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This article is written by Agniv Chatterjee. When we think of natural fibres, cotton comes first in our minds. Cotton is a plant-based natural fibre, and it is grown in many countries. Cotton is a cellulosic staple fibre. The length of cotton fibre determines the quality of fibre. The longer the length of the fibre the better the quality of fibre is. It requires adequate temperature and moisture to produce high-quality yarn. Hence it is mostly grown in hot and humid places. It has a density of 1.52 g/cm³ making it one of the heavy fibres. In this article, Agniv has explained properties of cotton fibre in the following four categories. Technical properties of cotton fibre Physical properties of cotton fibreChemical properties of cottonMiscellaneous properties of cotton1. Technical properties of cottona. Fibre density - 1.52 g/cm³ b. Fibre Diameter Micronaire - 2.0-7.0 Approximate denier - 0.7-2.5 c. Elasticity recovery At 2 % Extension - 74% At 5 % Extension - 45% d. Breaking elongation (dry) - 3-9.5 e. Tensile Strength (g per tex) per denier Dry: 27 - 44 / 3.0 - 4.9 Wet: 28 - 57 / 3.3 - 6.4 f. Moisture Regain at Standard Conditions - 7% g. Water Absorbing Capacity (USP method) Less than 24 grams of water per gram of fibre h. Density (g/cm³) - 1.54i. Degree of Polymerization- 9000-15000j. Crystallinity by X-ray Diffraction -73%(average) k. Color (Whiteness Index) - 90-1002. Physical properties of cotton a. Tenacity The strength of cotton is increased by its long polymers, the countless, regular, hydrogen bond formation between adjacent polymers and the spiraling fibrils in the primary and secondary cell walls. It is one of the few fibres which gains strength on wetting which occurs due to improved arrangement in the amorphous region of the fibre. 2.2 Elastic-plastic nature Cotton fibre is inelastic in nature because of its crystalline polymer system and hence for this reason cotton fibres wrinkle and crease easily. The polymer molecules can slide past each other only under considerable strain as they are prevented from doing so by their long lengths and countless hydrogen bond between them to hold the polymer molecules in position. Strong strain forces cause polymer fracture as the crystallinity of the polymers makes it difficult to bend and crush. These polymer fracture forms weak points on the polymer system and hence forming weak areas in the fibre structure. Therefore, cotton fibres get creased and wrinkled on the application of force. 2.3 Hygroscopic nature The cotton molecule is very moisture absorbent due to its abundant polar -OH group which attracts water molecules towards it. But the OH molecule can only enter the cotton molecule through the amorphous region as the intermolecular spaces in the crystalline region are very small. The swelling up of cotton fibre in presence of water is mainly due to the separation of polymers by water molecules in the amorphous region. Cotton fibres usually feel crisp on touching as it absorbs moisture from the skin of the finger. The hygroscopic nature of the fibre prevents cotton materials to develop static electricity. The polarity of the water molecule is attracted by the hydroxyl group of the polymer and hence static charges are dissipated. 2.4 Thermal Properties Cotton fibre has the ability to conduct heat energy, minimizing any destructive heat accumulation. Hence cotton fibres can withstand hot ironing temperatures. But excessive heating on cotton fibre chars and burns. It indicates that cotton fibre is thermoplastic. This prevents the fibre from assuming the new position when heat is applied. The polymers begin to vibrate on heating and gradually disintegrate. Relationship: Use of cotton fibre Chemical properties of cotton3.1 Effect of Acid Cotton fibres are weakened and destroyed by acid as acidic conditions hydrolyse the cotton polymer at the glucoside oxygen atom of the cellulose unit. Cotton polymers are more rapidly hydrolysed by mineral acid than organic acid. 3.2 Effect of Alkali Cotton fibres are unaffected by alkalis due to the lack of attraction between the polymer and the alkalis. Mercerization without tensioning or slack mercerization results in swelling of cotton fibres. The main reason of this swelling is due to alkali and radicals entering the amorphous region of the fibre polymer system thus forcing the polymers wide apart causing swelling. This allows them poorly oriented polymers to arrange themselves more orderly and hence increases the fibre strength. When mercerization is done under tension then little swelling or fibre contraction occurs. The fibre hence produced has less tenacity and distinct, subdued lustre. The increase in tenacity on mercerization under tension can be explained as the alkaline liquor helps to align the polymer molecules and form hydrogen bonds. It also causes the fibre to become smooth and more regular enabling it to reflect light more evenly and hence causing it to subdued lustre. Also, mercerization of cotton increases its dye uptake. Thus, mercerized cotton dye and print a deeper hue than any other mercerized fibre. 3.3 Effect of Bleach Sodium Hypochlorite and Sodium Perborate are the most common bleaching agents used on cotton textile. Sodium Perborate a white powder bleaches cotton fabrics at room temperature. Bleaching with sodium perborate is more effective at temperatures more than 50 degrees C. The bleach is effectively in an alkaline medium when cotton materials are resistant. Oxidising bleaches liberates oxygen and hence the interaction between the oxygen liberated by bleach and the molecules of fibre surface causes the discolouration of cotton. It is found that oxygen forms water-soluble molecules with the fibre which is rinsed off when the fibre is washed. Carefully bleaching the fabric can protect the fabric from chemical attacks of the bleach. 3.4 Effect of Sunlight and Environment The ultraviolet rays of sunlight provide photochemical energy to degrade cotton fibres in presence of atmospheric air, oxygen, moisture and pollutants. Atmospheric moisture is the main cause of the breakdown of cotton fibre by various hydrolytic reactions. First, the fibre starts to discolouration. Gradually the reactive nature of the hydrolytic compound increases the rate of degradation of cotton. The weakening and breakdown of polymer is a clear indication of the degradation of cotton fibre. Air pollutants are generally acidic in nature and hence readily accelerate the breakdown of cotton fibre through acid hydrolysis. 3.5 Colour Fastness Cotton fibre can be dyed by azoic dye, direct dye, reactive dye, sulphur dye and vat dye. It is one of the easiest fibres to dye and print. This is due to the polarity of the polymer molecules of the cotton fibre. Hence this attracts any polar dye molecules in the polymer system. Also, dye molecules that can be evenly dispersed in water can also be efficiently absorbed by this polymer system. The dye molecules enter the polymer through its amorphous region as the smaller spaces of the crystalline region prevent the entry of any dye molecules in it. 4. Miscellaneous properties of cotton4.1 Versatility Cotton fibres can be dyed with any colour and they retain dye well. Hence it is a versatile fibre and can be used for various purposes. It can be woven in three different ways namely plain weave such as chambray and gingham, twill weaves such as denim and khaki, and satin weave such as satin. 4.2 Wrinkling Cotton fabric wrinkles easily and needs to be ironed regularly to improve its appearance. Also, many cotton fabrics are finished in a way that will help them resist wrinkles. 4.3 Absorbency Cotton has the property to absorb liquid in large quantities. It has a capacity to absorb liquid up to 27 times its weight. This makes cotton comfortable to wear as it absorbs sweat well. For this reason, it can be used to manufacture towels and washcloths. 4.4 Shrinkage Cotton fabric has the tendency to shrink after the first wash. Hence to avoid this some cotton fabrics comes to the shopkeeper pre-shrunk for sale. Thus, they do not have to get worried about getting small after the first wash. 4.5 Breathability Cotton fabric allows air to pass through freely. It absorbs sweat and releases it on its surface. Hence making it a strong fibre. The tenacity of it is about 3-5 g/den. But sometimes the strength is affected by the moisture regain, which makes the fibre to be stronger than the dry strength. Because the water molecules only enter amorphous regions, which creates the hydrogen bonding between the adjacent polymer chains. This property influences the yarn and produced fabric to be more durable, which is a dependable feature of this fibre.Color: On the very beginning, the color of cotton fibre may vary to white to creamy white. But it also consists yellowish white, grey etc. The color of this fibre is totally based on the picking time. If we pick it at the right time we will get a good impact on the next stages like dyeing, controlling brightness, luster etc. and then on desired garments. So color has a very high impact on the produced fabric because only it holds the outlook of this fibre outstandingly.Elastic Recovery (ER): As the cotton fibre is a rigid fibre, it is not so elastic like other fibres. And it has a very low recovery from the deformation load. As we know, at 2% extension, it has an ER of 74% and at 5% extension it has an ER of 45%, which indicates it will not be able to ensure higher elastic recovery on the end products.Length: The length of cotton fibre may very as,Short Staple: Consists the length of 0.375 - 1 inch with a diameter of 13-20 microns. This type of fibres has medium strength and luster. Basically Indian and Asiatic cotton fibres are of this type.Medium Staple: Consists the length of 1-1.12 inch with a diameter of 12-27 microns. This type of fibres also has medium strength and luster. Basically American Upland cotton of this type.Long Staple: Consists the length of 1.12-2.5 inch with a diameter of 10-15 microns. This type of fibres has higher strength and fine luster. Basically Egyptian and American cotton fibres are of this type. These individual types of cotton fibres are used on basis of the regional demands. And every types plot a great impact on the desired products as all of them hold a good fibre quality.Fineness: It expresses that how many fibres are present in the cross-section of a yarn in any given length. And it depends on the length of the fibres. As the cotton fibre has an elegant to longer length, the fineness of cotton fibre is quite higher. And also the fineness will be short when the length of cotton fibre is short. It also influences the durability of the produced garments.Moisture Regain: The effect of moisture on cotton fibre is not easily degraded on the organic solvents.Effect of Micro-Organism: Basically, fungi, bacteria mildews are considered as micro-organism. Cotton fibre is not more resistant to them. So it also effects on the ultimate products. But by using of a chemical like copper naphthenate can give us a better solution here, which protects the fabrics from micro-organisms.Cotton fibre has basically very unique physical and chemical qualities that make it a valuable textile material for a variety of industries. Physically, it is famous for its softness, strength, absorbency, breathability and thus it has become popular for textiles and apparel. Cotton's chemical composition is largely of cellulose, that gives stability and durability, but its hydrophilic nature allows it to absorb moisture efficiently. Basically cotton fibre's biodegradability and other qualities make it a sustainable and widely utilized natural fibre.References:Chemical Properties of Cotton Fibre and Chemical Modification (Physical and Chemical Properties of Cotton Fibre-Based Composites (Founder & Editor of Textile Learner. He is a Textile Consultant, Blogger & Entrepreneur. Mr. Kiron is working as a textile consultant in several local and international companies. He is also a contributor of Wikipedia. The properties of cotton are the most important in fiber. Moreover, It is the backbone of all textile industry trade. Basically, cotton fiber is obtained from seed cotton. Cotton is mainly composed of cellulose. It belongs to the "Gysspium" family. Also, it is cultivated in tropical areas like Pakistan, India, Egypt, and the U.S.A. Physical properties of cotton Below are described the physical properties of cotton fiber. Color of cotton The color of cotton is normally creamy white. If the picking of cotton is delayed then it may be turned to grey, yellow, or bullish white. Strength of cotton Strength of cotton fiber is a moderately strong, structure of cotton fiber due to the intrinsic structure of layers of cress-crossed minutes-spirited fiber that compose the fiber cell. Also, the strength of cotton is determined by the character of the cotton yarn which should be a long staple and tightly twisted. Moreover, it is affected by moisture content. Hence, the strength of the cotton fiber is expressed in tensile strength and tenacity.Cotton has a tensile strength of 40,000 to 120,000 pounds per inch. Also, the strength of cotton is very important and can be improved by Mercerization. Generally, cotton strength is checked by a "Pressler strength tester". Tensile Strength of Cotton Cotton quality depends on its tensile strength e.g Tensile strength (103 pounds per inches2) Grading 89-07 Strong 81-88 Average 72-80 Fair 71-blow Weak Elasticity of cotton Cotton fiber has very little natural elasticity. Basically, this characteristic can be altered to varying extents by hard twisting the fibers into creped yarn and by using such fabric techniques as knitting. Also, at a 2% extension, it has an elastic recovery of 74%, and at a 5% extension, it has an elastic recovery of 47%. Elongation at break of cotton fiber When fiber is subjected to force this will stretch to some degree before it breaks, this stretching is called elongation at break. Cotton does not stretch easily. Generally, it has an elongation at a break of 5-10% depending upon a variety of cotton. The specific gravity of cotton Specific gravity is the ratio of mass measured in the air to the mass of an equal volume of water at 40C. Also, the specific gravity of cotton is 1.54. Fiber length of cotton Staple length is the term used for the length of cotton fiber. So, staple length is defined as the average length of the fiber in a mass of cotton. Also, on the basis of staple length cotton is classified into three classes. S.L (1/2~ 2/2) This type of length consists of fine twistier fiber, top-quality sea island, and Egyptian cotton included in this class. S.L (1/2~1 5/16) This type of cotton is not as fine as, the American upland cotton of this class. S.L (3/8~1 -1 ") This type of cotton is of poor quality course fiber. Basically, it is produced largely in China, India, Pakistan, and to a smaller extent in Iran, Iraq, Turkey, etc. Maturity of cotton fiber The maturity of cotton is the degree to of cell walls of cotton plant. This type of cotton plant will have well-developed cross-sections and be lustrous. Well-mature cotton fiber is mostly required in knitting and secondly for weaving. The fineness of cotton fiber It is defined as the weight of 1" of fibre in grams. Also, the fineness is checked by checking the fineness of fiber is called a micronaire. Fineness micronram per inch Grading Below 3 Very fine 3-3.9 Fine 4-4.9 Average 5-5.9 Coarse 6-above Very coarse Physical properties of cotton Cotton fiber chemistry can be altered by using chemical treatments such as bleaching, mercerization, for instance, is the process of treating yarn cotton or fabrics with sodium hydroxide for increasing luster, absorbency, softness, strength, and softness. Hence, in mercerization, the fiber wall swells and its cross-section becomes rounder. Also, the strength of the cotton fibres increases remarkably, and in effect, extensibility decreases due to the swelling effect, which moreover, causes creep of the fiber and untwisting. Hence further reducing its degree of crystallinity. Below are the chemical properties of cotton fibres. Effect of acids on cotton fiber Crystalline and non-crystalline structure of cellulose Cotton fiber is not affected by cold dilute acids but hot dilute acids or concentrated acids disintegrate it. A 2-gram-per-liter solution of H2 SO4 at 80 C reduces the strength of fabric by 25% in one hour. It is, therefore, such acid should be used with low concentration and low temperature. The hydrolytic effect of acids on cotton fiber depends in large measure on temperature e.g a slight increase in temperature in processing (80-90oC) produces a stronger effect than when the concentration of H2 SO4 doubled. Effect of alkalies on cotton fiber Oxy-cellulose in an alkaline solution The effect of alkalies on cotton fiber has excellent resistance. It Sewell into acoustic alkalies but is not damaged. Also, it can be washed separately in soap solution without harm. It is characteristic of the glucosidic linkage of the cellulose molecule that it is highly resistant to alkalies. At normal temperatures, a weak solution of caustic soda lime has no effect on cotton fiber cellulose, but on boiling in NaOH a small part of cellulose passes into the solution. As the alkalies can increase the cellulose solubility, becomes considerably high. The action of oxidizing and reduction agents Reducing agents do not affect cotton fiber, but oxidizing agents readily convert it into oxycellulose. Also, for chemical treating fibrous material wide use of oxidizing agents. This reagent causes less or more intensive oxidation of cellulose functional groups and breakage of chains as a result of glucoside linkage. The action of oxidizing agents is usually called oxy-cellulose. The oxidizing reagents are NaOCl, H2O2, NaCl, HNO3, etc. The action of salt solution on cotton fiber The solution of acid salts has some effect on cotton fiber cellulose as acids. A similar effect is produced such as natural salts NaCl and MgCl2 which undergoes hydrolysis when treated in heating. Cellulose swells into some concentrated solution of some natural salts and on being gradually heated first becomes jelly and then passes into solutions, the solution of the following salts Li, Li(N3), KCN, and Ca(CNS)2 strongly affects the swelling and resolving of cellulose. The ammoniacal solution of copper oxide is a specific solvent for cellulose. Effect of organic solvent on cotton fiber Few organic solvents that resolve cotton fiber completely. So, it has high resistance to solutions like alcohol, ether, benzene, and gasoline. But is distressed by copper complexes, cuprammonium hydroxide, and cupric-ethylene diamine and by the concentration of 70% of H2 SO4. The action of water on cotton fiber The dry cotton fiber constructed from its fiber of cellulose is fairly stiff and rigid ability. The cellulose molecules are held tightly together inside the fibril bundle by a band established between molecules lying close side one another. Also, water molecules tend to force the molecules of cotton fiber cellulose apart lessening the forces that held the cellulose molecules close together and destroying some of the rigidity of the entire cellulose structure. So, the glucoside linkage of cellulose molecules is readily hydrolyzed i-e they break up by combining with water which disintegrates molecules (C6 H10O5)n+n H2O to n(C6H12O6) were acts as a plasticizer for cotton Effect of microorganisms on cotton Cotton is attacked by microorganisms such as fungi, mildew, and bacteria. Mildews have a particularly troublesome effect on cotton that has been treated with starchy finishes. Mildew and bacteria will flourish on cotton, especially under hot moisture conditions. Effect of heat on cotton Cotton has excellent resistance to degradation by heat. So, it begins to turn yellow after several hours at 120oC and decomposes remarkably at 150oC. The heat effect on cotton becomes severe as it is damaged after a few minutes of 240oC. Effect of sunlight on cotton There is a gradual loss of strength when cotton is exposed to sunlight it turns yellow for a long time. So much damage is caused by ultraviolet light and by the shorter wave of the visible light. Uses of cotton fiber Cotton fabrics are and are largely used. However, the use of cotton may be classified into three main classes: Apparel uses: T-shirts, shirts, pants, underwear, hosiery, etc. Household uses: Bed sheets, towels, curtains, rags, and carpet. Industrial uses Industrial thread bags, shoes, ropes, conveyor belts, medical supplies, and equipment Cotton is the most important natural textile fiber, as well as cellulosic textile fiber, in the world, used to produce apparel, home furnishings, and industrial products. Worldwide about 40% of the fiber consumed in 2004 was cotton.Cotton fibres are seed hairs from plants of the order Malvales, family Malvaceae, tribe Gossypieae, and genus Gossypium. Botanically, there are four principal domesticated species of cotton of commercial importance: hirsutum, barbadense, aboreum, and herbaceum. Thirty-three species are currently recognized; however, all but these four are wild shrubs of no commercial value. Each one of the commercially important species contains many different varieties developed through breeding programs to produce cotton with continually improving properties (e.g., faster maturing, increased yields, and improved insect and disease resistance) and fibers with greater length, strength, and uniformity. The cotton fibers used in textile commerce are the dried cell walls of formerly living cells. Botanically, cotton fibers are trichomes or seed coat hairs that differentiate from epidermal cells of the developing cottonseed. The cotton flower blooms only for one day and quickly becomes senescent thereafter. On the day of full bloom, or anthesis, the flower petals are pure white in most hirsutum varieties. By the day after anthesis, the petals turn bright pink in color, and, usually by the second day after anthesis, the petals fall off the developing carpel (boll).Each cotton fiber is composed of concentric layers and a hollow central core is known as the lumen. The outermost layer, known as the cuticle, is a thin layer of fats, proteins, and waxes.Beneath the cuticle is the primary wall, composed mainly of cellulose. In some in which fibers are arranged in a criss-cross pattern. Further towards the center is the secondary wall composed of cellulose, which consists of the bulk of the fiber.Composition: CottonComposition (% Dry Weight)ConstanceTypical %Range %Cellulose95.083.0-96.0Protein (%N 6.25) % N - 1.9Pectic substances0.90.7-1.2Ash1.20.7-1.6Wax0.60.4-1.0Total sugars1.0-1.0Organic acids0.00.5-1.0Pigment tracesOthers1.4-Classing CottonCotton buyers judge cotton on the basis of samples cut from the bales. Skilled cotton classers grade or "class" the cotton according to standards established by the US Department of Agriculture such as cleanliness, the degree of whiteness, length of the fiber, and fiber strength.The classes pull a sample. They discard most of the cotton until just a pinch of well-aligned fibers remains. They measure the length of the fibers, referred to as staple fibers. Longer staple fibers are higher-grade cotton and are sold at higher prices. Long staples range from 1.1 inches to 1.4 inches long. The USTER® HVI classing is the standard classification system in the United States and also for the international cotton trade. USTER® HVI is used for measurement of the most important cotton fiber properties of micronaire, fiber length (UHML), uniformity, short fiber index, strength, elongation, color, trash content, and degree of maturity. HVI classing has been available to all growers since 1981.Methods for Classifying Cotton FiberMeasurements for fiber length, length uniformity, fiber strength, micronaire, color grade, and leaf grade are performed by precise High Volume Instruments, in a process commonly referred to as "high volume instrument classification." Only extraneous matter and special conditions are still officially classified by the traditional method of classer determination.Fiber LengthFiber length is the average length of the longer half of the fibers (upperhalf mean length). It is reported in both 100ths and 32nds of an inch. Fiber length is measured by passing a "beard" of parallel fibers through an optical sensing point. The beard is formed when fibers from a sample of cotton are automatically grasped by a clamp, then combed and brushed into parallel orientation.Fiber length is largely influenced by variety, but the cotton plant's exposure to extreme temperatures, water stress, or nutrient deficiencies may result in shorter fibers. Excessive cleaning or drying at the gin may also result in shorter fibers. Fiber length affects yarn evenness, and the efficiency of the spinning process. The fineness of the yarn that can be successfully produced from given fibers is also influenced by fiber length.Length UniformityLength uniformity is the ratio between the mean length and the upper-half mean length of the fibers, expressed as a percentage. If all of the fibers in the bale were the same length, the mean length, and the upper-half mean length would be the same, and the uniformity would be 100 percent. However, because of natural variation in the length of cotton fibers, length uniformity will always be less than 100 percent. The table below is a guide to interpreting length uniformity measurements.Length uniformity affects yarn evenness and strength and the efficiency of the spinning process. It is also related to short-fiber content (the content of fibers shorter than 1/2 inch). Cotton with a low uniformity index is likely to have a high percentage of short fibers. Such cotton may be difficult to process and is likely to produce low-quality yarn.Fiber StrengthStrength measurements are reported in grams per tex. A tex unit is equal to the weight in grams of 1,000 meters of fiber. Therefore, the strength reported is the force in grams required to break a bundle of fibers one tex unit in size. Strength measurements are made on the same beams of cotton that are used for measuring fiber length. The beard is clamped in two sets of jaws, 1/8 inch apart, and the amount of force required to break the fibers is determined. The table below is a guide to interpreting fiber strength measurements.Fiber strength is largely determined by variety. However, it may be affected by plant nutrient deficiencies and weather. Fiber strength and yarn strength are highly correlated. Also, cotton with high fiber strength is more likely to withstand breakage during the manufacturing process.MicronaireMicronaire is a measure of fiber fineness and maturity. An airflow instrument is used to measure the air permeability of a constant mass of cotton fibers compressed to a fixed volume. The chart below is a guide to interpreting micronaire measurements.Micronaire can be influenced during the growing period by environmental conditions such as moisture, temperature, sunlight, plant nutrients, and extremes in plant or boll position. Fiber fineness affects processing performance and the quality of the end product in several ways. In the opening, cleaning, and carding processes, low-micronaire or fine-fiber cotton requires less processing steps to prevent damage. Fiber length and strength measurements are made on the same "beard" of cotton.ColorColor GradeColor grade is determined by the degree of reflectance (Rd) and yellowness (+b) as established by official standards and measured by the high volume instrument. Reflectance indicates how bright or dull a sample is, and yellowness indicates the degree of pigmentation.The color of cotton fibers can be affected by rainfall, freezes, insects, fungi, and staining through contact with soil, grass, or cotton-plant leaf. Color can also be affected by excessive moisture and temperature levels during storage, both before and after ginning. Color deterioration because of environmental conditions affects the fibers' ability to absorb and hold dyes and finishes and is likely to reduce processing efficiency.TrashTrash is a measure of the amount of non-lint materials in cotton, such as leaves and bark from the cotton plant. The surface of the cotton sample is scanned by a digital camera, and the digital image is analyzed. The percentage of the surface area occupied by trash particles (percent area) and the number of trash particles visible (particle count) are calculated and reported.The ratio between the percent area of trash and trash particle count is a good indicator of the average particle size in a cotton sample. For instance, a low percent area combined with a high particle count indicates a smaller average particle size than does a high percent area with a low particle count.A high percent area of trash results in greater textile mill processing waste and lower yarn quality. Small trash particles, or "pepper trash," are highly undesirable, because they are more difficult for the mill to remove from the cotton lint than are larger trash particles.Leaf GradeLeaf grade is a measure of the leaf content in cotton. Recent extensive research and development work has resulted in acceptance of instrument leaf grade. Leaf grade is now determined by high volume instrument trash meter percent area and particle count (described above for trash). The leaf grade is calculated from these parameters based on the Universal Upland Grade Standards and American Pima Grade Standards.Leaf content is affected by plant variety, harvesting methods, and harvesting conditions. The amount of leaf remaining in the lint after ginning depends on the amount of leaf present in the cotton before ginning, the amount of cleaning, bedding, towels, and furnishings.Characteristics of Cotton Fibers and ProductsComfortable to wearNatural, cellulose fiberMade from the cotton bollAbsorbs water and "breathes"Slow to dryResists static electricity build-upWrinkles easilyCan withstand heat, detergents, and bleachAbout 20% stronger when wet than dryWash shrink unless treatedCan be damaged by mildewCan be damaged by prolonged exposure to sunlightLong-staple cotton (such as Supima, Pima, Egyptian, and Sea Island) can be woven into smooth, almost silky fabricFiber quality requirementsFor any material to qualify as a textile fiber, it must possess certain essential properties. The primary requirements include a high length-to-width ratio, sufficient tenacity, flexibility, and cohesiveness(Dever, 1995).In general cotton quality requirements Proceedings of the World Cotton Research Conference - 2. Athens, Greece, September 6-12, 1998, pp.85-93. U. Kechagja and H. Harig of all spinning systems are summarized as follows (Kechagja, 1994).Identifiable, measured fiber propertiesProperly ginned cottonContamination freeStickiness-freeEven running lotsHowever, fiber properties are differently interpreted by the various spinning systems and the selection of the correct raw material for any of them is of utmost importance to the spinner.The major quality parameters for the traditional ring system, the open-end or rotor spinning, and the recent innovations such as friction (DREF) and the air-jet spinning are given in table 1 in descending order of importance. In table 2 are given the acceptable limits for the same parameters in ring and rotor spinning.The use-value of fibers depends mainly upon the above physical properties but as we mentioned these are not sufficient to describe the spinnability of any cotton. Others not included in this table are of equal or sometimes of greater importance. The estimation of short fiber content (SFC %) of neps and seed coat fragments as well as of color, stickiness, and foreign matter became a necessity.Cotton fiber propertiesAn important consideration prior to any effort of improving quality is to obtain reliable information on the properties, likely to be improved as well as the technical specification of the input for various end uses.The molecular arrangement within the fiber and the conditions of fiber formation, impact the properties that make cotton fiber readily distinguished from all other textile fibers. All significant fiber properties are listed below, classified in relevant groups (Sleadman, 1997; Hunter, 1999).Length Related PropertiesStaple Length ValuesSpan Length ValuesUniformityParameters for Length DistributionShort Fiber ContentTransverse Dimensions of CottonMicronaireFinenessMaturityParameters for StrengthBreaking ElongationNon-Lint ContentAverage Trash/Trash ParticleSize DistributionTrash TypeDustLevel and SizeSeed Coat FragmentsForeign Matter and ContaminantsNepsCotton ColourMiscellaneous Fiber PropertiesFiber FrictionCleanabilityMicrobial AttackCohesivenessCompressibility and ResilienceMoisture Content.Fiber elongation is an important property that has received little attention so far. The role of elongation has not been fully defined yet but there is evidence that it strongly influences processing efficiency (Kechagja, 1996). Recent research is focused on clarifying the effect of elongation on yarn quality and improving or inventing methods to assess fiber elongation accurately (Uster, 1998).The main objectives of cotton fiber improvement are summarized in:Development of marginally longer and finer cotton.Improvement (where possible) of fiber maturity, strength, and elongation.Reduction of short fiber content, neps, and other impurities.Maintaining existing fiber quality.Improving the evenness of all-fiber characters.Improvement of fiber quality and color range of colored cotton.Commonly tested Cotton Fiber PropertiesNepsSpinning Consistency Index (SCI)MicronaireFiber IndexLength (mm)/UniformityShort Fiber IndexStrength (g/tex)Elongation (%)Moisture Content (%)Reflectance (Rd)Yellowness (+b)Trash Area (%)Trash GradeCotton fiber properties in different spinning systemsRing SpinningRotor SpinningFriction SpinningAir Jet SpinningLengthStrengthStrengthFinenessUniformityFinenessLengthStrengthLength(mm), UniformityFineness, UniformityL, UniformityStrengthElongationCleanlinessFiber FrictionCleanlinessSpinnability Index for efficient spinningFiber PropertiesRing spinningRotor or open-end spinningLengthmin 1 1/8 inchUniformity 7/8 inchUniformitymin 45%/min 45%/Micronaire3.5-5.0max 4.4Maturitymin 80%/min 70%/Strengththmin 25g/texmin 6g/texForeign mattermax 2%/max 1.5%/Tensile Properties of CottonFibersTensile properties of yarns and fabrics depend on both complex fiber arrangements (includes length, diameter, friction, etc.) inside the yarn and fiber structure, and also on the tensile properties of fibers. That is, while information about the complex relationship between fiber arrangement parameters is necessary, having knowledge about the tensile properties of fibers is crucial for a better understanding of the mechanical behavior of yarns and fabrics.Tensile properties of cotton fibres are influenced by the internal structure of the fibres. Cotton fiber is 98% cellulose. Cellulose molecule is synthesized from sucrose, the major type of sugar which can be found in the sap of the cotton plant. Sucrose will be converted within the cell into one molecule of glucose and one molecule of fructose; then, fructose will be converted into glucose.Afterward, two glucose molecules will react together to form cellulose; it will be then polymerized to form cellulose. It is reported that the rigidity of the cellulosic chains, the highly fibrillar and crystalline structure of cellulose macromolecules, and the extensive intermolecular and intramolecular hydrogen bonding are among the factors that affect most cotton fibres, tensile properties. Also, cotton fiber strength has been shown to be associated with the molecular weight of the cellulose, the crystalline regions in the fibers, and the reversals and convolutions of the fibres.Viscoelasticity of Cotton FibresViscoelasticity is the elastic response that occurs immediately after applying the load, and the viscous response which occurs smoothly and continuously when time goes on. The applied load, the cross-sectional area of fibers, the modulus of materials, are all affecting parameters for an elastic response. On the other side, the viscous response is a measure of a time-dependent deformation.In some other references, the term "creep recovery" was also used, which corresponds to the behavior of fiber after the load removal. It has been stated that, after the load removal, recovery will take place immediately and will continue over a period of time.Cotton Fiber Bundle Strength MeasurementsHigh Volume Instrument (HVI) is used in this study to measure the fiber bundle tenacity. HVI performs the fiber bundle tenacity test on the same specimen as the one used for the length measurement. In fact, after the length measurement, the specimen is repositioned; it is clamped between the two jaws (the gauge length is 0.3175 centimeters); then, the specimen is submitted to tensile test until it is broken. With this assumption, the tensile test does not affect the length measurement. HVI estimates the microtenacity of the specimen by measuring the force (g) required to break the specimen. The microtenacity and the breaking force (g) are used to calculate the bundle tenacity (g). The bundle tenacity was determined according to the protocol reported before (Hequet et al., 2006). Briefly, a small sliver of cotton fibers is mounted into a plastic tube. Fiber samples were embedded with a methacrylate polymer to behold in position. Fibers are cross-sectioned (one-micron thick cross-sections). Then microscopic slides are prepared after dissolving the methacrylate polymer from the sample. The images are viewed with a microscope and analyzed by the FIAS software. More than eight thousand fibers were tested for each sample.Individual fiber tensile measurementsFAVIMAT, an individual fiber tensile tester, measures the tensile properties of textile fibers at a constant rate of elongation. One hundred and fifty cotton fibers were tested for each replication using a ten-millimeter gauge length. In total, three replications were done on each cotton sample. This gauge (10 mm) was used because this is the minimum gauge length in which FAVIMAT can measure the linear density using the vibroscope method.Cotton Fiber Testing DefinitionsMaturity Index - is expressed in theta (the degree of thickening) which is defined as the ratio of the area of the cell wall to the area of a circle having the same perimeter as the fiber cross-section.Elongation (%) - is the extension of a fiber or a bundle of fibers during the tensile strength test. It is expressed as a percentage of the initial length.Force-to-break (or tensile force) - is the maximum tensile force to rupture an individual fiber or a bundle of parallel fibers. The normalized force-to-break by weight is called tenacity. The normalized force-to-break by cross-section is called tensile stress.Gravimetric fineness - it describes the linear density of fibers or yarns and is usually expressed in tex, mass per unit length.Elastic recovery - is the capacity of a stretched fiber when extended and then released.Stress-Strain curve - expresses the behavior of individual fiber under the gradually increasing applied force.Yield point - is a transition point between the initial steep slope in the stress-strain curve (first phase) and plasticity region (second phase) with rapid extension and permanent deformation.Initial Modulus - is equal to the slope of the stress-strain curve at the origin (after crimp removal) Table of ContentsCotton FiberPhysical Properties of CottonChemical Properties of Cotton Cotton is a cellulosic fiber. It is important to know the physical and chemical properties of this valuable fiber. Firstly, it has worldwide popularity for its variety of uses. Besides, it is the most used fiber for producing various types of fabric all over the world. Cotton fabrics are more comfortable to wear than other fiber products. After all, it is comfortable to wear in all seasons. If this fiber is properly ginned, it becomes soft, which makes it easy to use for dyeing when it has a high absorbency power. It has good strength and good drape ability at the same time. Like all textile fibres, cotton has its own physical and chemical properties, which require knowledge for better processing in spinning, weaving, knitting, dyeing, printing, and finishing. It is important to know the physical and chemical properties of this fiber. Here, I describe the properties of cotton fiber. The following are the physical properties of cotton fibres: Color: The color of cotton fiber could be white, creamy white, bluish-white, yellowish white, or grey. Tensile Strength: It is a moderately strong fiber. Moreover, it has a tenacity of 3-5 g/den. Moisture affects the strength of cotton greatly when the wet strength of cotton is 20%, which is higher than the dry strength. Elongation at break: It does not stress easily. It has an elongation at a break of 5-10%. Elastic Recovery: This is an inelastic and rigid fiber. Although at a 2% extension it has an ER of 74%, at a 5% extension it has an ER of 45%. Specific Gravity: The specific gravity of this fiber is 1.54. Moisture Regain (MR%): The standard moisture regain of cotton is 8.5. Effect of Heat: It has excellent resistance to degradation by heat. But it begins to turn yellow after several hours at 120 °C and decomposes at 150 °C. As a result of oxidation, this fiber becomes damaged several times after a few minutes at 240 °C. Lastly, cotton burns in the air. Effect of Sunlight: There is a gradual loss of strength when it is exposed to sunlight, and the fiber turns yellow. The degradation of this fiber by oxidation happens when heat promotes and encourages it. Although, sunlight causes much of the damage caused by UV light and by the short wavelengths of visible light. Effect of Age: It shows a small loss of strength when stored carefully. After 50 years of storage, this fiber may differ only slightly from the new fibers. It is a natural cellulosic fiber, and it has some chemical properties. The following are the chemical properties of this fiber. Effect of Acids: It is attacked by hot, dilute acids or cold concentrated acids, which disintegrate. Indeed, it is not affected by acids. Effects of Alkalies: These have excellent resistance to alkalis. It swells in caustic alkalis (NaOH), but it does not damage. However, it can be washed repeatedly in a soap solution without any problem. Effect of Organic Solvent: It has high resistance to normal cleaning solvents. Meanwhile, this fiber is dissolved by the copper complexes, such as cuprammonium hydroxide and cupriethylene diamine, and concentrated at 70% H2SO4. Effects of Insects: It is not attacked by moth-grubs or beetles, at least. Effect of Microorganisms: This fiber is attacked by fungi and bacteria. Mildew will feed on fabric, rotting and weakening the materials. Mildew and bacteria will flourish on it under hot and humid conditions. They can be protected by impregnation with certain types of chemicals. One of the substances is copper naphthenate. The above physical and chemical properties will indeed help us to be careful about the processing of this fiber in the different stages of processing, from spinning to garment making. I'm a textile engineer who is passionate about writing about the textile industry. With a B.Sc. in Textile Engineering, I've gained extensive knowledge about textile manufacturing and sustainable practices. My focus revolves around refining manufacturing processes, maintaining product quality, and staying updated on the latest textile technology advancements. If you're interested in collaborating on articles or have any pieces you'd like to submit, let's connect and discuss further!

