispersive Red 19

Dispersive Red 60

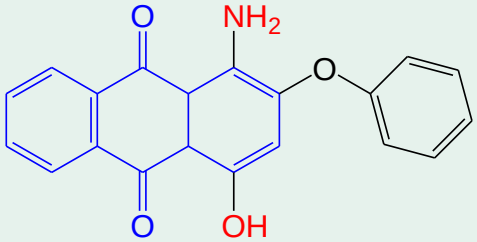
Dispersive Red 153

Health, environment & processes

Anthraquinone

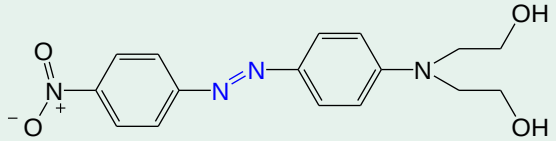


Dispersive Red 4

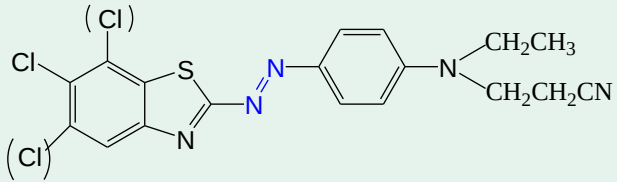


Dispersive red 60

Azo

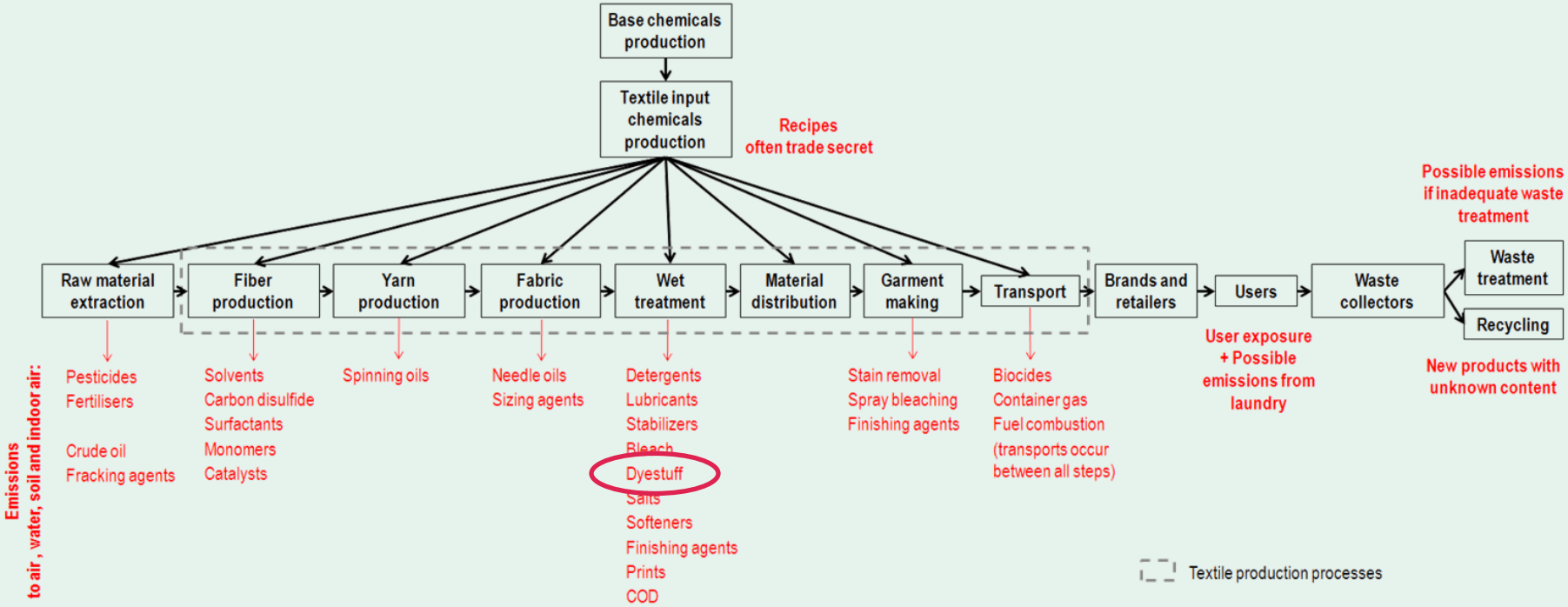


Dispersive Red 19

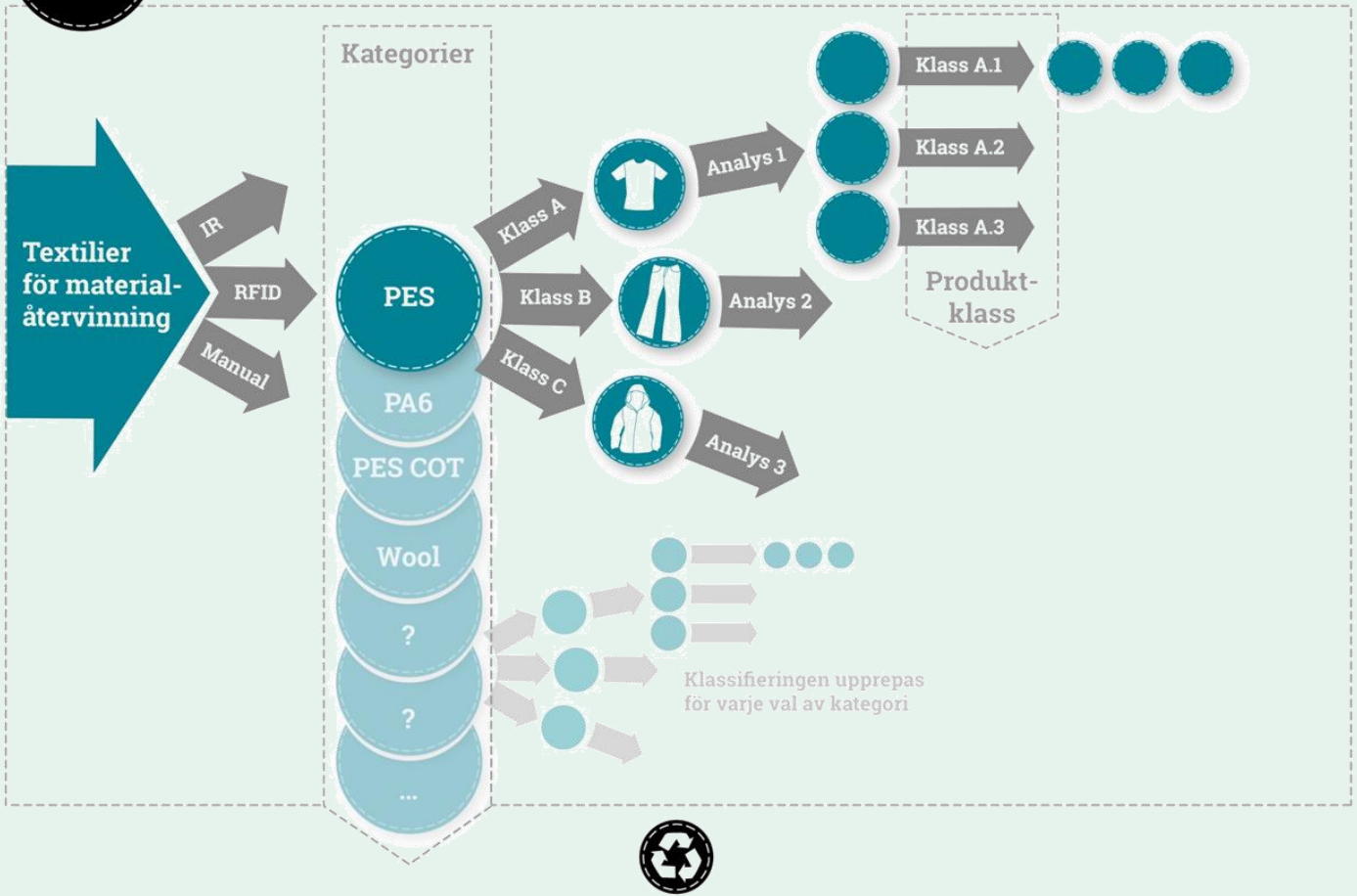


Dispersive Red 153

Chemical use in the textile value chain



Classification and risk assessment of textiles for recycling



Chemical analyses

Polyester

- APEO and AP
- Dimethyl fumarate
- PFC´s (OEKO-TEX version 1.0)
- Allergenic disperse dyes
- Arylamines derived from azo colorants
- Chlorinated benzenes and toluenes
- XRF screening – Pb, Cd, Ni, Cr, Br, Hg, Sb, Ti, Cl

Cotton

- All the above analysis except Chlorinated benzenes and toluenes
- Organic tin compounds
- Chlorinated phenols

Polycotton and Polyamide

- All the above analysis
- PAH

Results – Polyester – APEO (OEKO-TEX limit value NPEO - 100 mg/kg)

Test Material	$NP(EO)_{1-20}$	$OP(EO)_{1-20}$	4-nonylfenol	4-oktylfenol	4-pentylfenol	4-heptylfenol
1	**7.9 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
1	**6.2 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
1	**6.5 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
2	**33 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
2	**27 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
2	**32 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
3	**18 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
3	**15 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
3	**16 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg

Results Cotton – APEO (OEKO-TEX limit value NPEO - 100 mg/kg)

Test material	$NP(EO)_{1-20}$	$OP(EO)_{1-20}$	4-nonylfenol	4-oktylfenol	4-pentylfenol	4-heptylfenol
1a T-shirts/ hoodies	< 20 mg/kg	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
1b	< 20 mg/kg	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
1c	< 20 mg/kg	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
2a Sheets	< 20 mg/kg	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
2b	< 20 mg/kg	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
2c	< 20 mg/kg	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
3a Shirts	< 20 mg/kg	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
3b	< 20 mg/kg	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
3c	**35 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
4a jeans	**36 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
4b	**36 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg
4c	**44 mg/kg**	< 20 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg	< 5 mg/kg

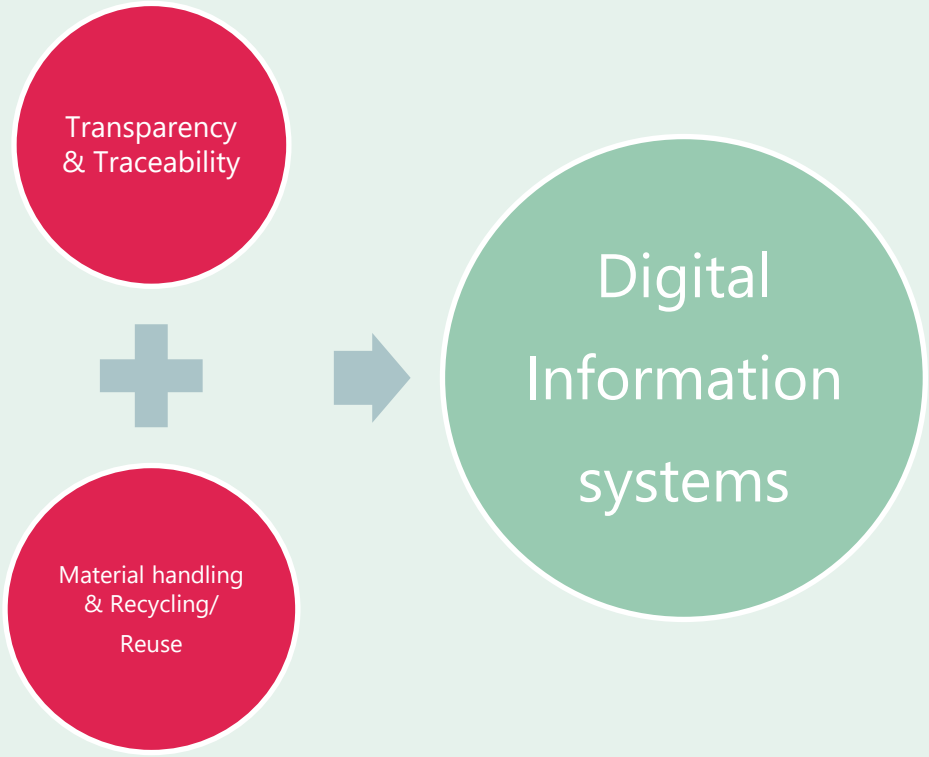
Categorization of recycled feedstock

How should a future recycled feedstock be specified and categorized?

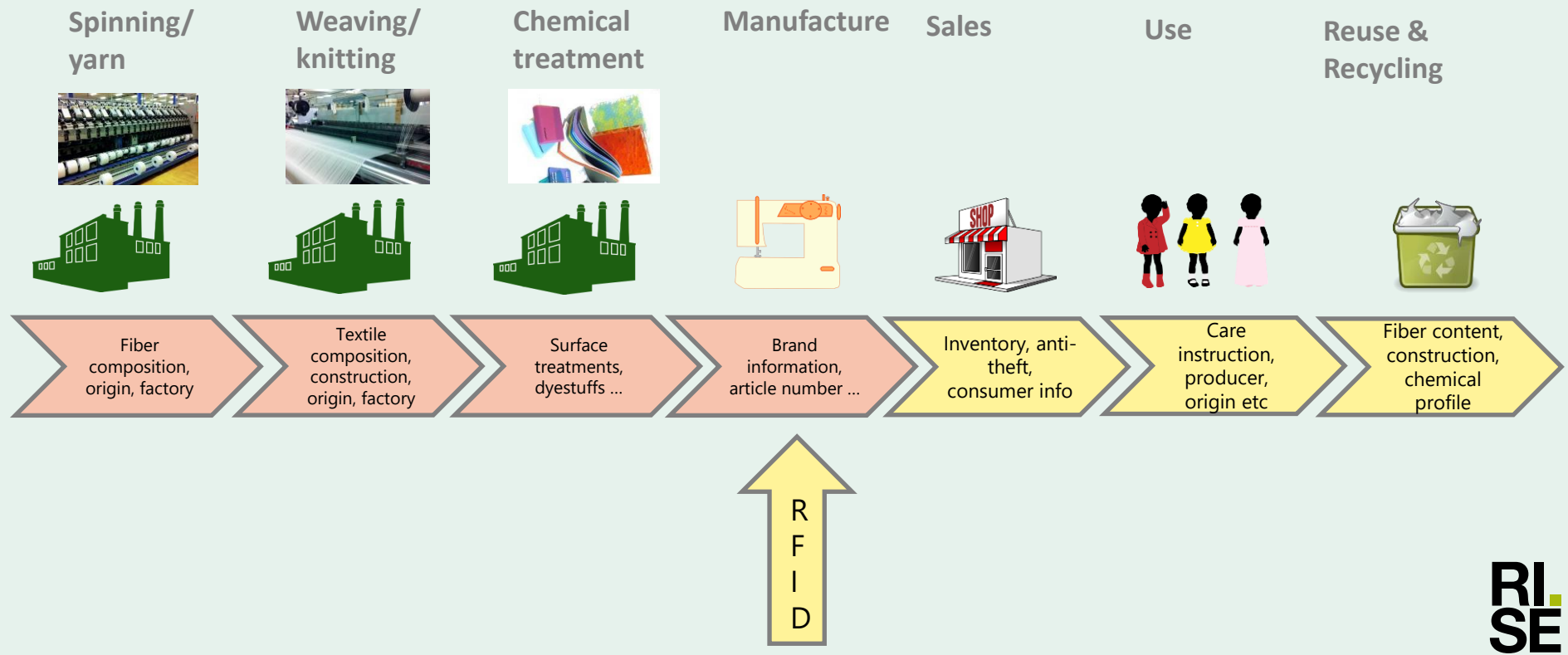
How should products from recycled feedstock be labeled?

Common terminology

Information is key



Complex textile value chain



Globality & Standards

Very important to work with a common system for structuring information in order to fully utilize this technology - a technology with a large number of possible applications as focus and area of interest differ among value-chain stakeholders

Important aspects:

- *International standardization*
- *Global RFID system*
- *Information management*
- *Access rights*
- *Data security and privacy issues*

Our journey and experiences

- Information requirements, ongoing work since 15 years
- Started working on system level in 2016
- Proof-of-concept & finding gaps in regard to system approach
- Include the entire value-chain in the work – move in the same direction
- Dialogue and knowledge transfer, consensus
- Include standardization early on
- Visit reality!

Conclusion

- *Large volumes, complex feedstock*
- *Implementation of several emerging technologies and solutions must be accomodated*
- *Critical need for information regarding materials in the system*
- *Entire value chain should be included*
- *Positive dialogue and information transfer throughout value chain needed*

EXAMPLES

Selected prototypes and demonstrators developed by RISE IVF and partners

Mechanical textile-textile

- Accessories removal
- Tearing
- Sliver
- Rotor spinning
- Knitting

Woolpower

Production waste

After tearing

Sliver, 50% recycled

Ring- & rotor-spinning

Nm 14

Knitted sample

Yarn under evaluation at woolpower

Several materials produced from post-consumer material

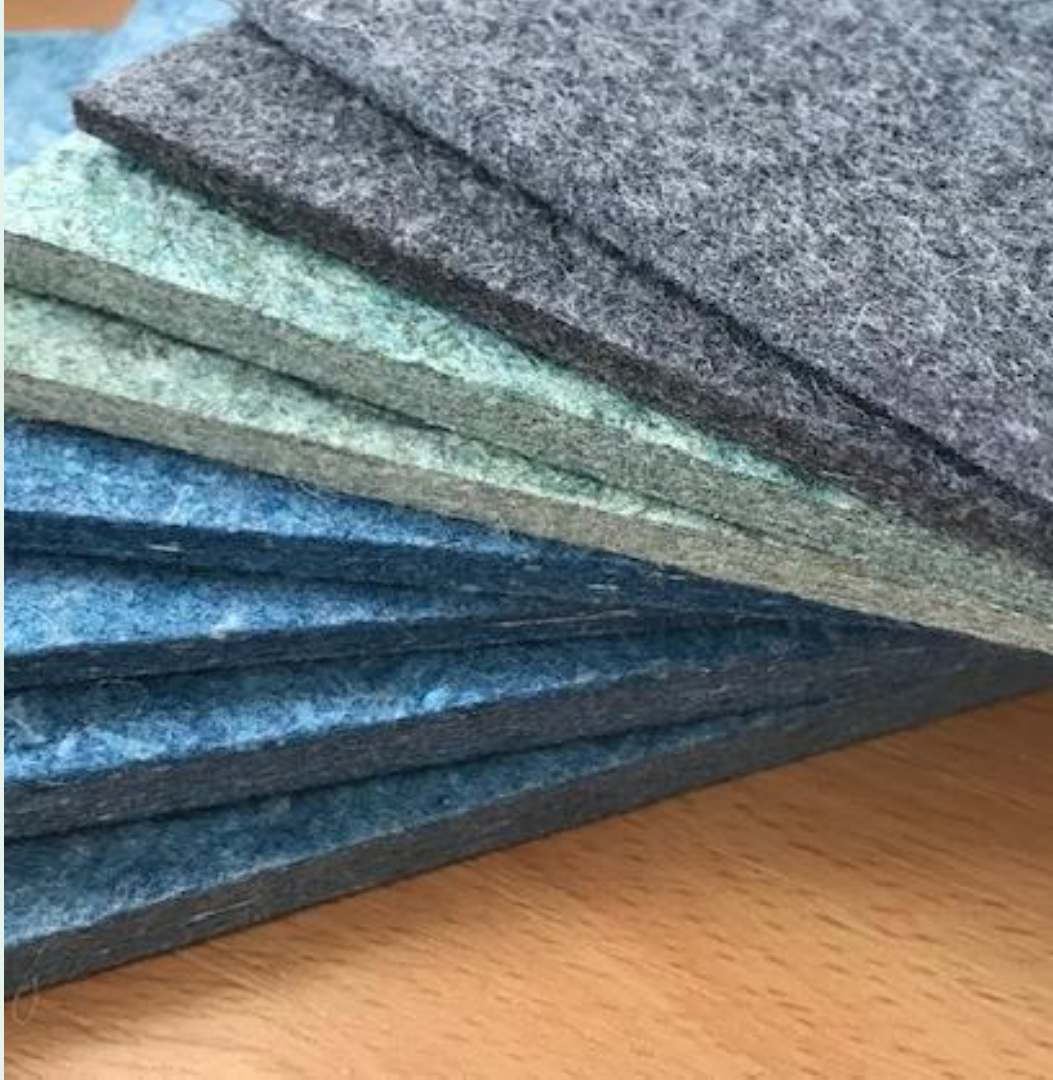
- Available during the tour of our facilities…..

Stadium - Post consumer football jerseys

50% recycled PES
50% Organic cotton

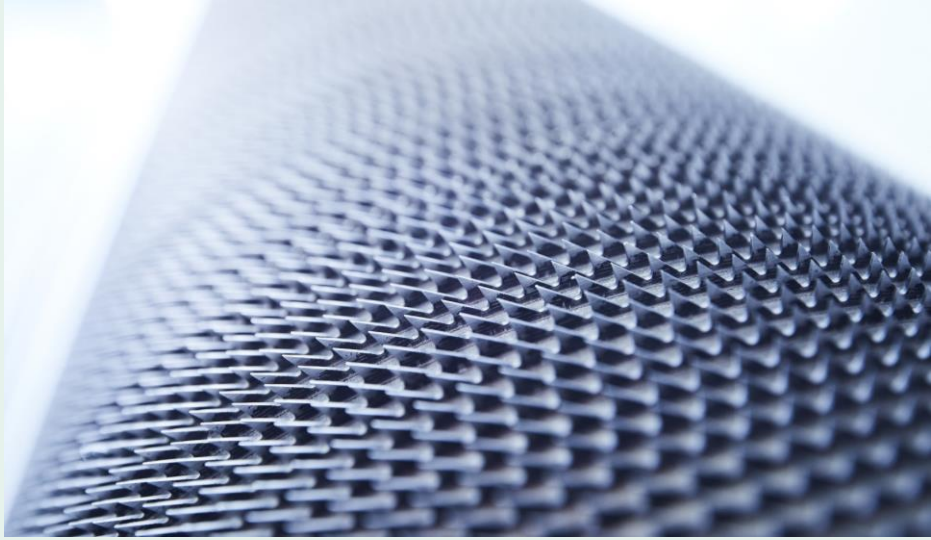
- Yarn under evaluation at Stadium & Trikåby
- Aiming to release capsule collection online to Stadium club members

Scratch prevention pads from recycled RAMI/wool



Process

- Tearing
- Carding
- Needling
- Press
- Punching



Results

- Recycled prototypes outperform reference

Prov nr	Prov nr på baksidan	Material	Innehåll	Densitet mm	Resultat skala 1-5	Laminatgolv gnidning	Plastmatta gnidning	Laminatgolv fiberutsläpp	Plastmatta fiberutsläpp
1	1	Ackurat	Original	4	1	ytskikt bortnött	gnidspår syns	Mycket	Lite
2	2	RISE IVF Rami	70/30	4	4	gnidspår sysn	gnidspår syns	medle	Lite
3	5	RISE IVF	70/30	5	5	gnidspår sysn	gnidspår syns	medel	Lite
4	7	RISE IVF	80/20	5	2	sträv yta gnidspår syns	gnidspår syns	medel +	Lite
5	7	The loop factory extra press	80/20	4	4	finns gnidspår	gnidspår syns	lite	Lite
6	4	The loop factory extra press	70/30	4	5	finns gnidspår	gnidspår syns	ytterst lite	Lite
7	1	The loop factory	80/20	6	1	finns gnidspår	gnidspår syns	lite	Lite
8	8	The loop factory	70/30	6	1	finns gnidspår	gnidspår syns	lite	Lite

Ackurat – foot plugs for furniture

	Ackurats ref 40% träfiber i PP	30%skjortor,2% MAPP, Rondo PP	20%skjortor,2%MAPP, **34% Novopren (WEEE)**,22%Rondo, 22% Total (MFI 80)	30%postkonsument,2%MAPP,RondoPP	PP Rondo
bomull/polyester	-	50/50	50/50	fibrer längre än för skjortor	
E-modulus	4007	2546	2195	2949	
Stress @ Yield (MPa)	38,1	38,2	34,6	41,1	
Stress @ Break (MPa)	37,7	37,4	34	41,1	
Strain @ Yield (%)	2,6	5,7	4,6	4,1	
Strain @ Break (%)	2,9	6,8	5,2	4,2	
Charpy, notched +23C (kJ/m2)		7,5	4,2	5,2	9

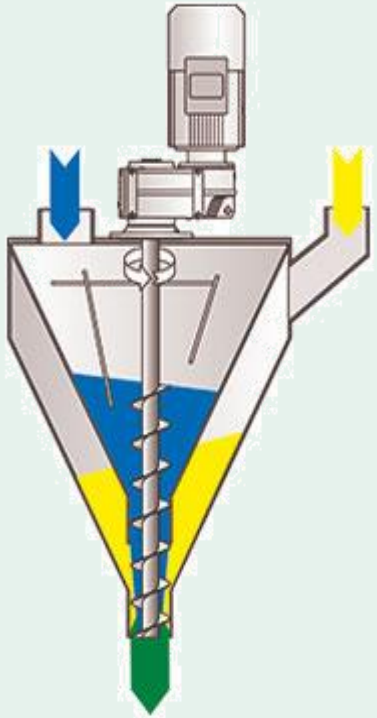
Healthcare products

- Must tolerate sharp and percing objects
- Must withstand a 1,2 m fall at -18°C with 1 kg dead weight
- 20-25% low grade recycled textile in recycled PP
- ~50% increased e-modulus
- ~100% increased impact resistance

Container for sharp, piercing clinical /medical biohazardous waste

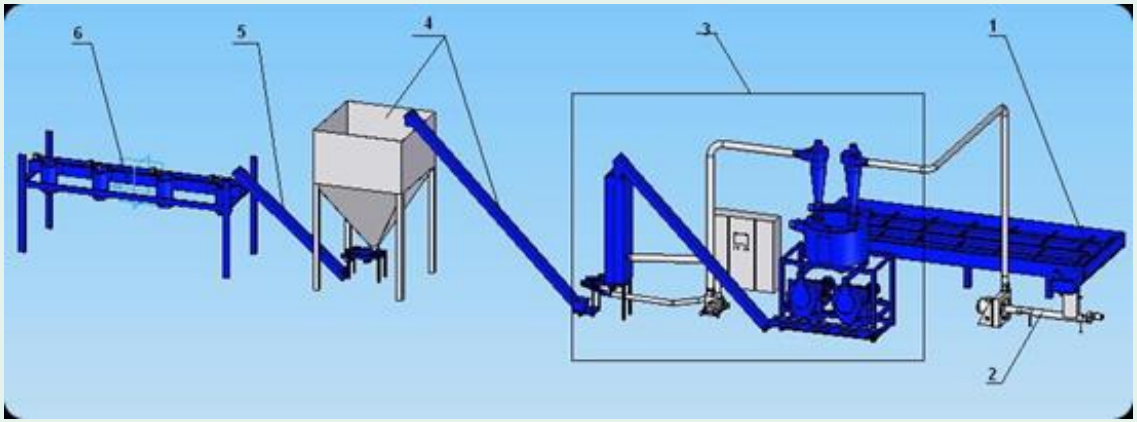
Uppskalning
Textil-plastkomposit

- Rivning av stora volymer återvunnen textil skapar ett material med *låg fyll densitet* som blir dyrt att transportera
- Tvångsmatning kan tekniskt sett lösa frågan om att trcyka ner fibrer i plast men kräver alltså egentligen att riv och kompoundering sker på samma plats
- <u>Önskas:</u> en metod att kompaktera riven textilfiber som tillåter högre densitet för materialet under transport, men som tillåter efterföljande dispergering (finfördelning) av fibrerna i den smälta plasten



Matning till kompounder

Pelletspress



Automatiskt spånförråd med hydraulisk stångmatare och utmatningsskruv för råmaterial.

Material som är större än 3 mm bör malas i hammarkvarn. Det torkade materialet finfördelas i en hammarkvarn. Malningen underlättas om materialet håller hög torrhalt. Hammarkvarn maler från kutterspån ner till sågspån/klyvspåns storlek. Under kvarnen är behållare och inmatare placerade.

Textile - Nonwoven

- Volvo CC, Björkå Frihet, National Högsäter, Sporda Nonwoven: Recycled textile compression moulded to car seat back
- Low grade post consumer polycotton

Thank you!