

Textile manufacturing

Textile manufacturing is one of the oldest human industries. The oldest known textiles date back to about 5000 B.C. In order to make textiles, the first requirement is a source of fiber from which a yarn can be made, primarily by spinning. The yarn is processed by knitting or weaving, which turns yarn into cloth. The machine used for weaving is the loom. For decoration, the process of coloring yarn or the finished material is dyeing.

Typical textile processing includes 4 stages: yarn formation, fabric formation, wet processing, and fabrication.

The three main types of fibers include natural vegetable fibers (such as cotton, linen, jute and hemp), man-made fibers (those made artificially, but from natural raw materials such as rayon, acetate, Modal, cupro, and the more recently developed Lyocell), synthetic fibers (a subset of man-made fibers, which are based on synthetic chemicals rather than arising from natural chemicals by a purely physical process) and protein based fibers (such as wool, silk, and angora).

Hand processing: yarn formation

Wool

This description is based on the assumption that wool is the fiber being used. For hand-spinning most of the fiber spun is wool, or a blend containing wool. Most animal hair fiber is handled with only a few modifications to the below description. Plant fibers are prepared for spinning very differently.

Sheep Shearing

The first step in processing the wool is to collect it. Shearing can be done with use of hand-shears (tools that look like big scissors) or powered shears. Professional sheep shearers can shear a sheep in under a minute, without nicking the sheep once. At many state fairs there are sheep shearing contests, to see who can shear a sheep the fastest. These contests mainly include older men, with only a few youngsters.



A half sheared sheep

When the fleece comes off the sheep it should be in one piece. Also, it is best if the shearer cuts close enough to the skin that a second cutting is not required. Second cuts make for very short fibers, which are more difficult and not as much fun to deal with and spin. Primitive breeds, like the Scottish Soay sheep have to be plucked, not sheared, as the kemps are still longer than the soft fleece, (a process called roeing) or the fleece must be collected from the field after it falls out.

Skirting

Skirting basically means disposing of all wool that is unsuitable for spinning (too short, has sheep dung in it, etc.) One often could spin this wool, with much extra effort, if one wanted. (The dung can be washed out, the short fibers - though with greater difficulty than longer ones - can be spun, and other objections can be similarly dealt with.) Thus this step can be skipped if necessary. It can also be done at the same time as carding.

Cleaning

Before carding the wool, it must be cleaned. At this point the fleece is full of lanolin and often contains vegetable matter, such as sticks, twigs, burs and straw. One way to prevent the vegetable matter from getting into the fleece is to have the sheep wear a coat all year round.



Wool in a shearing shed

At this point there are two ways to go. The first is to simply pick out the vegetable matter, and move on to the next step. The lanolin is kept in the wool. People who enjoy spinning 'in the grease' (i.e. spinning with the lanolin still in the wool) prefer this method, and wait to wash the lanolin out until they finish spinning. The lanolin can be left in the wool after spinning as well, making the fabric or garment water repellent. If one doesn't want to spin in the grease, the other option is to take both the vegetable matter and the lanolin out.

Washing the wool at this stage can be a tedious process, if you let it. Some people wash it a small handful at a time very carefully, and then set it out to dry on a table in the sun. Other people will stick the whole fleece in a tub of water and soap (dishwashing detergent works well), let it sit, swish it around, and refill the tub with new water occasionally until the fleece is clean (of soap and dirt). One carding mill puts the fleece in a washing machine (that has been slightly modified for this purpose) and melts the lanolin away by soaking the fleece in very hot water. All these methods work. The thing not to do when washing fleece is to rub it against itself too much. If the fleece gets agitated, it will become felt, and then spinning it is impossible. Felting, when done on purpose (with needles, chemicals, or simply rubbing the fibers against each other), can be used to create garments.

Carding or combing

Before spinning it is a good idea to get the fleece into a slightly more manageable state. It is possible to spin directly from a fleece, if it is a very clean one, but it is much easier to spin a carded fleece. Carding by hand yields a rolag, a loose woollen roll of fibers. Using a drum carder yields a bat, which is a mat of fibers in a flat, rectangular shape. Most carding mills return the fleece in a roving, which is a stretched bat; it is very long and often the thickness of a wrist. (A pencil roving is a roving thinned to the width of a pencil. It is often used for knitting without any spinning, or for beginning spinners.)

Many hand-spinners send their wool out to carding mills to be carded, as one good-sized fleece may take weeks to card with a drum-carder, or an eternity by hand. If the fleece is sent to a carding mill, it must be washed before carded. Most mills offer washing the wool as a service, with extra fees if the wool is exceptionally dirty. Other hand-spinners simply buy their fibers pre-carded.

Another technique, less used on raw fleece, is that of combing. Combing is another method to align the fibers parallel to the yarn, and thus is good for spinning a worsted yarn, whereas the rolag from handcards produces a woollen yarn.

Spinning

Hand spinning can be done many different ways, the two most common being by use of the spinning wheel or the spindle. Spinning turns the carded wool fibers into yarn which can then be directly woven, knitted (flat or circular), crocheted, or by other means turned into fabric or a garment.



A spinning wheel used to make yarn

Removing the yarn from the wheel

When spinning on a spinning wheel, the yarn collects on a bobbin. Once the bobbin is full, the spinner can either put on a new bobbin, form a skein, or ball the yarn.

If the yarn is to be plied then the most common action is to put a new bobbin on the wheel, and leave the yarn on the bobbin so that the spinner can ply directly from the bobbin. This makes for greatest ease when plying, but cannot be done if the spinner does not have enough bobbins. When plying from bobbins a device called a lazy kate is often used to hold the bobbins.



A lazy kate with bobbins on it in preparation for plying.

If the spinner has the end result (i.e. the yarn is already plied or is not going to be), then most likely they will make a skein out of the yarn. A skein is a coil of yarn twisted into a loose knot. It is either formed on a niddy noddy or some other type of skein winder. Traditionally niddy-noddys looked like an uppercase "i", with the bottom half rotated 90 degrees [1]. Now spinning wheel manufactures also make niddy-noddys that attach onto the spinning wheel [2] for faster skein winding.

Rarely is the yarn balled directly after spinning. Normally hand-spun yarn will be stored in skein form, and transferred to a ball only if needed. (For example, knitting from a skein, unless done very carefully, ends up with the yarn in knots, so it is best to ball it first.)

Ply

Plying yarn is when one takes a strand of spun yarn (one strand is often called a single) and spins it together with other strands in order to make a thicker yarn. There are several ways, the most common being regular and Navajo.



A niddy noddy ready to have a skein wound on it.

Regular plying consists of taking two or more singles and twisting them together, the opposite way. This can be done on either a spinning wheel or a spindle. The

most important thing to remember though is that the twist must go the opposite direction. If in spinning the single the wheel was spinning clockwise (which is called a "Z" twist, as on any given side the fibers appear to cross diagonally in the same direction as the diagonal of a "Z"), in order to ply it the wheel must spin counter-clockwise (an "S" twist). This is because otherwise you are not balancing the twist, just twisting it more. The concept is similar to when a heavily twisted piece of yarn is folded, and it twists up on itself. It is most common for singles to be spun with a "Z" twist, and then plied with an "S" twist.

Navajo plying consists of making large loops, similar to crocheting. First make a loop about 8 inches long through the loop on the end on the leader. (A leader is the string left on the bobbin to spin off.) Start spinning all three strands together in the opposite direction than that they were spun in. When only 2 to 3 inches (76 mm) remain of the loop, pull a new loop of yarn through the loop, and continue spinning. The new loop should be around 7 inches (180 mm) long. Repeat this process until the yarn is all plied. Only one single is necessary, and if the single is already dyed this technique allows it to be plied without ruining the color scheme. This technique also allows the spinner to try to match up thick and thin spots in the yarn, thus making for a smoother end product.

Most spinners (who use spinning wheels) ply from bobbins. This is easier than plying from balls because there is less chance for the yarn to become tangled and knotted if it is simply unwound from the bobbins. So that the bobbins can unwind freely, they are put in a device called a lazy kate, or sometimes simply kate. The simplest lazy kate consists of wooden bars with a metal rod running between them. Most hold between three and four bobbins. The bobbin sits on the metal rod. Other lazy kates are built with devices that create an adjustable amount of tension, so that if the yarn is jerked, a whole bunch of yarn is not wound off, then wound up again in the opposite direction. Some spinning wheels come with a built in lazy kate. Picture of lazy kates, with tension device.

Washing

If the lanolin was not washed out before, this is the point at which it gets washed out, unless the lanolin is to be left in the cloth as a water repellent. When washing a skein it works well to let the wool soak in soapy water overnight, and rinse the soap out in the morning. Dishwashing detergents are commonly used, and a special laundry detergent designed for washing wool is not required. The dishwashing detergent works and does not harm the wool. After washing, let the wool dry (air drying works best). Once it is dry, or just a bit damp, one can stretch it out a bit on a niddy-noddy. Putting the wool back on the niddy-noddy makes for a nicer looking finished skein. Before taking a skein and washing it, the skein must be tied up loosely in about six places. If the skein is not tied up, it will be very hard to unravel when done washing.

Flax

The preparations for spinning is similar across most plant fibers, including Flax and Hemp. Cotton is handled differently, as with cotton it is not the stalk of the plant that is used. Flax is the fiber used to create linen.

Harvesting

The first step in preparing flax to be spun is harvesting it. Flax is not cut, but instead it is pulled out of the ground about a month after the initial blooming. It should be pulled when the lower part of the plant begins to turn yellow, and when, on opening the pods, the most forward of the seeds are found in a soft state, and the middle of the seeds is green. It should be pulled in handfuls, straight up. Next, one should join several

handfuls together and tie them using a slip knot so that the sting can be tightened as the stalks dry. (Note that great care should be taken to keep the root ends even.) These bundles of several handfuls of flax (also known as "beets") should be left standing up till the whole is dry, pods and all. At this point the seed will then be ripe and the flax in the best state.

Removing the seedheads

At this point the seed heads are removed. Once the seed heads are removed it can be stored for many months if necessary, but they must be kept dry. An easy way to remove the seed heads is to take a board and hammer in a row of blunt nails at even intervals, like a comb. Spread a sheet out to collect the seed heads, as they can be planted to create more flax. Next pull the dry bundles of flax through the nails (also called a ripple). This will cause the seed heads to pop off. Make sure to maintain the evenness of the root ends.

In order to separate the seeds from the rest of the seed heads an easy method is to thresh the seed heads by use of a rolling pin. Then, on a windy day or in front of a fan, take the mixture and pour it back and forth between two containers. This action is called winnowing. The chaff will get caught in the wind and blow away, while the seeds will fall straight down into the container. A screen also works to filter out some of the chaff.

Retting

Retting is the process of rotting away the inner stalk, leaving the outer fibers intact. A standing pool of water or a plastic trash can is needed. Actually, any type of watertight container of wood, concrete, earthenware or plastic will work. Metal will not work, as an acid is produced when retting, and it would corrode the metal. A tall plastic trashcan with a spigot at the bottom works well. Place as many bundles of flax in the trashcan as will fit, and fill the trash can full of warm water (80 degrees Fahrenheit is best). It is suggested that a lid of some sort be put over the trashcan in order to keep the flax submerged, conserve warmth and contain the stench. After 4 hours a complete change of water is recommended, and 8 hours after that the scum should be washed off the top by the addition of some more water. From then on the scum should be washed off every 12 hours until the retting process is over.



Threshing and dressing flax in the Roscheider Hof, Open Air Museum

If kept at 80 °F (27 °C), the retting process takes 4 or 5 days, and any colder than that takes longer. When the retting is complete the bundles should feel soft and slimy, and quite a few fibers should be standing out from the stalks. When wrapped around a finger the inner woody part should spring away from the fibers. It is better to not let the bundles sit in the water long enough than to let them sit there too long, as they always can be submerged again if found to be wanting later, but the reverse problem cannot be solved (in this case the fibers are rotted as well as the stalk, and one cannot un-rot something).

Dressing the flax

Dressing is the broad term referring to removing the fibers from the straw and cleaning it enough to be spun. The flax is broken, scutched and hackled in this step.

Breaking The process of breaking breaks up the straw into short segments. To do it, take the bundles of flax and untie them. Next, in small handfuls, put it between the beater of the breaking machine (a set of wooden blades which mesh together when the upper jaw is lowered- it looks like a paper cutter but instead of having a big knife it has a blunt arm), and beat it till the three or four inches (102 mm) that have been beaten appear to be soft. Move the flax a little higher and continue to beat it till all is soft, and the wood is separated from the fiber. When half of the flax is broken, hold the beaten end and beat the rest in the same way as the other end was beaten, till the wood is separated.



Peasant woman breaking flax

Scutching In order to remove some of the straw from the fiber, it helps to swing a wooden scutching knife down the fibers while they hang vertically, thus scraping the edge of the knife along the fibers and pull away pieces of the stalk. Some of the fiber will also be scutched away, this cannot be helped and is natural.

Heckling In this process the fiber is pulled through various different sized heckling combs. A Heckling comb is a bed of "nails"- sharp, long-tapered, tempered, polished steel pins driven into wooden blocks at regular spacing. A good progression is from 4 pins per square inch, to 12, to 25 to 48 to 80. The first three will remove the straw, and the last two will split and polish the fibers. Some of the finer stuff that comes off in the last heckles can be carded like wool and spun. It will produce a coarser yarn than the fibers pulled through the heckles because it will still have some straw in it.

Spinning

Depending on the preference of the spinner, flax can either be spun from a distaff, or the spinner may simply lay flax fibers in their lap. It is recommended that the spinner keep their fingers wet when spinning, to prevent forming a fuzzy thread, and that the single be spun with an "S" twist. (See Ply above for details). From this point on much of the process is the same as that for wool.



Flax being spun from a distaff

Washing

One of the few differences in between flax and wool once the fiber is ready for spinning is the washing process. After flax is spun it should be let to sit in a pot of boiling water for a couple of hours to set the twist and reduce fuzziness.

Note: Many handspinners, instead of doing all the preparation themselves, will buy a roving of flax. This roving is spun in the same manner as above. The rovings may come with very long fibers (4 to 8 inches), or much shorter fibers (2 to 3 inches).

Machine Processing: yarn formation

The machines used for different fibers vary slightly in the initial steps, but once the fiber is in a rolag (ready to spin) the process and machinery is pretty much universal. Slight changes are made depending on the coarseness of the fiber or yarn desired.

Cotton

Cotton Gin

The cotton boll is white, roughly spherical and fluffy. After being harvested, the cotton is sent through a cotton gin because the seeds have to be removed before carding. A modern day cotton gin looks similar to a carding machine, in that the fiber goes through many different rollers. The teeth on the gin are different from those on a carding machine. The ginning process removes the seeds from the cotton fiber. The first cotton gin was produced by Eli Whitney. At this point, the ginned cotton is normally put into bales, and shipped to the cotton mill.

Picking

When the cotton comes out of a bale, it is all packed together and still contains vegetable matter. In order to fluff up the cotton and remove the vegetable matter, the cotton is sent through a picker. A picker looks similar to the carding machine and the cotton gin, but is slightly different. The cotton is fed into the machine and gets beaten with a beater bar, to loosen it up. The cotton then collects on a screen and gets fed through various rollers, which serve to remove the vegetable matter.

Carding

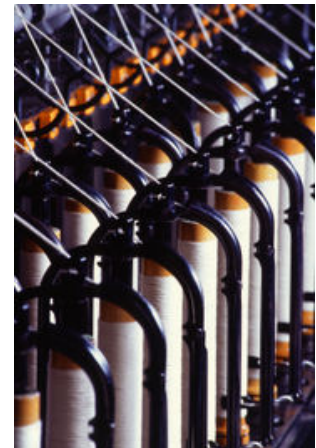
The cotton comes off the picking machine in large bats, and is then taken to carding machines. The carders line up the fibers nicely to make them easier to spin. The carding machine consists mainly of one big roller with smaller ones surrounding it. All of the rollers are covered in small teeth, and as the cotton progresses further on the teeth get finer (i.e. closer together). The cotton leaves the carding machine in the form of a sliver; a large rope of fibers.

Combining the Slivers

Next, several slivers are combined. Each sliver will have thin and thick spots, and by combining several slivers together a more consistent size can be reached. Since combining several slivers produces a very thick rope of cotton fibers, directly after being combined the slivers are separated into rovings. These rovings are then what are used in the spinning process. Generally speaking, for machine processing a roving is about the width of a pencil.

Spinning

The spinning machines stake the roving, thin it and twist it, creating yarn. The roving is pulled off a bobbin and fed through some rollers, which are feeding at several different speeds. This thins the roving at a consistent rate. If the roving was not a consistent size, then this step could cause a break in the yarn, or could jam the machine. The yarn is twisted through the spinning of the bobbin it is rolled on, exactly like a spinning wheel but just in a different configuration. This process was improved in the 1950s with the invention of the Wilson Yarn Clearer.



Cotton being spun

Plying

Plying is done by pulling yarn from two or more bobbins and twisting it together, in the opposite direction than that in which it was spun. Depending on the weight desired, cotton may or may not have been plied.

Yucca

While not an especially common fiber, Yucca fibers were at one time widely used throughout Central America for many things. Currently they are mainly used to make twine.

Leaf to Rolag

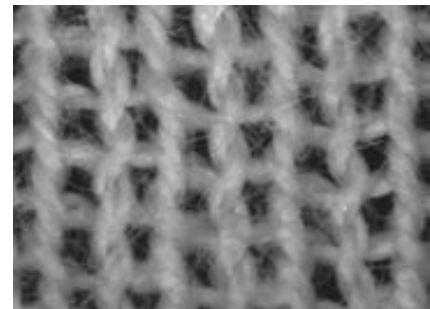
After being harvested, the yucca leaves are put on a conveyor belt, and then cut to a standard size. In order to separate the fibers from the rest of the leaf, the leaves are crushed in between two large rollers. The waste, a pulpy liquid that stinks, can be used as a fertilizer. At this point the fibers are bundled up and dried. This is easily done by draping them over trellises and leaving them out in the sun to dry. Once the fibers are dry they are combined into rolags. Then several rolags are combined to produce a more consistent rolag. At this point it is ready to spin.

Hand Processing- Fabric Formation

Once the fiber has been turned into yarn the process of making cloth is much the same for any type of fiber, be it animal or plant.

Knitting

Knitting by hand is a trend that is slowly growing throughout the United States. Commonly knitted goods are scarfs (both decorative and functional), sweaters, socks and shawls. Hand knitting can either be done "flat" or "in the round". Flat knitting is done on a set of single point knitting needles, and the knitter goes back and forth, adding rows. In Circular knitting, or "knitting in the round", the knitter knits around a circle, creating a tube. This can be done with either double pointed needles or a circular needle.



The front side of a plainly knitted object might look like this, under close inspection.

Since knitting in essence is pulling one row of loops of yarn through another row, a knitted object will unravel easily if the top has not been secured. Knitted objects also stretch easily in all directions, whereas woven fabric only stretches on the bias.

Crochet

Crocheting differs largely from knitting in that there is only one loop, not the multitude as knitting has. Also, instead of knitting needles, a crochet hook is used. Other than that it is vaguely similar, and is often mistaken for knitting. Lace is commonly crocheted, as well as a large variety of other items.



Knitting needles

Lace

A lace fabric is lightweight openwork fabric, patterned, with open holes in the work. The holes can be formed via removal of threads or cloth from a previously woven fabric, but more often lace is built up from a single thread and the open spaces are created as part of the lace fabric.

Weaving

The earliest weaving was done without a loom, but that is rare now.

Loom

In general the supporting structure of the loom is called the frame.

The frame provides the means of fixing the length-wise threads, called the warp, and keeping them under tension. When producing a long piece of material, the warp threads are wound on a roller called a beam, and attached to the cloth beam which will serve to hold the finished material. Because of the tension the warp threads are under, they need to be strong.

The thread that is woven through the warp is called the weft. The weft is threaded through the warp using a shuttle, which carries the weft through separated warp threads. The original hand-loom was limited in width by the weaver's reach, because of the need to throw the shuttle from hand to hand. The invention of the flying shuttle with its fly cord and picking sticks enabled the weaver to pass the shuttle from a box at either side of the loom with one hand, and across a greater width. The invention of the drop box allowed a weaver to use multiple shuttles to carry different wefts.

After passing a weft thread through the warp, a reed comb used to beat (compact) the woven weft.

Rather than having to lift each thread individually, alternate threads can be separated by introducing a bar between the threads: the gap created is called the shed. While an inserted bar only presents one orientation, alternating sets of threads can be lifted by connecting them with string or wires called heddles to another bar, called the shaft (or heddle bar or heald). Heddles, shafts and the couper (lever to lift the assembly) are called the harness — the harness provides for mechanical operation using foot- or hand-operated treadles. (Multiple harnesses can be used, connected to different sets of warp threads in a draw-loom.)

Sleying is the process of threading the warp yarn through the reed. Usually one speaks of "sleying the reed". You set (verb) the warp at X ends per inch and then you can say that its sett (noun) is X ends per inch.

Process

The first step in weaving is to make a warp, the threads that run lengthwise perpendicular to you. By hand this is done with the help of a warping board. The length the warp is made is about a quarter to half yard more than the amount of cloth they will be able to get off the loom, because of waste at the beginning and end. Since with smaller lengths of warp means a higher percentage of wasted yarn, and since threading the loom can be tedious, most weavers put on many yards at a time. The weaver decides what length of a warp to put on the loom, then measures it out on the warping board. Warping boards come in a variety of shapes, from the two nearest door handles to a board with pegs on it, or a device called a warping mill that looks similar to a swift.

Machine processing: fabric formation

Knitting

Knitting by machine is done in two different ways; warp and weft. Weft knitting (as seen in the pictures) is similar in method to hand knitting with stitches all connected to each other horizontally. Various weft machines can be configured to produce textiles from a single spool of yarn or multiple spools depending on the size of the machine cylinder (where the needles are bedded). In a warp knit there are many pieces of yarn and there are vertical chains, zigzagged together by crossing the yarn.

Warp knits do not stretch as much as a weft knit, and it is run-resistant. A weft knit is not run-resistant, but stretches more, this is especially true if spools of Lycra are processed from separate spool containers and interwoven through the cylinder with cotton yarn giving the finished product more flexibility making it less prone to having a 'baggy' appearance. The average t-shirt is a weft knit.

Lace

Weaving

Decoration

Dyeing

Bleaching

Further information: Bleachfield

Embroidery

Embroidery – threads which are added to the surface of a finished textile.