INDIAN INSTITUTE OF TECHNOLOGY DELHI

NPTEL

NPTEL PROGRAMME ON
TECHNOLOGY ENHANCED LEARNING

Video Course on
Advanced Textile Printing Technology

By
Prof. Kushal Sen
Department of Textile Technology
IIT Delhi

Lecture # 1
Conventional Printing

Alright, so we're meeting for the first class, and this subject is called the Advanced Textile Printing.

Now why we are calling it advanced is we believe that some printing we've already done and some new technology which are there or some topics which may not have been covered undergraduate level, so those are the kind of things that we'll be covering and therefore we calling it an advanced printing technology.

So the important thing will be some of the content which is been described in brief,
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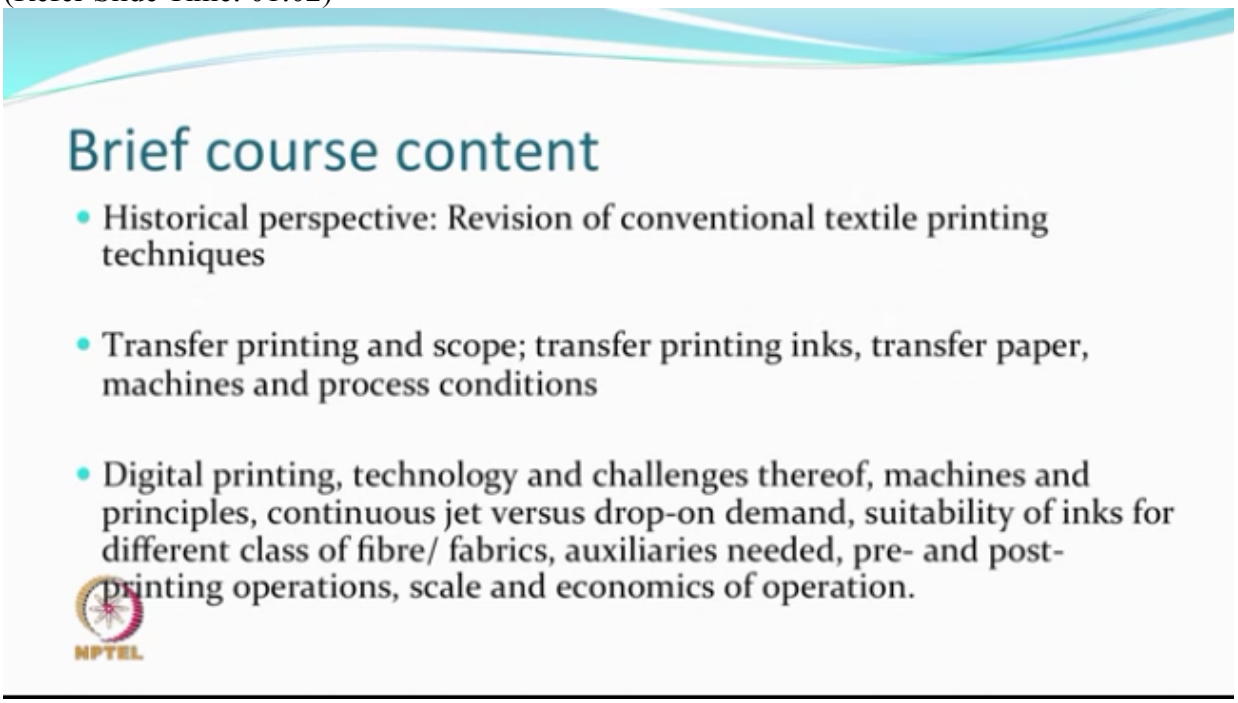

the detailed content of course is available, so from the historical perspective we will try to do revision of the textile printing techniques, and lay emphasis on little more, little more emphasis on some topics in various printing styles and methodologies.

And then we would of course have one topic it's quite believed that most of you may not have done the transfer printing which is not so popular, but it's getting more and more popular which would have its scope printing inks, the paper, the machine conditions some of those things which will cover.

And then the digital printing which is also becoming now popular is because of the cost that we find that most of the machines are not available as for the production is concerned, but people are getting into it and hopefully next decade would be a different decade, so there machines, the principles various types of jet systems, the drop-on demand stability of inks, different class of fibre or fabric, auxiliaries etcetera, pre post treatment of the operation and scale and economics this is what may be interesting as far as course is concerned.

So we start with the lecture one in the conventional printing, so obviously as we said that some of you have done textile chemistry undergraduates, some of you have not, and therefore those who have not done they will have to work harder in a different way to catch up, but there is a class, but we will spend some time revising, what you have done in the undergraduate and also some of the topics which you may not have, and then we'll discuss them as well.

So we revise what is printing, okay,
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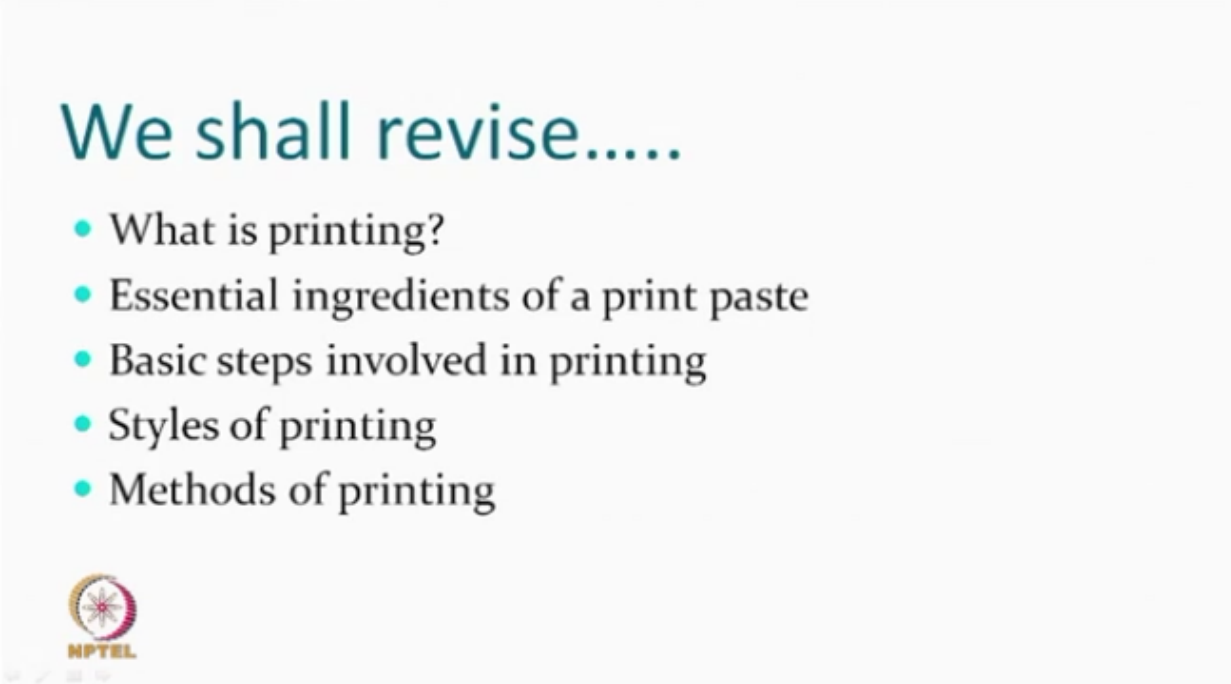

this is one important thing that we'd like to know what is printing. Essential ingredients in a printing paste, basic steps involved in printing, styles and methods, this is in terms of let's say the areas and which we will spend.

So before we take printing let us try to revise and you will help me what are the basic unit operations in chemical processing of textile, the whole gamete starting from the gray fabric to the finish fabrics, so what would be the first process? What did you say? Inspection, well, that's an inspection part of it, there is not really much of inspection, good, any other? Shearing and cropping which probably may have some similar operations of this type, and what do you do this process? Right,

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so we remove protruding fibres and this process is quite important from the point of your printing, because when you have lot of protruding fibres and you do a printing by any method, there is always chance those fibres will also get some paste, and when you lift a roller or a screen they may also jump, and when they jump then they will do something which you don't like. And so from printing point of view it's a very important process.

And what is the next process? Okay, so why do you desizing? Remove size, so this is a necessary evil that we do which is called sizing, this has nothing to do with the natural, it's a manmade problem which is then created but it was important for them to do that, and so various processes whether enzymatic or non-enzymatic processes are used to remove the material that you have added during the preparation or during viewing.

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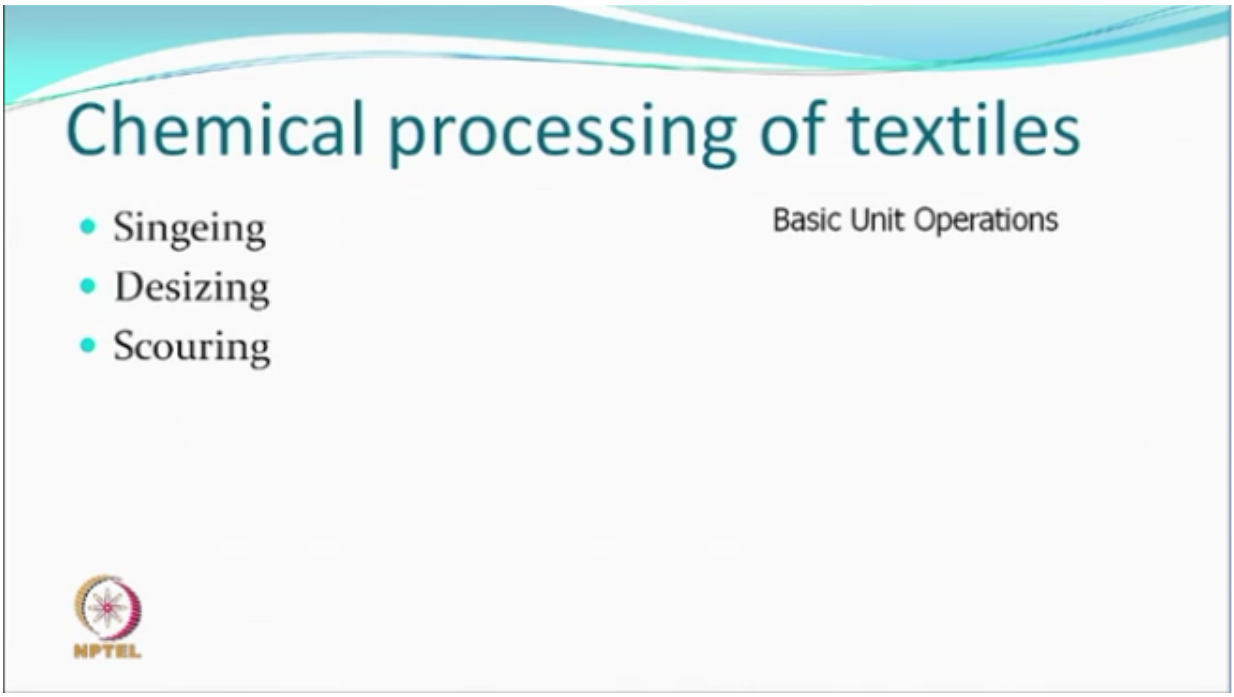

And then scouring, so this scouring is not for every fibre as such, but every fibre will have a different reason for scouring, cotton probably is one of the most important ones which requires lot of scouring, but why do you scouring? So you have various oil fatty materials and the thing and you like to remove so that the next processing becomes good and one of the reasons why you are looking at it is the vetability of the materials, so you want to increase the vetability because whatever chemicals that you want to add, we want these chemicals to diffuse into the fibre and then do proper reactions and proper bond making pond so that you get either dyeing or chemical finishing or whatever, this will be good if you do scouring.

How do you test whether scouring is good or not? Right, so you can drop, put a drop of water on the fabric or there are test which is sinking test and so on and so forth which can tell you as to scouring is good or not.

Next process could be? Right, so when you look at bleaching, again this bleaching is also different from different kind of fibre, I mean you are looking at cotton as a thing, but if you wool,
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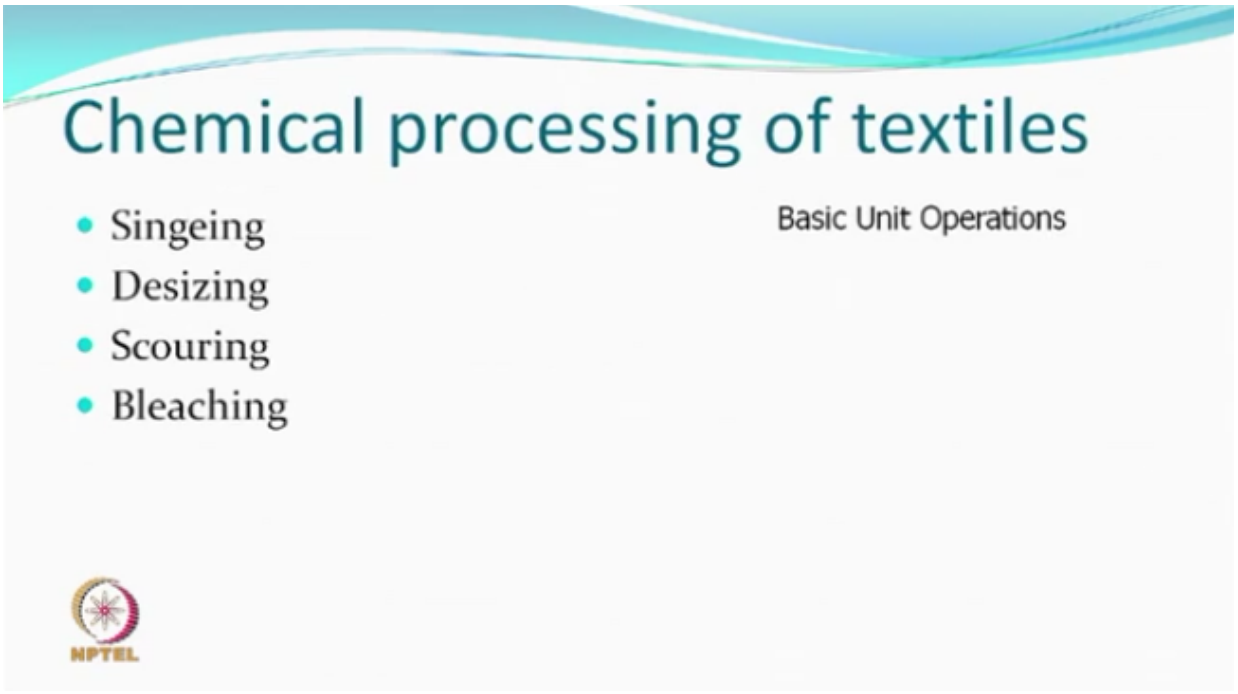

if you have silk you have polyester, if you have any other kind of material so you will be looking at different kind of bleaching agents.

Most important bleaching agent is? Alright, so this is called the hydrogen peroxide, so oxidative bleaching agents are there which you will use depending upon which fibre that you have.

Next, alright, so if you look at mercerization this is also very, very specific to only cotton, if you have other fibres,

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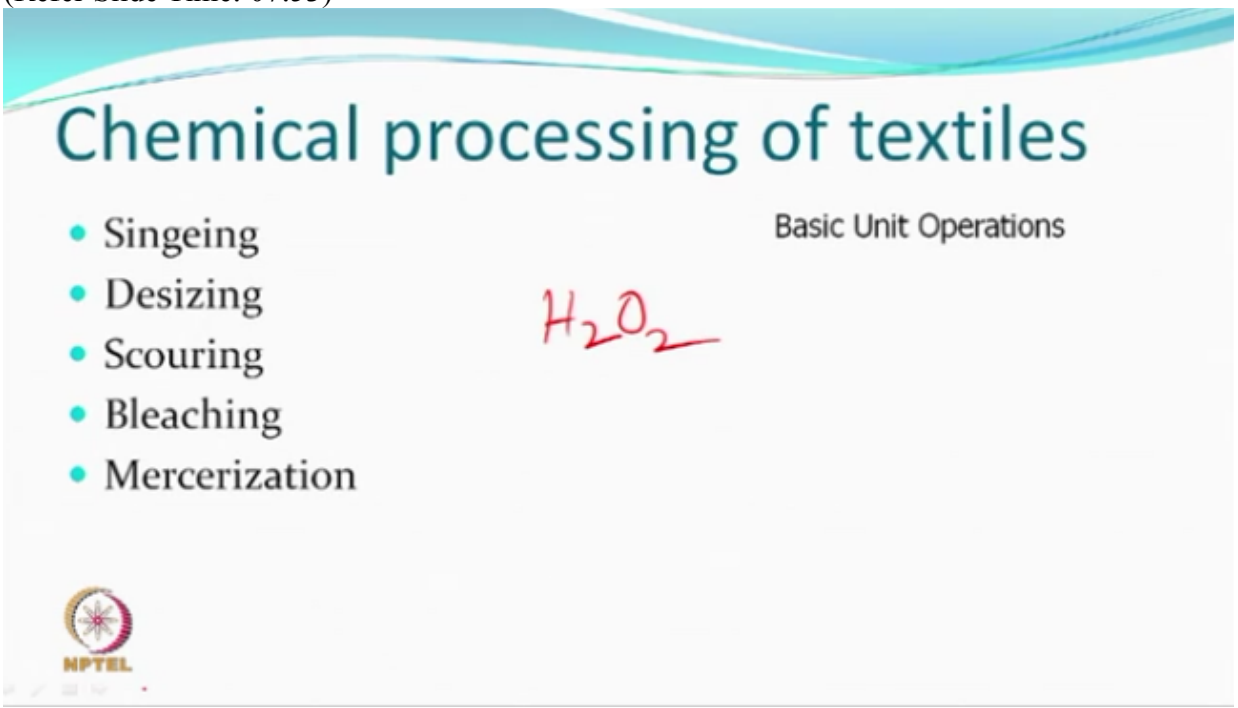

let's say viscous, do you do anything? You don't do anything of course not mercerization but there is a process called causticization, right, so which also is important for diffusion of chemicals into the fibre, and so but mercerization is specific to only cotton.

Can you mercerize wool? Why not? So it will just get destroyed, dissolved in the alkali, even mild alkali you can dissolve, this is too strong in alkali for wool, silk, and therefore this process is very specific, so when we talk about interpretation, so every fibre will have different unit operation, right, it's not that one single thing is going to work for everyone.

And then of course dyeing which is most interesting unit operation which adds lot of value,
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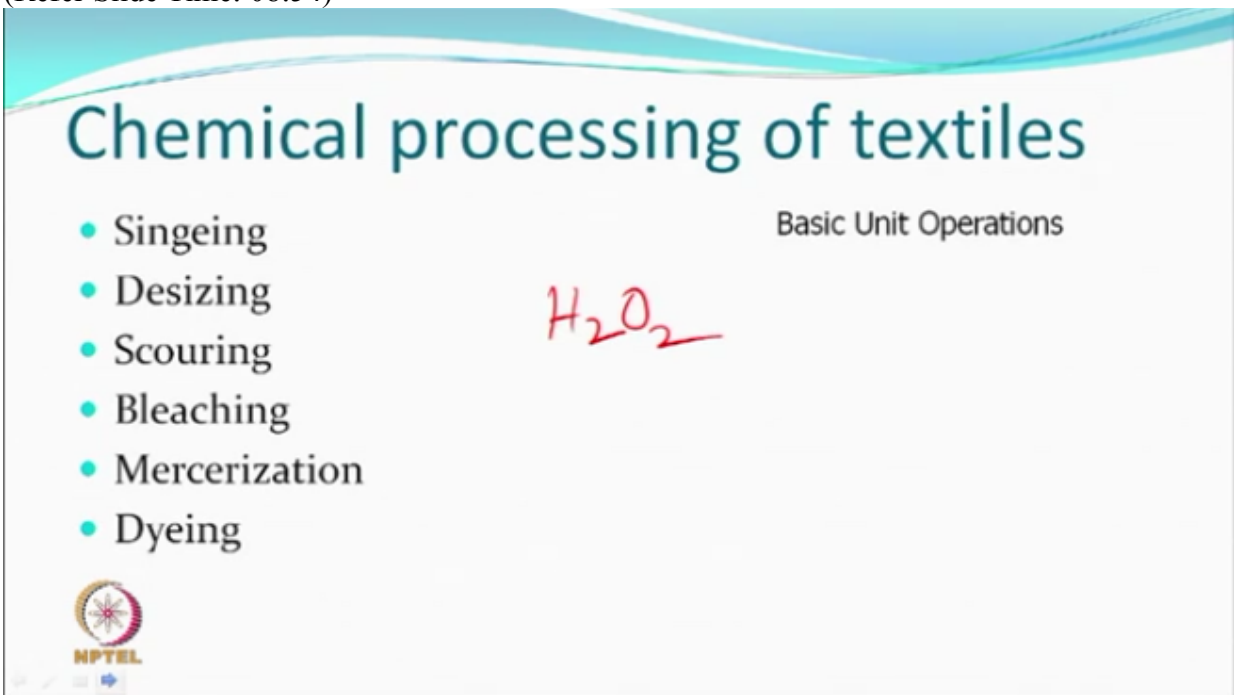

now most of the people who were sitting here or you meet them, there is only few who were only white, right, so they get identified, but large number of people would be wearing some coloured clothes, so the dyeing becomes an important part and so all things related to the chemistry of the fibre, the chemistry of the dye where interaction becomes important, and so we would like you to remember, we will be doing some course in this.

And then we come to our topic which is called printing, alright, one of the most important unit operations because it adds lot of value,
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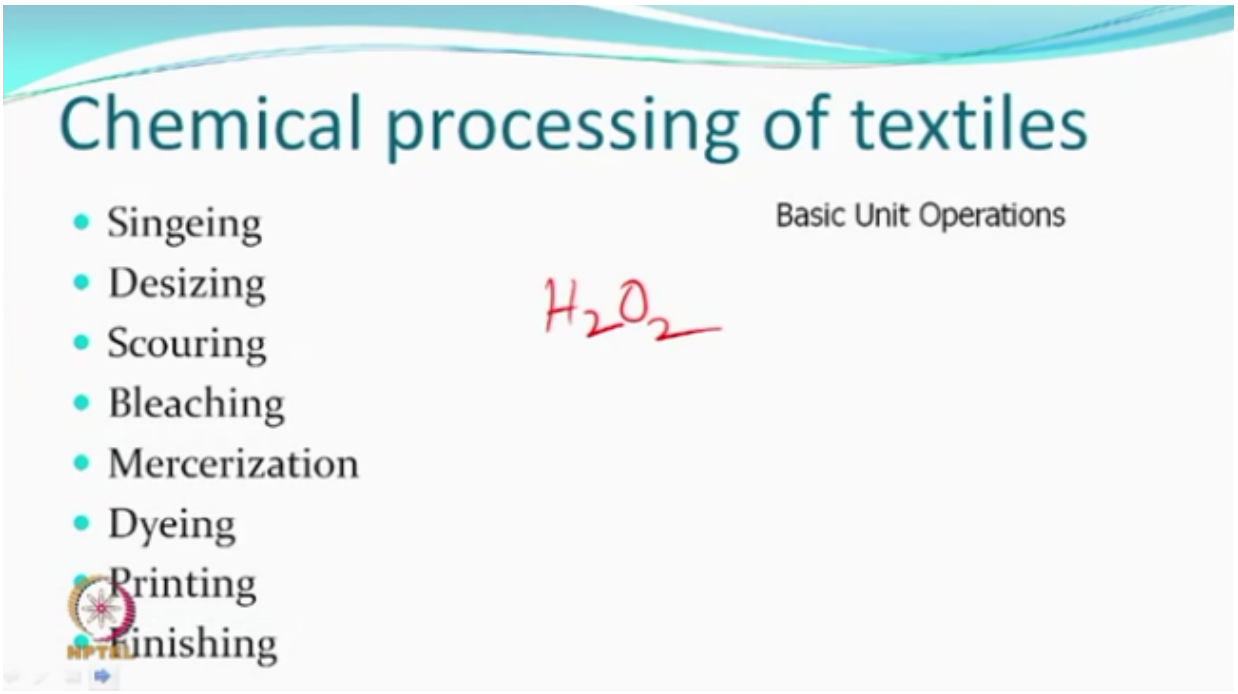

and finally a finishing which is also a general term, different fibres, different finishes and itself is a big area in which various types of functional properties can be imparted in onto the textiles, so let's say we are going to be concentrating on printing, this is what the thing is, and that the moment we're looking at conventional printing, so value addition as we said that unless and until you see colour, the customer would not like to touch anything, you go to a shop when you start looking at it, you look at the colours and you get impressed by them, and then the one who has made it ask for money, so the value addition happens quite a lot when you do printing and depending upon what kind of print which is a personalize print, then obviously the value is very high only for you, and if it's a mass produce print then obviously the cost is less and therefore the value also is less.

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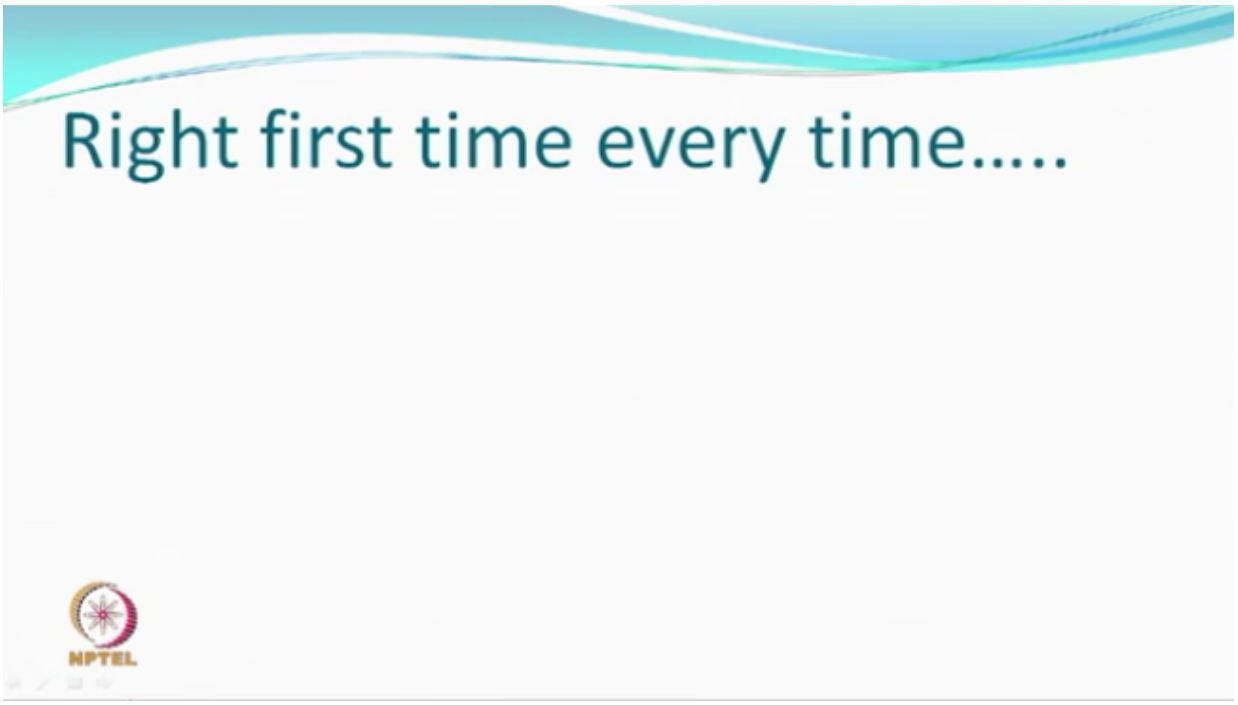

Therefore one is looking at printing as an operation, coming to all the unit operation that you saw, this has to be right first time, there is nothing you can say well doesn't matter, we'll try to repair, when you do something in the wrong in the dyeing that is say the depth of shade that you wanted is less, so you can top it up, it cost but you don't have so much of a wastage you can top it up.

If you find the depth of shade is little high, you have a stripping mechanism, so you can strip it up, if you find the errors are too many then you can say well I'll do another dyeing with deep shades, dark, black, blues, reds, and suddenly you will find well the value can still be recovered, you can't do in printing, if you've done something wrong there is no way you can correct it, you can't take a brush and start doing something, right, this is therefore a difficult, printing is a difficult unit operation, it's not easy.

Finishing, first of all people can't even find if there is a fault, let's say you are doing wash and wear finish, and how can anybody find whether wash and wear finish is very up to the mark or there is a variation or there is something else, we just go, the complaint will come after one month by that time the thing is gone, but not that complaint should come, but right first time, every time is printing, any textile operation starting from making of a fibre to the making of a yawn, the variations are there and people except some variations, this is okay, but if you do something wrong is okay is going the seconds, is going the thirds, if you make this mistake here the chances are there will be nobody to pick up the thing and that's a real loss, there is no correction that you can do.

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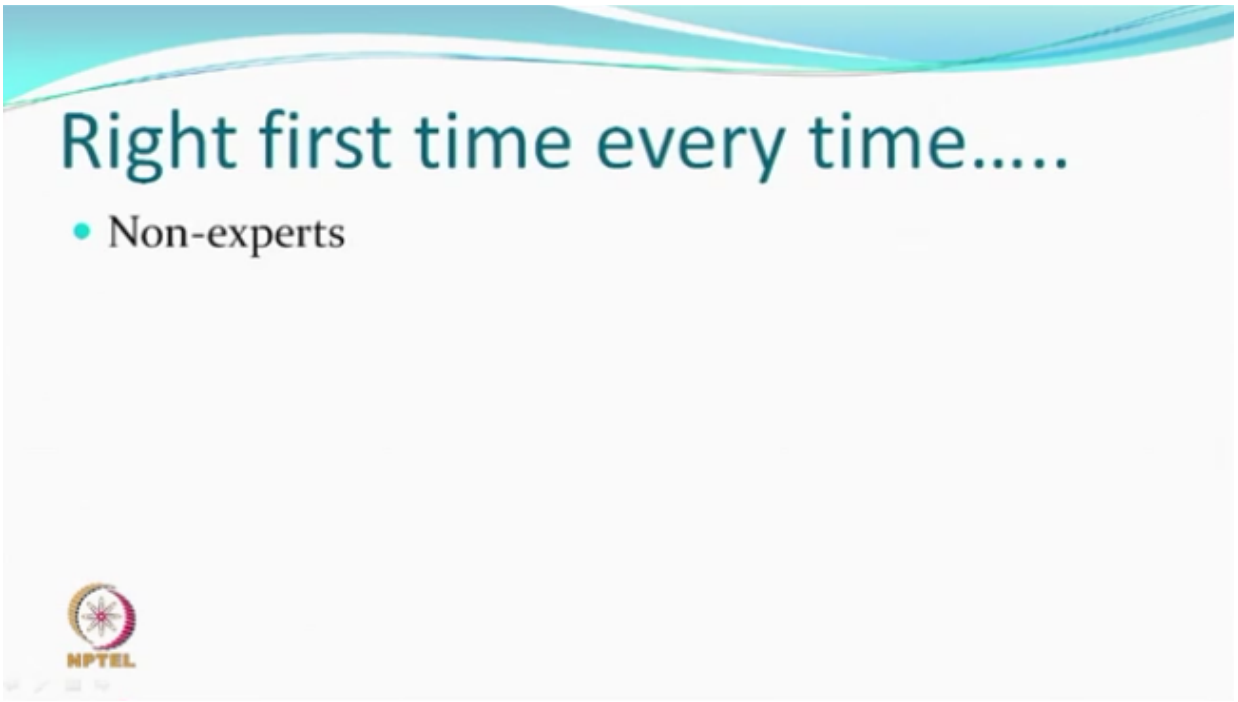

And this is difficulty, if non-experts can find your fault then you can select, in many other things which are let's say finishing which adds lot of value, non-experts can't tell you what is the fault, here they can tell because there is a design which looks like design, there are many colours there and so if one colour goes out of its boundary people will know it's come out of the boundary because he did not set it properly, could not print it properly and that's it, and you can't correct it, so you loss the value just like that.

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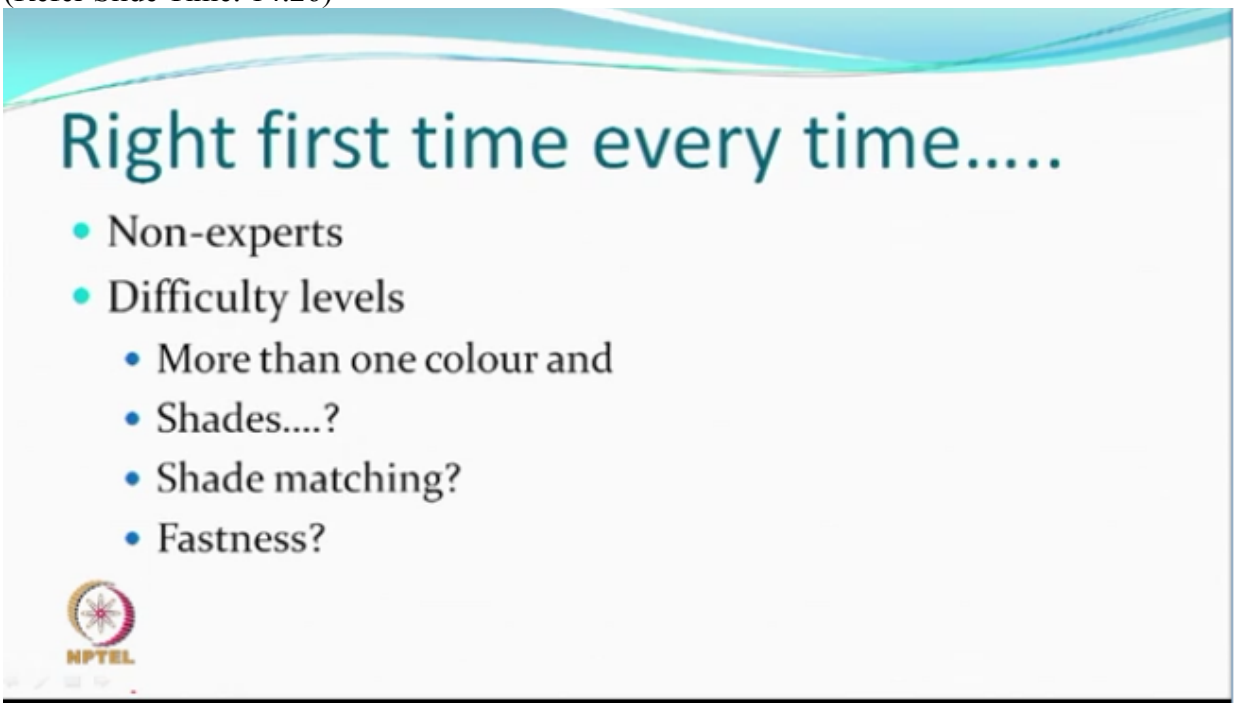

So the difficulty levels are others also, in dyeing for that matter, dyeing is also something where people can find some fault but not like printing, I just said we can correct it also, in this case you actually use more than one colour, so when you say there I'm printing, so you're not talking about one colour or one shade, so there are more than one shade, same green but different coupons, and so getting to many things in different areas of the fabric and hoping everything will be fine, when you say I want to match the shade, how do you match the shade? You will get the result only after a complete the filtering process, till the time you have not completed the printing process there are many ingredients around they themselves play various role in showing you what colour you are seeing, it becomes very difficult, the shade matching let's say computerized colour matching systems are very nicely, beautifully used for dyed material.

For printing material even if you get a shade well this part of the green is to be like this, that part of the green must be that, red must be this and the blue must be that, and all of them must match, it's a very, very tough thing, and therefore those who actually handle the printing department are really big names, they're really good experience, they understand when the fabric is running at 50 meters per minute and they can find a fault and they stop the machine, something has to be done, so it's a very serious business as I said non-experts can tell you, you are wrong.

And fastness, which fastness have we talking about? Every time we talk about a shade, this shade has been made by mixture of dyes, not one single component, and when you mix you can make errors there, when you choose the mix this time you had one type of dyed, a green the other type, another type of green, they are supposed to be similar but they are not same, okay, so you made them but even if you have mash the shade in your own, from your own perspective then what you do? You will ask them to wash, wash fastness, all the dyes can give you the shade when they may not have the same wash fastness, so when you have a dyed material or of maybe from a single component dyed material, when you wash something goes out the shade may keep decreasing, depth of shade may go down, but you may still be able to survive because most of the time will not remember what was original shade, lab of course will know.

In this case something which appear to be particular type of a blue is now different type of blue, because one of the components gone more other still there, the mix is changing, similarly when you look at the light fastness one maybe fading faster than the other, so what you see is a change of tone happening, a change of tone is much easily identifiable compared to the loss of depth, and so it becomes much more difficult, the selection which dye has to be selected, how it has to be applied, so you are looking at the fastness first, you're looking at the light fastness first, you're looking at the shade first, then you want to match the shade, and then you also find if you make a mistake somebody will find out, it's very difficult, so you must appreciate any product which is a printed product and actually you are liking it, then somebody has worked very hard, so as a engineer we should appreciate almost every product, but I'm not telling you a printed product is definitely something which you should be proud of and should appreciate and thank the guy, it's quite possible, the people who had the printing department maybe actually getting higher salary, at least in private sector compared to the finishing guys or the bank guys, simply, because if they had make mistake company losses straight, so they have to be right and so you right kind of people that of course experience is the one which helps.

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Now let's say what about somebody said is printing? Of course we understand a different points something is happening, they call it sometimes localize dyeing, printing itself is there, term which we are trying to understand you say now it is like dyeing, what is the special thing about dyeing? How a fibre gets dyed? How does it get dyed? That's the most important thing, dissolution,

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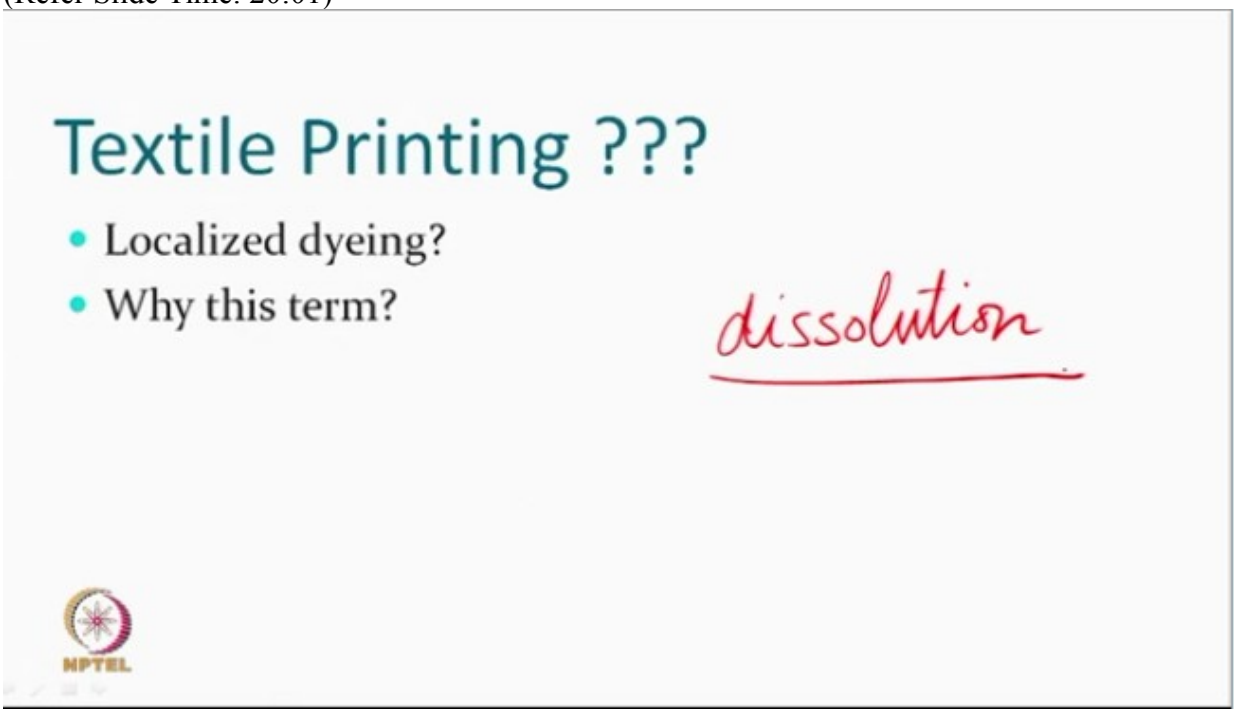

so important thing is dyeing is a process where a dye particle must get dissolve, get into a molecular form so that through whichever medium could be aqueous medium goes into, so you can't dye the solids, particle cannot go in, the size of a particle is too large compared to the space that maybe available for diffusion, but if you get in to the dissolution part of it you can dissolve it any solvent, let's say water then it comes in a molecular level, and then it goes, so in printing also something like dyeing must happen, otherwise printing as you know happens from a paste, paste has a very high viscosity, and based on the kind of a dye it the concentrations maybe different, but it still must act like a dye unless of course we are dealing with pigments, the pigments you know don't go inside just stay out, we have to use something else to fix them up.

But when you say dyeing that means this product the material has dissolved, and in a molecular way it has gone inside the fibre, that's one interesting thing therefore the dyeing, right, otherwise it could just kept it printing, yes the process is printing, but what is happening is dyeing, and therefore the chemistry of fibre becomes important, the nature of dye becomes important, the fibre and dye interaction becomes important, so everything is important, so whatever you are doing in dyeing you have to do it anyway, right, you will choose the dye based on the fibre, something else of course can also be done,
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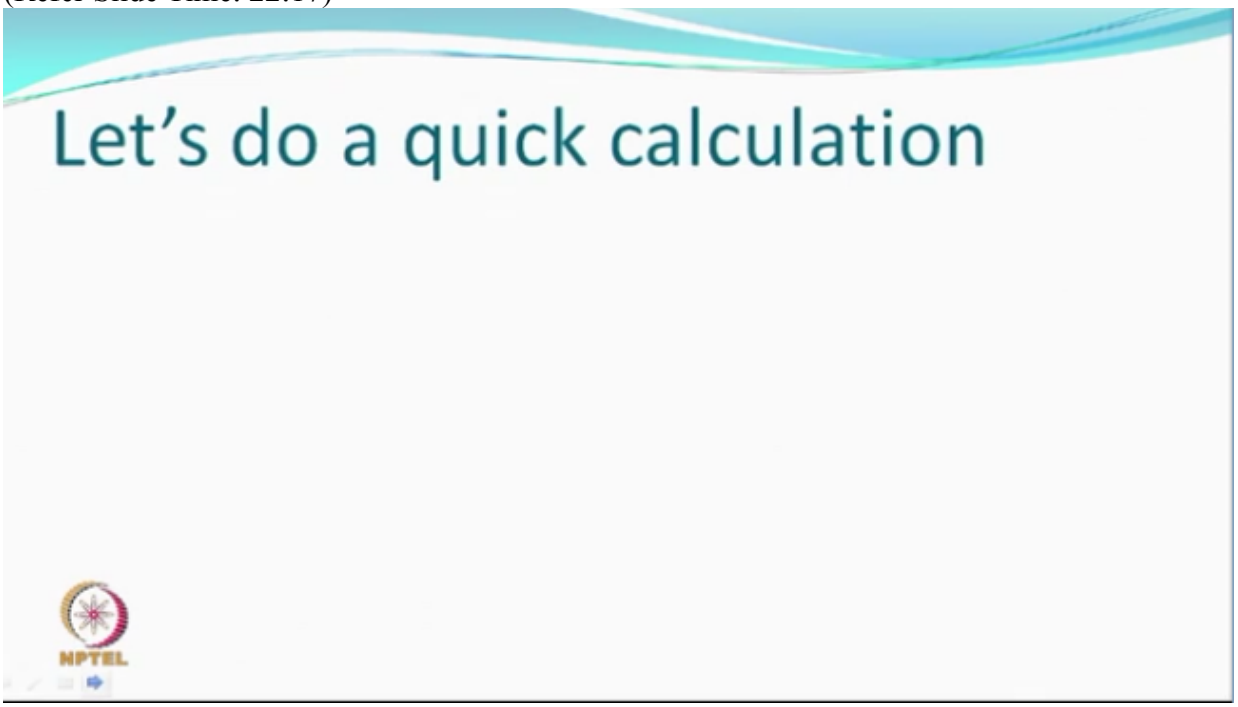

so let me just say because we are still in this topic, on this topic, a small calculation, this is not to check your mathematics,
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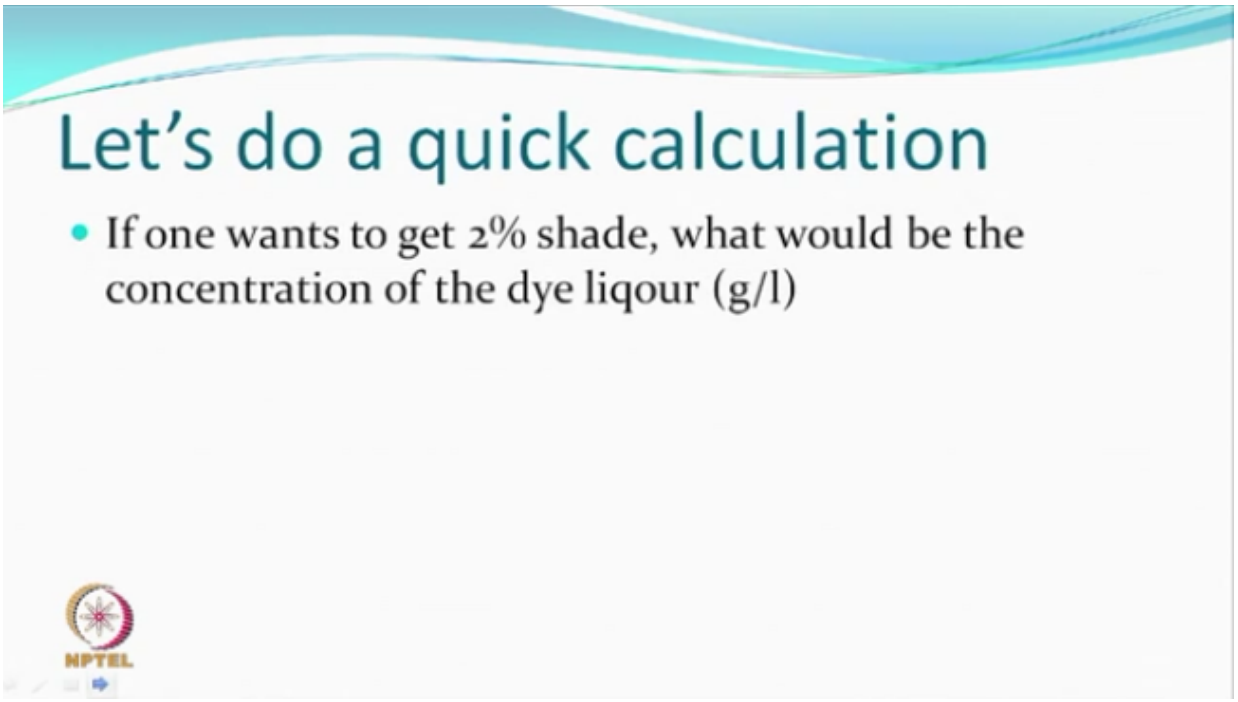

can you just tell me if I want to dye a fabric at 2% shade, you understand what's the 2% shade? 2 grams per 100 gram of fibre, that's the kind of thing at 2% shade, so you dyed from the dye liquor, you know we express it let's say the concentration grams per liter, so let me see.

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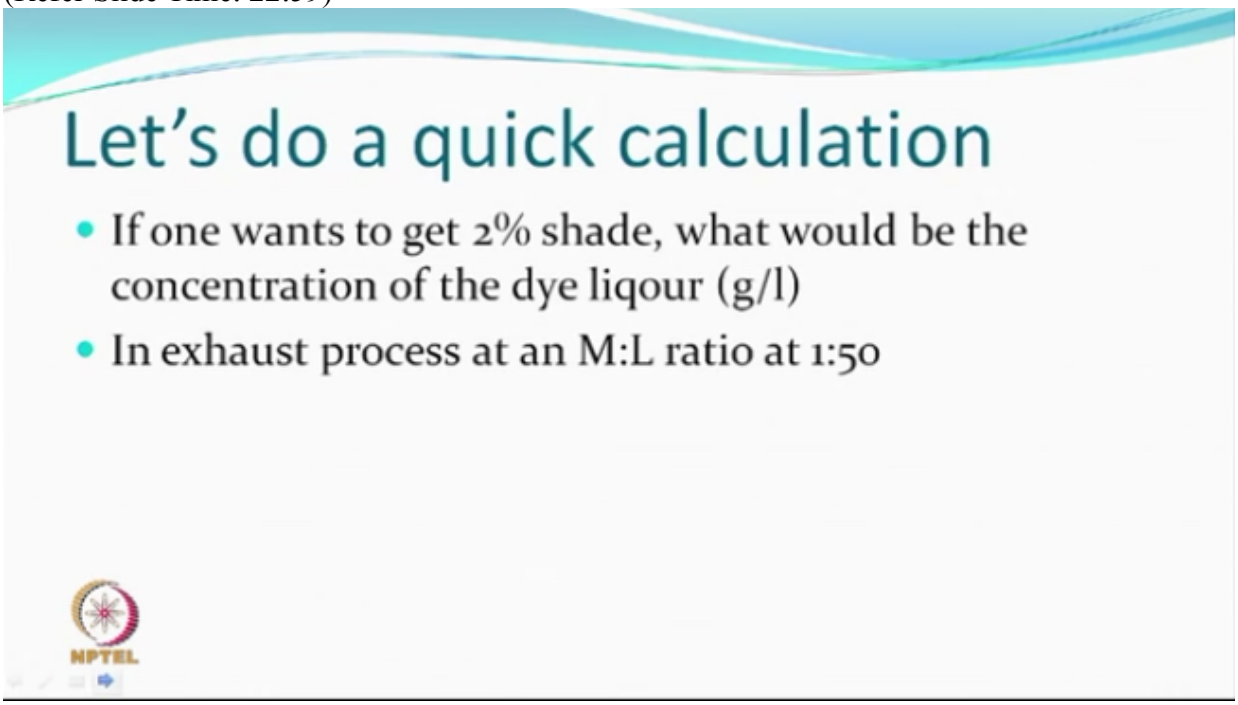

In an exhaust process okay, you understand what is an exhaust process? Everybody understands, so an exhaust process is where you take the fibre and the liquor and keep working on it till you believe dye has gone from solution to the fibre, the bath has exhausted, and when you stop the dyeing and get out of it, so what will be the concentration of a dye liquor in an

exhaust process when you want 2% shade at an ML ratio of 1:50, can you calculate? We're looking at the concentration of a dye bath, simple calculation whether like the value, what do you think is a value? Should not be difficult, so we are looking at finding the concentration of a dye liquor when we want 2% shade at an ML ratio of 1:50, very difficult, give me some figure, let's see if the figure is right or wrong, no problem, so you are taking too much time, anyone has come up? Difficult, because if you don't know this then you can dye it anyway, so you have to know how much dye has to be added in the solution so that you get a particular result, things can still go wrong, but at least the start must be right, anybody? You got some value? 0.4 grams per liter, right, so 0.4 grams per liter is the concentration.

Let's say in the other process which is called a pad process, so what you do in a pad process?
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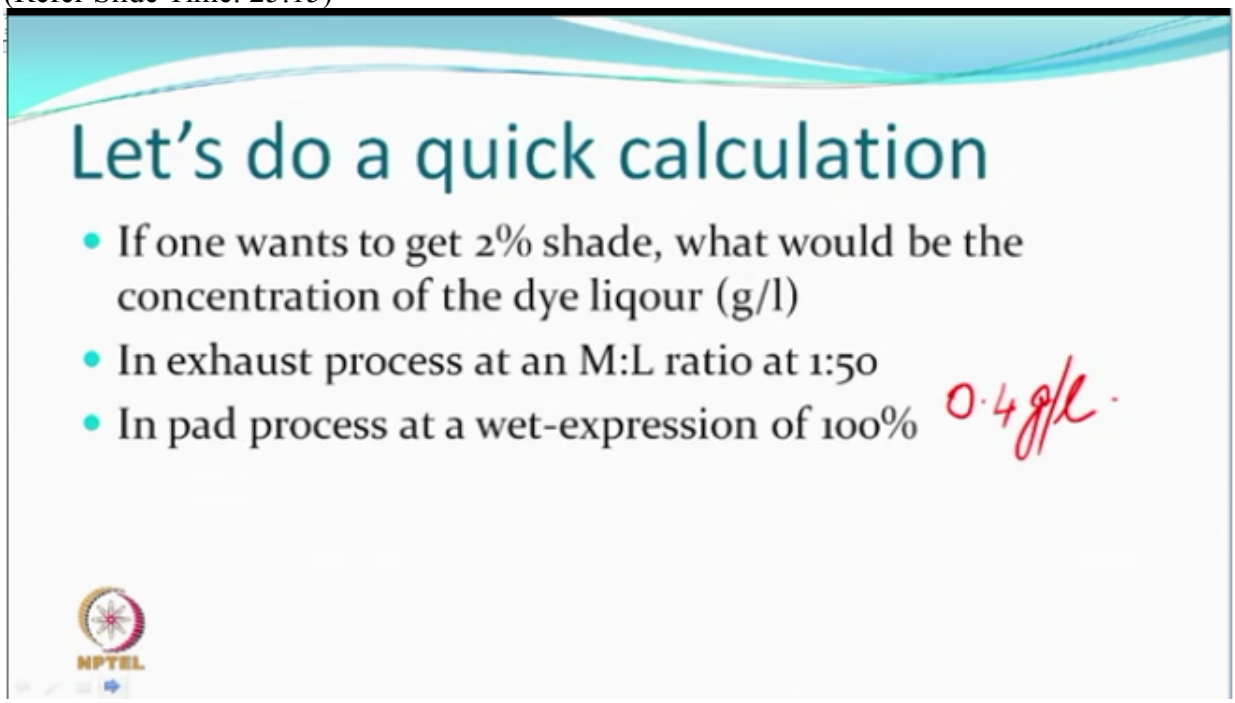

You have a dip and a nip padding mangle, you see in that padding mangle, so in a pad process what will be the concentration of the dye liquor if I want the same thing at 100% expression, so we want the result the same at 2% and we are looking at the padding method approximately we are believing that the expression is also 100%, so some constraints are I mean the sub constants are with you, so let's see some value, let's see who comes first? I do understand the terms you know, when you say 100% expression means what? What do you mean by 100% expression? If you know the meaning only then you can say all know, do you know the meaning? Who knows the meaning of a 100% weight expression? Right or solution, so you take 100 gram fabric after padding it will become 200 grams, right, that's what is 100% expression.

So what would be the concentration of the liquor when we really want only 2% shade? It shouldn't be that difficult, 20 gram per liter, so this will be 20 grams per liter, did you ever think that this kind of a concentration differences will be there, what is the order? You can see that order, so much of a difference in concentration.

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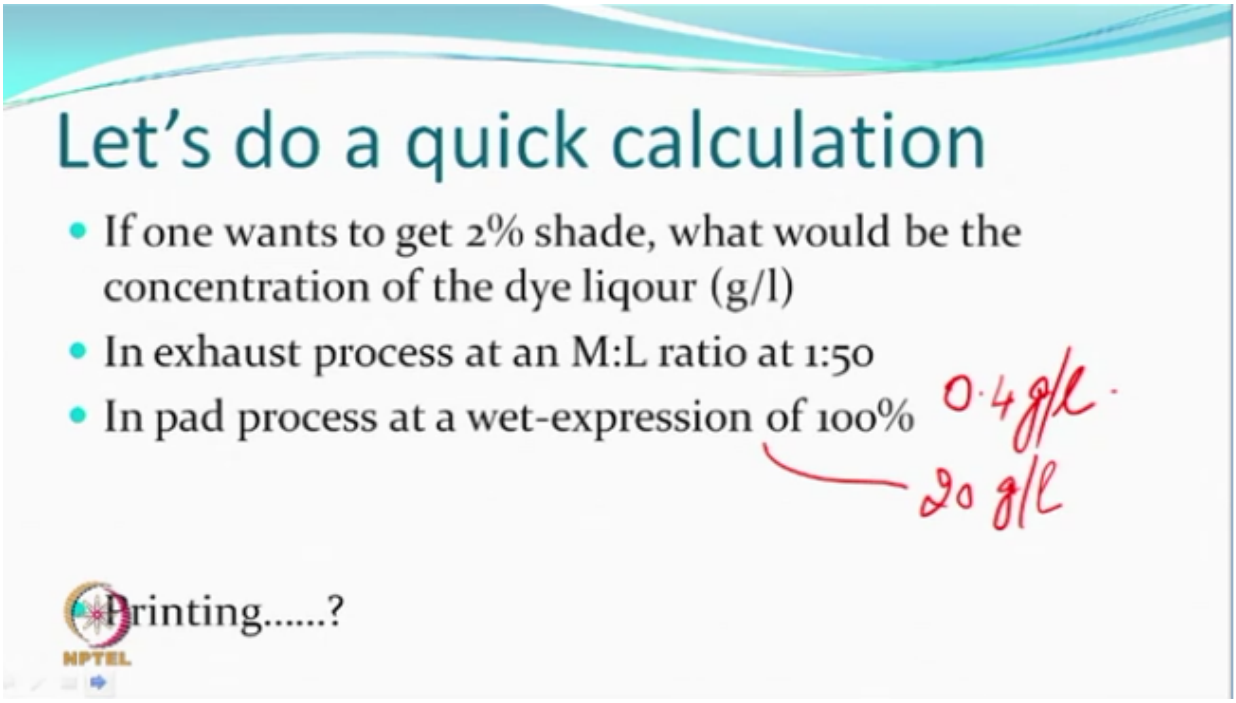

In printing if you want to calculate, in that such a small area there is hardly any water because after printing or dried, and then what are you doing? You are going somewhere to fix it and what fixing? Maybe it's a steam, and which you are fixing? Maybe it's dry heat, and what are you dependent on? You're dependent on something called urea or any other material which absorbs water from the environment, not from solution, so what concentrations will be thinking off? An order or more higher, the concentration of so called dye liquor, and a so called localized dyeing here, the concentration is very high, it has advantage, advantage is when you have high concentration, the difference in concentrations is high then the chances of transfer is also quick, when you have equilibrium nothing shifts you know, this one goes in that the other one comes out, so the remain equal, but if the potential difference is very high, the concentration difference then the rate of diffusion is also high, so we expect all these things to happen very quickly also, the diffusion, and so highly concentrated solutions they get generated only when they're supposed to diffuse, otherwise they are dry, right, so in that sense printing is a different one.

So all calculation that you'd like to make, what shade, what not, it will depend on whatever done, and how do you calculate? How do you calculate? In a case of dyeing you had the whole fibre which will dye it and what is here? Do we dye, do we print?
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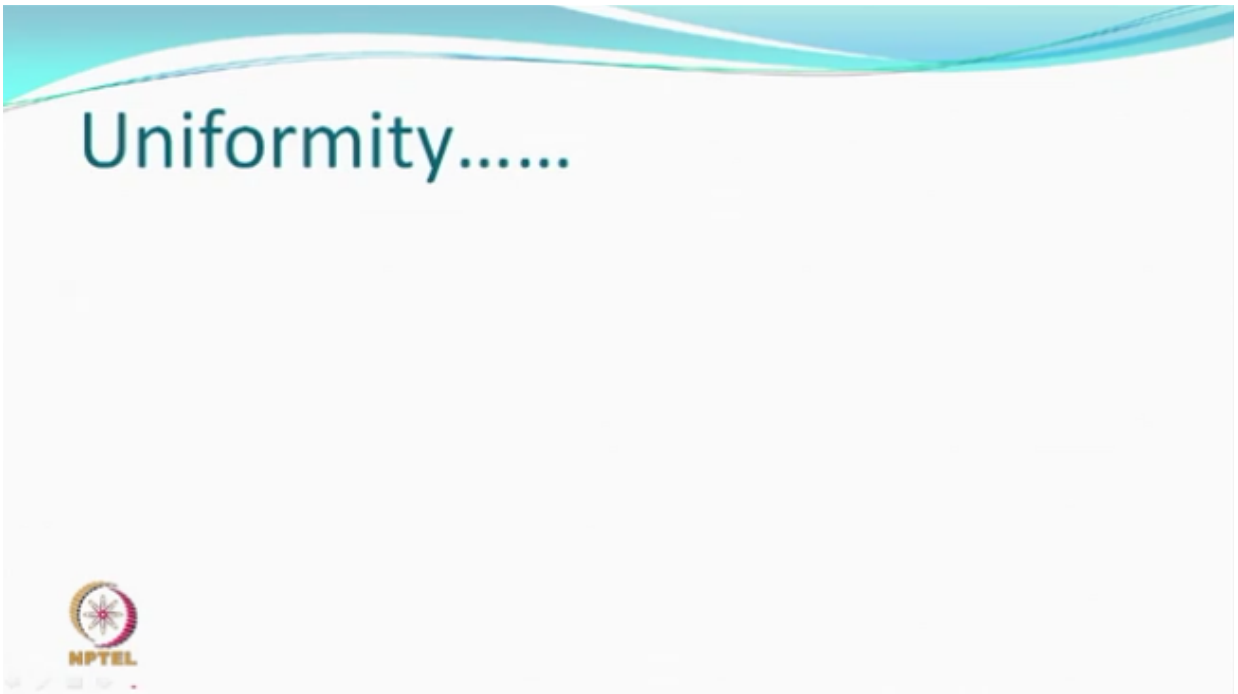

Or in a localized dyeing system do we do it uniformly? Do we do it uniformly? So what is the meaning by uniformity? Uniformity of what,

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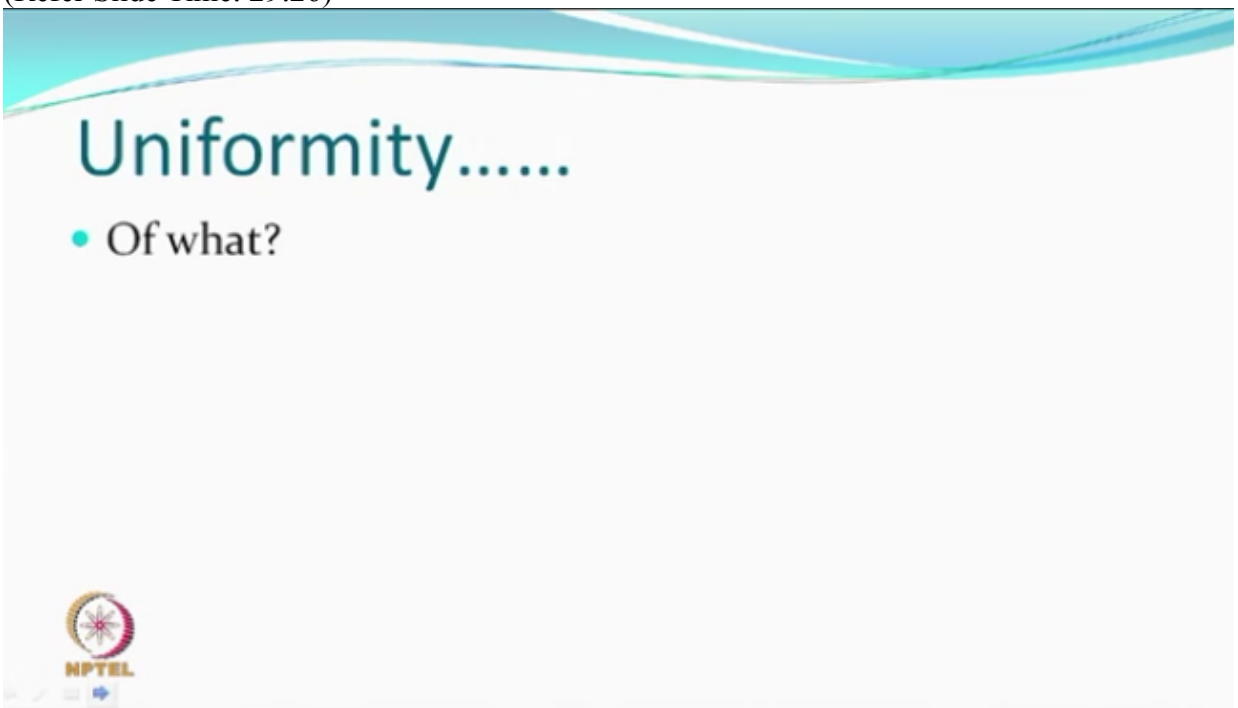

that's the question, of what means? There is a green here, then there is another green here, there is another green, this is repeated, all that flower pattern is repeated, so you expect this green to be equal to that green to be equal to that green is fine, that's fine, I mean at least nobody should say well I thought this was just green and now some other green is coming after every meter, that uniformity will expect that's a technological part, hopefully the machines will be able to do that after proper setting.

If you look at the printed fabric, take the fabric,
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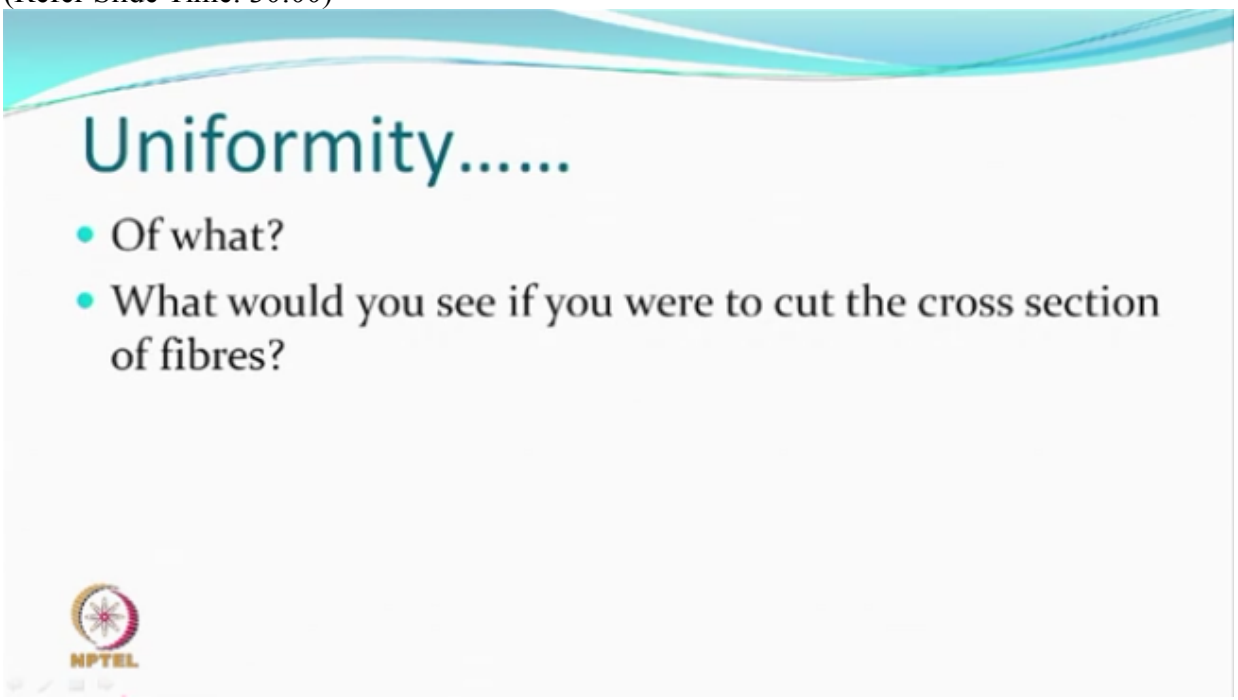

take the cross-section or the fibre and take the cross-section, do you think the fabric or the fibre across the cross-section has been coloured uniformly? Yes or no? No, so it is not coloured properly, that means it may happen at rate at 50%, it may happen at rate at 75%, it may happen at rate at 25% in the diameter part of it, then how do you calculate the shade? It is what you see, but what you see from the same recipe could become different if you change the time or steaming, and suddenly oh everything was same, shade is not matching because something else change, equilibrium is not reached, equilibrium can be reached only if the same print is seen on the other side.

The face and the back of fabric, do you think any printed fabrics face and the back are same?
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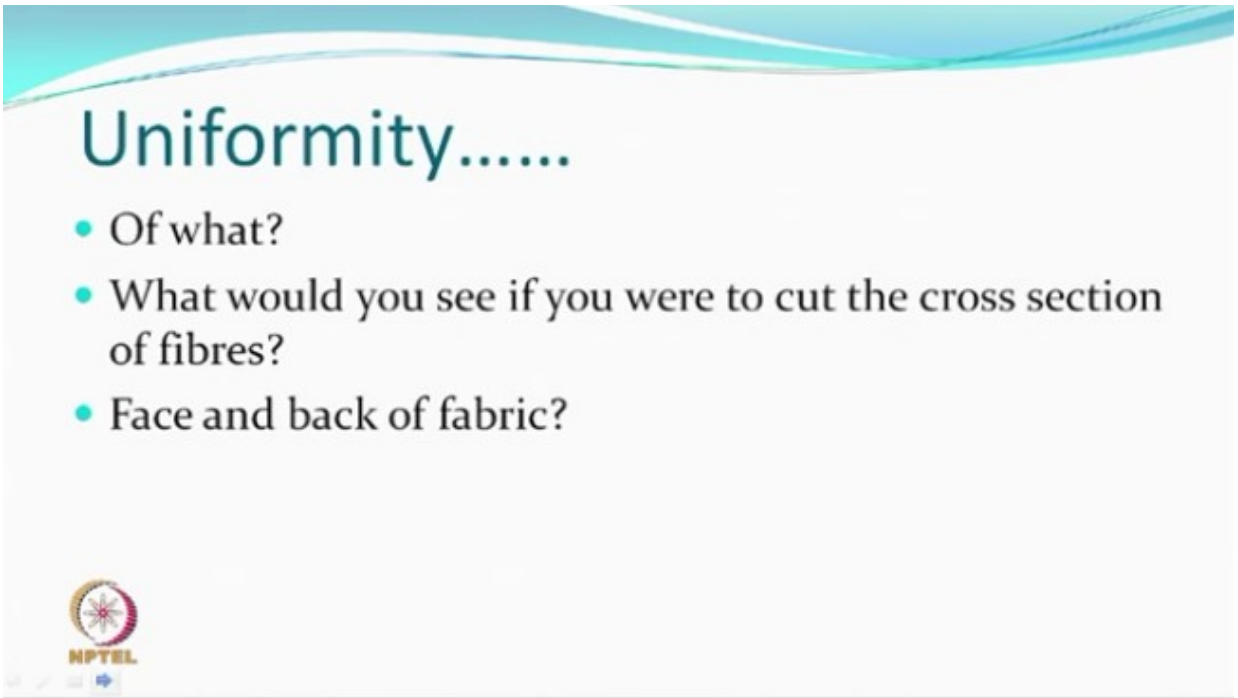

They're not, so even defining that this is percentage shade is a question, how do we define? You don't even know the weight of fabric, you can measure it, but you don't know how much it is penetrated, if it's penetrate 50% shade will be different, if it penetrates 100% shade will be different, although you had applied the same, that's the difficulty, so you keep lot of things which are not in your control, but you want to control and you must control, and that's becomes the difficulty level of the printing, so it's not a easy process, it's definitely not a easy process.

And so when somebody says well I have done some print in my lab after washing, I'm not sure you would ever like to wear that in the first go, and what's the question is uniformity? At least from the face to back uniformity is not needed,
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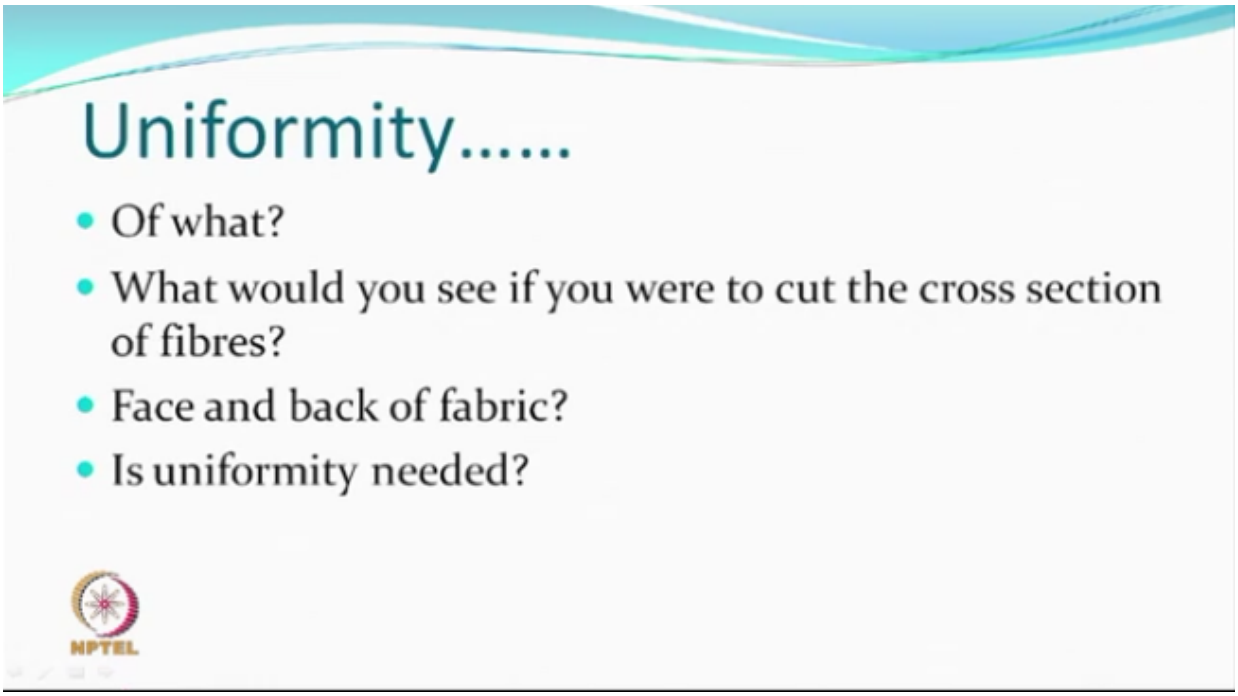

you don't want to print the back of the fabric in any manner, it would never look good and so you don't, but you have understood the difficulty also.

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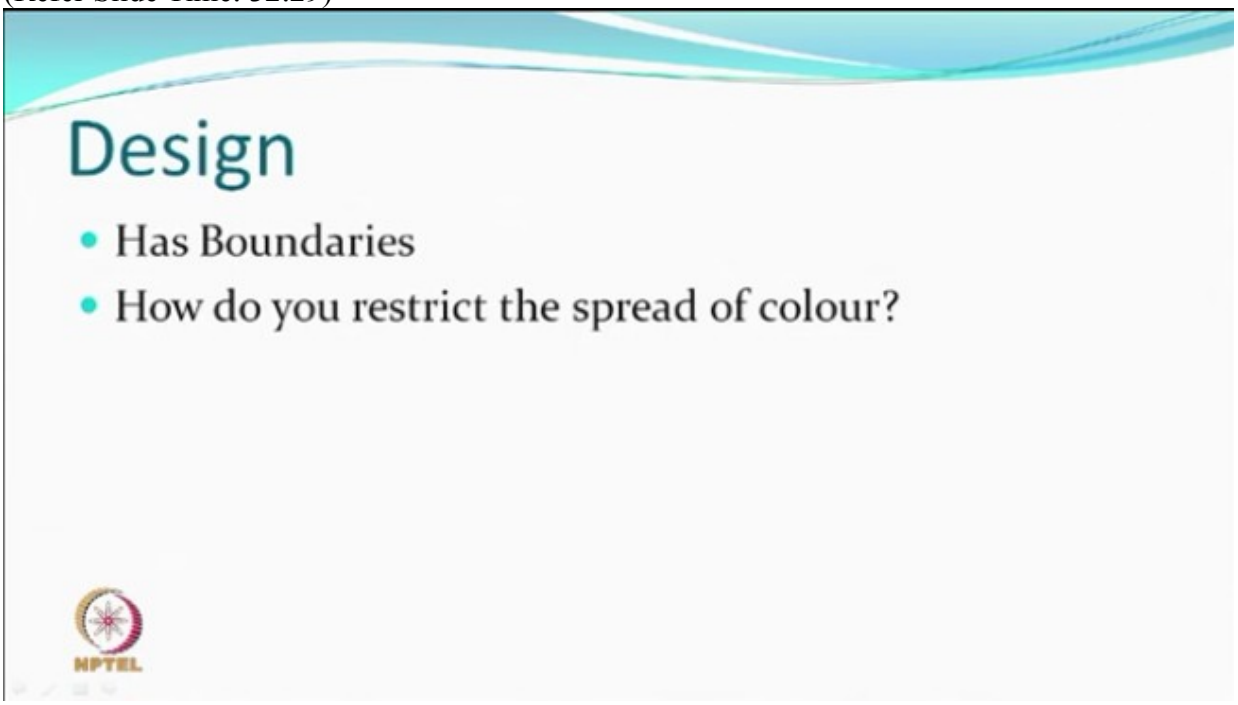

Then we say localized dyeing means you have to have boundaries, so you have to make sure that particular colour is only in that boundary, it does not go beyond, what have we done? We have done is covering, we have made more vat material vetting properties have been increased so that things can go, so radically we do not expect when you put a drop of water it goes only across the fabric, it goes around the fabric also, it goes in all directions, how do you restrict

that? So you say well, we'll be using highly viscous material called a paste, so as long as very highly viscous, it will remain there, then you dry it, it will remain there, only when you are just about to say, well it must diffuse, give certain amount of moisture, little bit of a dilution and then it diffuses, so you're hoping that it concentrated, it's a very small amount and very less amount of water, that means high concentration, therefore you do you know control the spread, it's important.

If everything is right the person who had printed very nicely, everything was on the right place, but whenever you're getting fixed something started diffusing, yellow going into the blue, so you have another boundary of a different colour which you never wanted, so somebody will find out, so now finds it out and now it's a different story,
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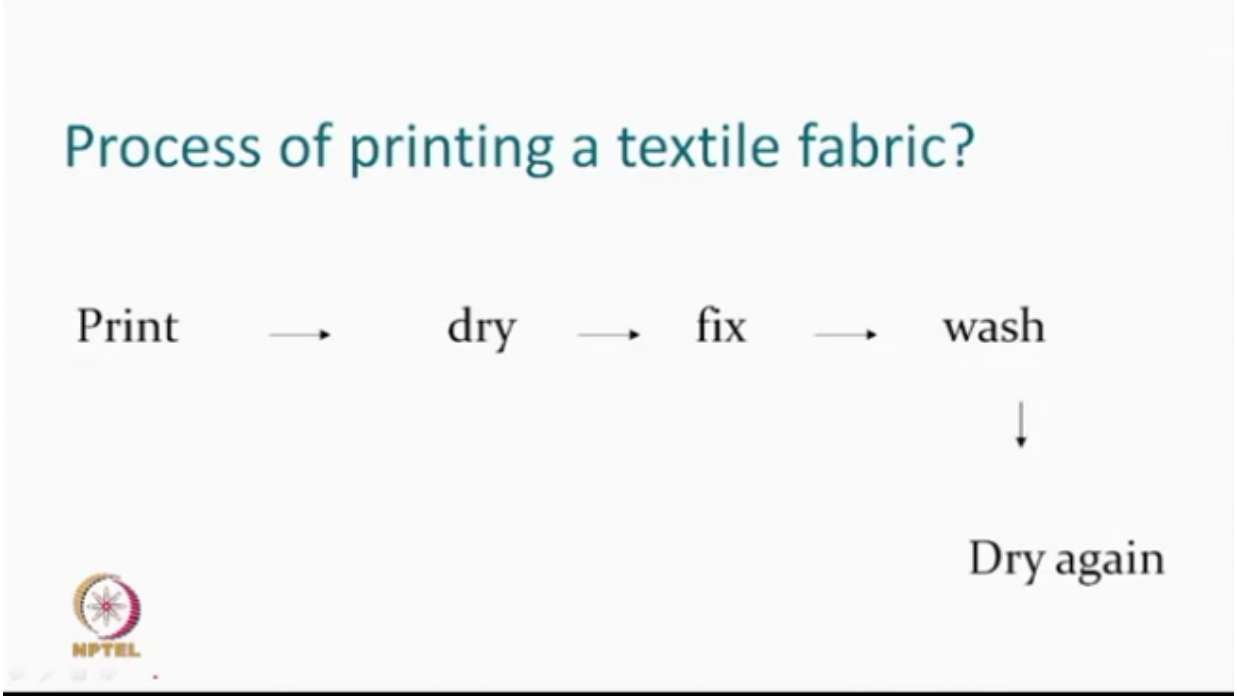

but the person who do the job is very unhappy that after all the hard work what you get is wrong design, so in this printing process of course you had to print and then you have to dry and fix, this is the most important step, all of them are very important steps you know, you make a mistake anywhere it's all over, drying of course it may have some levy that you just drying removing the moisture, but you can during drying and handling if there is a crack, the crack appears because you have a film of a thickening agent which has been dried then the moisture penetration through the tack will be different and you might see after print you actually have permanent mark which may not get fixed properly.

So your fixation which is important, you can do dry, steam, so these days your steam also is atmospheric steam or super-heated steam, so high temperature steam,
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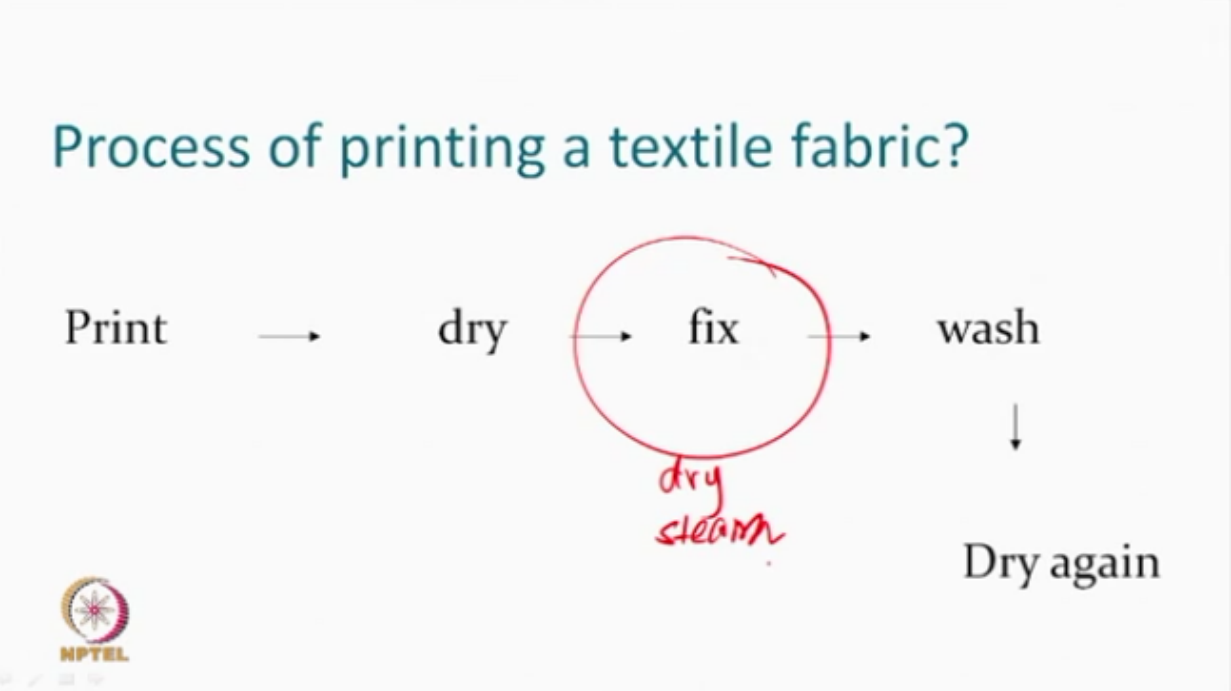

any of them can be used depending on which fibre, which dye combination you want, and then you wash, obviously you have to wash because you have added so many other things which will see, which were not part of your plan, you wanted only dye, but you have lot of things wash and then dry.

So drying, fixing, like any other chemical processing, unit operation, lot of energy is consumed, but that's it no problem we have to consume energy unless that happens, it becomes a problem, so this is the basic process of printing a textile fabrics, simple steps, essential, we've done everything, and you say now washing, washing itself is a difficult task,
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there are so many colours very near each other, they're now going to come out, the question is it's a very unlikely that 100% of all the colour that you have added have gone into the fibre and they are also fixed exactly in a manner in which you want to fix and nothing will come out, then the best thing, but doesn't happen because every reaction is an equilibrium reaction, 90% on the favor of fibre, 10% not in the favor of fibre, or maybe 95, 5 it doesn't matter, but whatever is unfixed is one will be washed which will not just be thickening agent or the auxiliaries which will come out, but the dye also comes out, the blue flows over the yellow, the yellow flows over the white, and so anything can happen during this process, so you got to be very, very sure.

When you dyeing you just wash, you just keep washing till everything is come out and say well now nothing will come out, go ahead, the same thing you want to do it here, but you have to be very careful, the moment the dye comes out from any region it should not go back to the fibre, at any portion of the fibre or the fabric that we mean, and so washing is a tough thing, so everything that you want to do in a printing is a tough thing, although it says simple process, print, dry, fix, wash, dry.

Well then there are fun things also,
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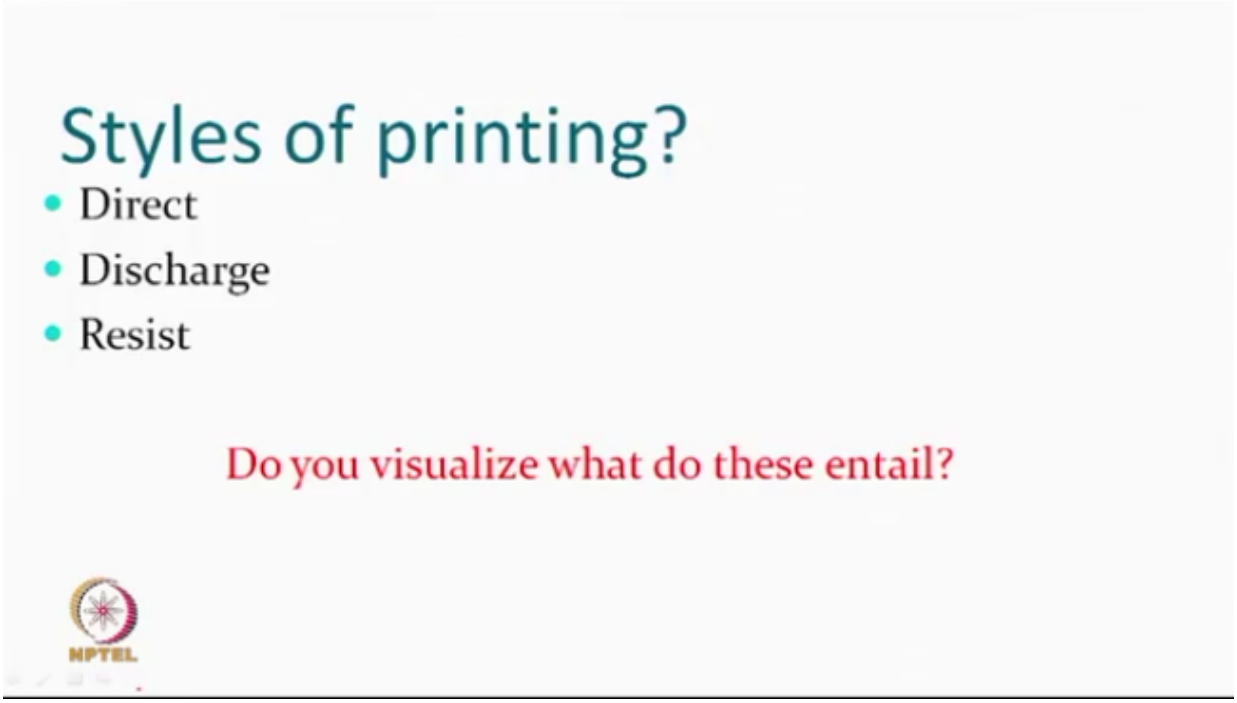

the fun things are where you can print in different ways and they are called styles, and these three names must be in your mind, the direct, discharge and resist styles of printing.

So what's a direct style?
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Yeah, somebody will tell me what's a direct style of printing? Right, like block printing, what do you say? Like block printing, right, so that is the technique of applying colour, but there is a style, so what it means is that you have a fabric on this you are putting some design, colour could be different, yeah, so whatever the design you print it on the fabric, right, that's one,

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you can have four colours so you will have four different times you have to work so that four different colours and four different parts of the design becomes the main part, main design.

Can we print with a direct style on coloured fabrics? Yes, good, so it doesn't matter, it's a white fabric, greyish fabric, yellowish fabric, bluish fabric, you just print directly if that is what the design is.

Suppose you have dark black, jet black fabric, and you want light lemon print on that, what happen? It may not be visible at all, so this style becomes relatively ineffective, and if that happens then we have the other style and which we say okay we have a coloured fabric, and coloured fabric generally deep dyed,
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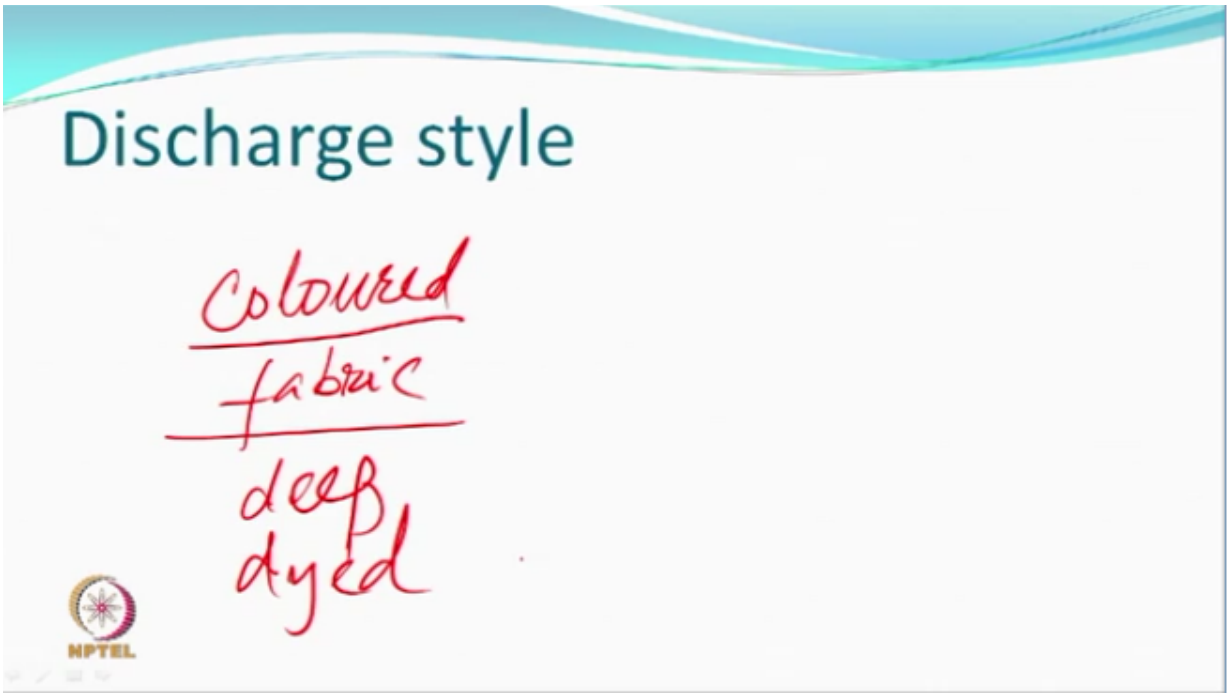

if it is in light colour people would probably go for the direct style and you get the same design, if it is coloured fabric then you say discharge style, and what does it mean? Is that from the coloured fabric you are going to be removing colour from the design, and how do you do that? You destroy,

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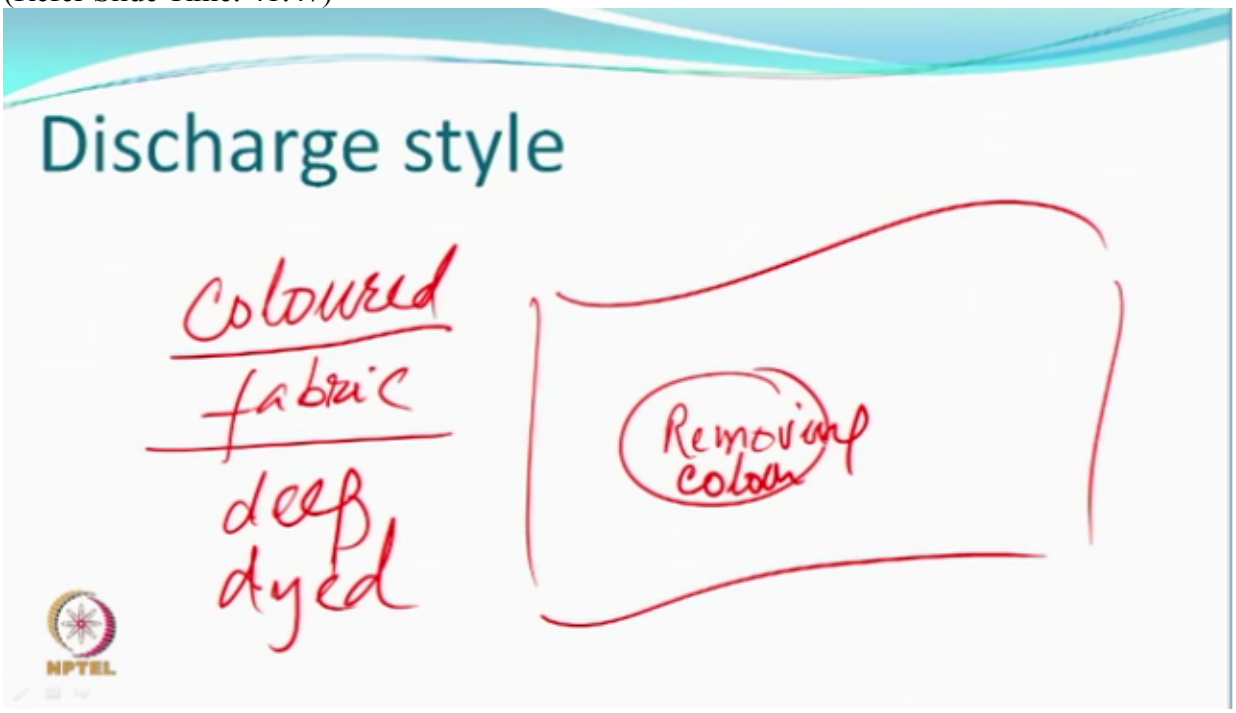

you destroy the colour by could be anything, generally reducing agent.

If you take a reducing agent and therefore you have to select a dye, and suppose you said I have dyed black with the word dye, do the discharge for me, will you be able to do that? No,

therefore you get restricted, you get restricted that the dye which has to be discharged, must be dischargeable, only then you can use the style, otherwise if you work very hard of course you can take an oxidizing agent, you work very hard and I'll like done bleaching, I'll make sure that there is no colour, you might find the fabric as damaged, any other thing can happen, and so normally we'll choose dyes because therefore you must know what is the design and what is the thing they are going to be used, accordingly you will choose that thing.

If suppose somebody is adamant, no in this style also I'll like to use direct, that means I'm not going to discharge, can you do that? Deep black shade light lemon to be brought in small dots polka, will you like to do that? Can you do that? You cannot, but you can, you can do that, you may not like it, what it means is that you print both print the small, then print the big, you can still get 2 prints, 2 screens, but printing is costly, printing is a costly process compared to dyeing and then discharging, so that's one print, in this also you can have white discharged or a coloured discharge, it's up to you, but then again selection of this so called colorant has to be very specific as to one which resist the discharge the other athlete as discharge.

Important thing is when we say that this is what the process is, this is only principle, the selection of a dye and a process will still be a TDS task, did you say I have discharge, you say it is not as white as I thought, then I'll do something else to look so that it looks whiter, so it's not something which you say well this is it, and end of the game, it actually starts from here.

In the resist style which are quite popular even before lot of things were done, you do the reverse, and that also sometimes you may like to do the reverse, because some of the patterns it may be difficult for example there is something called boutique, so irregular patterns to be created say do something and then dye on top or chemical resist where you print in a manner that the dye cannot get fixed, so invariably you may be able to get like tie and dye total mechanical thing, you get beautiful designs, so chemical, mechanical, resist systems have been developed for various style and various kind of designs which can fall in the category of resist style, right, like what you said,
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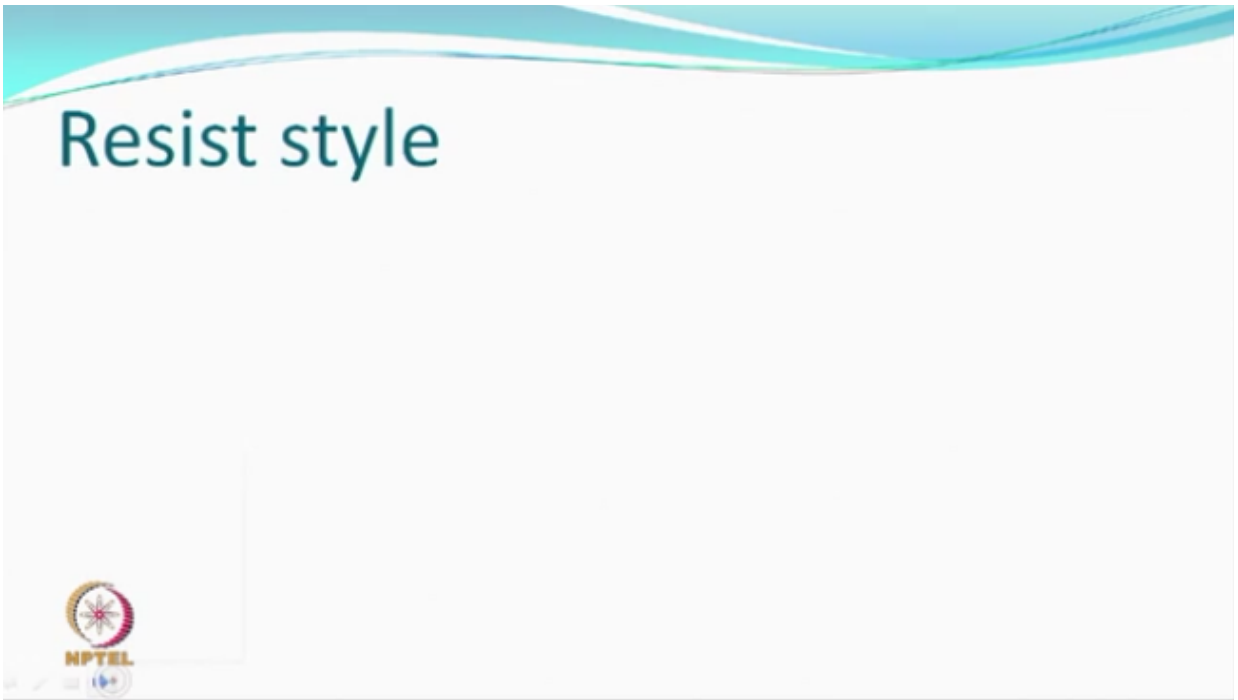

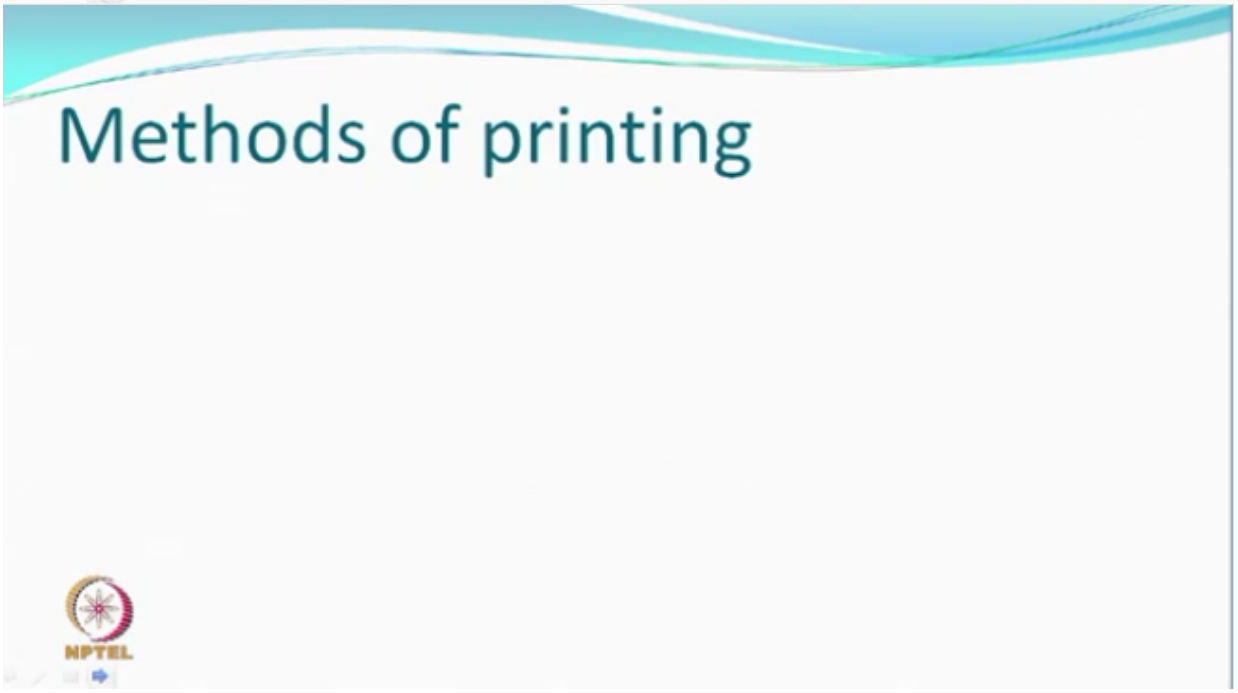

so what he was talking in the beginning of this small discussion of the methods of printing. You can use any method to adopt any style, method would depend again on whether you are doing higher production, low production, automated systems or just simple things.

So I was talking about block yes, there is a block printing method, batch wise process,
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one can think of automation and blocks also, one can have a machine which can have blocks and print in this mouse, I think you can print in the mouse you can do that also, but generally people are doing hand block printing, some traditional stuff that you can do all kinds of things.

The roller printing becomes a continuous process where the design is hatched on the roller, and now it doesn't matter whether it is discharge or resist or a direct, it doesn't matter, style is an important, it's a costly process, generating roller, design on a roller is a costly process, screen

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printing is one of the most popular things you can have a flat screen or rotary screen printing machines, the flat would be consider as semi-automatic systems or could be completely manual and rotary is generally continuous process where like a roller printing rotary screen is a continuous process.

And of course there are many things that you can do, like a stencil, you take a stencil painted the way people keep painting things, you'll get a design you can do spray you can get the things, so you can actually look at many other methods and these days the kind of methods that again we will be talking, the transfer printing is a method, so you do some printing somewhere else and then transfer onto textile, all the things that may done somewhere else and then you transfer, or now we're looking at digital printing, so all those things will be also methods, transfer, digital, they are methods,
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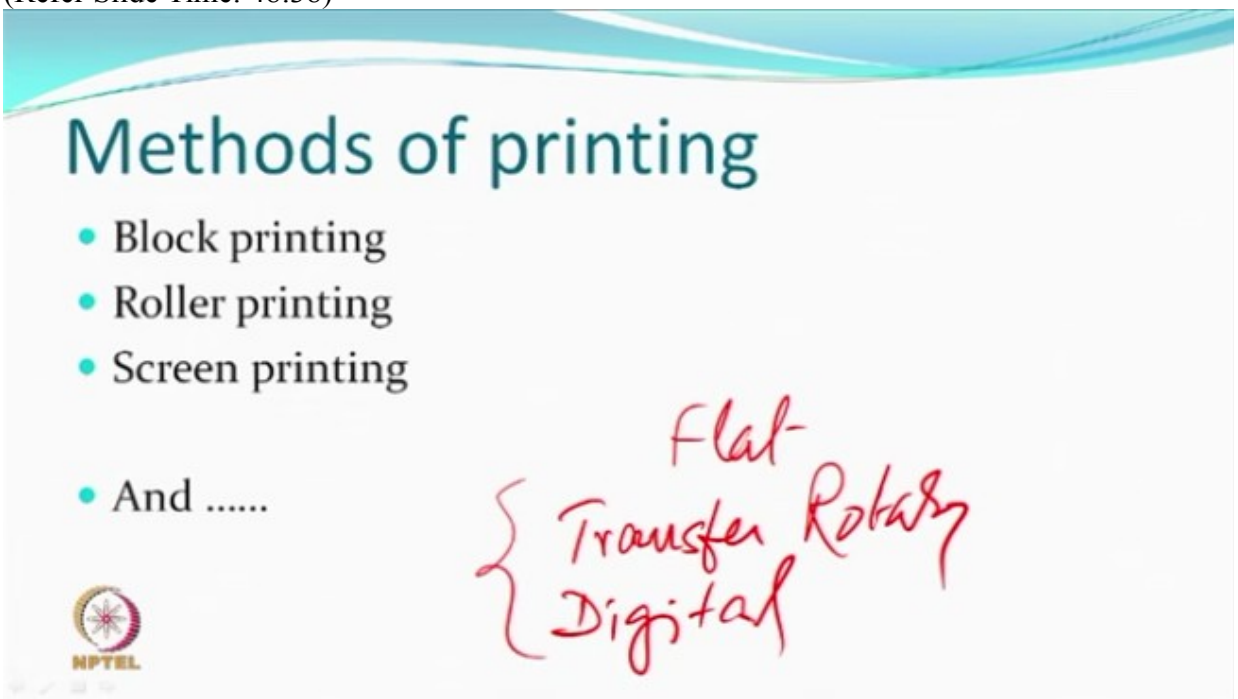

and these methods are in some way fascinating to begin with which are different from whatever being used and so we will spend more time here.

I think today we can stop here and then we'll take up later the other aspects of the conventional printing which are as serious as important as it can be. Thank you.

INDIAN INSTITUTE OF TECHNOLOGY DELHI

TECHNOVISION

For Further Details/Information Contact:
Head
Educational Technology Service Centre
Indian Institute of Technology
Hauz Khas, New Delhi – 110016

Phone: 011-26591339, 6551, 6131
E-mail: npteliitd@gmail.com
Website: www.iitd.ac.in

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