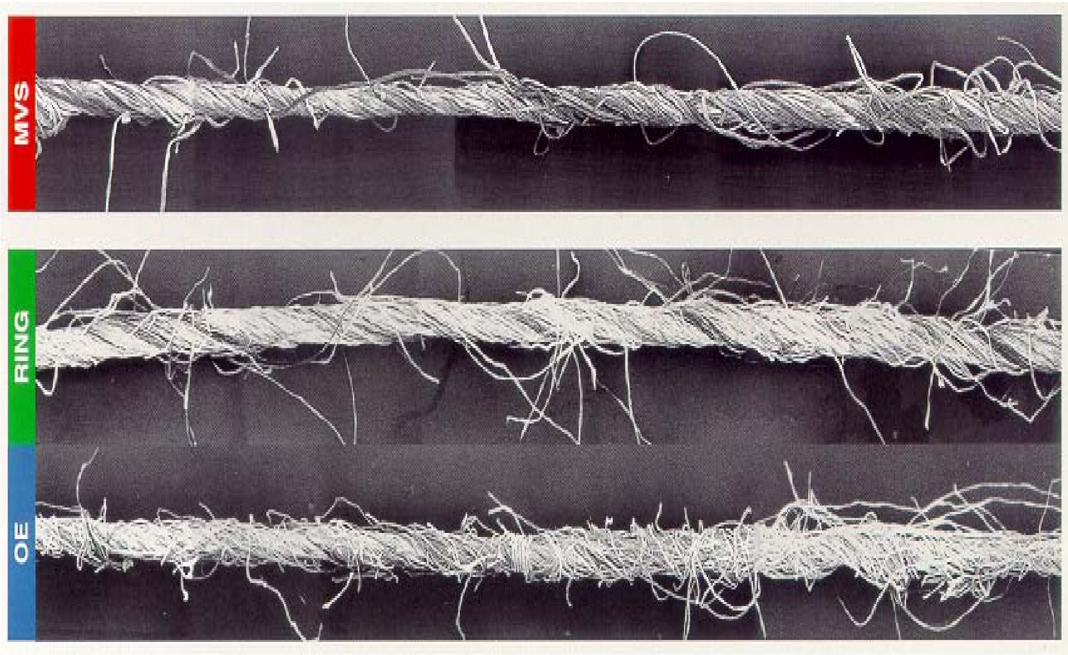
TEXTILE YARNS



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Textile Yarns

1.0 Introduction

A textile **yarn** is a continuous strand of staple or filament fibers arranged in a form suitable for weaving, knitting, or other form of fabric assembly. Also, a yarn is a textile product of substantial length and relatively small cross-section consisting of fibers with twist and/or filaments without twist. The yarn can be twisted with one or more yarns to create added value or aesthetics. Traditionally, yarns have been constructed of fibers of finite length called **staple** fibers. Today, **continuous filament** yarns are also used to construct yarns.

Filament yarns tend to be smoother, more lustrous, more uniform, harsher, and less absorbent. Spun yarns have a hairy surface, are more uneven in appearance, have lower luster, are softer, and more absorbent. Spun yarn is the yarn of choice in many woven and knitted fabric products. The short fibers can be natural fibers such as cotton where the fiber grows in short lengths. But they can also be synthetic fibers such as polyester that are manufactured in a continuous length and then cut into shorter staple lengths.

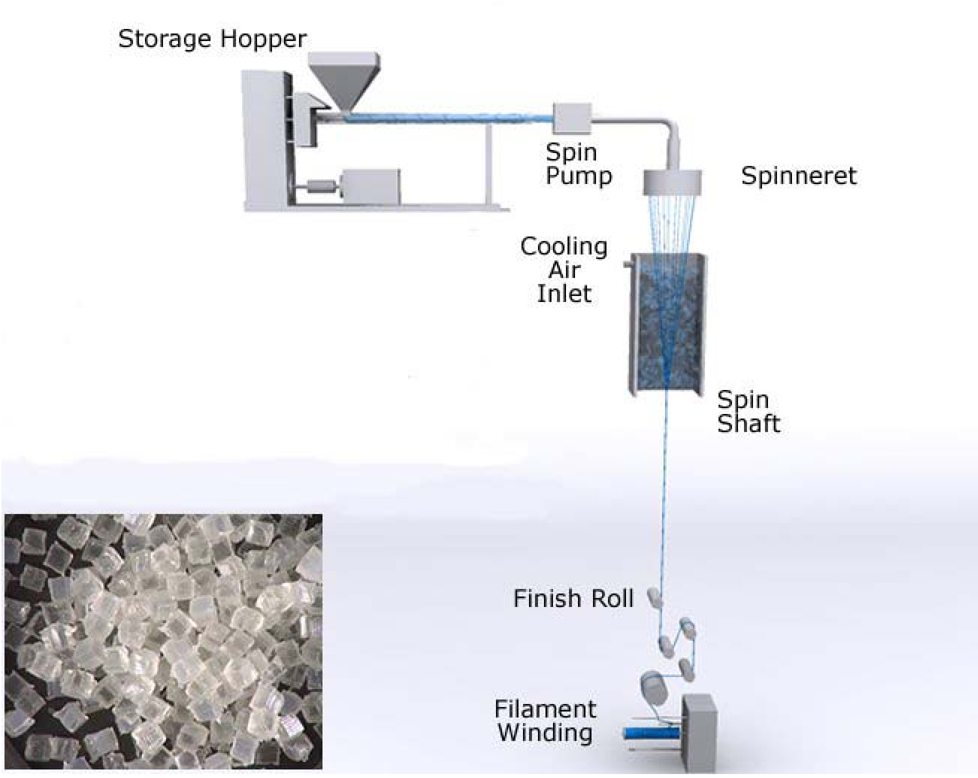
This document will discuss how yarns are formed. It covers fiber preparation and spinning for cotton and blends of cotton. Also covered is the production of synthetic filaments and their conversion to tow and how the tow in turn gets cut into short fibers. Then the steps in the processing of cotton and cotton/synthetic blended spun yarns and the various spinning systems used will be addressed. Emphasis will be placed upon the influence of the yarn on fabric properties and performance.

2.0 Fibers for Staple Spinning Processes

Natural fibers (with the exception of silk) are classified as staple fibers because their length can be measured and is typically less than 10 inches (25.4 cm). Cellulosic fibers including cotton are 2.5 inches (6.35 cm) or less in length and are labeled **short staple**. The vast majority of cotton fibers are less than 1.5 inches (3.8 cm). Animal hair fibers such as wool, cashmere, mohair, and others are less than 10 inches and are referred to as **long staple**. Regardless of source, staple fibers are considered ready for spinning when received at the textile spinning plant.

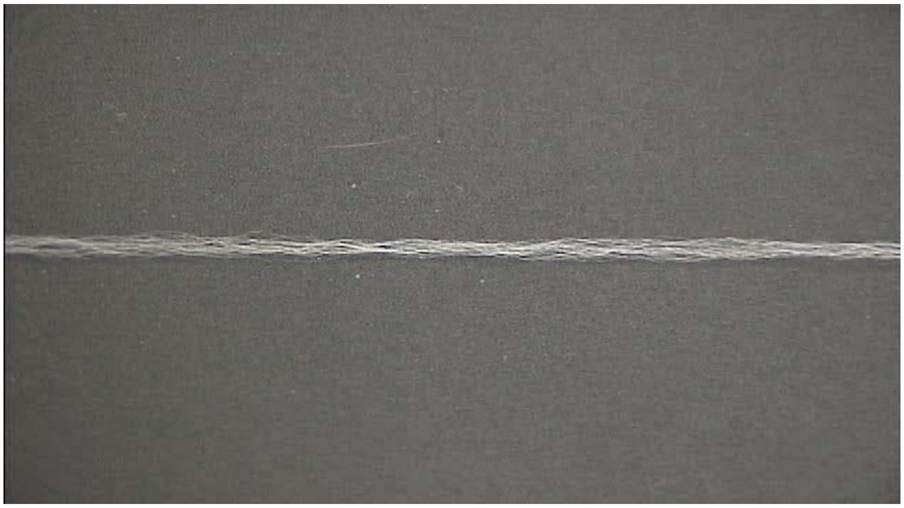
Manmade filament yarns are converted to staple fibers in order to spin on the short staple or English spinning system. Filament yarns have a limited number of filaments that are extruded from a spinnerette device as shown in Figure 1. The spinnerette is like a shower head, it contains a certain number of small holes which allow continuous filament fibers to be extruded. Left in this form the yarn is classified as a flat filament yarn. Plastic chips are shown here as the raw material for the manufacturing of these filaments.

Figure 1 - Filament Extrusion Through a Spinnerette.



Filament yarns can be textured as shown in Figure 2. Texturizing allows for better wicking, less luster, more stretch, more bulk, and a softer feel. To manufacture synthetic short fibers to be used in spun yarns, filaments from many extrusion heads are combined into a single strand called **tow**. The formed tow, containing several million filaments, is crimped to create good fiber-to-fiber cohesion and is then cut into short lengths of fiber for use in spun yarns. The cut fibers are blended prior to baling. At the yarn manufacturing plant, numerous bales are used in a lay-down to further blend out variation.

Figure 2 - Textured Filament Yarn.



3.0 Staple Spinning Systems

3.1 Ring Spun Yarns

The processing of a **cotton ring spun** yarn must go through a carding machine. If it is desired, the fiber may also be combed which would be in addition to the carding. A **carded cotton ring spun yarn** begins with a **bale lay-down**. Figure 3 shows the flow of cotton staple fiber from the bale laydown through ring spinning. There are multiple bales in the lay-downs (see Figure 4). A lay-down is a grouping of bales of fiber based on fiber properties to meet the specifications of a particular yarn. Each lay-down feeds into a series of opening and cleaning equipment. Bales are then placed in an individual lay-down according to fiber strength, fiber length, fiber micronaire (thickness of the cotton fiber), and color. Cotton from different growth regions may be in different lay-downs or in the same lay-down. A lay-down of cotton fibers would be in a separate area from a lay-down of another fiber type such as polyester.

Small tufts of fibers are plucked from the bales by a top-feeder which automatically moves up and down the lay-down. The bales are normally computer selected so that lay-downs are controlled according to important properties of the fibers assuring consistency from lay-down to lay-down.

The fiber tufts are then processed through various types of **opening and cleaning** machinery in order to open or separate the fibers which also aids in cleaning or removal of trash particles mixed in with the fiber. The trash is composed of cotton plant materials such as leaf trash and seed hull fragments.

Figure 3 – Carded Ring Spun Yarn Processing Route

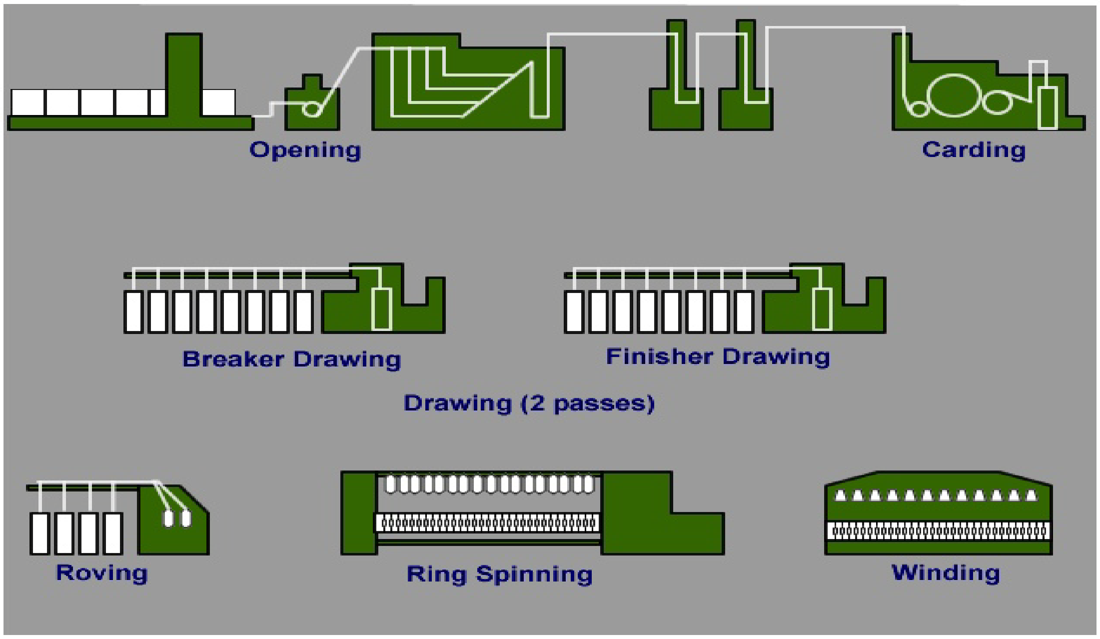


Figure 4 – Multiple Laydowns

Coarse opening equipment is used to open larger fiber tufts and remove larger trash particles followed by fine openers to open smaller tufts and remove smaller trash particles (See Figures 5 and 6). Good opening and cleaning will enhance improved carding which is the next process. Careful attention is given not to overwork the cotton fibers which would lead to fiber breakage and weak and uneven yarn. Improper opening leads to poor cleaning and uneven product formed at the carding process. Most opening and cleaning equipment utilizes wire-covered rollers to progressively open and clean the cotton fibers. Waste removed during the opening process will normally be recycled to capture any lost fiber while extracted plant waste may be used to supplement cattle feed or be used as an energy alternative such as incineration for energy.

Figure 5 – Coarse Cleaner.

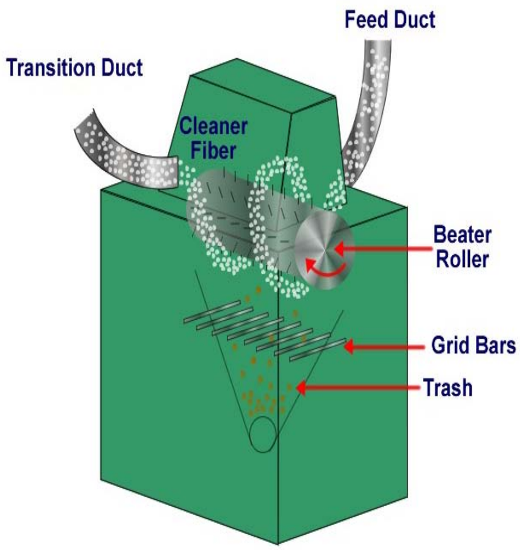
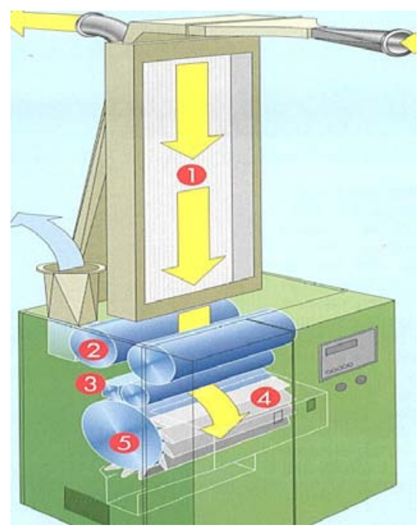


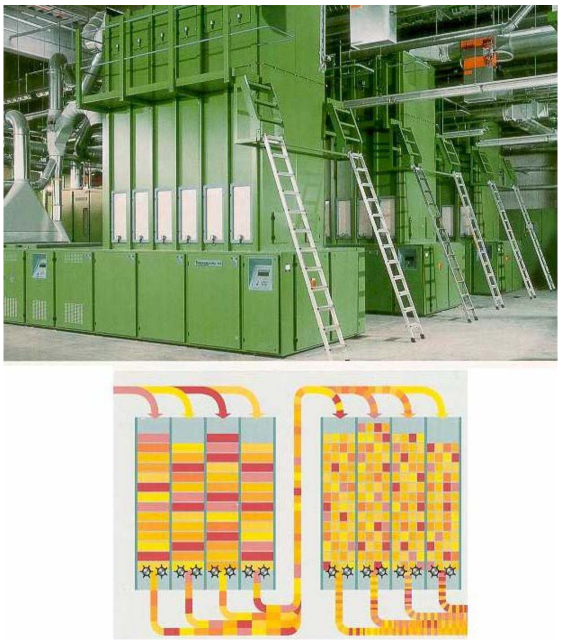
Figure 6 – Fine Opener.



The fibers are moved via duct work to a multi-cell blender which is used to create a more uniform blend of cotton fibers. They can also be used to further blend different fiber types together. A multi-cell blender can be seen in Figure 7.

Intimate blending of cotton fibers with other fiber types can be done using a series of machines that weigh different amounts of each fiber and then drop the fiber onto a conveyor belt (see Figure 8). A rotating beater at the end of the conveyor belt will mix the fibers together. Additional blending of the fibers is done on other equipment such as multi-cell blenders. This intimate blend of fibers is especially helpful when dealing with dyed fabrics with a potential for shade variation and other dyeing problems.

Figure 7 – Multi-cell Blender.



It is now time for the opened, cleaned, and blended fibers to go through the **carding** process. The carding machine shown in Figure 8 has a chute feed which delivers a thick mat or blanket of fibers to rotating wire-covered cylinders that separate individual fibers to create total fiber opening. Most small particles of trash that are left in the fibers and neps (small entanglements of fibers) will get removed at carding. The card wires will form a thin layer of fibers which looks like a spider web. The action of the carding surfaces helps to align the fibers. The card web gets condensed at the front or delivery end of the carding machine to form what is called a **sliver**. The strand of sliver will be placed into a large cylindrical can and transported to the next process (see Figure 9). It must be remembered that all fibers are carded whether cotton or cotton blends, including fibers that go into combed yarns.

Figure 8 – Intimate Blending – Fiber Blending

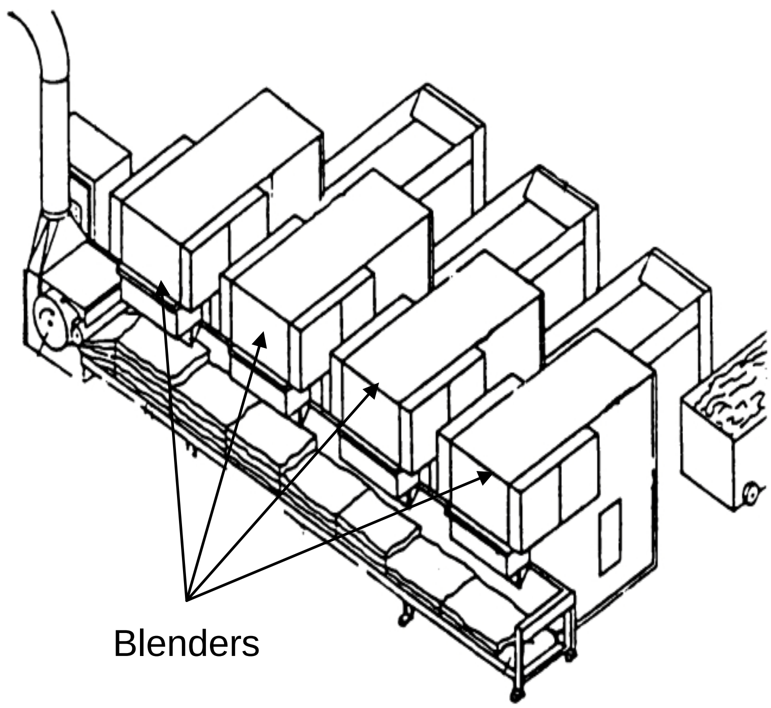
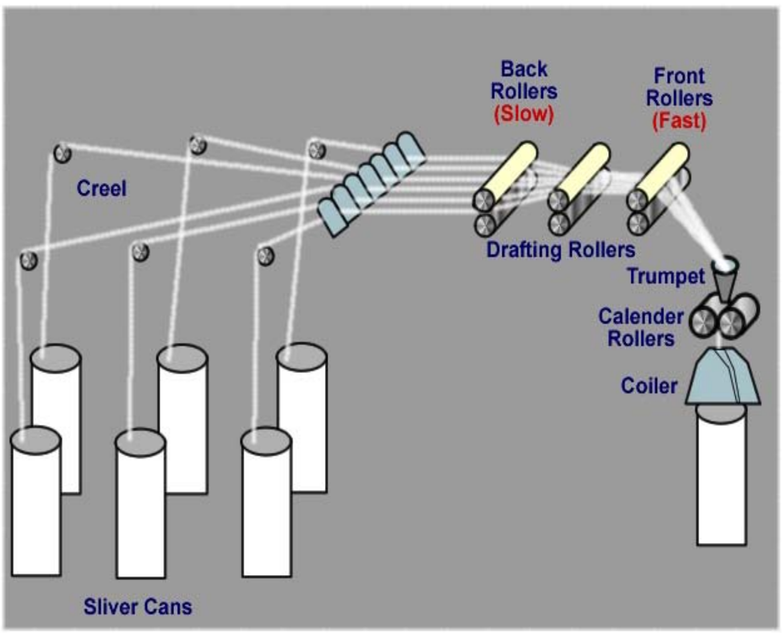


Figure 9 - Carding Machine Delivering Sliver.

Carded sliver is then transported to the **drawing** process where multiple cans of sliver are placed behind the drawing machine. The multiple ends of sliver are fed simultaneously through a set of progressively faster rotating rollers which aids in better fiber alignment and improved blending (see Figure 10). A 100% cotton blend would have all slivers of cotton.

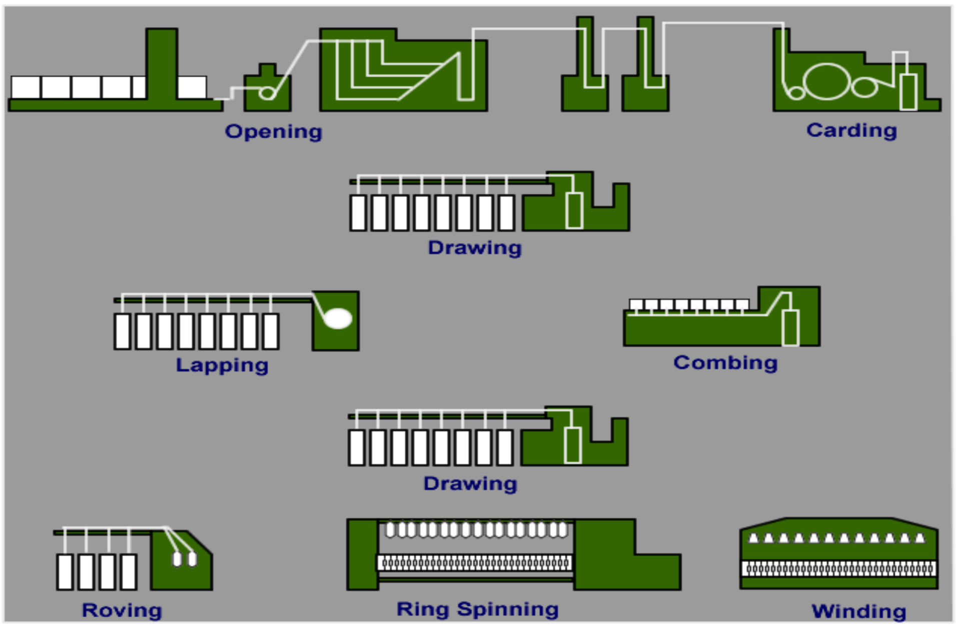
If desired, slivers of different fiber type can be blended at drawing to produce a fiber blend referred to as a draw blend. In Figure 10, if three cotton slivers were blended with three polyester slivers, the result would be a 50/50 cotton/polyester blend in the delivered sliver. Draw blends are used when shade variation in dyeing will not be as critical and also when forming a fiber blend for heather yarns. Sliver blending is more productive than fiber blending.

Figure 10 – Drawing for Fiber Blending.



When processing **combed ring spun yarns**, some additional processes must be included (see Figure 11). After card slivers go through one drawing step, lap winders wind multiple ends of sliver in a parallel arrangement onto a spool or package called a comber lap. Laps are in turn placed onto the combing machines. **Combing** is a value added process and will make various improvements to the sliver quality. It removes short fibers, neps, and any remaining small trash particles while parallelizing the fibers. Thus the resulting yarn will contain longer fibers, fewer neps, and be cleaner. Improved fiber alignment will lead to more uniform yarns. Combed fibers are mainly used in ring spun yarns. Combing allows the spinning of finer counts of yarn that cannot be spun with just carded fiber.

Figure 11 – Combed Ring Spun Yarn Processing Route.



Shown in Figure 12 is a comber lap containing 24 carded and drawn slivers that is fed at each position on the comber. A typical comber has eight positions, each one producing a sliver. One single combed sliver will ultimately be delivered from each line of comber heads from the combing machine, and will later be blended with combed slivers from other machines.

When sourcing combed yarns, one must be aware of the different qualities. Qualities of combed yarns will vary according to the percentage noil (waste removed) and whether or not the yarn is fully or only partially combed. A fully combed yarn will be produced when all slivers making up the yarn have been combed. Partially combed yarns are produced from a mixture of combed and carded slivers. When evaluating combed yarns based upon noil removed, one must be aware of the quality of the incoming fiber. Percentage noil removed may range from as low as 4% to as high as 24%. Based on a consistent input quality, 16% noil removal would produce a better quality combed yarn than 10% noil removal.

Since combed yarns contain longer fibers, less twist can be added for comparable strength and thus the yarn and resultant fabric will be softer. Less yarn twist also leads to less yarn and fabric skew or torque. Combed yarns are more even in diameter and size with lower tendency to pill and shed fibers. Normally one or two additional drawing processes will follow combing to help improve combed sliver evenness or uniformity.

Figure 12 – Comber Lap With 24-Drawn Slivers.

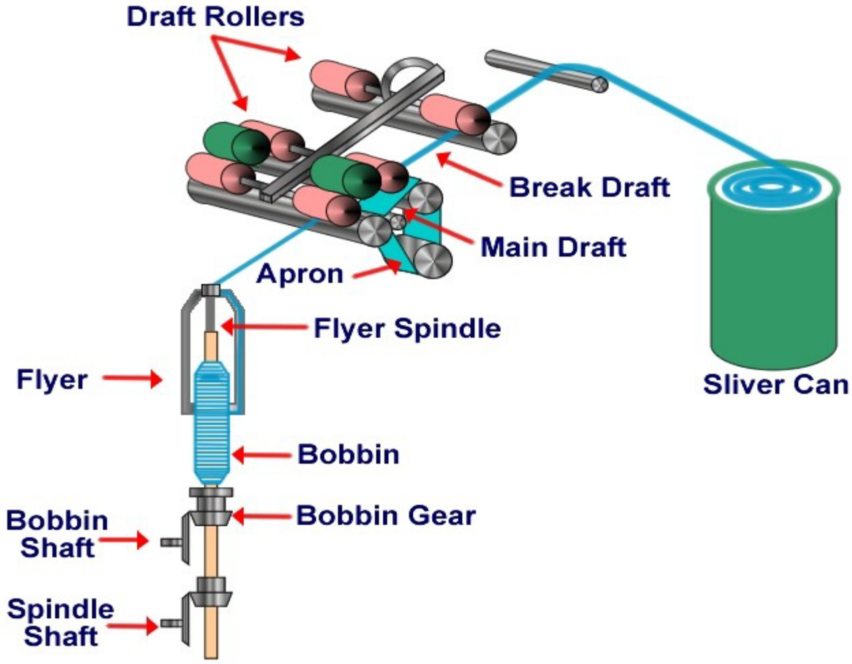
The following chart summarizes the differences between carded and combed yarns.

Carded and Combed Ring Spun Yarn Comparison

	Carded	**Combed**
Staple Length	**Shorter**	**Longer**
Evenness	**Less even**	**Even**
Neps	**More**	**Less**
Trash	**More**	**Less**
Fiber Orientation	**Less**	**More**
Strength	**Lower**	**Higher**
Range of counts	**Coarser**	**Finer**
Yarn surface	**Hairy**	**Smoother**
Diameter	**Thicker**	**Thinner**
Luster	**Less**	**More**
Processing Costs	**Less**	**More**

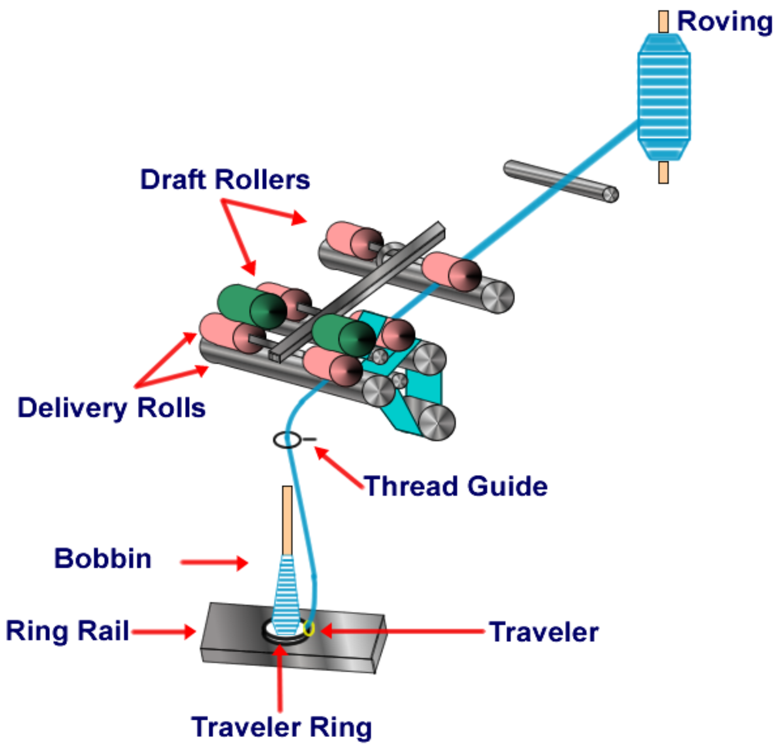
Whether making carded ring spun yarn or combed ring spun yarn, the next step will be the production of roving. **Roving** is a strand of fibers lightly twisted together with a thickness similar to a pencil or pen. Drawn slivers are fed into the machine and bobbins of roving are delivered. Roving is the product that is fed into the ring spinning machine that follows the roving process. In Figure 13, a drawing of a typical roving machine shows the drafting rollers that control the roving thickness. The rotation of the flyer and bobbin inserts a low level of twist into the roving, just enough to hold the roving together.

Figure 13 – Typical Roving Machine.



In **ring spinning**, roving is fed through a series of rotating rollers which draft or reduce the roving thickness into the final yarn thickness which equates to the yarn count or yarn number (see Figure 14). By adjusting the differential speed of the drafting rollers to reduce the linear mass, a range of yarn counts can be produced from the same roving. The reduced mass of fibers is passed through a traveler which rotates around a stationary ring device. At the same time the bobbin of wound yarn is also rotating (slightly higher rate than the traveler). The rotation of traveler and bobbin allows the necessary yarn twist to be inserted. The rotational direction of the ring bobbin can be clockwise or counterclockwise to produce Z and S twist yarns (explained later). The twist will migrate from the traveler up to the nip of the front roller. Since the spinning bobbin rotational speed is constant, the front drafting roller is slowed down to allow more twist insertion and speeded up to allow less twist insertion. Finer yarns require more twist and therefore the production is lower while coarser yarns require less twist which promotes a higher productivity. That is why finer yarns tend to cost more compared to coarser yarns.

Figure 14 – Ring Spinning.



Looking at the magnified picture of a ring spun yarn in Figure 15, it is evident that the fibers form a very regular orientation. The natural unevenness of the yarn is created by the variable lengths of fibers going through the drafting rollers on the ring spinning machine. Shorter fibers get trapped between the rollers, forming thick and thin areas in the yarn. Ring spun yarns have higher strength and have a softer hand (feel) compared to the other spun yarn types. The higher cost associated with ring spun yarns is due to lower productivity, more processes involved, and more personnel needed.

Compact ring spun yarns are formed when an extra set of rollers are placed in front of the original delivery roller. These rollers create pressure and have a perforated screen through which air suction is applied to keep the fibers tight around the yarn axis and to lay the fiber ends into the yarn surface, making the yarn smoother, stronger, more even, and less hairy. Therefore pilling is reduced which can be a savings in downstream processing. Figure 16 shows a conventional ring spun yarn being formed on the left and a compact spun yarn being formed on the right. Notice the higher levels of hairiness on the conventional ring spun yarn.

Figure 15 – Longitudinal View of Ring Spun Yarn.

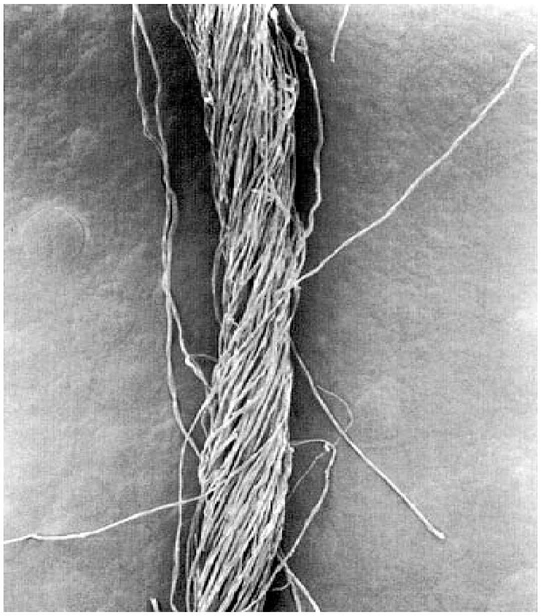
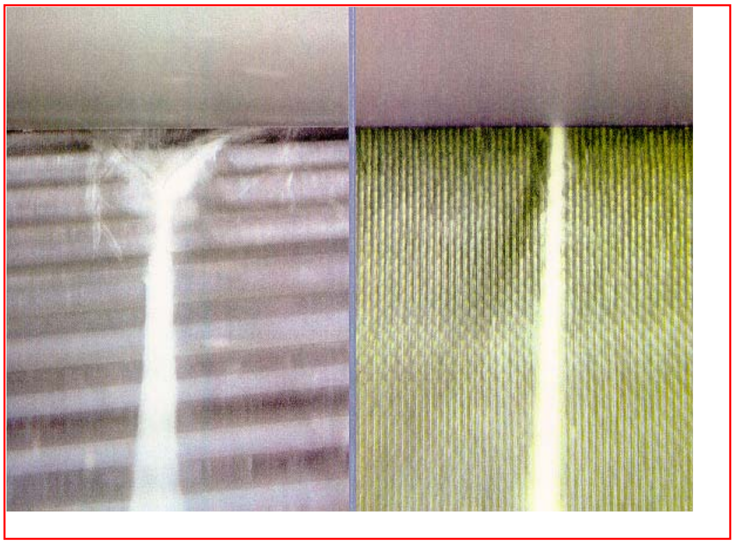


Figure 16 – Comparison of Conventional Ring Spun to Compact Ring Spun.



Once ring spun yarn is formed onto the small ring bobbins, the bobbins must be delivered to a separate **winding** operation where a number of yarn bobbins will be consecutively unwound and their yarn transferred to a much bigger yarn cone or tube. At winding the yarn can be “cleared” which means that imperfections can be electronically detected and automatically removed right before the yarn is placed on the package. Also a disk of wax can be located just before package winding in order to lubricate the yarn surface. Wax is applied mainly to knitting yarns in order to reduce yarn surface friction which allows more constant yarn tension and less needle abrasion, and a more consistent product.

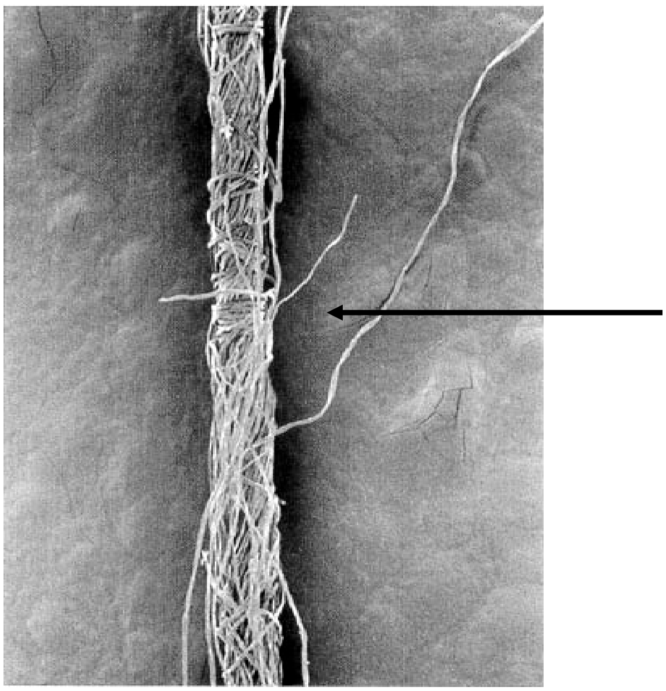
3.2 Open End Spun Yarn

Open end spun yarn (sometimes called **rotor spun yarn**) is produced with fewer processes as seen in Figure 17 and more automation compared to ring spinning. Therefore it is less labor intensive. The productivity is generally 8-10 times higher compared to ring spinning. Because no roving is necessary for open end spinning, typically single-processed or double-processed drawing sliver is fed into the machine. No separate winding operation is needed in open end spinning since the yarn packages are formed on the machine as the yarn is delivered from the rotor. Also, open end spun yarns offer better evenness and less skew than ring spun and air jet yarns.

Figure 17 – Open End Spinning Machine

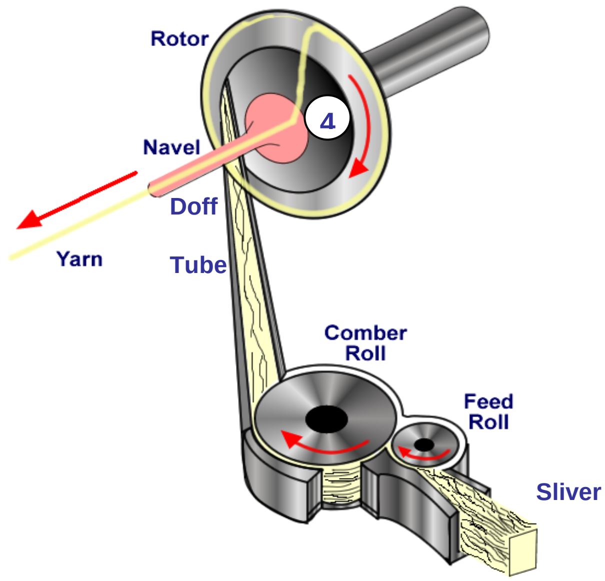
The fibers are mostly parallel in the open end yarn core but are more randomly arranged on the yarn surface. There is also the presence of wrapper fibers which tend to be perpendicular to the yarn axis. The wrapper fibers are like a belt around the waist of the yarn. These wrapper fibers are very unique to open end yarn and make it easy to identify microscopically. Wrapper fibers do not contribute to the yarn strength; therefore, the yarn is generally 15 to 20 per cent weaker than ring spun yarn. The wrapper fibers also create a harsher hand than found in ring spun yarn. Figure 18 shows a longitudinal view of the wrapper fibers and fiber orientation of an open end yarn. However, open end spun yarns are more uniform and exhibit less torque than ring spun.

Figure 18 – Longitudinal View of an Open End Yarn



The rate of feeding the sliver into the open end rotor controls the yarn count or size of the yarn produced (see Figure 19). Thus different counts of yarn can be produced from the same size sliver by adjusting the speed of the feed roll. The combing roll has a wire-covered surface to aid in separating the fibers from the sliver and introducing them to a tapered channel for transport to the rotor. The rotation of the rotor stays constant while a delivery roller controls the rate of yarn delivery from the rotor. A slower delivery allows the rotor to turn more times which puts more twist in the yarn. A higher delivery speed would do the opposite. As in ring spinning, finer yarns need more twist and coarser yarns need less twist. After the yarn is formed, it travels through the navel which is located in the center of the rotor. The navel can be easily changed to produce a more or less hairy yarn which affects the hand of the yarn and resulting fabric. Navels can have high frictional surfaces or be smoother to enable the processing of different yarn characteristics. The rotors in open end spinning turn in a clockwise direction only and thus only Z twist can be inserted.

Figure 19 – Schematic of Open End Spinning Box.



3.3 Air Jet Yarn

There are two types of air jet spinning technologies. These are MJS (Murata Jet Spinning) and MVS (Murata Vortex Spinning).

3.3.1 Conventional Air Jet Spinning (MJS)

Conventional **air jet spinning** is referred to as the MJS (Murata Jet Spinning) system since Muratec, a Japanese company, is the only supplier of the technology. As shown in Figure 20, air jet spinning also does not use the roving process and does not need a separate winding operation. The productivity is 20 to 22 times higher than ring spinning and approximately twice that of open end spinning. Air jet spinning has automation similar to open end spinning. Conventional air jet spinning is restricted to the use of 100% manmade fibers and blends of cotton and manmade fibers. Yarns containing 100% cotton are too weak for normal end uses.

Air jet yarns have a parallel core of fibers which are held together by a narrow band or ribbon of fibers that are spirally wrapped around the yarn surface. The tightness of the wrapping of the ribbon fibers is controlled by an air nozzle. Tighter wrapping leads to stronger but stiffer yarn. These yarns have a reputation of producing less pilling in fabrics. Figure 21 shows MJS air jet nozzle N_1 and N_2.

Figure 20 – Air Jet Yarn Processing Route.

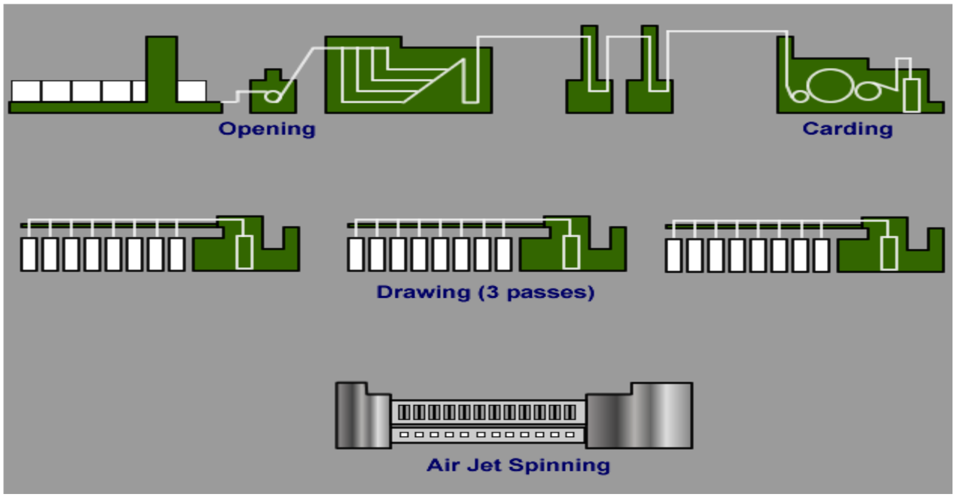
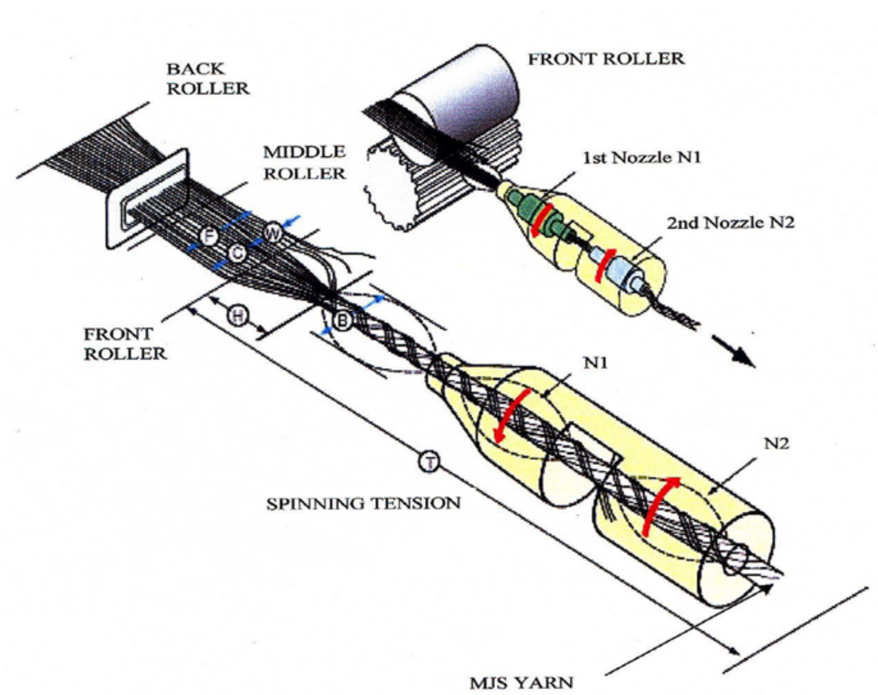


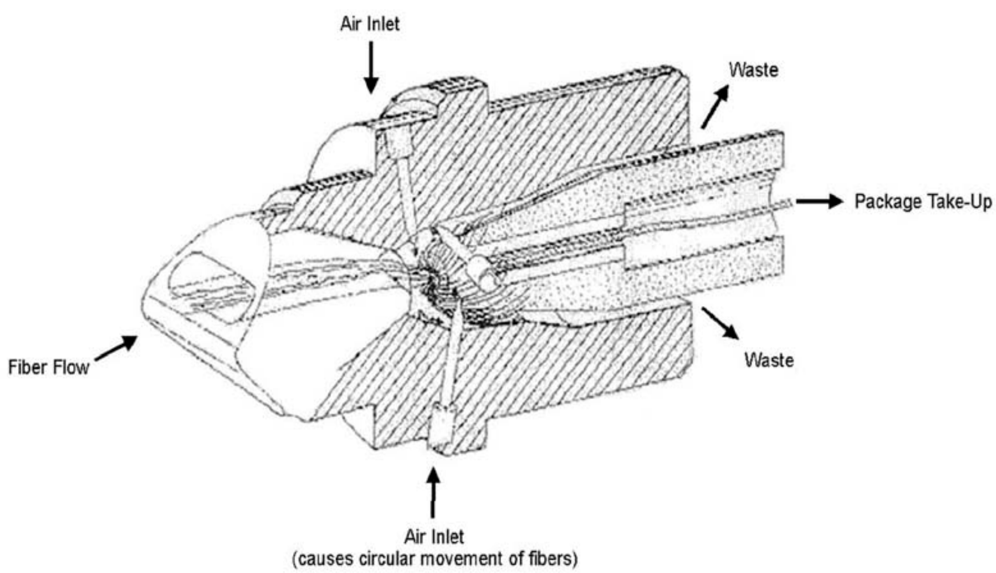
Figure 21 – MJS Air Jet Nozzle.



3.3.2 Vortex Spun Yarns (MVS)

The newest method of air jet spinning is known as **vortex spinning** or MVS. A vortex of highly rotating air flow is created by multiple air nozzles to form a yarn that has similar properties as ring spun yarn. This system of spinning is capable of producing 100% cotton yarns and cotton /synthetic blends compared to MJS. MVS imparts better fiber orientation thereby allowing 100% cotton to be used. Figure 22 shows the fibers flow into the vortex area and flare out prior to moving through a narrow channel. The flared fibers form the outer spiral wrap of fibers that get twisted around the yarn core fibers, creating a ring-like hairiness. Any short fibers in the fiber mix will be vacuumed away and end up as spinning waste. The waste will be recycled into another form of yarn.

Figure 22 – MVS Air Jet Nozzle

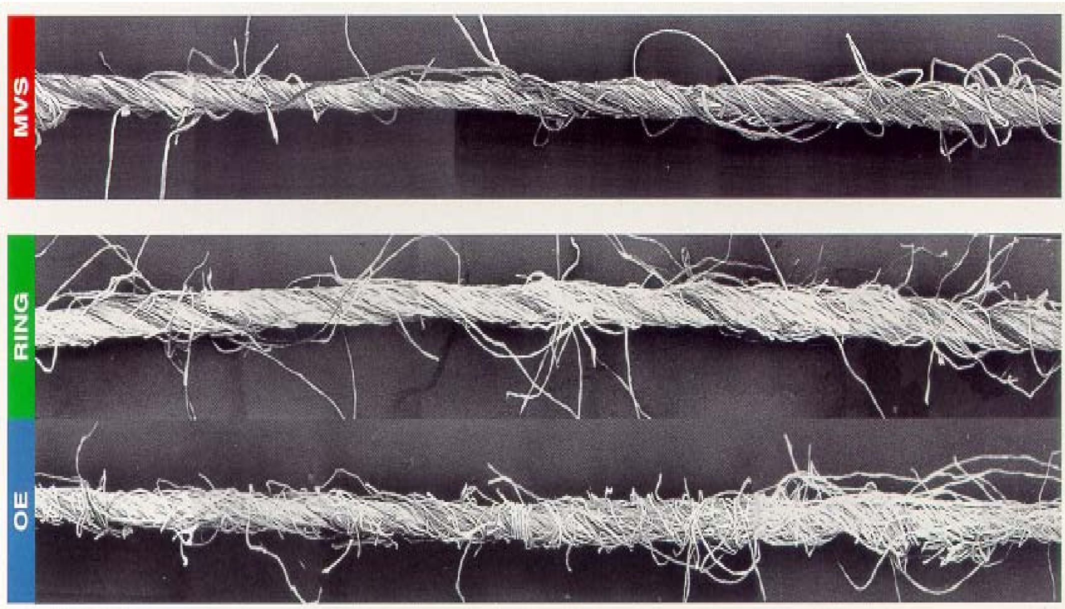


4.0 Summary of Short Staple Yarn Characteristics

4.1 Longitudinal View

When comparing the microscopic views of the different yarn types, the similarity between the ring spun and vortex (MVS) yarns is evident. Figure 23 shows longitudinal views of MVS, ring, and open-end yarns.

Figure 23 – Longitudinal Views of Different Short Staple Yarns.



4.2 Comparison of Properties of Different Spinning Systems

The following chart illustrates the differences in ring, open end, MJS air jet, and MVS vortex spun yarns. The upper part of the chart lists advantages of each type of yarn and the lower part of the chart lists disadvantages of each type. Ring spun and open end yarns dominate in apparel fabrics today with air jet and vortex yarns playing a much smaller role. Lighter weight fabrics, referred to at times as top weight fabrics, will typically contain ring spun yarn since open end yarn has a lower spinning limit (coarser counts formed). Air jet yarn is used in a lot of sheeting fabrics and shirting. Open end yarn is used in underwear, socks, denim, sweaters, and other outerwear garments. Sometimes it is desirable to have a more uneven look in fabrics (homespun look) and for that reason ring spun yarn is chosen.

With respect to the count ranges that can be spun on the different systems, ring spun has the widest range of sizes. Ring spun frames can make yarns from a 1/1 Ne up to well over 100/1 Ne with long staple fibers. Open end systems can spin yarns economically from 1/1 to 40/1 Ne. The finer counts require combing in order to spin without defect and weakness. Air jet spinning can produce yarns from 20/1 Ne to 80/1 Ne.

Comparison of Properties of Different Spinning Systems

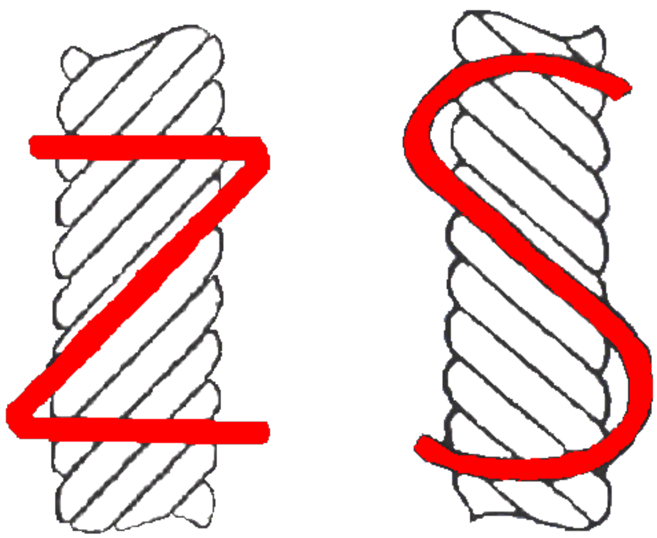
Ring Spun	Open End	MJS – Air Jet	MVS – Vortex
Advantages 1. Strongest yarn 2. Finest yarn 3. Softest yarn 4. S and Z twist	**Advantages** 1. More even 2. High strength uniformity 3. Higher production rate 4. Fewer processes 5. Lower costs 6. Fewer imperfections	**Advantages** 1. Very high productivity 2. Fewer processes 3. Good evenness 4. Less pilling 5. Fewer imperfections 6. S and Z twist	**Advantages** 1. More ring-like 2. Lower hairiness 3. Dyes darker 4. Good hand 5. Highest productivity
Disadvantages 5. Lowest productivity 6. Most uneven 7. Most expensive 8. More hairy generally 9. More torque	**Disadvantages** 7. Harsher hand 8. Not as strong 9. Limited count range 10. More abrasive 11. Z twist only	**Disadvantages** 6. Weaker yarn 7. Limited count range 8. Harsher and stiffer hand	**Disadvantages** 6. Lower elongation 7. More torque 8. More waste in spinning 9. Z twist only 10. Limited count range

5.0 Twist in Spun Yarns

Twist is necessary in spun yarns in order for the yarn to have adequate strength for a given end use. However, added twist will make the yarn harsher, stiffer, and have more torque. The following is a list of yarn properties affected by twist: diameter or fineness, contraction, softness/hand, torque or liveliness, bending behavior, absorbency, covering power, permeability, tensile strength, stretch and recovery, crease resistance, abrasion resistance, pilling behavior, and luster.

The amount of twist in a spun yarn is described as turns per inch (tpi). There are two directions of twist, Z and S. As mentioned previously, Z and S twist yarns can be formed in ring spinning but only Z twist in open end spinning. Air jet yarns do not have a true conventional twist; however, MJS machines are offered in both Z and S fiber wrap directions. Figure 24 gives a drawing of “Z” and “S” twist of fibers in a yarn.

Figure 24 – Comparison of Z and S twist of Fibers in Yarns.

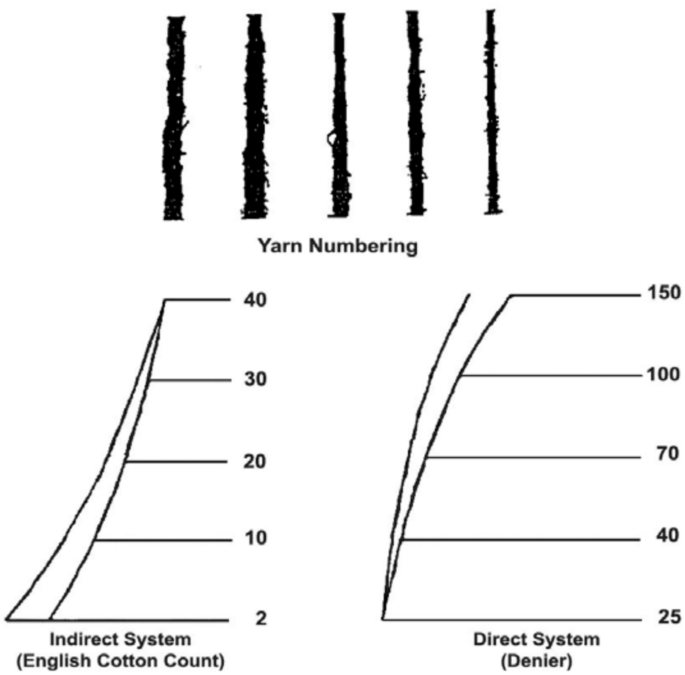


Twist direction becomes important in twill designed woven fabrics. Any time the twill direction in the fabric is opposite from the twist direction in the yarn, the twill line will be raised more on the fabric surface. Twist direction is also important in plied yarns which are discussed later in this document. Skewness in knitted fabrics is related to yarn twist direction and machine rotational direction. Twist direction opposite from the rotational direction of the knitting machine tends to produce fabrics with less torque or skew. Alternating Z and S twisted yarns supplied to the knitting needles can reduce fabric torque or skew. However the appearance for some fabrics may be negatively affected since every other knitting course will have knit loops slanting in opposite directions.

6.0 Yarn Numbering

Spun yarns and filament yarns are assigned a number to represent their respective thicknesses. **Yarn count, yarn number, and yarn size** are terms related to the thickness of a yarn. Overall, there are two types of numbering systems, indirect and direct. In the indirect numbering system, it is important to remember that the bigger the yarn number, the finer the yarn, but in the direct numbering system, the bigger the yarn number, the coarser the yarn. Spun yarns are typically numbered using the indirect system and filament yarns are typically numbered using the direct system. Figure 25 gives a graphic image of the difference between direct and indirect yarn numbering.

Figure 25 – Comparison of Indirect and Direct Yarn Numbering.



English cotton count (Ne) is an indirect numbering system along with **metric count (Nm)** and **worsted count (Nw)**. All yarn numbers represent the linear density of the yarn and really describe a ratio of length to weight or weight to length. A Ne 20/1 yarn means that twenty 840 yard lengths of yarn weighs one pound. This would equate to 16,800 yards of yarn per pound of yarn. On the other hand a Ne 10/1 yarn means that only ten 840 yard lengths of yarn weigh one pound. Thus the Ne 10/1 yarn is coarser than the Ne 20/1 yarn. A Nm 20/1 yarn means that 20 kilometers of yarn weighs one kilogram. A Nm 10/1 yarn means that only 10 kilometers of yarn weighs one kilogram. Nw 20/1 yarn means that twenty 560 yard lengths of yarn weighs one pound. Nw 10/1 yarn means that ten 560 yard lengths of yarn weigh one pound. Yarn numbers are an important bit of information on fabric specification sheets. The yarn size will affect fabric characteristics such as weight, thickness, stiffness, luster, appearance, and hand.

Denier is a direct numbering system along with **tex** and **decitex**. A 150 denier yarn means that it takes 150 grams of yarn to measure a standard length of 9000 meters. Thus a 200 denier yarn requires 200 grams of weight to measure 9000 meters. So the yarn number is simply the number of grams of yarn in a standard yarn length of 9000 meters. A 20 tex yarn means that a standard yarn length of 1000 meters weighs 20 grams and a 200 decitex yarn means that a standard length of 10,000 meters of yarn weighs 200 grams. So these yarn numbers are simply the weight of yarn in grams equating to different standard lengths of measure.

Many times it may be necessary to convert one yarn number into another yarn number in order to understand its relative size or for consistency. Some common conversion factors are listed below.

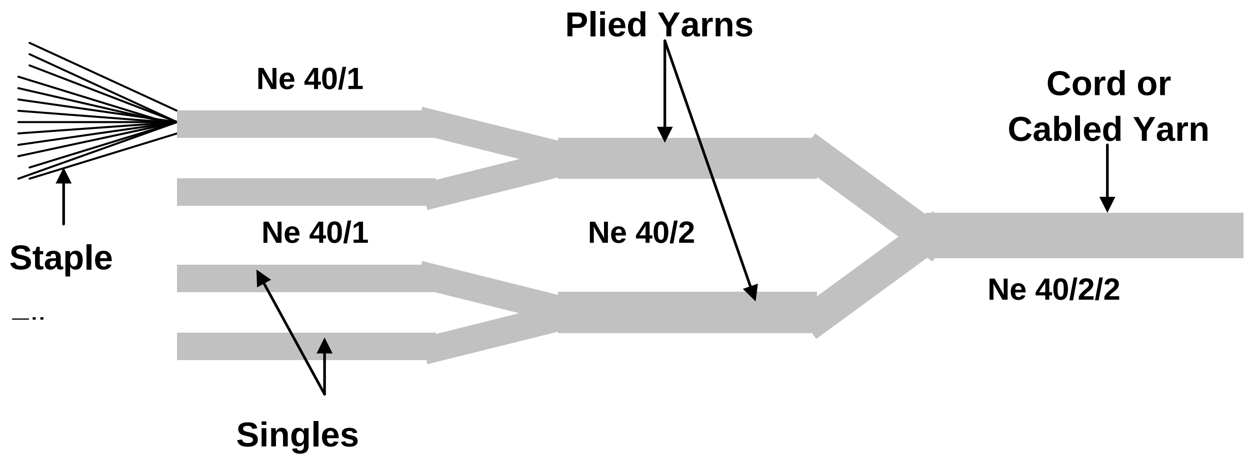
Ne = 5315/Denier	Ne = 2/3 Nw
Denier = 5315/Ne	Denier = 0.9 x Decitex
Ne = 590.6/Tex	Ne = Nm/1.693

A yarn numbering conversion chart is found in the Appendix.

7.0 Plied Yarns

Plied spun yarns are numbered so that the number of plies can be indicated along with the count of each individual yarn making up the plied yarn. For example, a 36/2 designation would represent two 36 single yarns (36/1) plied together. Sometimes the number of plies is written first and then the single yarn number such as 2/36. Technically speaking this is a designation for a worsted or long staple yarn. Generally, the twist direction of the single yarns is opposite from the ply twist direction in order to reduce yarn torque and fabric skew. Plied yarns will be stronger and can be made with less stiffness compared to a single yarn equivalent. The extra step of plying adds some additional cost to plied yarns. Most sewing threads are plied or cabled. Plying also improves yarn uniformity. The term “doubles” should not be confused with plied yarns. Doubles is when two yarns are fed to a fabrication method parallel to each other. This can be done on a knitting machine or loom and are not plied together. Thus, in the fabric, they will randomly cross over one another. Plied filament yarns have a different designation. For example, the 2/150/34 designation means that two 150 denier yarns are plied together and each contains 34 filaments. Figure 26 shows twisting of fibers into a singles yarn, twisting of singles yarns to a ply, and twisting of plied yarns into a cord or cabled yarn.

Figure 26 – Yarn Assembly By The Use of Twist.



8.0 Special Effect Yarns

8.1 Slub Yarns

Novelty or fancy yarns have special effects placed into the yarn strand and give a unique look to fabrics. The effect may be **slubs** of various lengths and thicknesses. For example, engineered denim fabrics have this novelty look. A leading supplier of equipment for making slub yarns is Amsler and some refer to these yarns as **Amsler yarns**. Figure 27 shows a yarn board showing yarns with slubs of various lengths and diameters. These can be formed in a random manner to prevent patterning.

Figure 27 – Slub Yarn.

Simple and complex slub yarns can be formed today. In fact, you can design a particular slub pattern and download it into the spinning machine. Technology is also available to simulate how the yarn slub pattern will look in the resultant fabric.

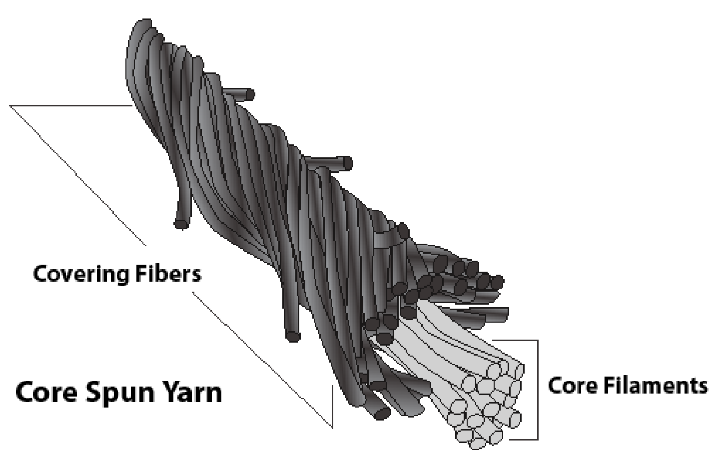
8.2 Core Yarns

Core yarns are those made that have a core of one type of fiber or configuration and an outer core of the same or another type fiber and configuration.

8.2.1 Core Spun Yarns

Core yarns have multiple components. A yarn is placed in the core and other fibers or yarns are placed around it. A very common core yarn is called **corespun**. This yarn has a core yarn which can be a spun or filament yarn and it is covered with staple fibers. The core can be a stretch yarn or a hard yarn (non-stretch). A very common corespun yarn has spandex in the core and cotton fibers twisted upon its surface as shown here. This yarn gives the look, feel, and dyeability of a cotton spun yarn but has excellent stretch and recovery properties. Figure 28 is an illustration of a typical corespun yarn. Corespun yarns are typically made on ring spinning machines but can be made on open end and air jet spinning machines. A roving supplies the staple fiber covering in ring spinning a core yarn, and a sliver supplies the staple fiber covering in open end and air jet spinning.

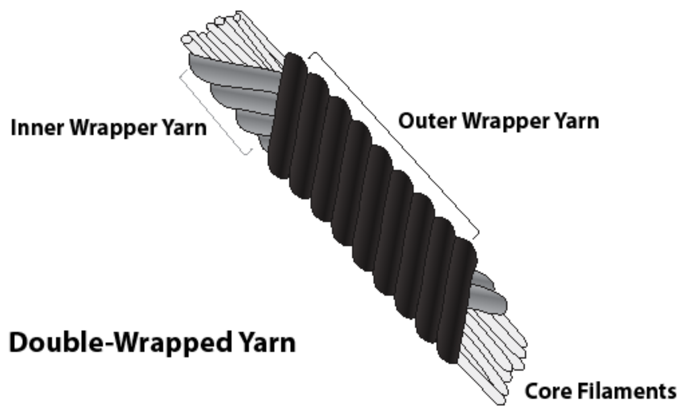
Figure 28 – Schematic of a Corespun Yarn.



8.2.2 Wrapped or Covered Yarns

Another method to make a core yarn for novelty and stretch applications is by wrapping one yarn or filament around a core of a monofilament or multi-filaments. Figure 29 show a double wrapped yarn. The same type of yarn or different types of yarn or fiber can be incorporated.

Figure 29 – Illustration of a Wrapped Yarn.



8.3 Other Novelty or Fancy Yarns

Boucle and many other novelty yarns are formed on fancy twister machines which utilize a hollow spindle. A core yarn runs through the hollow spindle and yarn located on the hollow spindle comes off and wraps around the core yarn. The wrapping yarn can be overfed to produce the looping effect in the boucle yarn. Figure 30 shows drawings of common fancy yarns. Figure 31 shows a typical hollow spindle machine.

Figure 30 – Illustrations of Fancy Yarns.

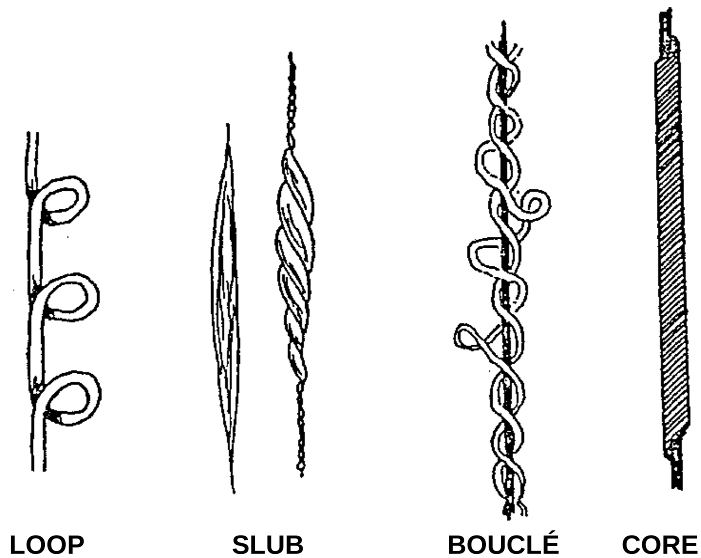
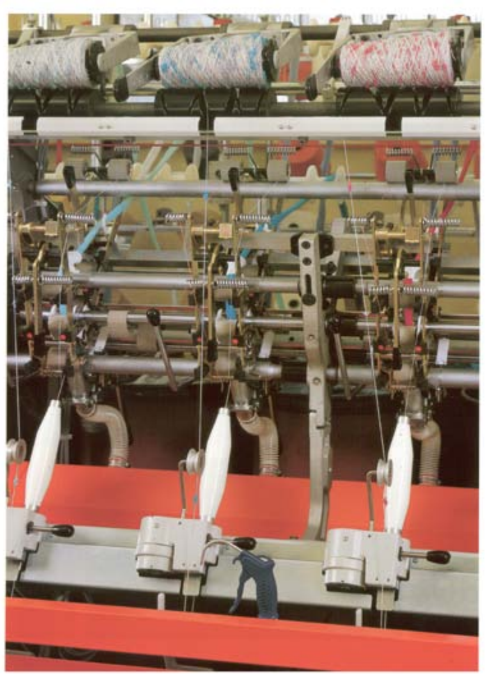


Figure 31 - Hollow Spindle Fancy Twister for Modifying Yarns.



8.3 Sirospun Yarn

Sirospun yarn assembly is an example of different spinning techniques to alter yarn appearances and characteristics. Different colored fibers can be blended at roving and different rovings can then be fed into Siro spinning to achieve the desired effect. The two rovings can be of different color, different fibers, or different weights. Figure 32 shows the combining of the fibers from separate rovings to make the yarn.

Figure 32 – Siro-Spun Yarn.

8.4 Glossary of Effect (Novelty) Yarns:

The following yarns are defined as to their construction.

8.4.1 Compound Yarns (Composite Yarns)

A compound yarn is a structure consisting of at least two strands, one forming the center axis, or core, and the other forming the covering or wrap. These yarns are uniform or even in diameter, relatively smooth, and available in the same size ranges as spun and filament yarns.

Example:

Covered Yarns consist of a readily separate core surrounded by a wrap or cover formed by one (single-covered) or two (double-covered) spun or filament yarns. The Core may be an elastomeric fiber such as rubber or spandex, or a hard fiber, such as polyester or nylon.

8.4.2 Fancy (Novelty) Yarns

A fancy yarn consists of irregularities deliberately introduced during their formation and usually composed of two or three strands. All novelty yarns have a fancy, or effect strand. Random variation, irregularities, abrupt variations in diameter, as well as modulation between low and high twist along the length of the yarn represent a dramatic departure from the uniformity of spun, filament, and compound yarns.

Examples:

Boucle, Loop, and Snarl Yarns are characterized by tight loops projecting from the body of the yarn at fairly regular intervals. They are comprised of a twisted core with an effect yarn wrapped around it so as to produce wavy projections on its surface. They are characterized by tight loops projecting from the body of the yarn at fairly regular intervals. Three components of the yarn are the core, the effect, and the binder.

Generally speaking, *bouclé* yarns exhibit an irregular pattern of semi-circular loops and sigmoid spirals; *gimp* yarns display fairly regular semi-circular projections, and *loop* yarns have well-formed circular loops.

Chenille Yarns are composed of tufts of staple fiber held between plied yarns that form the core of the yarn. The effect fibers resemble a caterpillar in appearance. Hence the French word for caterpillar – *chenille.* They are originally made from a cut-pile fabric held by axial yarns that secure the file. Today, chenille yarns are made on a machine which constructs the desired yarn without having to weave a pile fabric.

Cloud Yarns are a type of yarn using two thread of different colors in such a manner that each thread alternately forms the base and cover to ”cloud” the opposing thread.

Crepe Yarns are produced with very high levels of unbalanced twist to give them a tendency to kink and snarl. They maybe single or plied and create a rough, pebble-like texture in the fabric.

Eccentric Yarns are undulating gimp yarns.

Flame Yarns are yarns incorporating injected slubs which can be multi-colored. These yarns are characterized by the gradual thinning of the linear density of the slubs at both ends as they emerge from and then merge back into the support or ground yarn.

Flammé Yarns are colored over short sections by printing, intended for use in Flammé fabrics.

Fleck Yarns are a mixture yarn of spotted and short streaky appearance, due to the introduction of a minority of fibers of different color and/or luster.

Gimp Yarns are yarns made of one or more strands twisted around a usually finer central ground yarn and overfed to form a clear spiral wrapping.

Grandelle Yarns are fancy yarns produced by twisting together two single-ply yarns of contrasting colors.

Ikat Yarns are made on a process in which a warp is dyed to a pattern by preventing dye penetration by tightly binding sections of warp in rope form.

Ingrain Yarns are spun from a mixture of differently colored fibers.

Jaspe' Yarns are skein dyed yarns in two tones of the same color or with two different colors.

Knickerbocker Yarns are yarns made on the woollen system and showing strongly contrasting spots on their surfaces that are made either by dropping in small balls of wool at the latter part of the carding process or by incorporating them into the blend. (Nepp yarn, knicker yarn)

Knop Yarns are yarns that contain prominent bunches of one or more of its component threads, arranged at regular intervals along its length.

Loop Yarns are compound yarns comprising a twisted core with an effect yarn wrapped around it so as to produce wavy projections on its surface (see bouclé).

Marl Yarns are characterized by a mottled (spotted) appearance created by twisting two strands of different colors or shades of staple fibers.

Metallic or Laminated Yarns have a central core of metal and a coating that is usually a plastic film but is sometimes a metallized film. They are produced in a flat, ribbon-like form to achieve maximum light reflectance. As a result, high-gloss, metallic sparkle is added to fabrics.

Mock-Chenille is a doubled corkscrew yarn (see spiral yarn).

Multi-count Yarns are yarns in which the thickness is varied for much longer lengths than found in normal slub yarns. The appearance is that of using different yarn counts, producing heavy and light streaks in the fabric.

Nub, Splash and Seed Yarns have the effect strand twisted around the core strand a number of times in a small area to form an enlarged bump or "nub." The bump is large and short in a nub yarn and longer and thinner in a slash yarn. Seed yarns have bumps that differ in size and spacing.

Ratine Yarns (Gimp) have a slightly wavy appearance. The effect strand is twisted around the core strand. The effect strand lies closer to the core strand than is typical for boucle and loop yarns.

Slub Yarns are a variation of spun yarns in which dramatic changes in width occur along the length of the yarn, creating *slubs*, or short thick places. With newer technologies being used today, these yarns are sometimes referred to as *engineered* yarns.

Snarl Yarns are compound yarns that display snarls or kinks projecting from the core.

Spiral or Corkscrew Yarns are plied yarns displaying a characteristic smooth spiraling of one component around the other. Usually one strand is a soft and bulky yarn, and the other strand is a fine yarn. In a spiral yarn, the thicker strand is usually wound around the finer strand and just the opposite for a corkscrew yarn.

Stripe Yarns are yarns that contain elongated knops (see knop yarn).

9.0 Overview of Yarn Requirements for Weaving and Knitting

Warp yarns for weaving need to be strong, uniform in strength, have good evenness values and a low degree of hairiness. These yarns are subjected to the strains and stresses of the weaving process and are in very close proximity to one another. Air jet weaving places the highest demand on warp yarn quality due to the air used in filling yarn insertion being easily disrupted by any non-uniformity in the warp yarn. In most cases, cotton spun yarns used in the warp are slashed (sized) with a protective coating or film to provide abrasion resistance as the yarns go through the different weaving machine elements. It is very essential that yarn elongation values are good since yarn is under relative high tension during the rigors of weaving. Yarn imperfections, especially thick places, should be avoided since the yarn path on the weaving machine includes various eyelets and other devices which could cause the yarn to catch and increase tension levels and/or break the yarn.

Filling yarns do not need to be as strong as warp yarns and therefore will typically have lower levels of twist. This lower twist level will lead to a bulkier yarn structure which is advantageous for filling yarns because of added cover in the fabric produced. For air jet weaving the filling yarns need to have a good level of evenness so the air and yarn interaction will remain consistent leading to fewer miss-picks and partial picks.

Cotton spun yarns for knitting should exhibit good hand or softness. This is made easier due to the fact that these yarns do not need to be as strong as weaving yarns and therefore need less twist. This lower twist leads to softer yarn and fabric. Yarn torque or liveliness should be at a minimum to help prevent excessive surface distortion, skew and torque. Good elongation values in the yarn will reduce fabric holes. Good evenness values will prevent machine stops and fabric holes. Thick places in the yarn need to be at a minimum because they can lead to yarn tension problems, broken needles and bent latches. Yarn count variations can lead to horizontal streaks in knit fabrics known as barré.

10.0 Influence of the Yarn on Fabric Properties

Many times there is an emphasis on **fabric softness**. Ring spun fabrics will be softer than open end fabrics. Lower twist yarns will produce softer fabrics than higher twist yarns. Yarn containing finer fiber will make the fabric softer. Using longer fibers will allow for lower yarn twist, resulting in softer fabrics. Open end yarns formed on a machine with grooved or roughened navels will produce a softer open end fabric.

There is a direct correlation between yarn strength and **fabric strength**. Yarns are made stronger when an optimum twist level is used, when stronger, longer, and finer fiber is used, and when ring spun yarn is used instead of open end yarn. Yarns are stronger when they are more uniform and have fewer imperfections. Cotton yarns are stronger when they have sufficient moisture and are not dry. Fabrics tend to be stronger when plied yarns are used compared to use of single yarns.

Fabric luster and appearance can be influenced by the yarn. Ring spun fabrics tend to be more lustrous than open end fabrics. Fabrics containing lower twist yarns tend to be more lustrous than fabrics containing higher twist yarns. Fabrics containing combed yarns are more lustrous than fabrics containing carded yarns.

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WORLD HEADQUARTERS

6399 WESTON PARKWAY

CARY, NORTH CAROLINA 27513

TEL. (919) 678-2220

FAX (919) 678-2234

CONSUMER MARKETING HEADQUARTERS

488 MADISON AVENUE, 20TH FLOOR

NEW YORK, NEW YORK 10022-5722

TEL. (212) 413-8300

FAX (212) 413-8377

For other office information, visit our website at:

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