Natural Dyes

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Lecture No. # 25

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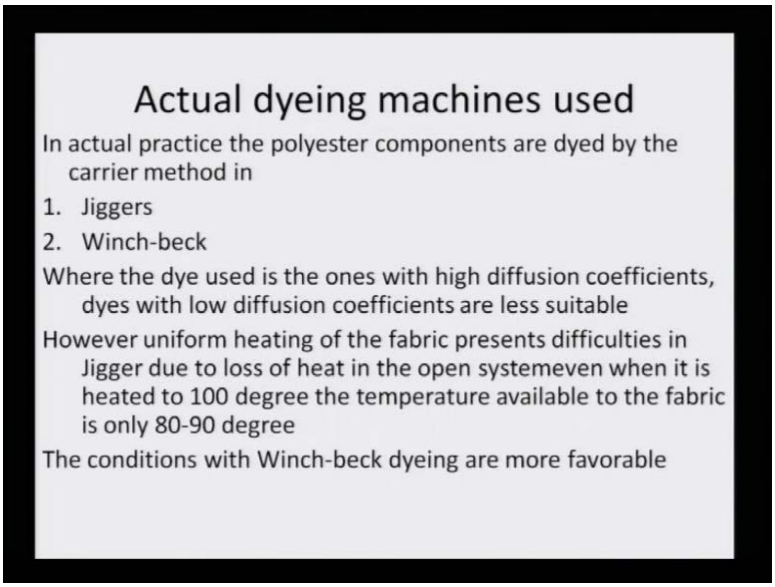

So, when we were talking about the actual dyeing machine that is used, I said that it is possible to use (( )) for polyester dyeing, jigger and winch-beck; however, there are other machines and other techniques also, where the dye used is the one with high diffusion coefficients, dyes with low diffusion coefficients are less suitable. So, whether we are using jigger or whether we are using winch-beck, we need to understand one very important fact that the dye or the disperse dye that is using, being used must have high diffusion coefficient. And therefore, should avoid the dyes, which have low diffusion coefficient, because they will not be found suitable for jigger and winch machine, because there is no possibility of creating any high temperature high pressure.

However uniform heating of the fabric presents difficulties in jigger, due to loss of heat in the open system; even when it is heated to 100 degrees, the temperature available to the fabric is only between 80 to 90 degrees, and as I told you that polyester require high heating. So, therefore, jigger is not one of the best machine, but of course, if one has only

jigger in the dye house, it is possible to do polyester dyeing in that jigger itself, the conditions with winch-beck is dyeing is much favorable as compared to the jigger

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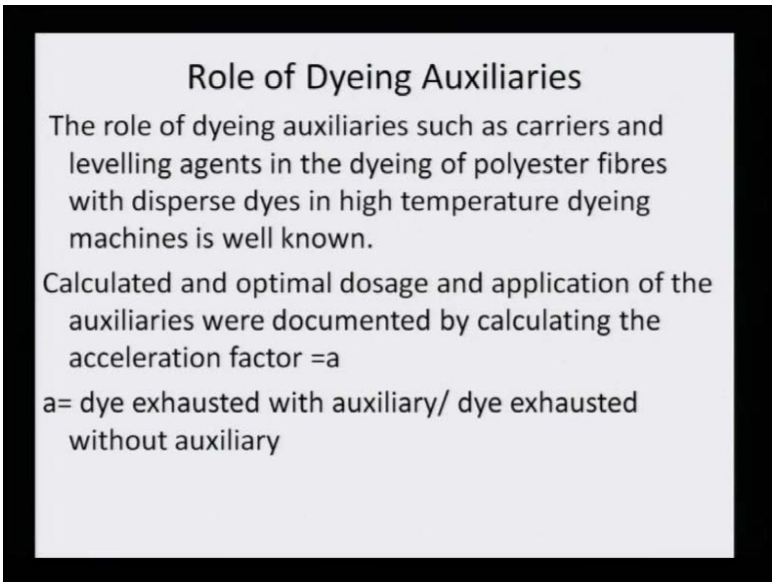

Even dye auxiliaries play a very vital role; the role of dye auxiliaries such as carriers and leveling agents in the dyeing of polyester fibres with disperse dyes in high temperature dyeing machines is well known, because you see unless and until, these facilitating chemicals are added for swelling of the fibre, for the dispersion of the dye molecule, it is not going to get facilitated, even at high temperature and pressure calculated and optimal dose and application of the auxiliaries, where documented by calculating the acceleration factor that is equal to a. And a is equal to dye exhausted with the auxiliary, upon dye exhausted without the auxiliary; then only we can know the role of the auxiliary.

Suppose if I say that a is a good swelling agent, a is a good b is a better career; will you believe that? There has to be some scientific data to assure that a or b are better, and in order to find out that, the best practices is to find out auxiliartion factor; is it auxilirating? If it is auxilirating, the value will be positive, because with the use of the auxiliary will always be a higher finite number, then the second value, which is without the auxiliary; and if there is the rate of diffusion is enhanced; that means, there is an auxiliration. So, that is how the role of auxiliary in dyeing is ascertained.

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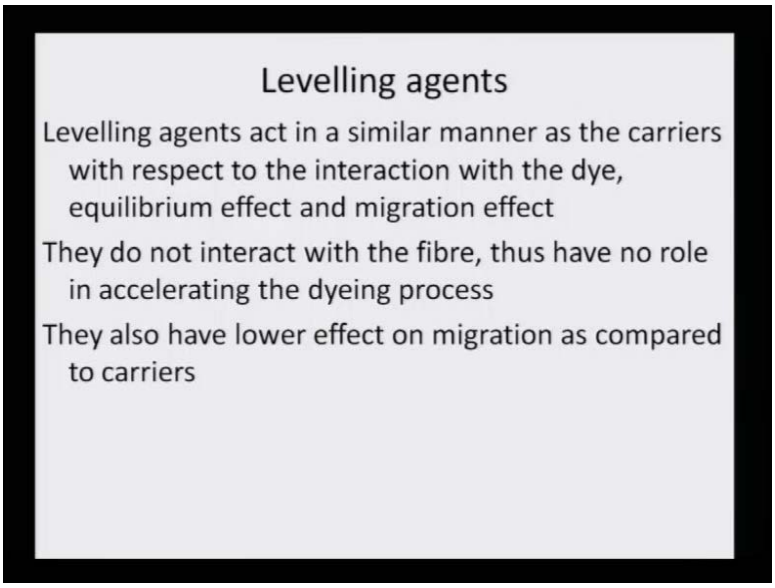

Leveling agents act in a similar manner as the carriers with respect to the interaction with the dye, equilibrium effect and migration effect. So, they play a role of creating the evenness, although the dye has diffused, but it needs to be dispersed completely on the even surface. And this is done with the help of these barriers, and because they effect the equilibrium effect and the migration. The dye must migrate properly on to the entire surface, they do not interact with the fibre; thus have no role in accelerating the dyeing process, they are just facilitator.

They are facilitating the process, but they are not actually playing a direct role in that; they also have lower effect on migration as compared to the carriers. So, both leveling agents and carriers go hand in hand, and when they are actually going hand in hand, they play a big role in finding out how they are going to affect each other; and when they both are added, they have overall effect on the dyeing process.

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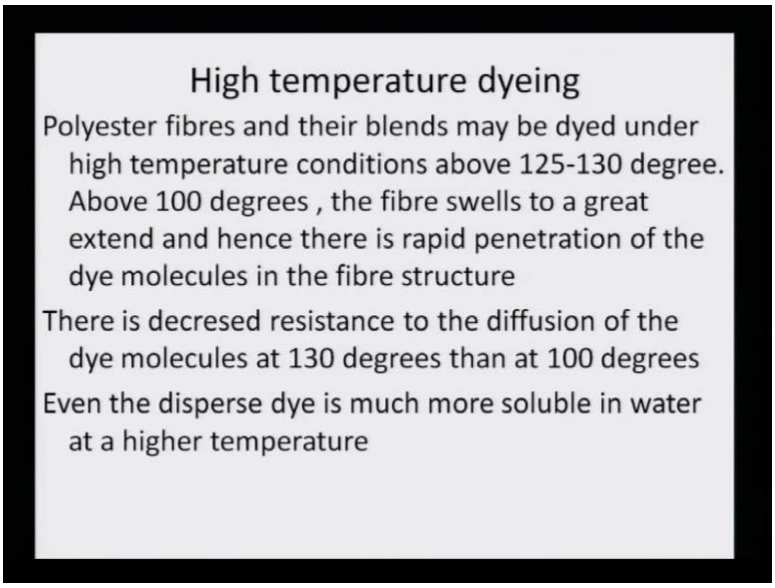

High temperature dyeing; polyester fibres as what I mentioned a little while ago; polyester fibres and their blends may be dyed under high temperature condition, above 125 degrees or even sometimes 130 degrees, above 100 degrees the fibres swells to a great extend, and hence, there is rapid penetration of the dye molecules in the fibre structure. So, because it has to be done at a higher temperature, this requires a special attention; we were not heating at 125 degrees or 130 degrees, when we were talking about natural dyeing and natural fiber dyeing, but this fiber being hydrophobic needs some special attention and some special treatment. There is decreased resistance to the diffusion of the dye molecules at 130 degrees than at 100 degrees.

So, because it is facilitated more and more at higher temperature that is why higher temperature is preferred. Now, you will also appreciate one thing that to attend high temperature, more fuel more energy would be required. So, unless and until that it is mandatory process, people will not do it; and because they found that by heating it at a higher temperature, the effect is better; that is why it was recommended. Even the disperse dye is much more soluble in water at higher temperature, so it also helps in the solubility of the dye. So, the dye solubility and the you know, dye dispersion everything takes place well at 130 degrees as compared to 100 degrees.

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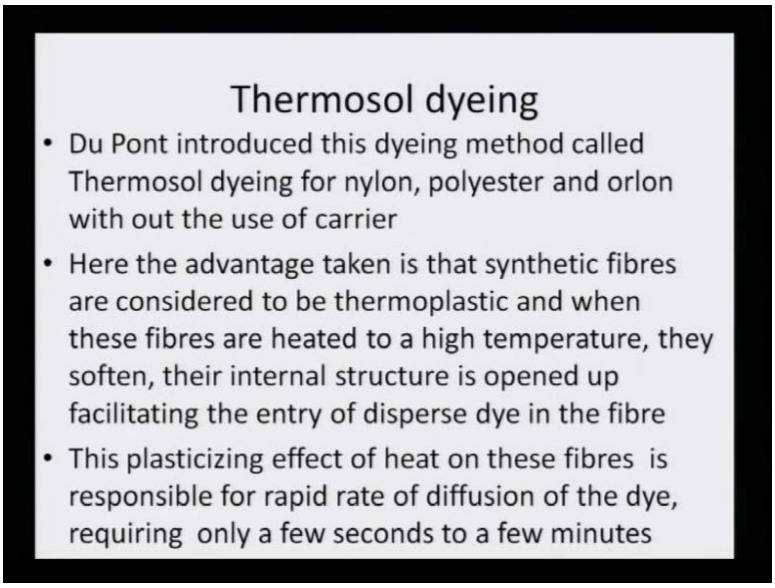

Therefore, a company came up with a new process called thermosol dyeing. Now Du Punt introduced this dye method called thermo sol dyeing, which was meant for nylon, polyester and oblong, without the use of carrier. That means, they found that there is, there can be another process for the industry; and this innovation was done by a very renowned company called Du Punt.

Here the advantage taken is that synthetic fibers are considered to be thermoplastic, and when these fibers are heated to a high temperature, they soften; their internal structure is opened up, and facilitating the entry of the disperse dye in the fiber; this plasticizing effect of heat, on these fibers is responsible for rapid rate of diffusion of the dye requiring only a few seconds to a few minutes. This heating need not be done at a very high temperature for a very long time, but only for a short while a few seconds to a few minutes, without using any carrier. And this rarely brought down the cost, because as you would recall, the cost of the carrier was fairly high; and therefore, if it can be avoided, the processes can be done at a low cost.

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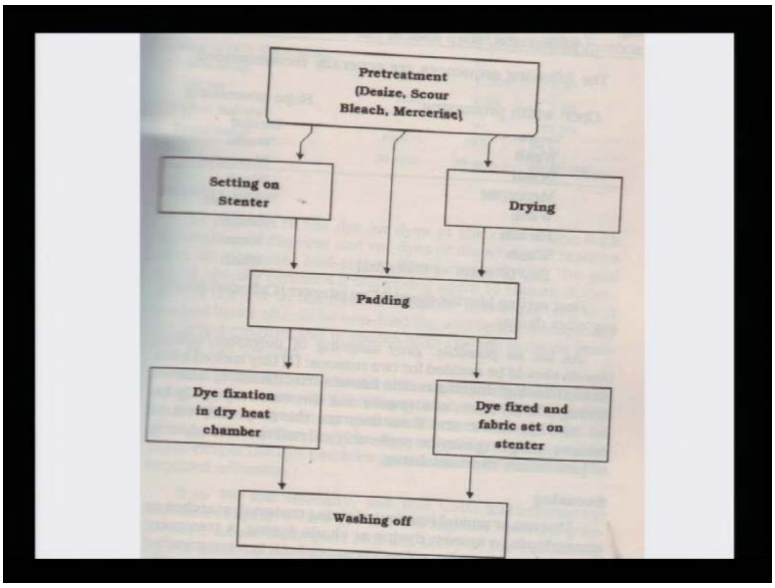

Now, this is how the pretreated material was you know, pass through bleaching, desiring scouring and so on. And then through padding and then dry fixation in a dry heat chamber and then finally, the dye fixed was put into the stenter, and then washed off. So, putting it into the stenter actually helps it to get into the thermoplastic material. So, that was the whole idea.

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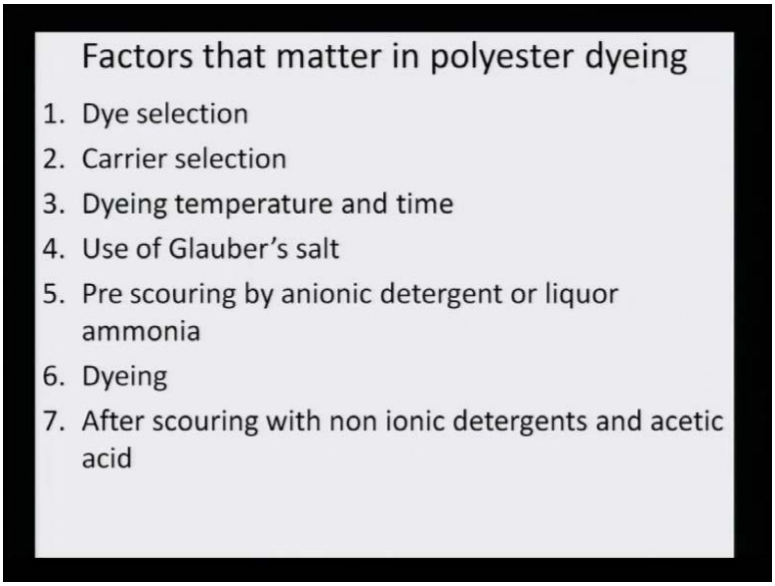

Factors that matter the polyester dyeing is dye selection, carrier selection, if we are not following the thermosol process, dyeing temperature and time, use of Glauber's salt for

using as a leveling agent, pre scouring by anionic detergent or liquor ammonia. Then finally dyeing, after scouring with non ionic detergent and acetic acid to fix the dyeing; so this is the order of you know, factors that needs to be kept in mind, when one is learning or doing polyester dyeing.

So, with this we have come to an end of this chapter, which is related to polyester dyeing; but we just saw few things about the bleaching, the scouring, the other pretreatments that the fabric needs to go through. So, we will try to now look at the pretreatments of the synthetic fibers, which need to be carried out, before they are taken for dyeing. Remember when we were doing natural fibers like cotton silk and wool, the pretreatment was very simple; it only had to go through you know, scouring and sometime bleaching, and then the fabric was ready, the gray fabric was just ready for use for dyeing. But that is not the same case, when we take synthetic fibers particularly, nylon, polyester, polyacrylic material, polyamide and so on and so forth.

So, we will now take this chapter on the treatments that are required for these kinds of synthetic fibers. So, that is the difference between what we learnt earlier. And now what are we going to learn something new; and this newness is because these synthetic fibers need different kind of pretreatment.

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Why pretreatment is needed? While as a whole, this process consist of desizing process, scouring and bleaching; pretreatment process basically aim to removal of all impurities found on fibers, especially cellulose fiber, so that the materials have a degree of whiteness, and they are good absorbent of the dyestuff. This is what we had learned in the previous section, when we were looking at the scouring and the bleaching and the desizing of the cotton; but that was only when the fabric was brought, after it was woven that all kind of impurities that are adhering on the surface, which can hamper the dye uptake though should be removed.

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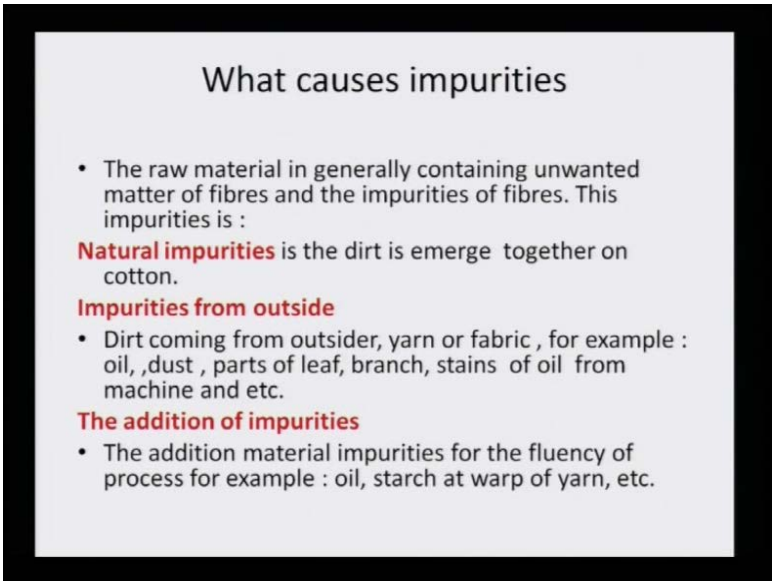

What causes impurities; the raw material in generally containing unwanted matters of fibers and the impurities of the fibers; these impurities are natural impurities, that is it is the dirt that emerge together in the cotton, and other fiber, when they are being woven. Impurities from outside that is dirt coming from outsider yarn or fabric for example, oil dust, parts of leaf, branch, stains of oil from the machine etcetera, etcetera; because you see when the fiber is being woven, there are many places, where it is touching the ground, it is not every place is clean. So, it is bound to take up the dust and dirt from the vicinity; the addition of impurities like additional impurities, material impurities of the fluency of process, like oil, starch, these are added to the yarn, in order to weave them into the fabric. So, these also need to be removed.

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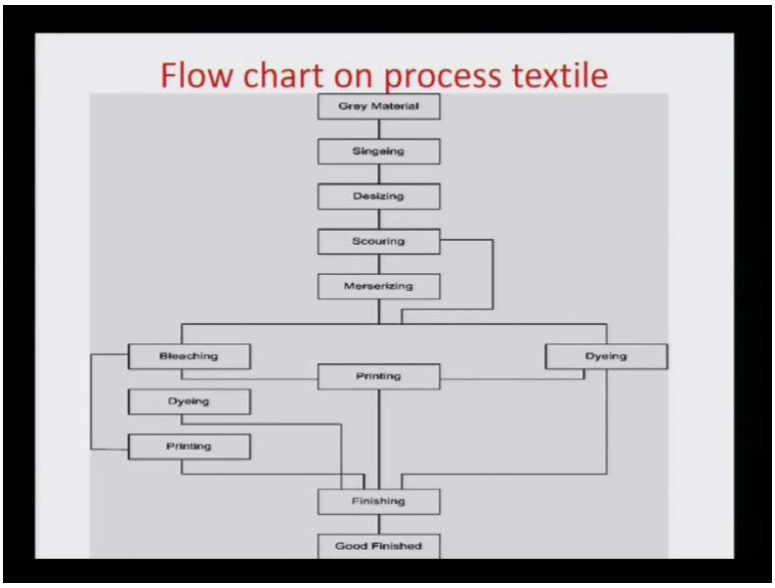

A grey material; this the usual flow chart; a gray material goes through singeing, desizing, scouring, merserizing. And then it goes through bleaching, dyeing, printing or it can go to dyeing or it can go to printing and finally to finishing, and to the finish good. So, this the flow charts, so there are several, several steps, which need to be understood clearly as to what is their role.

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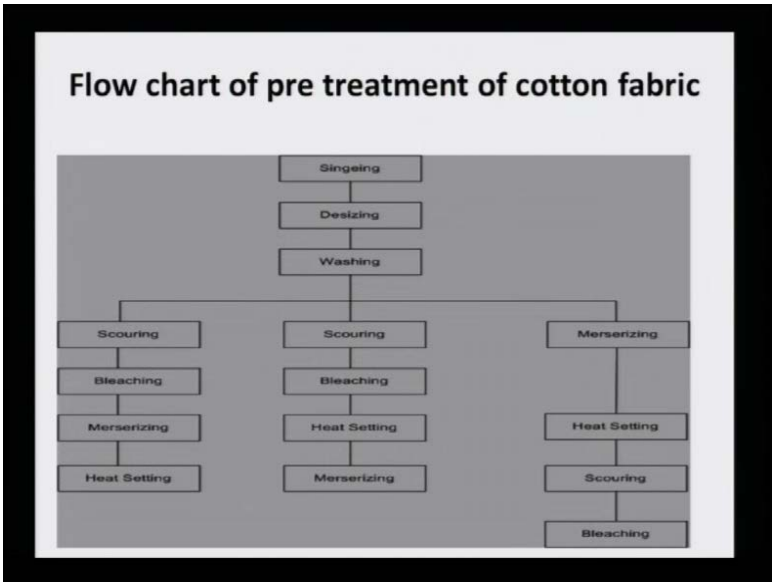

Now, if one tries to just look at cotton, we did not do this so much in detail, when we were doing cotton preparation, we just said okay; cotton was simply scour or cotton was bleached or bleached cotton was taken, and it was simply scour. But here apart from scouring, there is this singeing, desizing, washing, and then scouring is carried out, after that again it can go through bleaching, merserizing. And there are various, various options that can be done with cotton; so, but these are the main initial steps are singeing, desizing, merserizing and scouring, this cannot be avoided.

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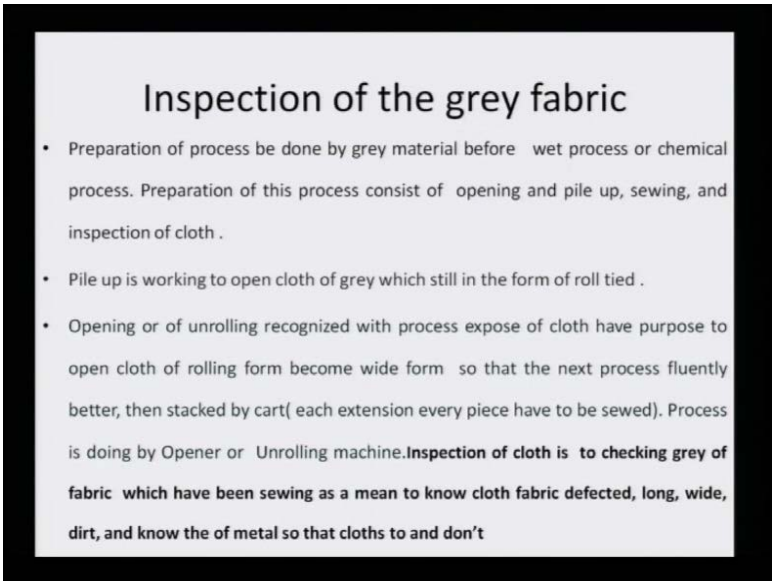

So, let us try to take a look at the grey fabric. Inspection of the grey fabric; preparation of process be done by grey material before wet processing or chemical process is carried out first one has to make an inspection; how dirty it is. Preparation of this process consist of opening and pile up sewing and inspection of the cloth; pile up is working to open cloth of grey, which still in the form of roll tied; opening or of unrolling recognized with process expose of cloth, have purpose to open cloth of rolling form before wide form, so that next process fluently stacks happens fluently. Main thing that you have to understand is that inspection of the cloth for checking the situation of the grey fabric; what is it? Is it very dirty? Is it less dirty? Is it less oily? Is does it have too much of oil stay? And then one has to be decide, what is to be done next.

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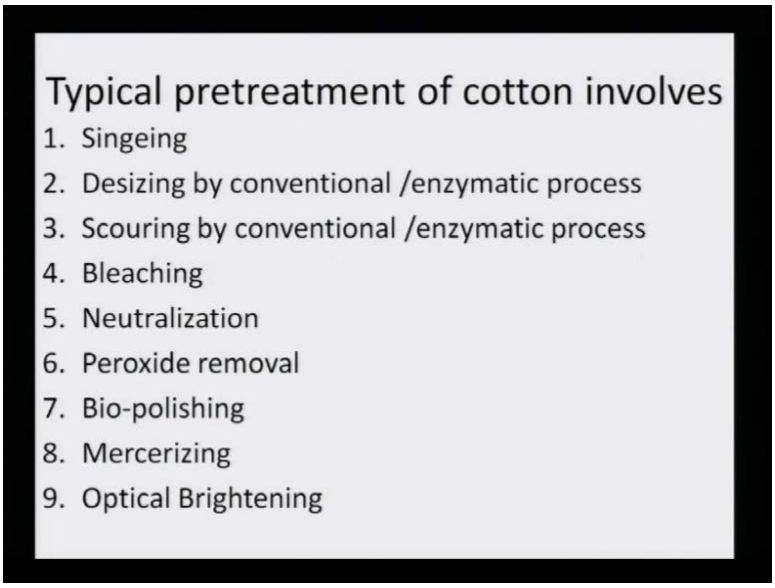

Typical pretreatment cotton involves singeing, desizing by conventional or enzymatic process, scouring by conventional or enzymatic process, bleaching, neutralization peroxide removal, bio-polishing, mercerizing, optical brightening. So, these are the various steps that the cotton has to go through; similarly we have synthetic fibers, we have to see what all needs to be done; is it dirty, while being woven; and if it is becomes dirty, it needs to be scoured or bleached and so on. This is a typical machine that shows that how the gray fiber is you know, evaluated and it is processed.

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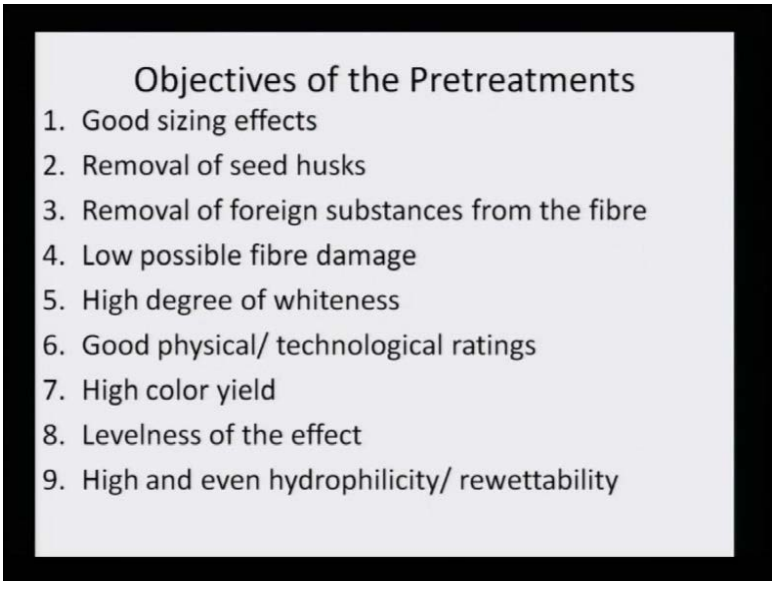

Objectives of the pretreatments: Good sizing effects, removal of seed husks, removal of foreign substances from the fiber, low possible fibers damage, high degree of whiteness, good physical technological ratings of the fiber, high color yield, levelness of the effect, high and even hydrophilicity or rewettability. Now you see that all this is required for two simple reasons; first is that the fabric should not have any color or stain or oil marks. Second thing is it should be so pure white, that the color that the entering or the dyeing will be taking place subsequently must have evenness.

That is the two motto; and for that, it is important to remove the husk, all foreign particles, all dust particles and as far as possible; the processes should be so soft and mild that they should not eventually cause any damage to the fiber or fabric. And it should eventually, create high degree of whiteness; and therefore, the color will definitely be taken up more effectively.

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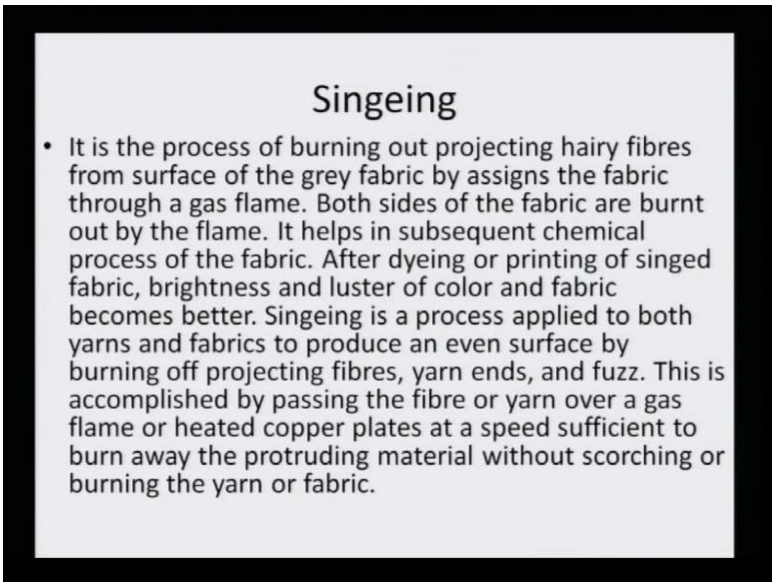

Singeing: It is a process of burning out projecting hairy fibers from surface of the grey fabric, by assigns that fabric through a glass flame; both sides of the fabric are burnt out by the flame; it helps in subsequent chemical process of the fabric, after dyeing or printing of singed fabric brightness and luster of the color, and fabric becomes better. Singeing is a process applied to both yarns and fabrics to produce an even surface by burning off projecting fibers, yarn ends and fuzz.

This is accomplished by passing the fiber or yarn over a gas flame or heated copper plates at a speed sufficient to burn away the protruding material without scorching or burning the yarn and fabric. So, this a very fast process on to the very heated copper plates or over the gas flame, the fabric is quickly fast; now every striation or you know, these you know, fuzz or yarn ends or fabric ends are burnt off so that, these are the places where the dust actually accumulates.

So, if these are burnt off, the singeing would be carried out, and these projecting hair fibers really create a very bad look on the fiber. So, if they are removed by burning it off, and at the same time, it does not burn the fabric. So, it is only burning the surface protruding fibers.

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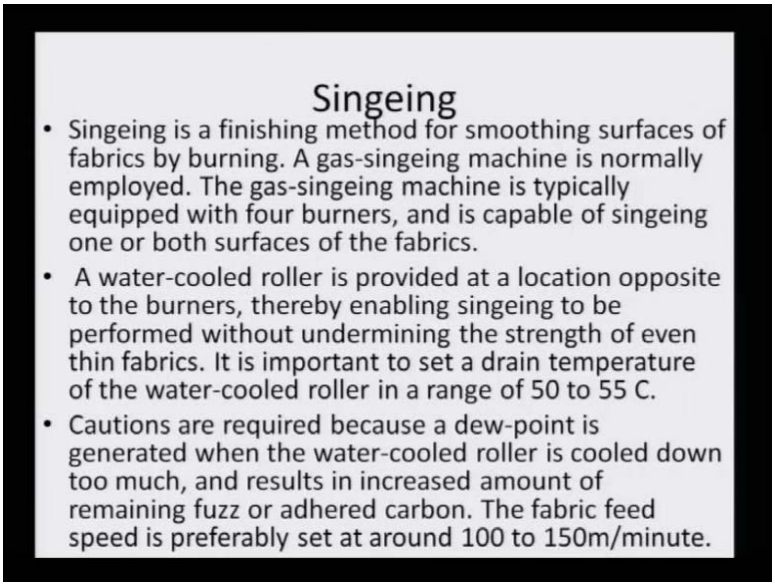

Singeing is a finishing method for smoothing surfaces of the fabrics by burning. A gas-singeing machine is normally employed; the gas-singeing machine is typically equipped with four burners, and is capable of singeing one or both surfaces of the fabrics. A water-cooled roller is provided at a location opposite to the burners, thereby enabling singeing to be performed without undermining the strength of even thin fabrics. It is important to set a drain temperature of the water-cooled roller in the range of 50 to 55 degrees.

Cautions are required, because a dew-point is generated when the water-cooled roller is cooled down too much, and results in increased amount of remaining fuzz or adhered carbon; the fabric feed speed is preferably set at around 100 to 150 meters per minute.

So, you see that is the kind of speed of the singeing machine, and this is the reason why it has to be very fast; it is a four burner system, and there is a water cooler. So, that water cooler helps to remove the burn part as well as it washes of the the all the dirt and the other particles that are associated with the process of burning.

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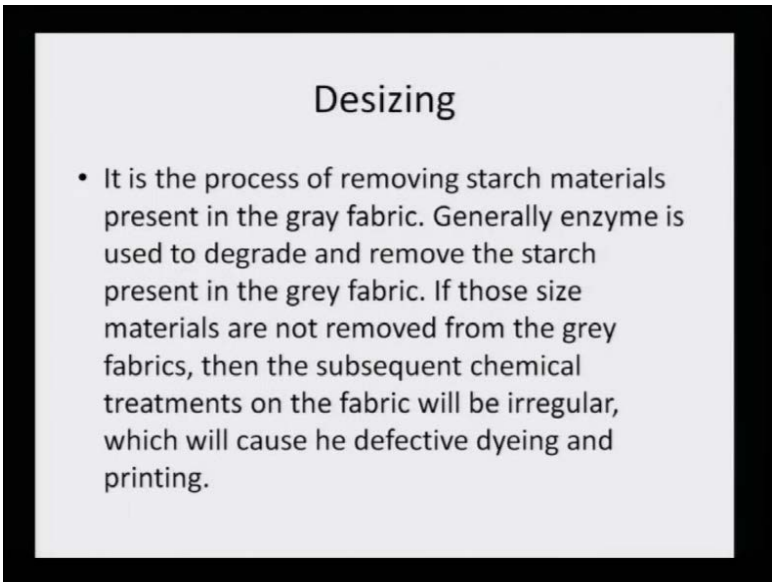

Desizing: It is a process of removing starch materials present in the grey fabric; generally enzyme is used to degrade and remove the starch present in the gray fabric. So, the desizing is done enzymatically now days. If those size materials are not removed from the grey fabric, then the subsequent chemical treatments on the fabric will be irregular, which will cause defective dyeing and printing. So, because these chemicals, which are treated at the time of processing the yarn you know, from the cotton or from the initial striation of the fabric, when the yarn is being woven, that time some starchy material are added, in order to add strain to the yarn; they need to be removed and that removal of the starchy material by enzymatic reaction is done in desizing processes.

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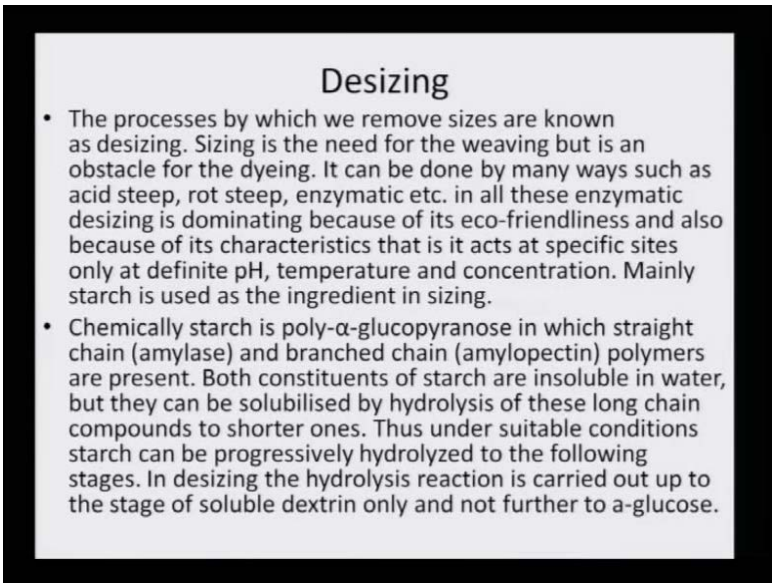

The process by which we remove sizes are known as desizing; sizing is the need for the weaving, but is an obstacle for the dyeing, it can be done by many ways such as acids steep, rot steep, enzymatically etcetera. In all these enzymatic desiring is dominating, because of its eco-friendliness; and also because of its characteristics, that is it acts at a specific sites only at definite ph, temperature and concentration; mainly starch is used as a ingredients in the sizing. So, we know that it is an important part, because in order to weave the yarn, the desizing material of starch has to be coated on the yarn; now it is like decoating the starchy material, which is done bydesizing; and to do that, there are many methods to do that enzymatic desizing is found to be the best method.

Chemical starch is poly-alpha-glucopyranose, in which straight chain amylase and branch chain amylopectin polymers are present; both constituents of starch are insoluble in water; but they can be solubilised by hydrolysis of these long chain compounds to shorter ones. Thus under suitable conditions starch can be progressively hydrolyzed to the following stages; in desizing, the hydrolysis reaction is carried out up to the stage of soluble dextrin, only to and not further to alpha glucose. So, from insoluble state from the starch, it has to be simply converted into the solubalised form; that is all. It needs not to be break down to its smallest component. So, these amylopectin and amylase must be broken down only till there.

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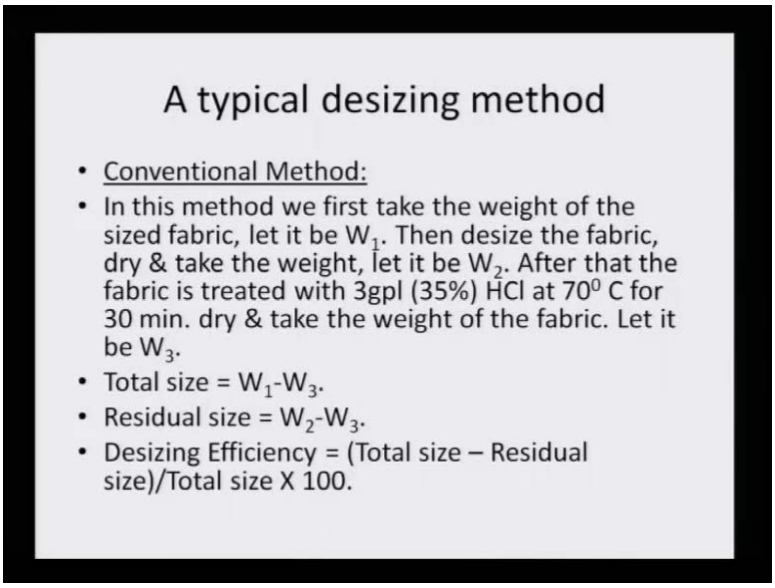

And a typical sizing method by conventional method is that in this method, we first take the weight of the sized fabric; let that be W 1, then desize the fabric dry and take the weight, let it be W 2. After that the fabric is treated with 3 gpl, 35 percentage HCl at 70 degrees not enzymatically, it is done by acid for 30 minutes; dry and take weight of the fabric. Let it be W 3. Now total size would be W 1 minus W 3 and residual size will be W 2 minus W 3 and desizing efficiency will be calculated on the total size minus the residual size upon total size into 100. So, that is how the calculations are done whether the desizing has been done efficiently or not and typically calculation method has also been discussed with here

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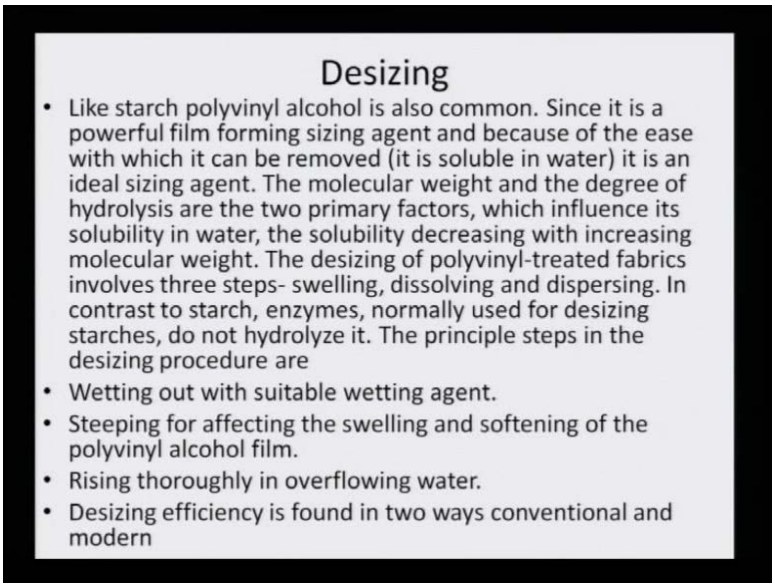

Like starch polyvinyl alcohol is also one of the common compounds. Since it is a powerful film coating sizing agent, and because of the ease with which it can be removed, it is soluble in water, it is an ideal sizing agent. So, apart from starch, there is an another compound called polyvinyl alcohol, which is also used as sizing agent; and therefore, it has to be removed too, and it the removal of polyvinyl alcohol is much easier, because it is water soluble.

The molecular weight and the degree of hydrolysis are the two primary factors, which influence its solubility in water, the solubility decreasing with increasing molecular weight. The desizing of polyvinyl - treated fabrics involves only three steps - swelling, dissolving and dispersing; the in contrast to starch, enzymes normally used for desizing starches, do not hydrolyze it. The principle steps in the desizing procedures are wetting out with suitable wetting agent, steeping for accepting the swelling and softening of the polyvinyl alcohol film, rising thoroughly in overflowing water, desizing efficiency is found in two ways both conventional and modern. So, whether it is you know, desizing of starch or desizing of polyvinyl alcohol; there common method is to remove them by washing it out, in or by hydrolyzing it.

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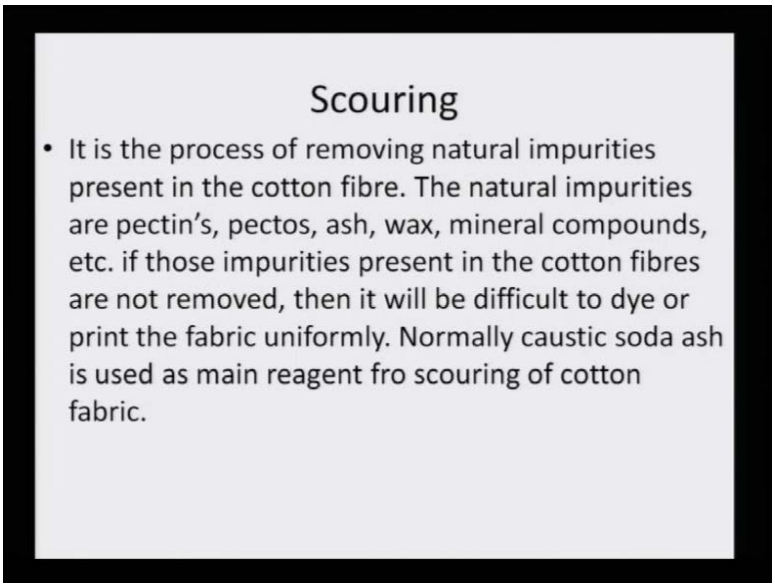

Then comes the next step - the scouring step; it is the process of removing natural impurities present on the cotton fiber as well as on the synthetic fibers; the natural impurities are pectin's, pectos, ash, wax, mineral compounds, oil stains. If those impurities present in the cotton fiber or in other fibers are not removed, then it will be difficult to die or print the fabric uniformly. Normally, caustic soda ash is used as main reagent fro scouring of cotton fabric, but we have also seen that scouring can be done by mild detergents as in the case of silicon wool. So, be it any fiber, be it any fabric, this process is common to all.

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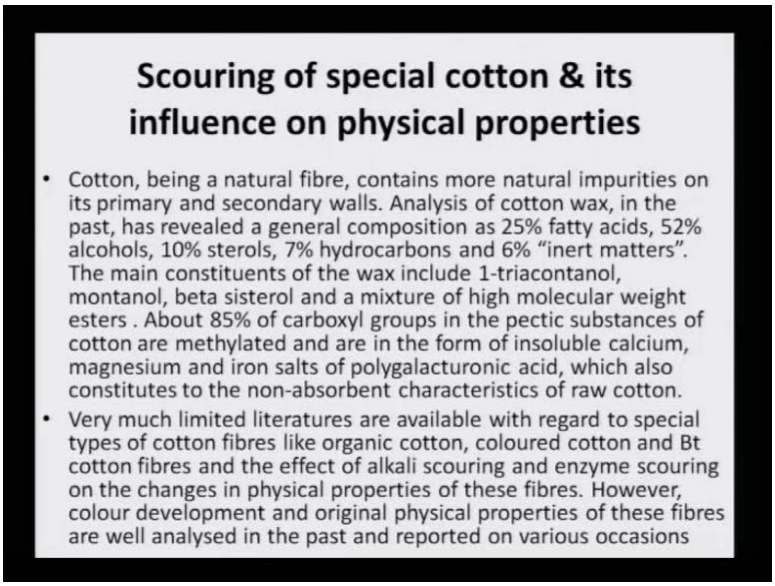

Scouring of special cotton and its influence on the physical properties; cotton, being a natural fiber contains more natural impurities, in its primary and secondary walls. Analysis of cotton wax is the past has revealed a general composition as 25 percent fatty acids, 52 percent alcohols, 10 percent sterols, 7 percent hydrocarbons and 6 percent inert matters. The main constituents of the wax include one triacontanol, montanol, beta sisterly and a mixture of high molecular weight esters, about 85 percent of the carboxyl groups in the pectin substances of cotton are methylated are are and are in the form of insoluble calcium, magnesium, iron salts of polygalacturonic acid, which also constitutes to the non-absorbent characteristics of raw cotton.

So, in order to make even cotton, which we thought that was very hydrophilic. There were many hindrances, which were actually needed to be remove, because these compound also make cotton as hydrophobic; very much limited literature are available with regard to special types of cotton fiber like organic cotton, colored cotton. But cottons fibers and their effect with alkali scouring and enzyme scouring are the ones, which actually change the physical properties; because we need to change these physical properties, in order to increase the dye ability of the cotton; and therefore, scouring is a very important step.

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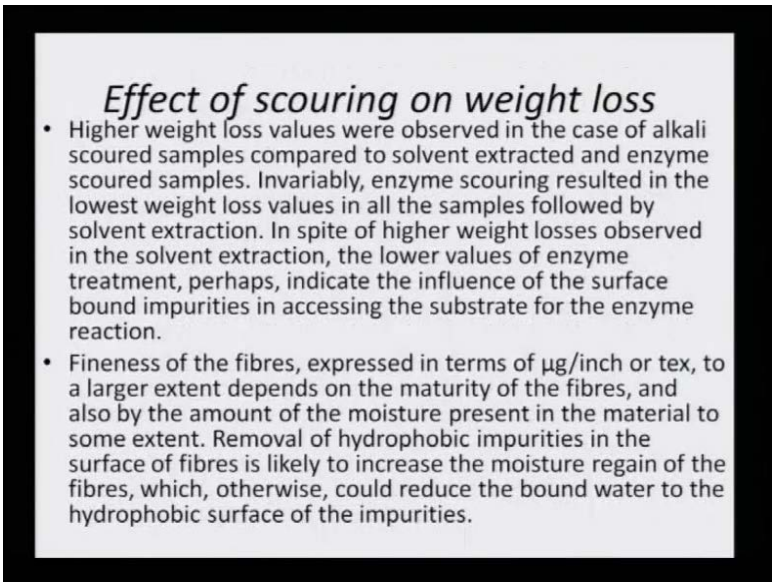

Effect of scouring on weight loss: sometimes you know, higher molecular values were observed in the case of alkali scoured samples compared to solvent extracted and enzyme

scoured samples. Invariably, enzyme scouring resulted in low weight loss where as the values of the sample followed by the solvent extraction. In spite of high weight losses observed in the solvent extraction, the lower values of enzyme, treatment, perhaps, indicate the influence of the surface bound impurities in accessing the substrate for the enzyme reaction.

So, if we were make a comparison of doing a scouring with solvent extraction verses enzyme, what would have a bigger weight loss; what that it is found that enzyme are found to be the best, the finest of the fiber express in terms of microgram per inch or text to the larger extent depends on maturity of the fibers; and also by the amount of the moisture present in the material to some extent, removal of the hydrophobic impurities in the surface of the fibers is likely to increase the moisture regain of the fiber, which otherwise could reduce the bound water to be hydrophobic surface of the impurities.

So, it is absolutely necessary and important to do the scouring; time and again I am telling you that scouring, even cotton if not scoured, will be as bad as polyester what we saw just now. So, I am tracking this comparative data, and making this comparison more clearly to you, only to make you understand that scouring for cotton is very important. If not done on cotton, it will be as bad as for dye up take, as what we saw in the last lecture that polyesters were very tough to dye.

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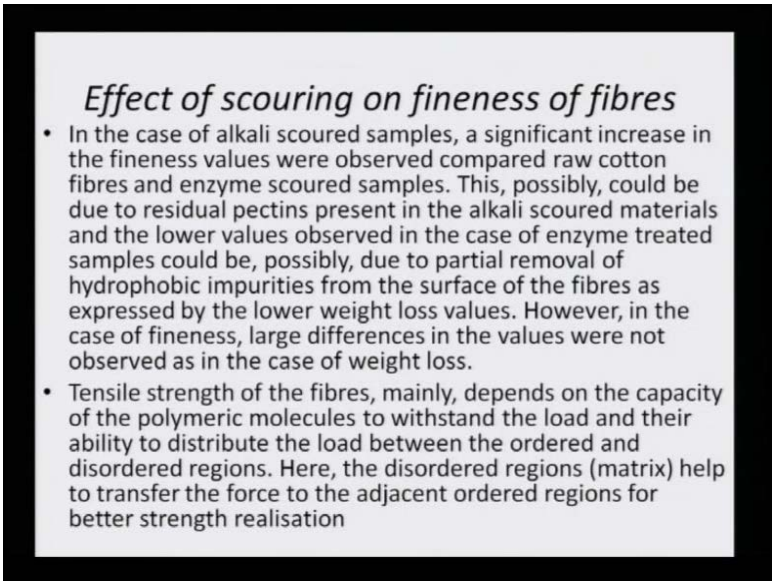

Effect of scouring on the fineness of the fabric: In case of alkali scoured samples, a significant increase in the fineness values were observed; compared raw cotton fibers and enzyme scoured fibers, this possibly could be due to residual pectin's present in the alkali scoured materials, and the lower values observed in the case of enzyme treated samples could be possibly due to partial removal of hydrophobic impurities from the surface of the fiber as expressed by the lower weight loss values.

However in the case of fineness, large differences in the values were not observed in the case of weight as in the case of weight loss. Tensile strength of the fiber mainly depends on the capacity of the polymeric molecules to withstand the load, and their ability to distribute the load between the ordered and disordered regions, that is where ever there is a crystalline, and the whenever there is a amorphous structure within the cotton, it kind of distributes the tensile strength. Here the disordered regions, that is the matrix helps to transfer the force to the adjacent ordered regions for better strength realization.

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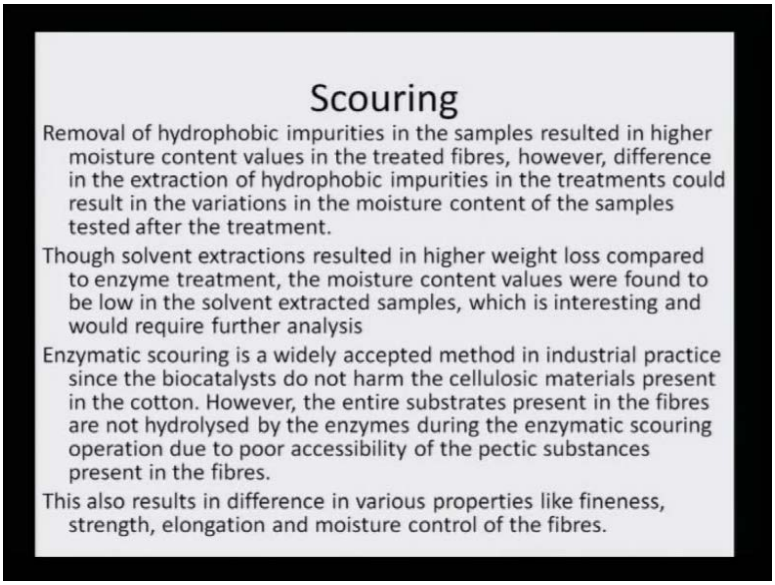

Scouring; therefore, removal of hydrophobic impurities in the sample resulted in higher moisture content values in the treated fibers; however, difference in the extraction of the hydrophobic impurities in the treatments could result in variations in the moisture content of the samples tested after the treatment. Though solvent extractions resulted in higher weight loss compared to enzyme treatment, the moisture content values were found to be low in the solvent extracted samples.

Therefore again and again, we are coming to one basic idea that enzyme scouring is the best method for the fibers; enzymatic also because it is eco friendly, it is bio degradable, every processes needs to be evaluated from the point of eco friendliness also; enzymatic scouring is a widely accepted method in industrial practice; since, the biocatalysts do not harm the cellulosic materials present in the cotton. However, the entire substrates present in the fibers are not hydrolyzed by the enzymes during the enzymatic scouring operation due to poor accessibility of the pectin substances present in the fibers. This also results in difference in variation, and various properties like fineness, strength, elongation and moisture control of the fibers. So, you see even that a process is not full proof, but it is to a large extends acceptable, because it removes a lot of impurities.

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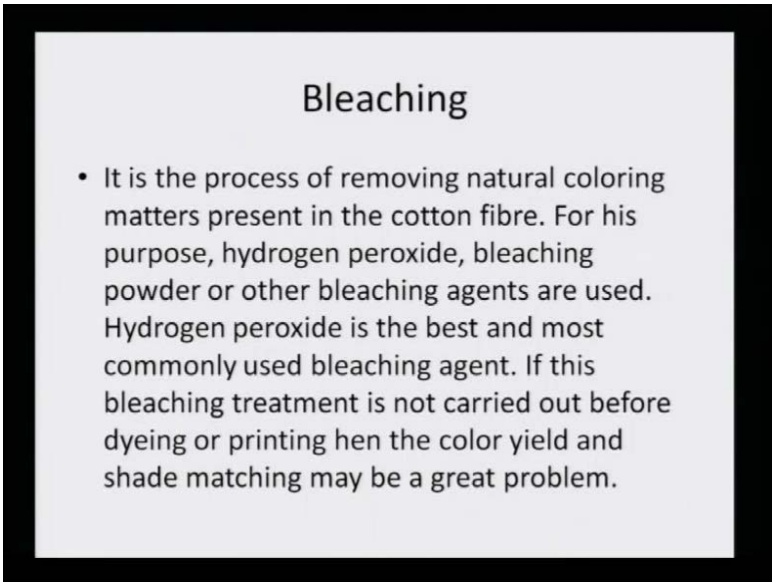

Then comes the bleaching; it is the process of removing natural coloring matters present in the cotton fiber; for his purpose, hydrogen peroxide, bleaching powder or other bleaching agents are used. Hydrogen peroxide is the best and most commonly used bleaching agent, because other bleaching powder and other chlorinated bleaching are banned now. If this bleaching treatment is not carried out before dying or printing, then the color yield and shade matching may be a great problem, because bleaching and making the fabric as white as possible, is a must, when one is doing the dyeing; and that is why I took this chapter of pre treatment. After I have taught you about the dyeing process, because then you will understand why this bleaches are important; why the

fabric should be absolutely color free color free so that it can take up color during the process of dyeing.

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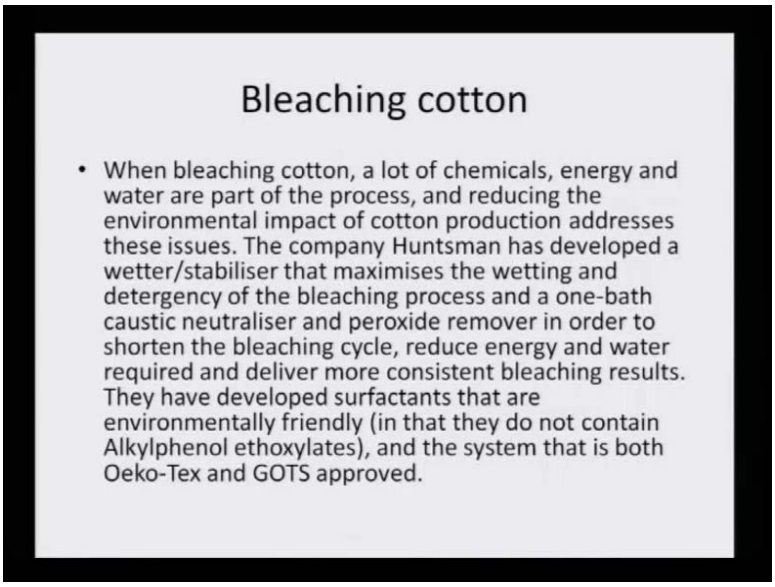

Bleaching cotton: While bleaching cotton a lot of chemicals, energy and water are part of the process, and reducing the environmental impact of cotton production addresses these issues. The company called Huntsman has developed a wetter/stabilizer that maximizes the wetting and detergency of the bleaching process in one-bath caustic neutralizer and peroxide remover in order to shorten the bleaching cycle, reduce energy and water required and deliver more consistent bleaching results. They have developed surfactants that are environmentally friendly, in that they do not contain alkylphenol ethoxylates and the system that is both Oeko-Tex and GOTS approved. So, these are certain processes which need to be to be understood, and new and new advancements are coming up.

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And finally, we come to the mercerizing, this is the process chemical treatment - pre treatment of cotton improves the property and performance of the cotton fabric; the cotton fabric is treated under tension with 20 percent caustic soda solution and this process is called mercerizing. Mercerization increases the fabric strength, increases absorbency power, fabric luster, fabric softness and handling property, and also dye consumption is good, when this is mercerized cotton, chemical consumption in dyeing is also reduced if mercerizing is done to the fabric. So, with this, we have come to an end of the chapter called pre treatments.