

# MAKING & FINISHING TEXTILES

What  
&  
How



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# INTRODUCTION

Once we have turned our discarded textile products yarn, we then use this yarn to produce cloth, or fabric, which is then used to make textile products. To make fabric, there are three main production methods: weaving, knitting, and nonwoven technology. We will briefly describe these three methodologies in the following sections. Without finishing, however, no textile product is ready for use. In the final section of this chapter, we will discuss finishing techniques like dyeing and printing.

Before we begin, however, we must provide a brief disclaimer. These areas of cloth production are huge industries. The amount of knowledge, technology, and variation in production methods is such that we cannot cover all of it. We will only discuss the basic principles in this chapter and leave out the more detailed information.

## KNITTING

Knitting is a traditional way of creating fabric and garments by using needles to loop yarn into a pattern of interconnected stitches. These stitches are then joined together in a series of rows, which eventually form a mesh (the fabric). Garments are usually made up of a large number of stitches (often more than a few hundred). Knitting needles hold the initial row of stitches in place (so it does not unravel) while subsequent loops are pulled through the first row using the working needle. This process is repeated until the garment is complete.

Knitting is a versatile technique that can be used to create a wide range of diverse and varied fabrics. Factors such as needle size, stitch pattern, fibre type, and yarn weight can all affect the properties of the final product. Open lace patterns worked in a lightweight cotton yarn, for instance, will not retain as much heat as denser stitch pattern knit in a yarn made from wool.

One can knit a garment by hand, by using a small hobby machine, or by using large industrial machines. Flatbed knitting and circular knitting are the two main techniques used in industrial knitting. The following videos provide a good visualisation and cursory explanation of how machine knitting works:

- [Knitting Technology / Loop/Stitch Formation](#) by Elias Khalil
- [Single Jersey Circular Knitting Machine's Needle Action](#) by Textile School

Virtually all textile materials can be knit, but wool is the dominant material in knitting. Wool is quite often blended with nylon and acrylics to make the wool stronger or more wear-resistant. Obviously, as we discussed in previous chapters, blends are not particularly well-suited to recycling.

## **INDUSTRIAL CIRCULAR KNITTING**

Knitting allows for a broad range of patterns suited to a variety of uses, from jersey knits (suitable for t-shirts) to 3D knitwear (suitable for technical and interior applications). Industrial circular knitting is a technique by which one knits on a circular needle bed. In this process, yarn is fed into a series of latch hook needles arranged in a circular needle bed that rotates to create a tube of fabric. For a more thorough explanation, [see this video](#). Once the tube is knit, it must be cut open for further use.

Industrial circular knitting machines are advantageous because they have a high output capacity and can produce very fine knits. However, the size of the knit fabric is limited to the size of the circular knitting machine. As a result, the material created from these industrial machines must often be cut and sewn together to form a completed garment.

## **INDUSTRIAL FLATBED KNITTING**

Industrial flatbed knitting machines use a carriage to draw yarn across a flat needle bed. See [this video](#) for a good visualisation of the process.

Because flatbed knitting machines don't have the same output capacity as circular machines, they are best used for individual garment creation rather than large quantities of knitted fabric.

There are two main types of flatbed knitting machines currently in use in the textile industry: hand flat machines and computerised Jacquard machines. Both of these machines have specific applications, but a detailed description of their place in the textile ecosystem is beyond the scope of this article.

Fully fashioned knitting machines are a particularly important piece of technology because they have the ability to produce an entire garment. Arms and collars, which would usually be knit and sewn on separately, can be produced from one skein on a single fully fashioned knitting machine.

## **DID YOU KNOW?**

Knitted products are recycled on a large scale. Because the structure of knitted fabrics can be easily unravelled, recycled yarn can be harvested at scale. The collected yarns are then sorted by thickness, material, and colour before being sold to produce new knitted products.

# WOVENS

## HOW WEAVING WORKS

In weaving, two different threads (or yarns) are interlaced to form fabric. Threads running lengthwise are referred to as the warp, while the threads running laterally are known as the weft. The cloth's properties are affected by the way in which these threads are woven together. Weaving normally takes place on a loom, a machine that holds the longitudinal threads in place as the weft threads are woven between them. Threads can be woven through each other in a variety of ways. The manner in which the threads are woven together is referred to as the weave.

## INDUSTRIAL WEAVING

Most industrial woven products are created using three basic weaves: satin, plain weave, or twill. Woven cloth can either be plain (e.g. woven in a single colour or using a simple pattern), or it can be woven in a decorative or artistic design. The basic principles of industrial weaving can be seen in [this video](#).

One of the key features of weaving is that the warp is wound onto the warp beam and the warp threads are carefully guided through the reed. This, in conjunction with the healds, determines the fineness of the cloth. The reed acts as a guide for the shuttle, which passes from one end of the loom to the other, while also helping maintain the position of the warp threads. In fact, it is the reed that determines the number of threads per cm. The heald shafts are the parts that move up and down. They determine the design, or pattern, in a fabric. The heald shaft is also useful in identifying broken warp threads during the weaving process.



**Above:** A traditional loom with the warp beam, heald shafts, reed, and shuttle labeled. Photo by [Zuzana Kacerová](#) published August, 2019 and was retrieved from [Unsplash](#) in June of 2021.

## JACQUARD WEAVING

Another technology used within the industry is known as Jacquard weaving. In Jacquard weaving, a pattern is produced using programming with the Jacquard hard/software system. Jacquard weaving makes it possible to produce large figure patterns by controlling each warp yarn separately at any pick. When using the Jacquard shed or Jacquard shedding, you can produce a high quality, expensive fabric. To see how this works, check out the following videos:

- For modern Jacquard technology, watch [this video](#).
- For the archiac, traditional form of Jacquard weaving, see [this video](#).

To recycle a woven textile, it must go through all the steps described in the previous parts of this series. Needless to say, blending and using different types of yarn or yarn compositions in woven fabrics makes recycling them more difficult.

## NONWOVENS

### WHAT & HOW

Nonwovens are made from either short staple fibres or long fibres, which are then bonded together by chemical, mechanical, heat, or solvent treatments. This process bears some resemblance to paper making. Nonwoven fabrics can be broadly defined as a web of structures bonded together by entangling fibres mechanically, thermally, or chemically. Because they are flat, porous sheets made from fusing separate fibres together, they do not require yarn.

Nonwovens are typically manufactured by fusing small fibres together to form a sheet, and then binding them either mechanically (e.g. as in felt making), with an adhesive, or thermally (i.e. by applying binder in the form of powder, paste, or polymer melt and then melting the binder onto the web). There are also special types of nonwovens, like meltblown or spun bonded nonwovens. In the production of spun bonded nonwovens, melted thermoplastic material is sprayed directly from an extruder onto a cylinder or belt. After cooling, the nonwoven is ready for use (see [this video](#) for more information).

There is usually a certain amount of recycled fibres and oil-based materials present in staple fibre nonwovens. The amount of recycled fibres depends largely on the desired properties and intended use of the material. Because some nonwoven fabrics can be recycled, they are considered by some to be more environmentally friendly in certain contexts. For instance, fields and industries that must use disposable products (e.g. schools, hospitals, and nursing homes). For an overview of nonwoven production technology, watch [this video](#). To get an idea of the size of the machine used in this process see, watch [this video](#).

## APPLICATION & IMPACT

Nonwoven fabrics can be engineered to embody a variety of characteristics (e.g. softness, resilience, absorbency, etc.) and perform a variety of functions (e.g. insulation, cushioning, filtration, etc.). Producers of nonwovens can create fabrics that balance cost effectiveness with durability and are suitable for a variety of applications. When combined with other materials, nonwovens allow for a wide variety of products with diverse properties.

Applications for nonwoven materials include: medical products, surgical masks, household cleaning wipes, and filters. While any type of staple fibrous material can be turned into nonwoven material, thermoplastic polypropylene (PP) is the most commonly used fibre for medical applications because it is water and dirt repellent and easy to recycle.

## HOW IS REFLOW CONNECTED?

Nonwovens have long been the subject of environmental debate. Because they are most often used as disposable products, their environmental profile is dubious. Yet, because they are usually made of a single material, recycling them is relatively easy. Nonwoven material is also found in many reusable shopping bags. We should aim to use these bags as long as possible to reduce their environmental burden.



**Above:** Nonwoven fabrics can be broadly defined as a web of structures bonded together by entangling fibres mechanically, thermally, or chemically. This process bears some resemblance to paper making! Photo by Waag and was retrieved from Flickr in June of 2021.

# TEXTILE FINISHING

Once textiles reach the consumer, they have usually been treated with dyes, prints, or coatings. These treatments are part of the textile finishing industry. In the case of woven materials (and sometimes knitted materials), the yarn or thread is often coated with a polymer (for cotton) or oil (for polyester) to lubricate the thread as it runs through the loom. However, if these surface coatings are present, the fabric cannot be bleached, dyed, or printed on.

To remove this coating, we use a process called **de-sizing**, or washing (for polyester). For printing or dyeing, particularly with lighter tones, the textile must be bleached before dyeing or printing.

## DYEING

Sometimes the yarn or thread has already been dyed before weaving, but the majority of textiles are dyed as a cloth. There are, however, a few factors to consider when dyeing various textiles. Cotton is made of cellulose, which is made up of molecules containing reactive hydroxy groups. As a result, the industry has developed a broad range of reactive dyes for cotton. In addition, vat dyes, like indigo for blue jeans, are used because of their superior light fastness.

There is also a class of dyes known as **substantive dyes** or direct dyes, which adheres to textiles by non-ionic forces, known as "substantivity". The higher the substantivity, the greater the attraction of the dye for the fibre. Substantive dyes work best on textiles with high cellulose content, such as cotton, and are well-known for their light fastness.

Polyester, which is a thermoplastic polymer, is dyed with **disperse dyes**. Disperse dyes are used in dyeing hydrophobic fibres (e.g. cellulose acetate, nylon, polyester, acrylic and other synthetic fibres). Wool and nylon can be dyed with **acidic dyestuff**. The final method is known as **pigment dyeing**, which is not really "dyeing" in its truest form because the pigments stick to the fabric with the help of binders.

These dyes are not only used for dyeing textiles, but also for printing on textiles. The most important dyeing methods are:

- The pad batch process (see [this video](#) for more information)
- Jet dyeing (see [this video](#) for more information)
- Jigger dyeing (see [this video](#) for more information).

## PRINTING

Printing is another important textile finishing technique. While printing makes use of the dyes mentioned above, the process is completely different. **Screen printing** and **digital or inkjet printing** are the most frequently used printing techniques. Flat screen printing and [rotary screen printing](#) are still widely applied, but rotary screen printing (invented by Stork, the Dutch machine builder) is being gradually replaced by digital printing.

Digital printing, which is becoming the dominant technique in the industry, requires less energy and fewer chemicals for printing, which makes it more environmentally friendly. Watch [this video](#) for more information about how this technique works.

Transfer printing is another important technique, particularly for polyester printing. The pattern or design is printed on transfer paper, which is then brought into contact with the polyester cloth on a heated calendar. The heat causes the dye to evaporate, and this vapour transfers the printed image onto the polyester cloth.

Finishing textiles also involves applying various coatings: water or oil repelling finishes, flame retardants, anti-crease finishes, antifungal finishes, or insect repellents. With the advent of nanotechnology, there are now finishes that prolong the lifetime of textiles by reducing wear and tear, which benefits the environment. The goal of these coatings is to make the textile suitable for a specific application (e.g. military gear, tarpaulins, roller blinds, etc.).

## HOW DOES THIS CONNECT TO REFLOW?

The textile finishing process fixes textiles with a variety of dyes and coatings. Obviously, all of these coatings impede recycling and a few have a dubious environmental profile, like some water or dirt repellent finishes and flame retardants.

For mechanical recycling, discarded textiles must be selected by colour as well as material. For chemical recycling, these dyes must first be removed before the process can begin. Coated textiles are usually not suitable for recycling and must be incinerated.

Nevertheless, a lot of research is going towards making finished textiles suitable for recycling, and a lot of progress has already been made. For instance, breaking down the molecule from which the textile is made often releases the dye from this polymer, which makes it suitable for recycling. At the same time, the dyestuff released during this process can sometimes be collected and used again.

Replacing rotary screen printing with digital inkjet printing, as we discussed earlier, reduces the environmental impact of printing. Additionally, processes like CO<sub>2</sub> dyeing reduce the water consumption in the dyeing of textiles. Thus, both sustainable finishing processes and improved recycling technology contribute to the reduction of the environmental footprint of textiles.





**Above:** The industry has developed a broad range of reactive dyes for cotton. In addition, vat dyes, like indigo for blue jeans, are used because of their superior light fastness.

## QUICK FACTS

- Screen printing and digital or inkjet printing are the most frequently used printing techniques.
- Digital printing is becoming the dominant technique in the industry.
- Digital printing requires less energy and fewer chemicals for printing, which makes it more environmentally friendly.

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