SPINNING RECYCLED YARN

Methods & Application

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INTRODUCTION

Once we have used extrusion, mechanical recycling, or chemical recycling techniques to produce fibres and filaments from used textiles, we must move to the next step in the recycling process: spinning yarn.

Spinning is one of the most complex and demanding parts of the textile production chain. While approaches to spinning are similar, there isn't a one-size-fits-all solution. For instance, the material produced by chemical recycling can be spun into yarn using well-known standard yarn spinning techniques, but mechanically recycled material must use adapted methods.

When we are able to spin a high quality yarn, we are able to produce high quality textile products. Millions of spinning machines around the globe produce millions of kilograms of yarn each day. As one might imagine, spinning technology is a broad and complex subject, so we will only focus on the highlights.

THE BASICS OF YARN SPINNING

Yarn spinning is the activity of making yarn from staple fibres (i.e. fibres short in length). Spinning involves bringing the staple fibres in close contact with each other, twisting them around each other while simultaneously stretching the fibre bundle (known as the sliver) to the required diameter or thickness.

You can get a basic idea of the process by watching the following video about the ancient drop spindle technique (here). An up-to-date overview of various aspects of yarn spinning can be seen in the document here. This document also describes how specific spinning techniques influence yarn properties.

INTERMEZZO YARN NUMBERING

The diameter or thickness of yarn is not trivial. The yarn number indicates the thickness (diameter) of the yarn. Because the diameter is difficult to measure, this measure is indicated as the ratio of the mass (weight) and length of a piece of yarn. There are 2 systems to determine the yarn number:

- weight numbering: determined by measuring the weight of a fixed yarn length
- length numbering: determined by measuring the length of a fixed yarn weight

For weight numbering, tex is technically the only official numbering, but in practice tex is usually only used for filament yarns. Tex is the weight in grams of 1,000m of yarn. Prefixes such as dtex and ktex are used with this unit. For example, 13.5 tex is 135 dtex, so dtex is the weight in grams of 10,000m of yarn.

Length numbering is the numbering that was traditionally used. These are still in use in the Netherlands and use the abbreviations Ne (number English) and Nm (number metric). As the names indicate, Ne works with imperial sizes and Nm with metric sizes. In length numbering, the relationship between yarn thickness and yarn number is inversely proportional: a thicker yarn has a lower number.

YARN SPINNING

SPINNING PRE-PROCESSING

The object of spinning, and the processes that precede it, is to transform the single fibres into a workable, continuous length of yarn. In the case of natural fibres, the processing involves opening, blending, carding (and in some cases combing), drawing, and roving to produce the material for the spinning frame.
This is followed by the spinning itself.

The steps are as follows:

- Bales with staple fibres are brought into the blending chamber and are opened. Depending on what the requirements of the final product are, different kinds of staples may be mixed at this stage. Cotton staple fibres are often mixed with polyester staple fibres to produce polyester/cotton yarns. This process is known as intimate blending.
- After thorough mixing, the fibre pack is transported through a system that removes tiny fibres and other impurities to improve the quality of the final yarn.
- In order to produce the sliver, fibres must first be cleaned and untangled using a process known as carding. Carding on an industrial scale involves feeding fibres between two drum rollers covered in small pins. This process separates the fibres and arranges them into a uniform, parallel mesh known as the **sliver**.

The resulting sliver can then undergo all kinds of treatments like making it denser, stretching it, or combining several slivers into a new, thicker sliver.

SPINNING METHODS

Once the staple fibres have been processed, the resulting sliver is then fed into the spinning machine. There are a few different spinning techniques, which differ in the way the sliver is manipulated and transformed into a yarn. Most recycled textiles can be processed into new yarn by using the technologies described below. However, mechanically recycled textiles require further processing.

OPEN-END / ROTOR SPINNING

The first technique is known as **open-end** or **rotor spinning**. The first functioning rotor spinning machine was developed in 1967. Rotor spinning is a more recent method of yarn formation compared to techniques like ring spinning. The sliver is fed into the machine, combed, and individualised by the opening roller. The fibres are then twisted together by the spinning action of the rotor, and the yarn is continuously drawn from the centre of the rotor.

The resulting yarn is cleared of any defects and wound onto packages. Rotor spun yarns are more even, somewhat weaker, and have a harsher feel than ring spun yarns. Yarns spun in this fashion have several end uses, which include a variety of products like: denim, towels, shirts, and more.

RING SPINNING

The second technique is known as **ring spinning**. Ring spinning is a method of spinning fibres (e.g. cotton, wool, flax, etc.) by drawing sliver (also called roving) through a series of rollers, spinning the material into yarn, and then winding the material around a rotating spindle within a ring flyer. For a more detailed explanation, check out this article by Textile School.

AIR JET SPINNING

One of the latest developments in spinning technology is a process known as **air jet spinning**. In this method, a sliver is first fed into a drafting system. The drafted sliver then enters a spinning unit and, once inside, the fibres are twisted using air. However, the fibres are not always uniformly twisted.

FRICTION SPINNING

Another new development is a method called **friction spinning**, which is related to the open-end spinning process. In friction spinning, the fibres must first be fed through an opening roller before being gathered into a suction area. The yarn is then twisted using the friction between the fibre and two spinning perforated drums. This method of spinning allows for an especially high twist rate in the resulting yarn.

SPINNING CHEMICALLY RECYCLED TEXTILES

The chemical recycling process produces filaments: extraordinarily long thin threads, collected on bobbins. Occasionally, several of these thin filaments will be twisted together to produce sewing thread. To be used in industrial scale yarn spinning, filaments produced by chemical recycling are chopped into pieces measuring between 30mm (for cotton fibres) and 40 or 50mm length. These pieces, called the staple, are then spun into the yarns we use to produce garments.

SPINNING MECHANICALLY RECYCLED FIBRES

Spinning high quality yarn from mechanically recycled fibres is quite difficult. Mechanically recycled fibres are often much shorter than virgin fibres. Due to the various sources of post-consumer textile waste, these fibres also have a much broader range of length (from short dust fibres to the length of virgin fibres) and thickness. For these reasons, virgin fibres are almost always added when spinning mechanically recycled yarns (except in the case of wool, which has much longer fibres compared to cotton).

Recycled PET fibres (from bottles) are the most frequently used, but virgin cotton and viscose may also be blended with the recycled fibres. In some cases, renewable, sustainably grown hemp and linen are added to mechanically recycled cotton fibres. In the future, they will be blended with chemically recycled fibres, like SaXcell, to obtain 100% recycled cotton products.

Due to the variation in fibre length, open-end spinning technology is used predominantly in spinning mechanically recycled fibres, as this technology is the most versatile. However, when the fibre length of the mechanically recycled fibres is longer, ring spinning is also an option. The fibres produced from blends of mechanically recycled fibres and virgin fibres are not as fine as yarns produced from entirely virgin fibres (mostly between Nm 5 and 40). Therefore, the range of potential applications for these yarns is not as broad.

Mechanically recycled fibres used for spinning mostly come from industrial waste. On average, between 10-20% of the material used in spinning, weaving, and clothing production is waste. Fortunately, this large volume of waste material can be reused for recycling. Many specialised spinning companies (particularly in Italy, Spain, and many Asian countries) use mechanically recycled fibres. These include companies like:

- Comistra and Fil3 in Italy, using recycled wool
- Recover in Spain, using recycled cotton
- Belda Llorens in Spain, using recycled cotton

Many of these companies have already been using mechanically recycled fibres for a long time, but did not use sustainability as a unique selling point until recently. These companies have adapted their spinning systems (especially the pre-spinning processes) in such a way that they are able to produce high quality yarn for products like business suits, jeans, and T-shirts.

THE PROBLEM WITH BLENDS

Blending fibres is a well-developed technique for producing yarn (and ultimately textile products) with specific, predictable properties. In fact, the current practices within the textile industry are such that a world without blending is almost unthinkable.

But this presents us with a problem: recycling blended materials is very difficult! Fortunately, there is a lot of research going into developing processes for recycling textiles that take blends into account. With the current SaXcell recycling process, it is possible to separate cotton from polyester and to then use each in further recycling processes.

Elastane, however, is still a big problem. Although research is underway to solve this issue, textiles that contain elastane cannot currently be chemically recycled. Because of these issues, blends currently reduce recycling efficiency and are, therefore, not good for the environment.

Above: *Spinning is one of the most complex and demanding parts of the textile production chain. Spinning involves bringing the staple fibres in close contact with each other, twisting them around each other while simultaneously stretching the fibre bundle.*

QUICK FACTS

- Currently, around 2.5 million tonnes of recycled fibres per year are taken from various stages of the textile manufacturing chain and fed back into the spinning system. See this article for more details.
- Mechanically recycled fibres, often from industrial waste, are already present in a wide variety of textile products. It is even possible that you own products containing these fibres—you just never noticed!

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SPINNING IS AN ANCIENT TECHNOLOGY

SOME SPINDLES DATE BACK TO THE NEOLITHIC ERA OF HUMAN HISTORY

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