Consumer demand and textile industry targets are driving the circularity agenda, but it is technology that will actually make it happen.

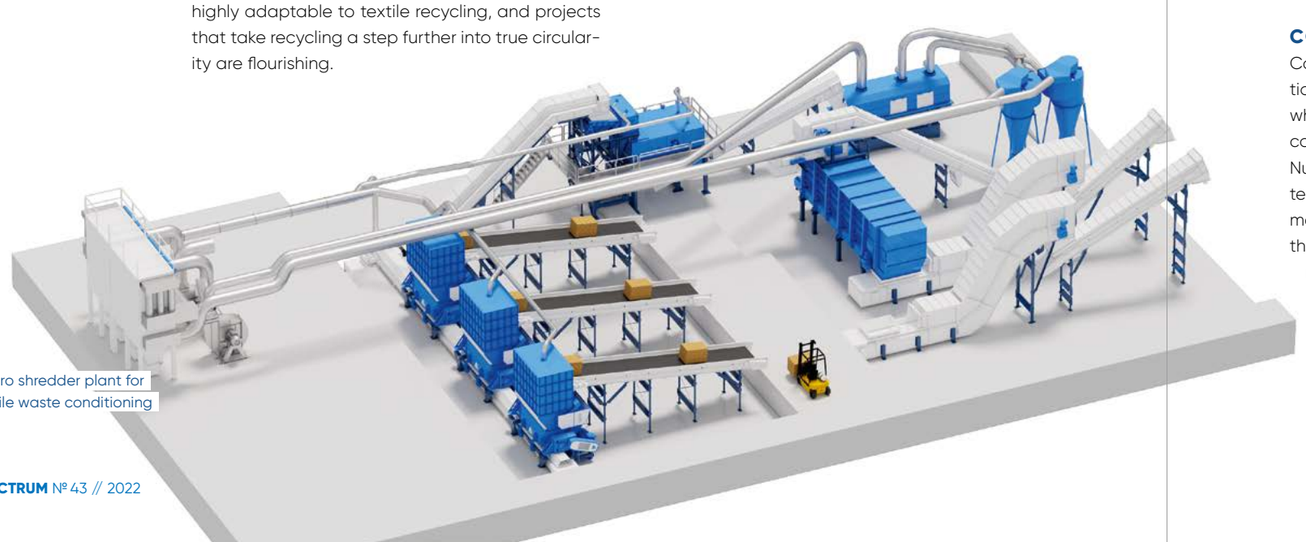
Textile-to-Textile: THE NEW OPPORTUNITY

CHALLENGES. SOLUTIONS.

The world of textiles and the textile industry should be under no illusions about their responsibilities. The price of fast fashion is that making clothes accounts for around 10 % of CO_2 emissions from human activity. Despite the need for circularity in our use of resources, the clothing industry has been fed by a distinctly linear value chain. Clothing is notoriously over-supplied, and while it might be resold, recycled into cloths or insulation, much of it ends up incinerated or in landfill. Textile-to-textile circularity has been conspicuously absent.

But this is changing thanks to media pressure, consumer demand, regulations, and technology. Our ignorance about the price the planet pays for our full wardrobes is at last being replaced by a deep concern about the impact of textiles on the environment. There is also an increasing awareness of the need to make greater use of sustainable raw materials in the fiber and textile production. Meanwhile, existing technologies are proving highly adaptable to textile recycling, and projects that take recycling a step further into true circularity are flourishing.

As part of its Environment Social Governance (ESG) program and with the goal to generate 50 % of its revenue with sustainable products and solutions, the ANDRITZ GROUP is at the core of the movement to provide industrially and economically viable solutions for recycling pre- and post-consumer waste made from natural and synthetic fibers. There is no single, catch-all solution to the recycling of textiles, and this plays to ANDRITZ's strengths because the group has such a diversity of solutions to offer and several cooperation partners covering the value chain from recovery of fibers to chemical modification and preparation for the production of yarn.



ADuro shredder plant for textile waste conditioning

Some solutions are derived from strong expertise in the field of pulp and paper; others have been developed specifically for textiles. As a whole, they offer single and multiple complementary technologies to address the needs of different textile recycling challenges.

What follows is a brief resumé of ANDRITZ's scope of supply for textile waste recycling machinery.

CONDITIONING OF FEED MATERIAL

Conditioning of textile waste lays the foundation for the subsequent textile recycling process, whether it is based on mechanical, chemical, combined, or other customer-specific treatments. Numerous parameters influencing the choice of technology include the nature of the waste (garments, linens, carpets, white/colored textiles, etc.), the feeding conditions (e.g., baled or loose feed material), the required size of the shredded textiles in output, the presence of impurities such as zippers, the output purity, the capacity, and all other requirements of downstream processing.

CIRC and ANDRITZ cooperation includes mechanical, thermal, and chemical process period

ANDRITZ Reject and Recycling offers single equipment units and complete conditioning systems, from material feed and shredding right up to the finally conditioned material. A landmark was ANDRITZ Reject and Recycling's order in 2021 from Swedish company Renewcell for a 60,000 t/a textile recycling line, featuring ADuro shredders, for its first large-scale textile-to-textile recycling plant in Sundsvall. At the same time, shredding systems capable of managing volumes of up to 200 t/d are being developed and optimized in combina- →

tion with the separation technique, based on trials conducted in the ART Center (ANDRITZ Recycling Technology Center) near Graz, Austria.

Complementary to the services of ANDRITZ Reject and Recycling, ANDRITZ Laroche offers a different mechanical conditioning process based on tearing. With more than 2,000 reference projects worldwide offering one of the largest installed bases for textile recycling mills, ANDRITZ Laroche's mechanical recycling process can be preparatory to the following main options: nonwovens production lines, short staple fiber spinning mills for yarn "respinning" with the creation of woven or knitted fabrics, including blends of up to 100 % recycled fibers, or to downstream chemical processes for the production of new man-made fibers if required. Let's look at those markets.

MECHANICAL RECYCLING FOR TEXTILE-TO-TEXTILE

Today, ANDRITZ Laroche offers a complete process range of tearing equipment, from 50 up to 3,000 kg/h, applicable to almost all types of pre-/post-consumer waste textiles with the aim of maintaining the nature of the original fibers by – with cotton for example – maximizing fiber length, strength and feel. Today, Ne24 and Ne30 yarn counts use 70 % recycled cotton fibers in some blends. In addition, the mechanical recycling process uses less water, no chemicals, and allows for a reduced machinery installation footprint.

NONWOVENS BRING NEW LIFE TO TEXTILES

Transformation of recycled textile fibers into technical nonwoven felts is one of the key methods for recycling textiles into new products, and ANDRITZ offers complete nonwoven roll-good production lines to process recycled fibers from textile waste. This includes lines such as spunlace, wetlace, needlepunch, and airlay processes. In general, these lines include fiber opening and blending, fine openers and web forming (in which fibers are treated and laid to form a sheet), web bonding (in which the sheet is entangled/bonded), as well as slitting and winding equipment. New products, such as wipes, building insulation, mattresses, car interiors, and furniture fillings, can be created with these roll goods.

CHEMICAL RECYCLING

Chemical recycling of textile waste is a vital, emerging business area. It is the piece of the puzzle that completes the picture of textile-to-textile circularity. ANDRITZ is a key player because the core process steps involved can use the same equipment as in existing pulp and paper technology, where ANDRITZ is an acknowledged expert.

The process often requires the input of raw material based on a blend of different fibers that have been mechanically treated prior to chemical modification. ANDRITZ has the equipment and expertise to offer technology solutions for new chemical processes according to the customer's needs, including complete production lines and individual equipment for chemical recycling processes such as washing, mixing, cooking, bleaching, and drying.

Depending on the customer's technology solution, cellulose-based fibers and polyester from fiber blends, for example, are further modified to allow them to be used in any textile fiber spinning process (such as viscose or Lyocell production) in the same way as market dissolving pulp.

ANDRITZ AND INFINITED FIBER COMPANY. COOPERATION BRINGS RESULTS.

Infinited Fiber Company and ANDRITZ signed a cooperation agreement in 2020 to develop the process and equipment solutions for Infinited Fiber Company's textile fiber regeneration technology. Under the cooperation agreement, the two companies will work together to develop the factory process and equipment solutions, aiming to optimize every process step in preparation for the technology to be scaled up to commercial production.

Infinited Fiber Company is building a 30,000 t/a flagship plant in Finland, representing an investment of 220 MEUR, which is due to go into operation in 2024. The plant will be one of a kind in the

NOW WE CAN UPCYCLE, TOO

The key textile brands are strongly motivated to find circular solutions and are especially keen to add recycled fiber to their clothes.

So far, recycling of post-consumer textile waste has been limited to the production of lower quality/value products, such as cleaning rags, in a "downcycling" process. Although downcycling is an important part of the complete recycling process, textile waste can now find new life as textile yarn, in an "upcycling" process, and be turned into a product of equal, if not better, quality and value. With this addition of upcycling opportunities to existing downcycling processes, we are seeing a parallel evolution in recycling. The effect on feed material conditioning is that we need to be even more precise in the way we carry out sorting and shredding to create high-quality secondary textile material for subsequent textile recycling process steps.

Michael Waupotitsch
Vice President,
Reject and Recycling, Paper,
Fiber and Recycling Division

Anastasia Zefkili
Head of ART Center,
Paper, Fiber and
Recycling Division

Fiber length, for example, which affects fiber strength, depends on the downstream process, and there are contaminants to manage, attached to the textiles, such as zippers and buttons, and external ones like bale wires. Overall, we are consistently improving process steps with purity up and textile loss down. The choice for the customer is how many process steps they want to include from an investment and capacity point of view. We are here to help ensure the most suitable technology is applied. The ART Center (ANDRITZ Recycling Technology Center) is a valuable tool to achieve this, where shredding is tested in combination with the separation technique and optimized together according to the customer's material and process requirements.

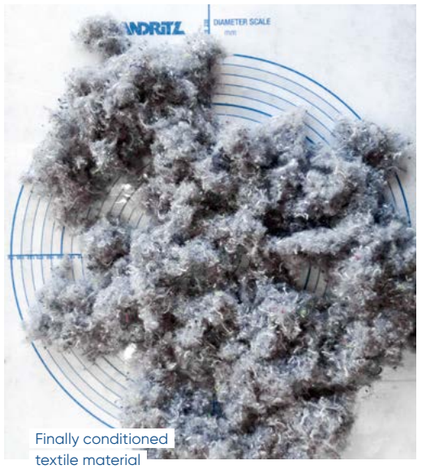
MORE PULL THAN PUSH

Jorma Latva-Kokko
Vice President,
Mechanical Pulping, Paper,
Fiber and Recycling Division

Demand has certainly been a strong driver for the development of circular textile recycling. It's a mammoth problem, but brands and consumers really are waking up to it. There is more pull than push I would say.

It is remarkable how we have been able to use existing pulp and paper equipment for the processing of textile waste, and mostly we are looking at one or more complementary technologies from our various divisions to achieve the desired outcome. To a large extent, the achievement of textile-to-textile recycling is, therefore, an evolution of existing solutions. This is great for customers because it involves less risk for them.

One of our strengths is that we don't have to direct people towards a particular technical solution because we can offer them all. The partnerships we are involved in, most specifically Infinited Fiber Company and CIRC, are the catalysts for big advances in technology. We have learned a tremendous amount from these partnerships – we have caught a big wave.



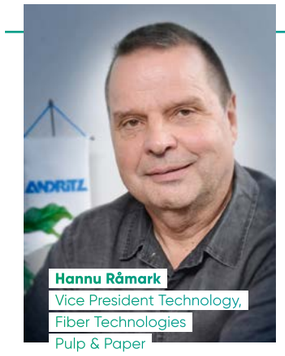
Finally conditioned textile material

ANDRITZ mechanical recycling line based on tearing

COOPERATION IS THE KEY

It was a big feature in the establishment of our cooperation with Infinited Fiber Company that they saw we have so many different technologies, essentially a one-stop shop, and that ANDRITZ Fiber Technologies has the already-validated chemical pulping equipment that is suitable for their needs.

ANDRITZ is happy to work with Infinited Fiber Company to create solutions for textile recycling, especially bearing in mind that the EU Waste Framework Directive legislates that Member States should set up separate collection for textiles by January 1, 2025.



Hannu Råmark
Vice President Technology,
Fiber Technologies
Pulp & Paper

Elina Pesonen
Product Manager,
Fiber Technologies
Pulp & Paper

Alongside our work with Infinited Fiber Company, we have successful collaborations with universities and research institutes, which are particularly strong in the area of chemical pulping and have great facilities. This is helping us take large strides in developing our equipment for chemical treatment of textiles.

world, and Infinited Fiber Company's technology, with ANDRITZ equipment, can be used in new fiber factories or as retrofits in existing viscose fiber lines. At the moment, ANDRITZ is conducting pre-engineering for the pre-treatment of textile waste for the flagship plant.

Infinited Fiber Company's technology can turn any cellulose-rich raw material, including discarded textiles, used cardboard or rice/wheat straw, into Infinna™ cellulose carbamate fibers. These unique, high-quality textile fibers have the look and feel of cotton. In the process itself, impurities including buttons and zippers are mechanically removed prior to a chemical pre-treatment step in which textile colorants and non-cellulosic fibers are separated before pure cellulose is synthesized into carbamate ready to be spun into a CCA fiber.

ANDRITZ AND CIRC: POLYCOTTON PROGRESS

Meanwhile, on the other side of the Atlantic, ANDRITZ signed a cooperation agreement in 2021 with CIRC, located in Virginia, USA, to pool each party's expertise in the field of textile recycling and upscale CIRC's recycling technology for commercial use.

The concept is based on the extraction of both recycled PET and cotton from polycotton to produce new textiles, while only non-recyclable elements like buttons and zippers in the feed material are rejected.

The CIRC/ANDRITZ concept is a combination of mechanical, thermal, and chemical process steps. First, PET is dissolved, separated, and transformed into recycled PET. The cotton released is processed in the fiber line, where the quality is adjusted and all the residuals of PET and other impurities, including dyes, are removed. Recycled cotton can then be used as a feed material in the Lyocell process, for example.

Of course, processing polycotton has its challenges, one of which is to understand end-use requirements and find ways to measure relevant parameters to control final quality and the process as a whole. ANDRITZ has proved the feasibility of the concept in repeated small-scale production runs at its Springfield, Ohio, pilot plant in the USA. CIRC intends to have its first factory up and running in commercial operation in 2024, with ANDRITZ equipment installed.

The CIRC/ANDRITZ concept is a combination of mechanical, thermal, and chemical process steps.

THE FULL SUITE

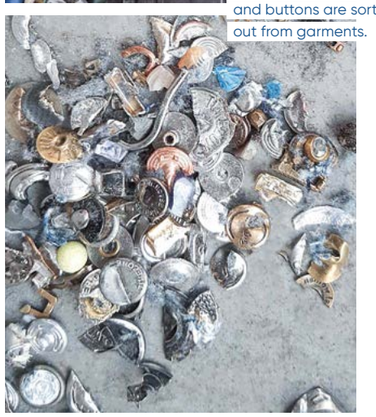
ANDRITZ has the full suite of expertise and technology to provide tailormade textile recycling processes that manage diverse types of textile waste. It also leads the way in research and development, with a worldwide network of pilot plants and technology centers, offering an excellent platform for customer trials and R&D work. In addition, the ANDRITZ GROUP'S capabilities in the field of digital solutions offer an excellent platform to optimize equipment and system performance.

Already a formidable brand across several sectors, ANDRITZ has established itself as a globally operating partner when it comes to textile recycling processes, in a sector in which there is no such thing as a one-size-fits-all solution. Complementary technologies backed by an over-arching vision are the way forward.

With the experience and skills for material conditioning, mechanical, chemical, and combined recycling methods, ANDRITZ cooperates with innovative technology partners and focuses on continuous further development of machinery and recycling processes to accompany the customer throughout the product lifecycle and beyond. Quite simply, ANDRITZ is the partner with the vision, expertise, and capability when it comes to textile recycling processes.

CONTACT
textile-recycling@andritz.com

Impurities like zippers and buttons are sorted out from garments.



THE GAME CHANGER

Chemical and mechanical processes are fully complementary in the drive to achieve the desired end result, but the addition of chemical treatment is certainly a game changer for textile-to-textile recycling.

The great thing with our range of technologies is that we can adjust the process according to the end use. If you require a certain colour of yarn, then this can be achieved through a combination of the choice of textile waste, the use of dyes, and the chemical input – these can all be balanced to optimize the process and minimize the use of bleach, for example.

Alexandre Butte
General Manager,
ANDRITZ Laroche

Charles Junker
Head of Sales,
ANDRITZ Laroche

Our customers come to us with their ideas and raw materials options, and depending on their target, we use our equipment to fulfil their ambitions. We have almost all the relevant technology in our technology center at ANDRITZ Laroche, France, but the ART center in St. Michael, Austria, is a great partner because it has what we don't – shredders, for example – and then there is the pulp testing center in Graz, Austria. We have projects in the pipeline for which we can combine technologies to achieve great things for our customers.

Looking at the costs associated with textile recycling technologies, clearly it makes a difference how much one is paying for the end product. The cost of yarn in a 2.99 EUR T-shirt will have considerably more impact than in a premium item. But industrial scale will bring the price of fiber down, and we need to look at the whole value chain: Through our own development work and in-depth collaboration with, for example, the CETI technical center equipped by ANDRITZ in northern France, we are looking to produce fiber that is easily processable, and this needs to be taken into account when assessing the total cost. Also, with more advanced customers, if it comes to a choice between a virgin fiber and one that is recycled for a price difference of plus or minus 10 %, then it won't be a hard decision to choose the recycled option. It will come naturally.

It is critical that this is driven by the big brands – they are the ones that can really push this forward.