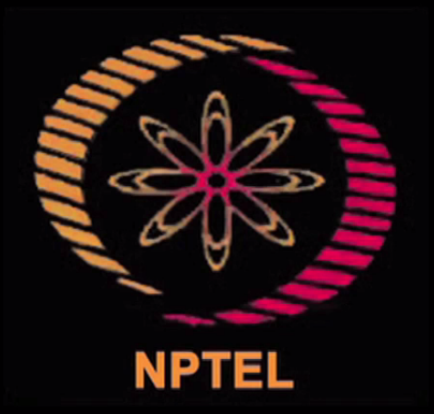
INDIAN INSTITUTE OF TECHNOLOGY DELHI



National Programme on
Technology Enhanced Learning

Video Course on

Advanced Textile Printing Technology

by

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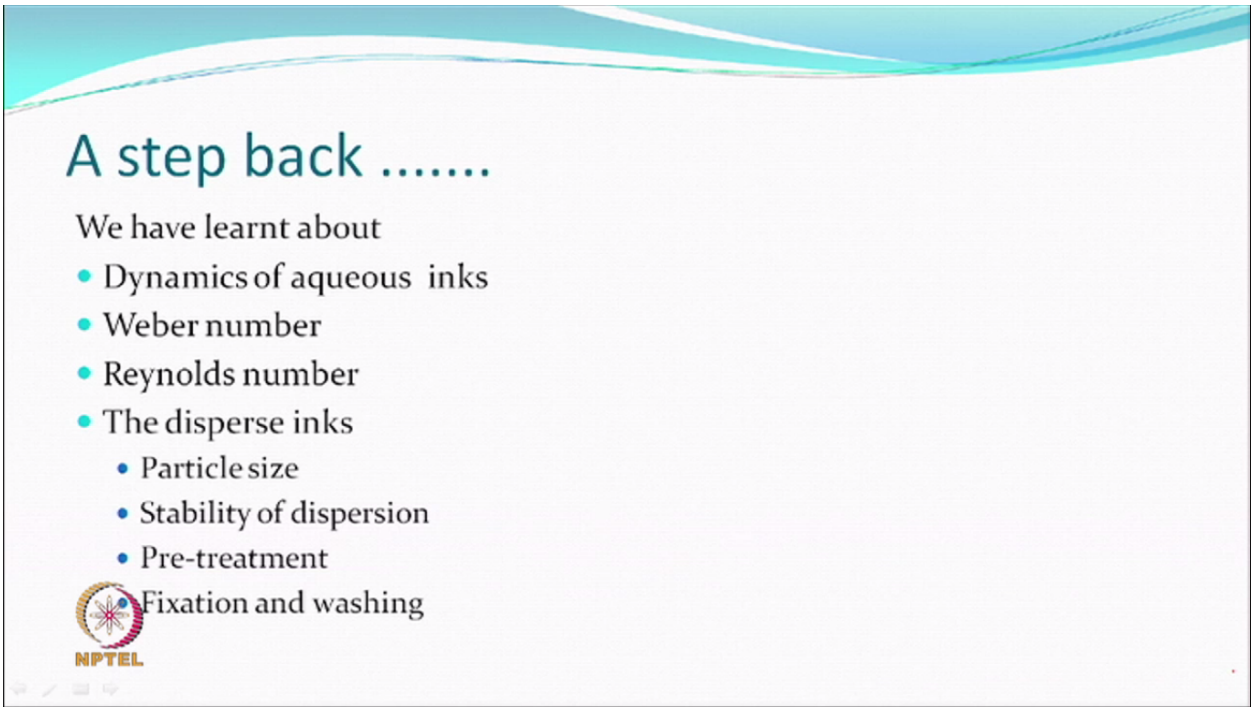
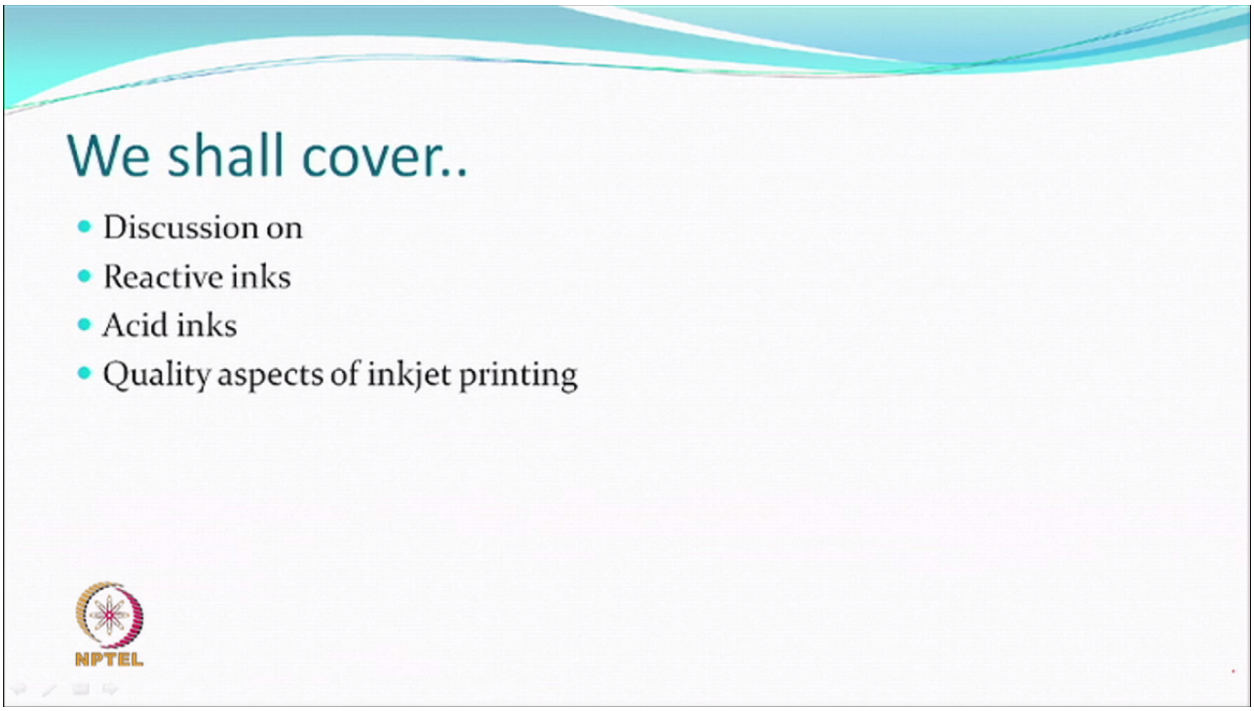
Lecture # 19

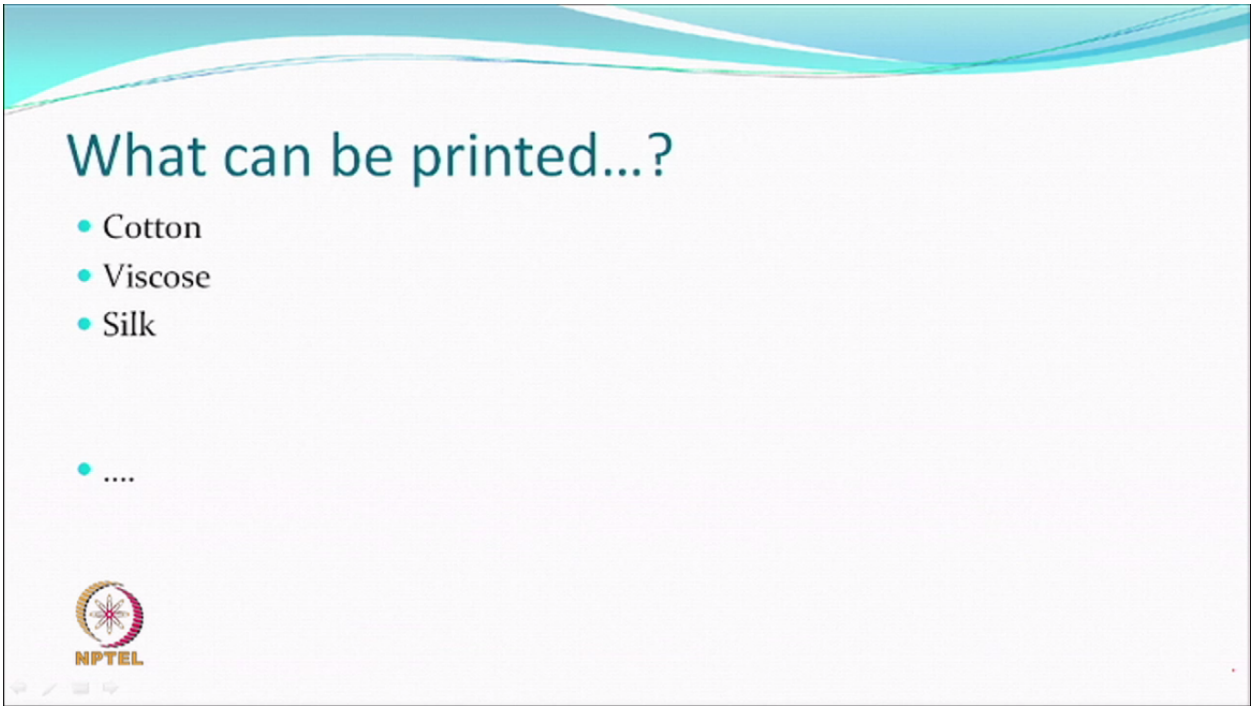
Water-based inks contd...



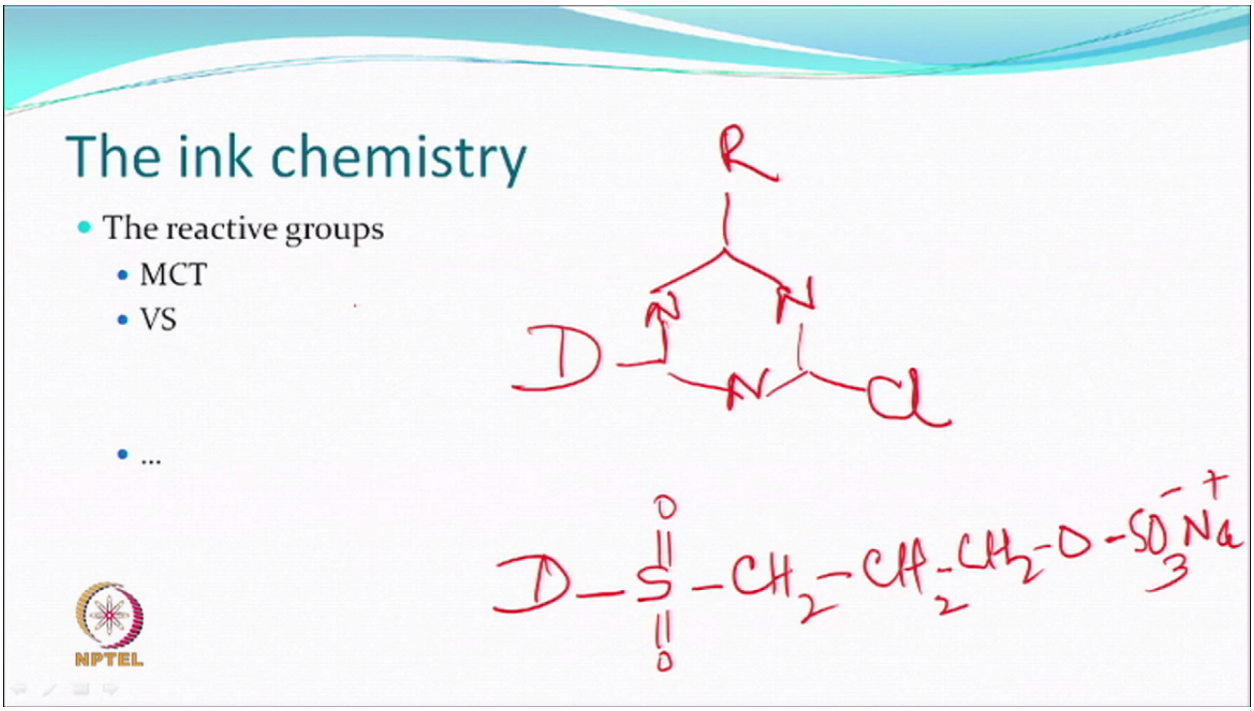
So we're continuing with what we were doing with aqueous based inks. So last time we looked at the dynamics of aqueous inks. The significance of Weber number, Reynolds number and we did talk something about dispersed inks which in some sense is similar because they are dispersed like pigments but because they are not pigment they're dyes. Their sizes also are different and so the stability of dispersion obviously is a concern which is what people work on. We did learn about the pretreatment, what needed to be done and fixation and washing which means the reduction clearing also becomes a part of the washing sequence.



So continuing with that we just have some discussions on reactive inks which have also become popular. Acid inks are also there. Not so much popular but they have their share of market and general quality aspects of inkjet printing which people may like to see those who want to do research to find out whether this is doing well or not doing so well.

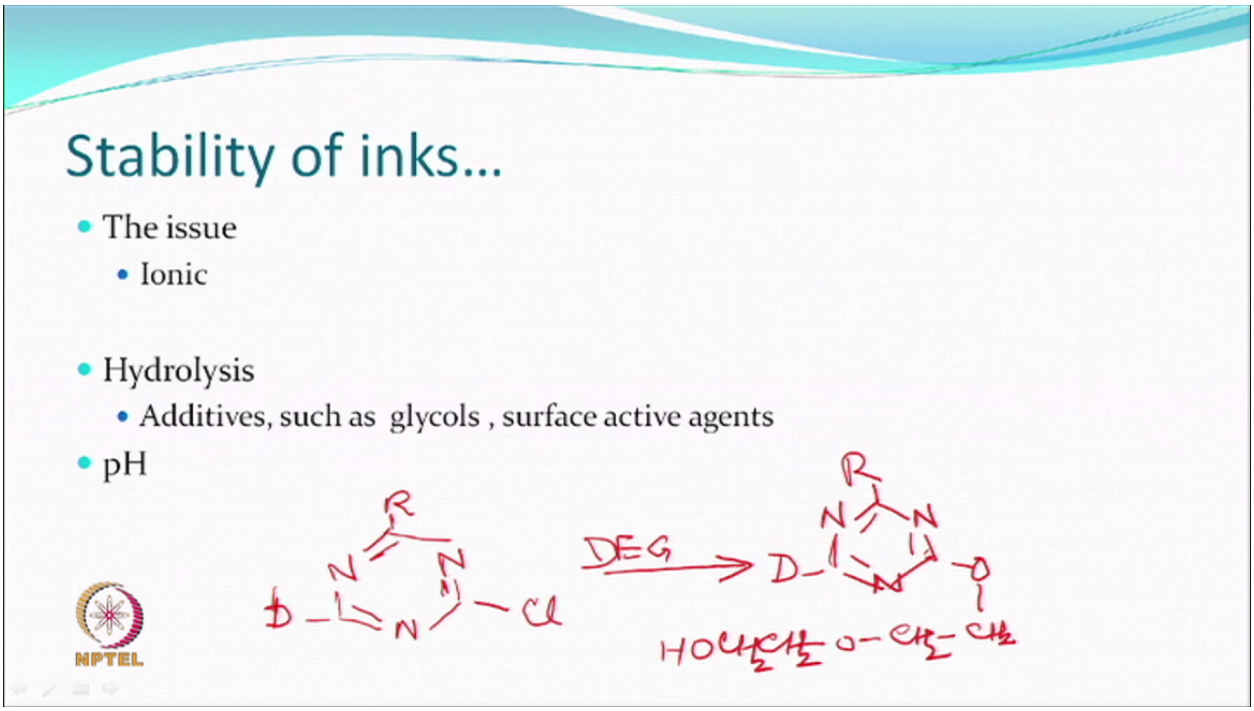


So in general reactive inks obviously can be used for printing cotton viscose for which they were designed and developed but as we understand now silk or any polyamide or polypeptide we should be able to print depending upon the surface. Chemistry is one aspect. In textile the surface is another aspect. So if you have a woven knitted, non-woven fabric the same fiber you may be getting different challenges. So otherwise reactive is concerned this is what generally would be happening.



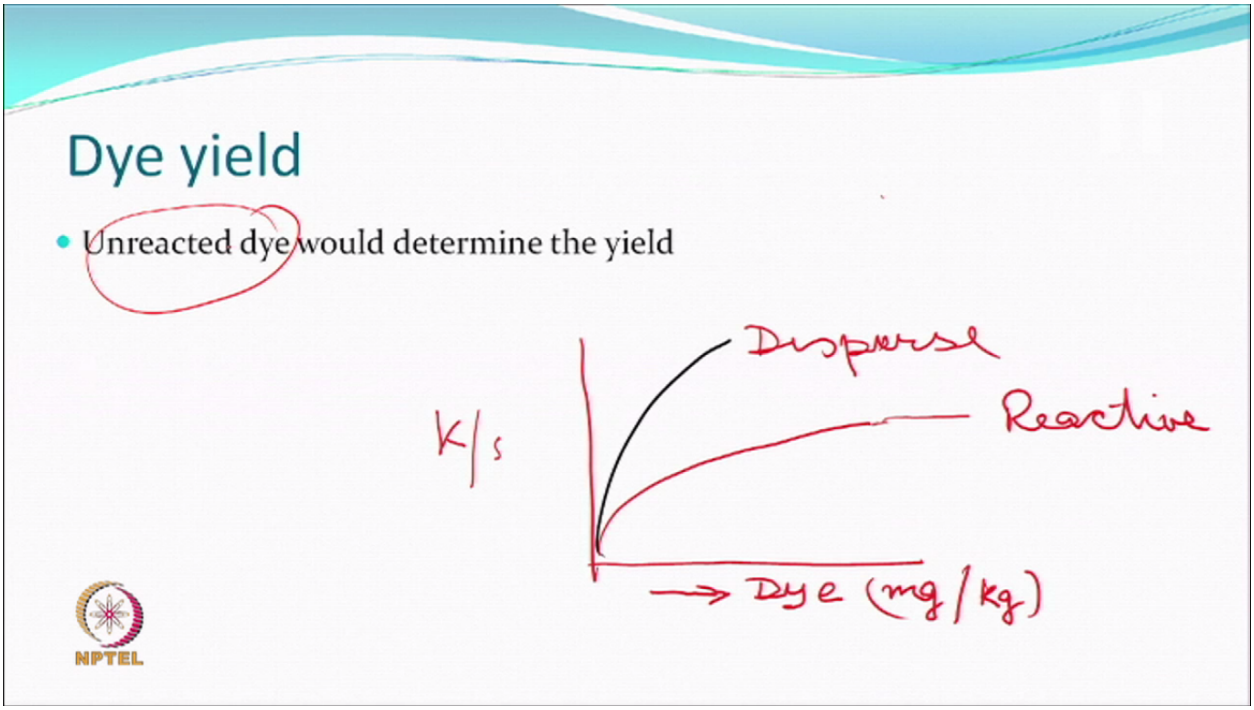
So the chemistry of the ink I mean there are many reactive groups that we know of, reactive species but still the two most popular ones which is the mono chlorotrzine and [00:03:06] are the ones which are definitely being used as the reactive systems for the ink development. Within this you can think of multi functional that is a bi-functional dyes also which may be homo or heterogenus type of [00:03:28] functional reactive dyes so all that will be part of the ink making process. So apart from chemistry of course you are looking at the gamut as to which type for dye is finally going to reproduce what you see on a screen. So that work is a much harder work than just deciding so what is the reactive group.

So the chemistry of the molecule actually from the point of view of inkjet this also will be equally important and not just the reactive group which is true with dispersed dye also which is true with -- going to be true with the AC dye as well.



So although we did talk about stability of dispersed inks. We talked about the stability of the pigments, there the stability as something to the dispersion breaking. In the case of reactive dyes, the dyes are ionic in the sense that there is a solubilizing group. So what can be added what cannot be added will also be dependent on any reactions that you have. So they have a lot of additives. In disperse system adding various kinds of additives is relatively easy because disperse dyes don't interact but these dyes obviously can interact and some of the things you may not be able to add. So that choice has to be made. Hydrolysis one can say well unless and until you have gone for an alkaline pH you would not be getting the hydrolyzed dye but that is just one argument. That argument is when you are doing fixation but hoping that the dye which is a reactive dye is actually in water and is stored for one month, six months, one year would be exactly same and will remain absolutely inert that is too much of expectation. Therefore large amount of studies that are done are what to do and how to maintain, which type of a pH has to maintained so that the stability of the ink is very high. So you do add a surface active agent. You do add other than water there are glycol which is to control viscosity and surface tension issues. So all these additives are as good or as bad as far as stability is concerned of the reactive because the reactive system can have a problem. Dye would have no problem. So theoretically one should be happy it's a water soluble dye and there should not be any change but the reactive group is there, although it may do very less hydrolysis but that means it is not exactly same what you had started with. And so at the end of the day whatever you said same company same dye and you may get a different result because you either you used it late and so, but this is a challenge which people obviously have to worry about. So pH balance, pH management of the ink has to be done so all the studies people do a different pH what is the stability, how much, how many months what kind of changes are taking place and based on that you say well the buffer. So you buffer it in a manner which keeps the pH stable and there is no doubt that towards neutral and less than neutral towards acidic side is a better pH to maintain.

So I said some of these reactions also possible. We have been discussing other than hydrolysis but all these reactions are possible.

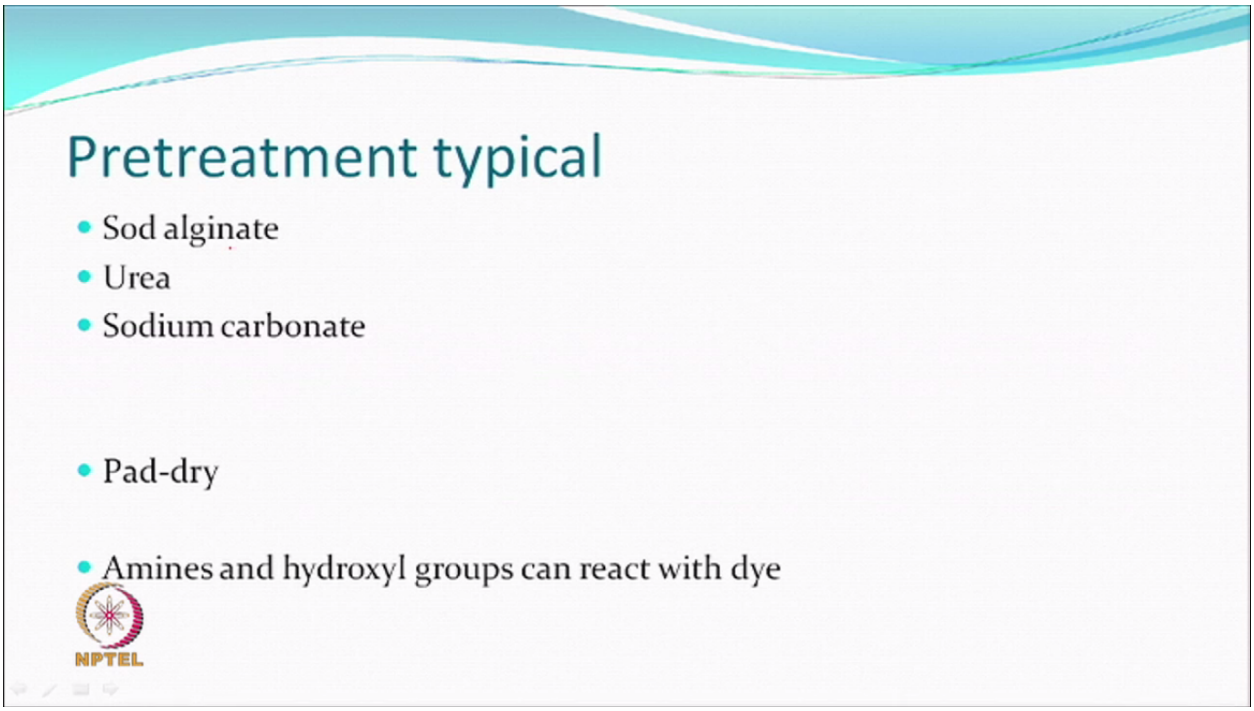


So ethylene glycol or diethylene glycol or PG non-ionic surface active agents all of them will have some group or the other which can participate. So the dye yield finally or what you say otherwise it's very simple how many you put a drop how much solid in a drop is there that should determine this is going to be my final yield but this would also be determined by a dye which does not react because finally you're going to washing. It is not like a pigment print where everything is there nobody's doing any washing whatever happens happen. So when you wash something will go and that finally something may decide what would be the final yield.

It's very interesting to see if you have a dispersed ink so you apply a similar amount of dye you get less k/s in reactive systems. So the yield is because something is going somewhere obviously you don't want anything which is unreacted to be on the substrate. So you will be washing it off. So although you may put the same amount of dye but you get higher yield for example in a dispersed rather than a reactive despite best attempts. So then somebody said well I am doing digital printing whatever is on your thing I'll be able to bring it on the fabric very good. At the end the day this also may make some difference and in case you have obviously four colors minimum more than four colors in various cases and if the affinity and stability of different colors is different, so you're not just talking about the dye and color, you're talking about stabilities also and they are different for whatever reason, then anything can change. The yellow may be less than what you would desired then the sign for that matter and so it may not look exactly same.

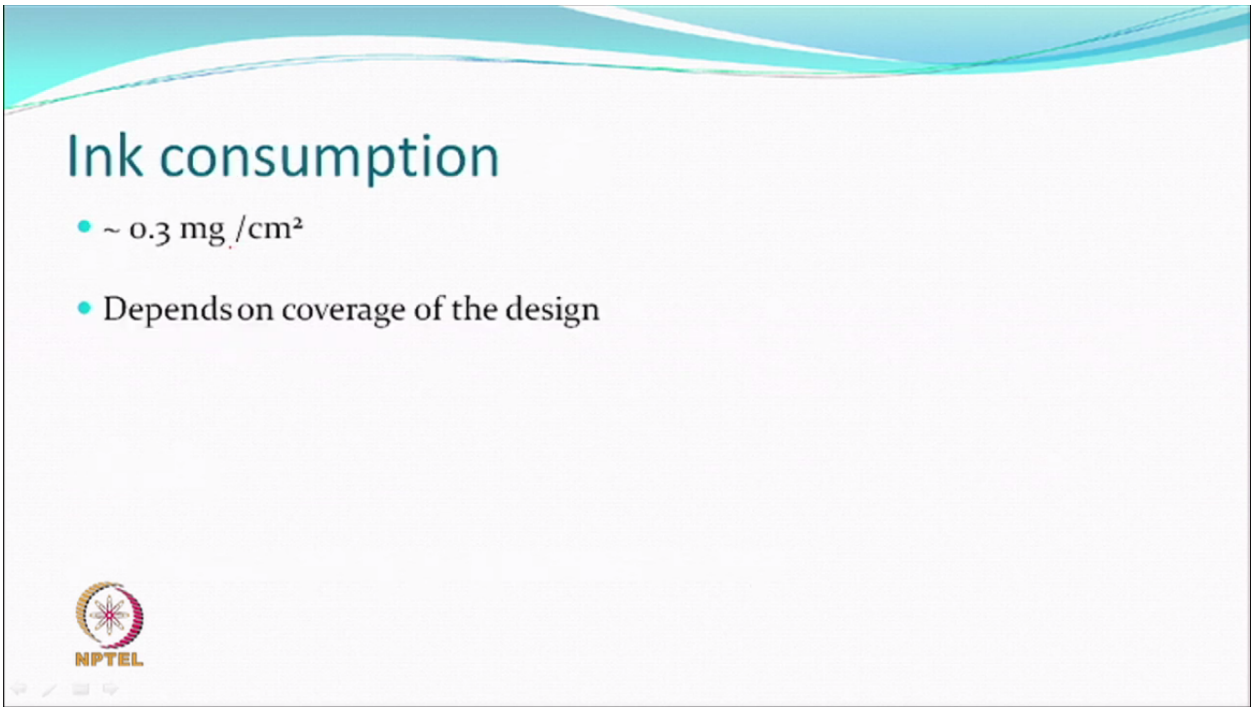
So the challenge is a very different order. You see when you do a normal printing you have done all mixing before. We also want there all the fasteners to be same, rate of fading should be same,

it's alright but still it is one kind of a mixed bag. Here nothing is being mixed. All of them are independent and so you want all the independent entities to actually behave exactly the same.

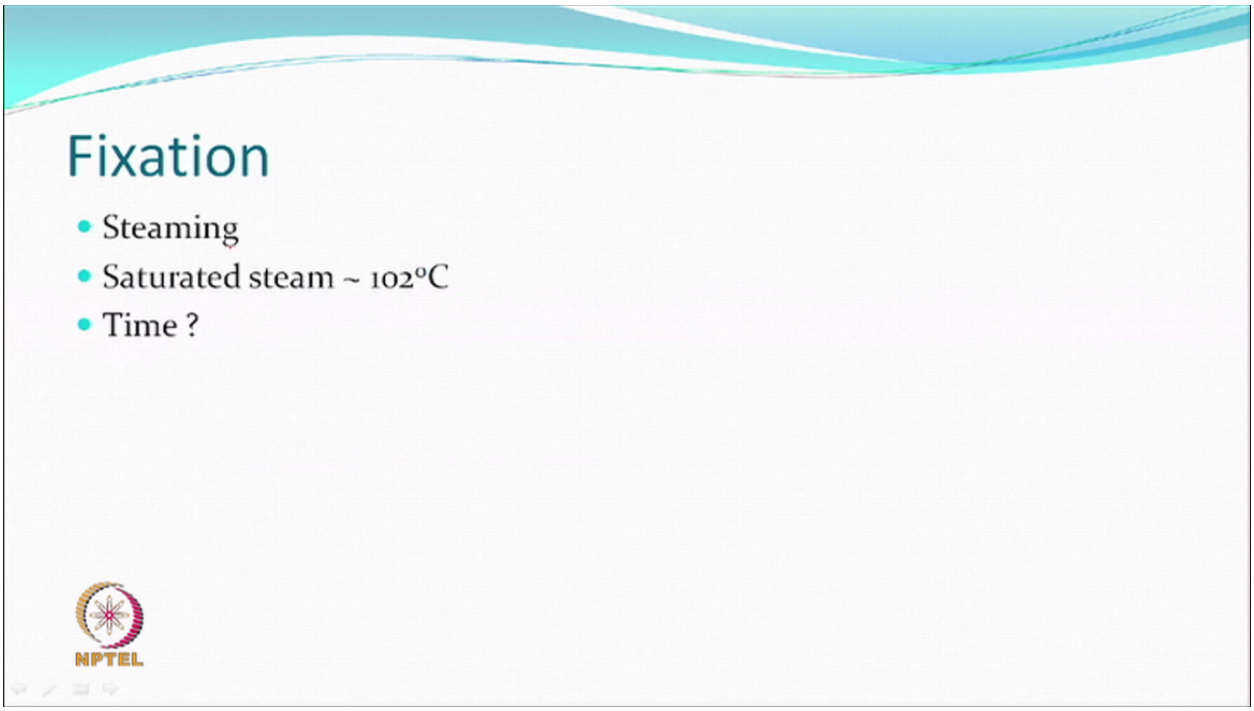


So challenge is always more and that's the reason why a large number of companies don't enter into the digital ink making. So there are more complaints than – so in this case a typical pretreatment with some alginate urea and sodium carbonate. That means this material has been parried and dried on the fabric. So we know exactly what we want. So fixation is only because of sodium carbonate but all others are helping to get to the quality of the print. Otherwise you don't need them and particularly if there are hairs which are on the surface cotton has so many of them. And so that is what you're going to basically want to take care.

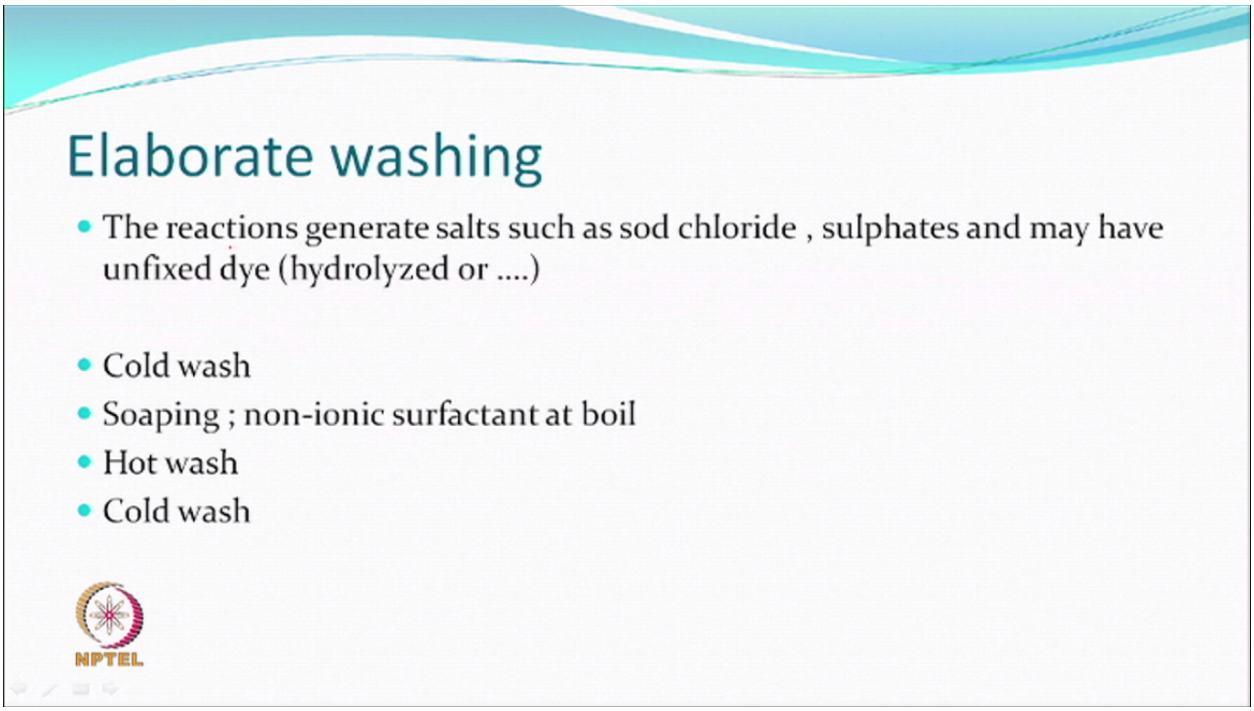
Urea in some kind of a you know reactive systems it can also react if a pH - different pH it'll catch. So some reaction can take place in these conditions. So it is not just that you have only water that you have to bother about but what only means is not that you are losing so much that you say oh my god my capital has gone out because the question you are not able to match what you want to do. That's the reactive system.



So compared to dispersed you have to probably add maybe consume more dye per centimeter square area because as we earlier also understood that the consumption is measured or evaluated in terms of how much you have spent per unit area not per unit weight of the fabric as such because that would be very difficult. How much is penetration taking place that can change the perception. So that also means that if your penetration is taking place quite a lot the same amount of dye can give you different depth. So when you look at an image the depth is also part of an image which is not only tone and a shade. So suddenly if something was supposed to be dark and is actually light then you obviously feel it's a dull print. So that can also happen.

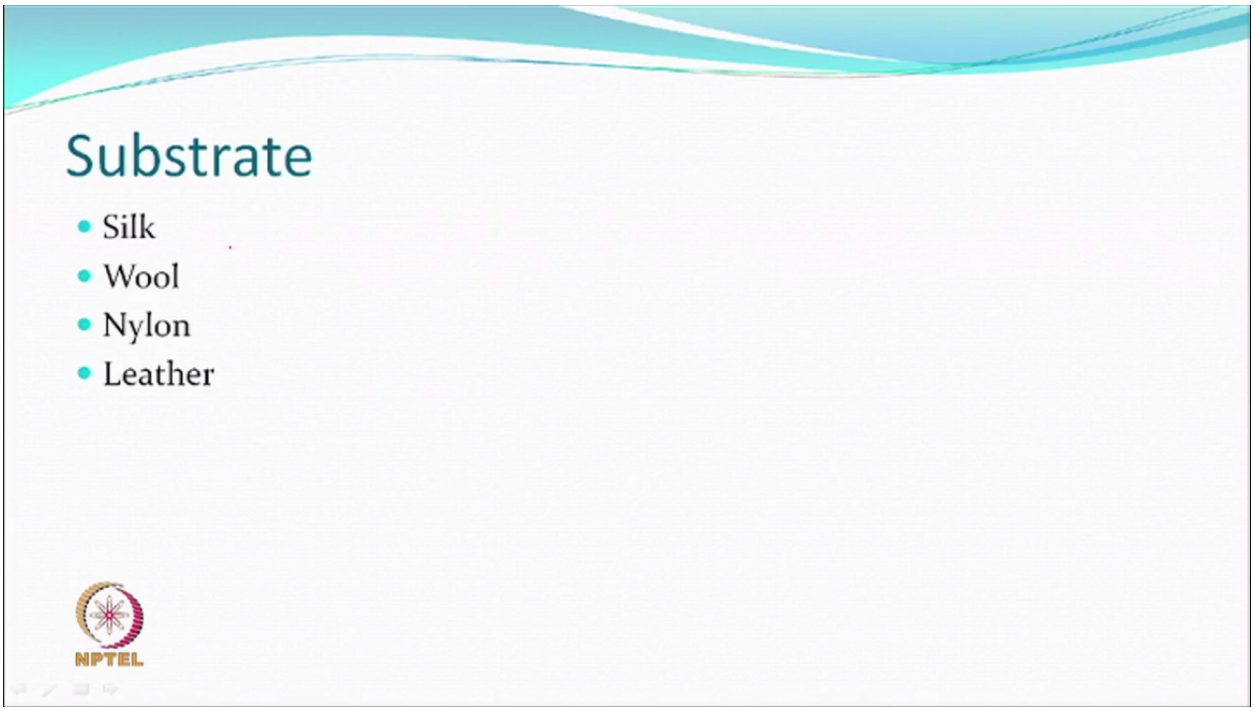


So fixation is easy. I mean normally we will do steaming. Saturated steam approximately almost atmospheric pressure and time that depends on print itself and maybe seven to eight minutes but that's in a steamer. If you are batch steamer they don't know how to actually put seven minutes. People are working on a continuous system then you can actually talk about the steaming time but people who work on a batch system you put a open a steamer put the batch inside and then steam the time that you take to generate the steam versus time you take to open and close if you add that it can go to 15-20 minutes you can add extra to whatever you are working.

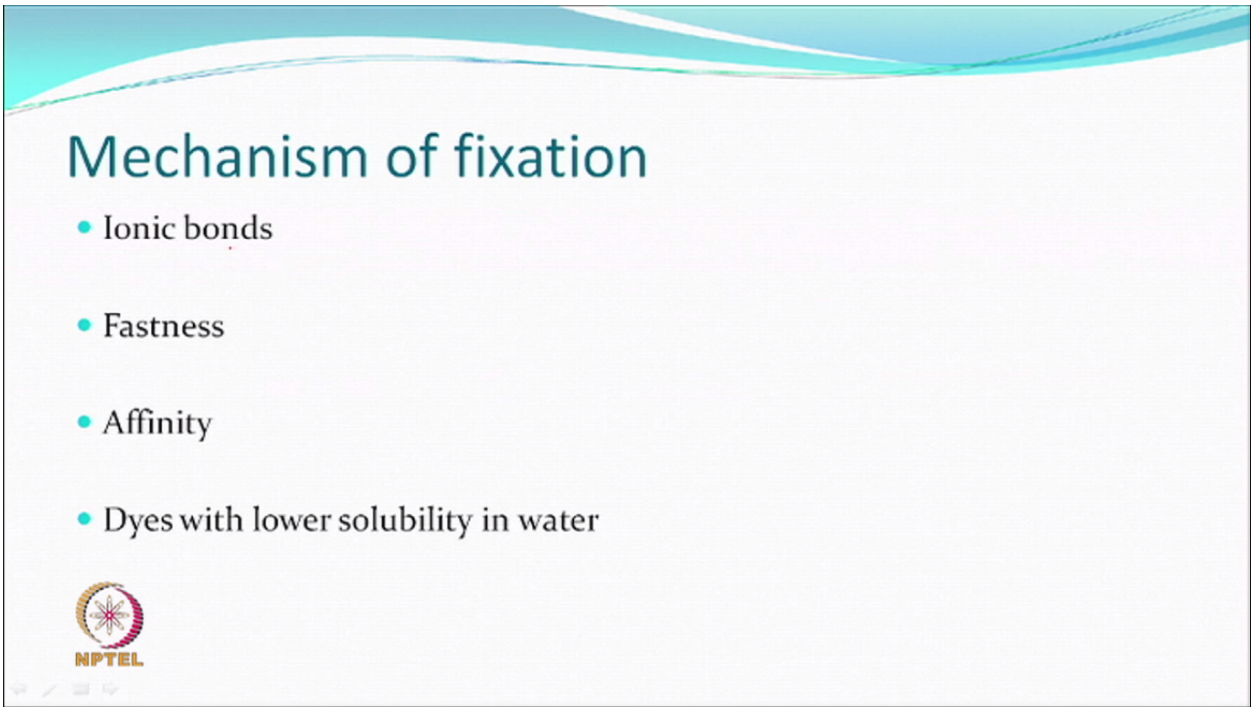


So like in all reactive systems so some salts will be generated like sodium chloride, sulfates, etcetera. and maybe unfixed dye also. They have to be all removed. How many of you have done printing as such with your own hands? What difficulties did you find? Right. So that's the most important thing and can you imagine that you are trying I am doing a photographic print and after washing color is everywhere. So it look like a washed out print. So you may not be able to impress anyone except an artist who believes in creating designs which have different meaning. They have a different emotions coming out of it.

So you have the cold wash then you hard at boil with non ionic detergent. Then hot wash and then cold wash and you dry. Sometimes people try to do some initial wash in little acidic medium also because then re-deposition may be less and then can just get washed out also. So all that has nothing to do with digital printing. Somebody pointed out if you do reactive systems the pretreatment is going to be as important as the printing and post treatment is still more important. So it is not like digital is fine but as far as the design part is concerned but you have to do hard work if you want to get good results. So reactive is obviously for all kinds of articles for apparel and home textiles and things how that can be used, dress material particularly is quite popular. But then the competition is going to be we'd like to go for a pigment where you're quite sure at least the home textiles that irrespective of the substrate the print is not going to be the washing of problems are not there, other type of problems are not there. While reactive one advantage is that you would not have a binder so you're actually looking at a real color. So acid last time when you attended one of the lectures the gentleman said that in India hardly anybody wants to use acid but what it means therefore it is not as popular as one would love normally that you can dye anything any kind of [00:16:56] systems with acidic systems. So reactives have become definitely more popular.



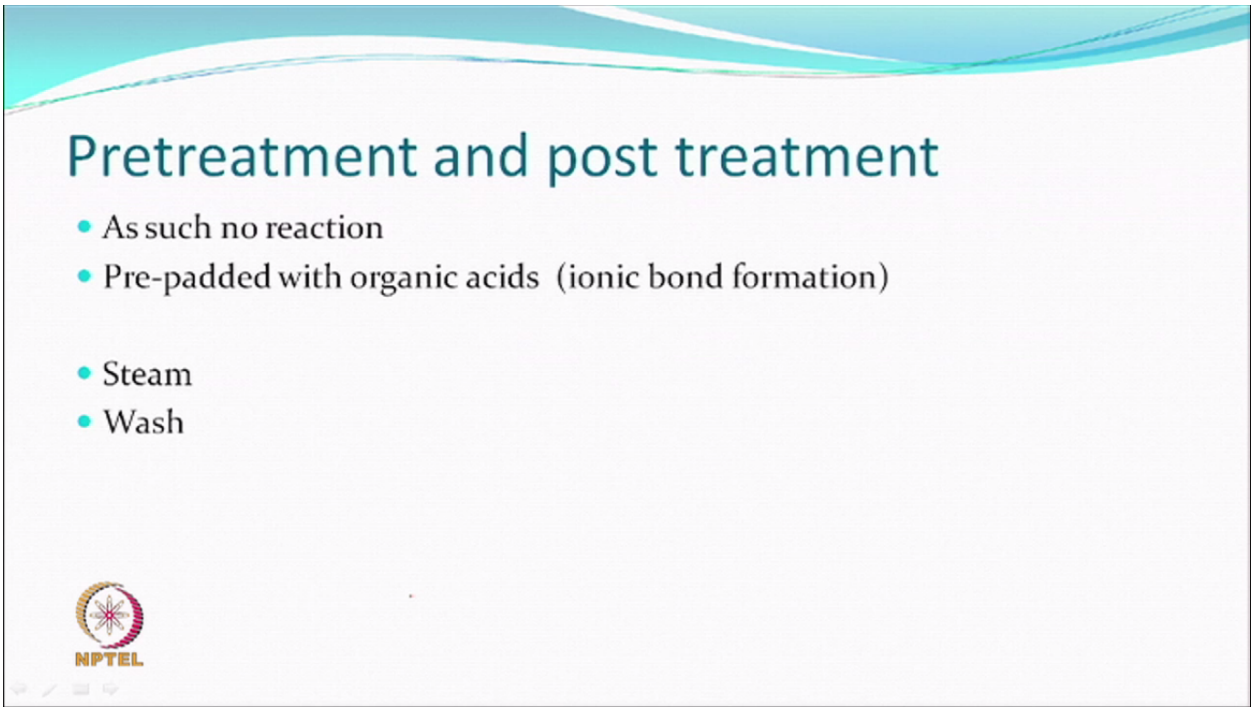
So silk, leather, nylon, wool, silk whatever. Acid dyes obviously are meant for them traditionally and if we need that and can do this also. So mechanism fixation we understand is the ionic bonds.



So the fastness is always an issue because ionic bonds are water soluble and if a pH is adjusted, readjusted then you can get bad thing. That's why they say if you done silk dry clean the sort of

wash and if your soaps are alkaline which is quite possible then you will obviously have more bleeding taking place. So here the only way they are there is because of ionic bonds. In proteins we understand the positive charge gets generated in acidic medium and which is not available let's say an alkaline medium. So if you change the pH during washing also something will happen. Everything may not come out so. That issue always remains which obviously if reactive dye has reacted that issue never comes. So you try about affinity means that you see water. So basically looking at harden bonding capabilities invariably acid dyes are relatively in smaller, the size is smaller compared to let's say direct dye where affinity is different. So complete dependence on ionic bond fixation. As long as you do not change that condition the fastness can be seen.

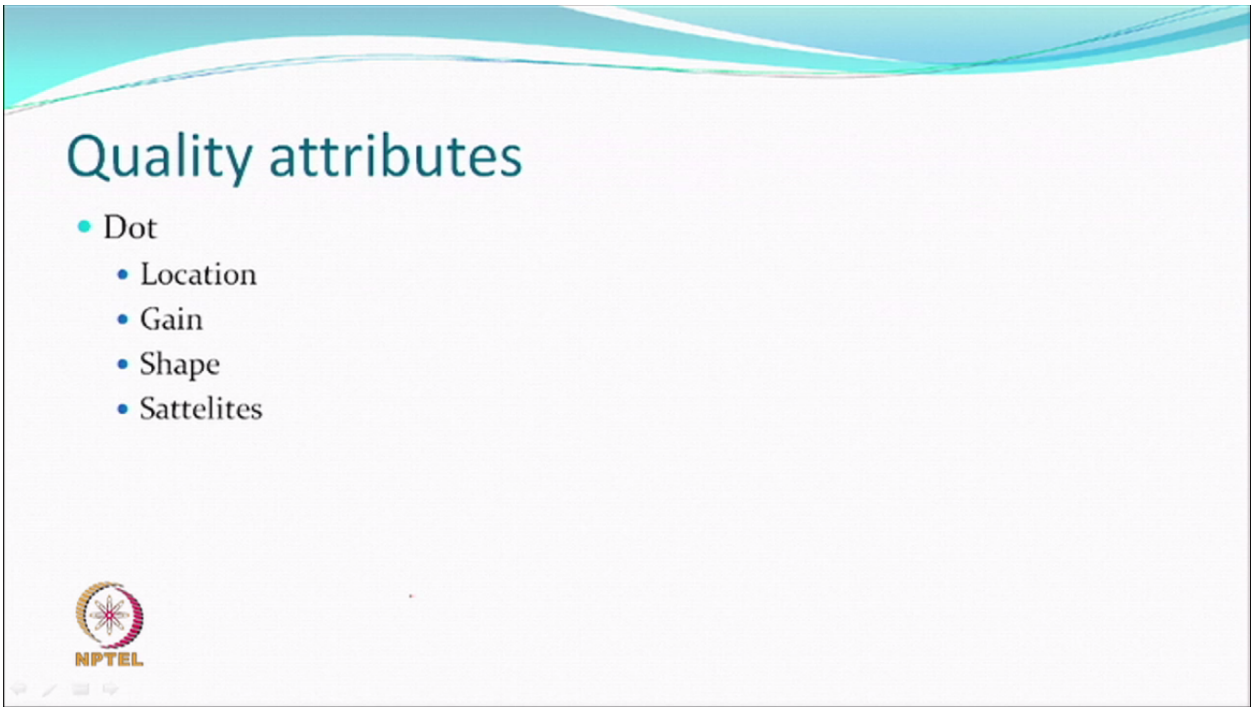
So lower solubility dyes for the inkjet printing. So it makes sense because it will be less water-soluble and so we will have relatively more reason to be on the fiber. So go doing a lot of hard work so this is what a few things can be done. Instead of having three sulphonic acid groups less then. So that's the the kind of thing you can reduce solubility. But definitely they are water soluble.



So the pretreatment concern we're not expecting any chemical reaction will take place but the substrate should be positively charged. That's the only thing we're looking at when the printing takes place. So some acidic pH has to be generated. If you add anything like a thickener this is to improve the print quality. It's nothing to do with the reaction. Then steam as you need and wash as you can. So acid dyes in that sense can do certain things. So there are companies which are making acid ink also. The companies are making reactive inks also. Right.

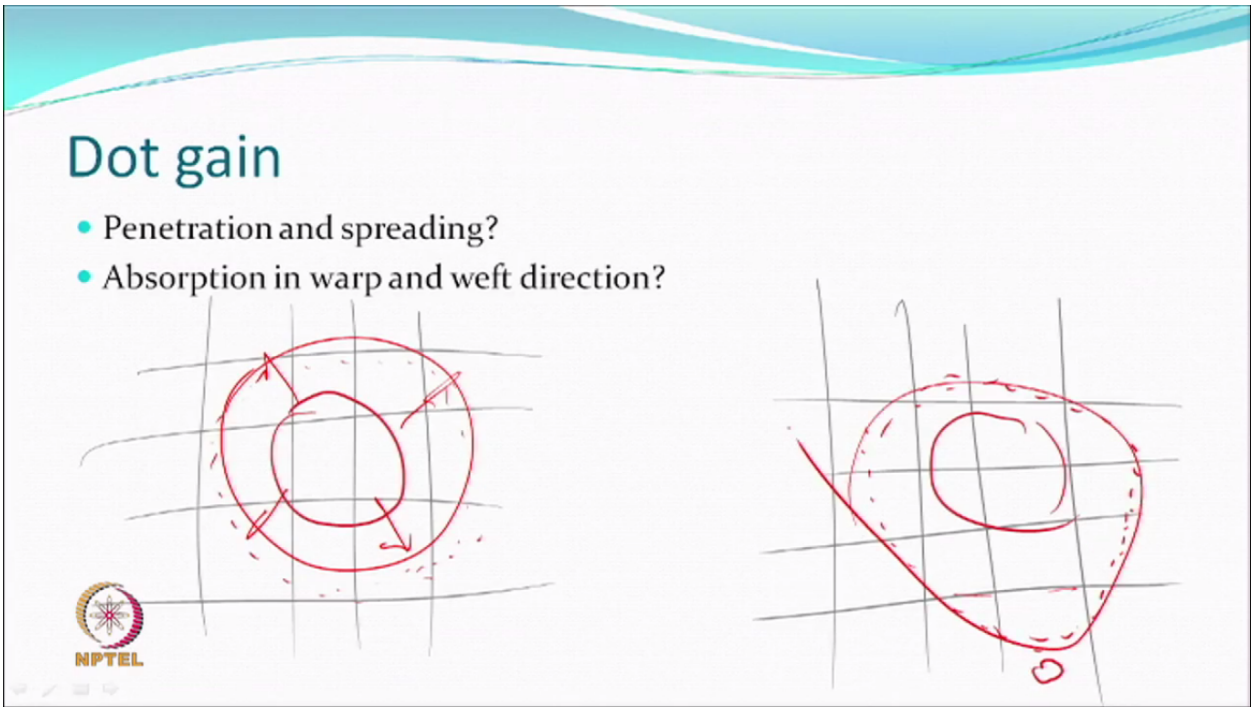
So before we close this aspect some few quality attributes of all the digital printing systems particularly aqueous based systems. I will just spend a few minutes. Most of the inks of the textile are aqueous based whether it's a dispersion, or it's [00:20:41] dye including disperse dyes

which are printing polyester. That is how it goes and therefore spreading of the drop as it falls, absorption more deep, less deep, hydrophilicity, hydrophobicity of the fiber. There like you start were the blending. Then you have woven knitted garments. Knitted garments may have maybe more hydrophobic compared to the other fiber because they actually apply waxes under knitting [00:21:33] So all of them can have some effect.

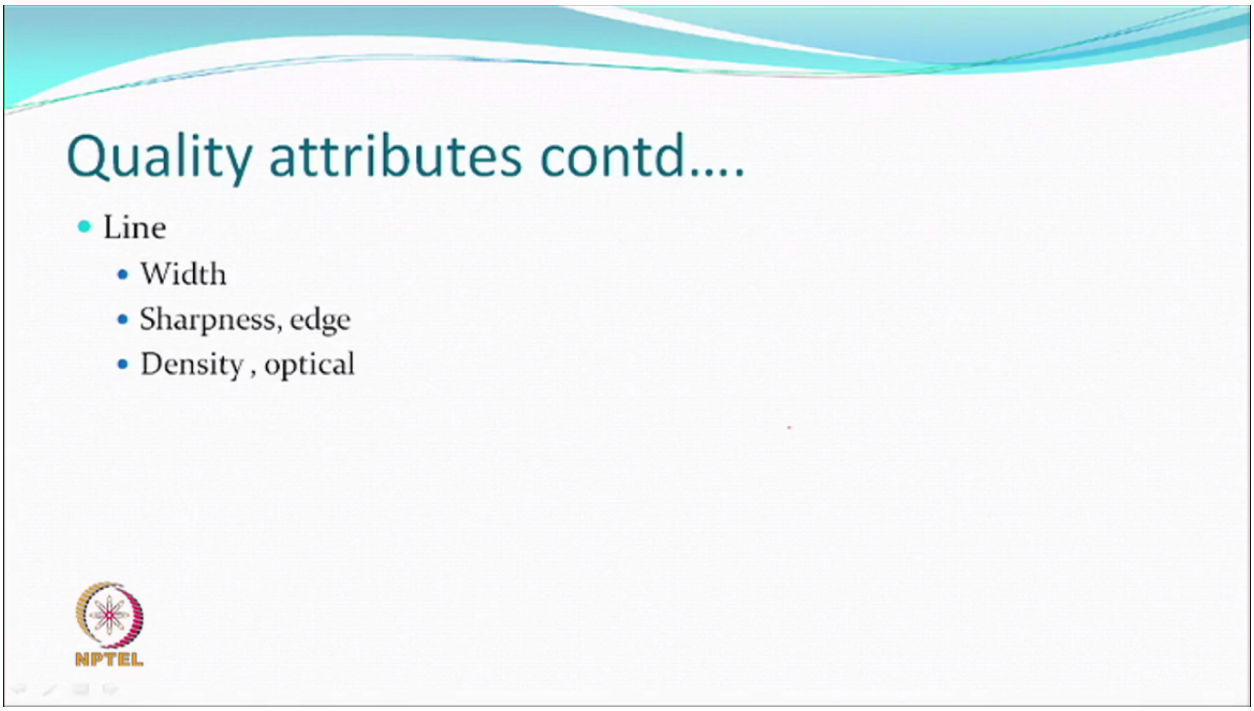


So one says well what is the quality then you look at the dot itself. The quality of a dot so you say latency, startup problems, all those are there. So based on either the startup or anything else whether the dot actually has gone to the same location where you want it to send that's your desire but then desires may or may not be met. The gain is like you wanted a certain pico litters of a drop and you wanted a certain drop size. So gain directly here means is the drop size is increased after falling on the textile because it can spread on the surface and they because of thing it can penetrate both the thing will happen. This is not I mean we'll be happy that there is only penetration takes place and no expansion but how do you ensure that. Then the shape on one side there is more attractive force than the other side. Shape may not be same and for some reasons smaller droplets then the main drop size can also form. So you may not be worried about it. That's okay. you can always say well whatever print you could do without with a conventional printing look at that and look at this and you'll say well I'm happy but from the purpose of quality people who like to assess these things also. So those who say well I am going to make a printing machine he says I'm making everything doing right. The drop is exactly what you wanted and still on the textile you see something different and that difference could be because of this dot attribute, dot quality attributes. So the gain means the area changing. One was a viscous effect that the drop is spherical as it falls and then because of the momentum and the rebound that it actually comes and falls again but after it settles down it can spread because we are dealing with the aqueous systems and we are also hoping that our fabrics have been prepared very well which

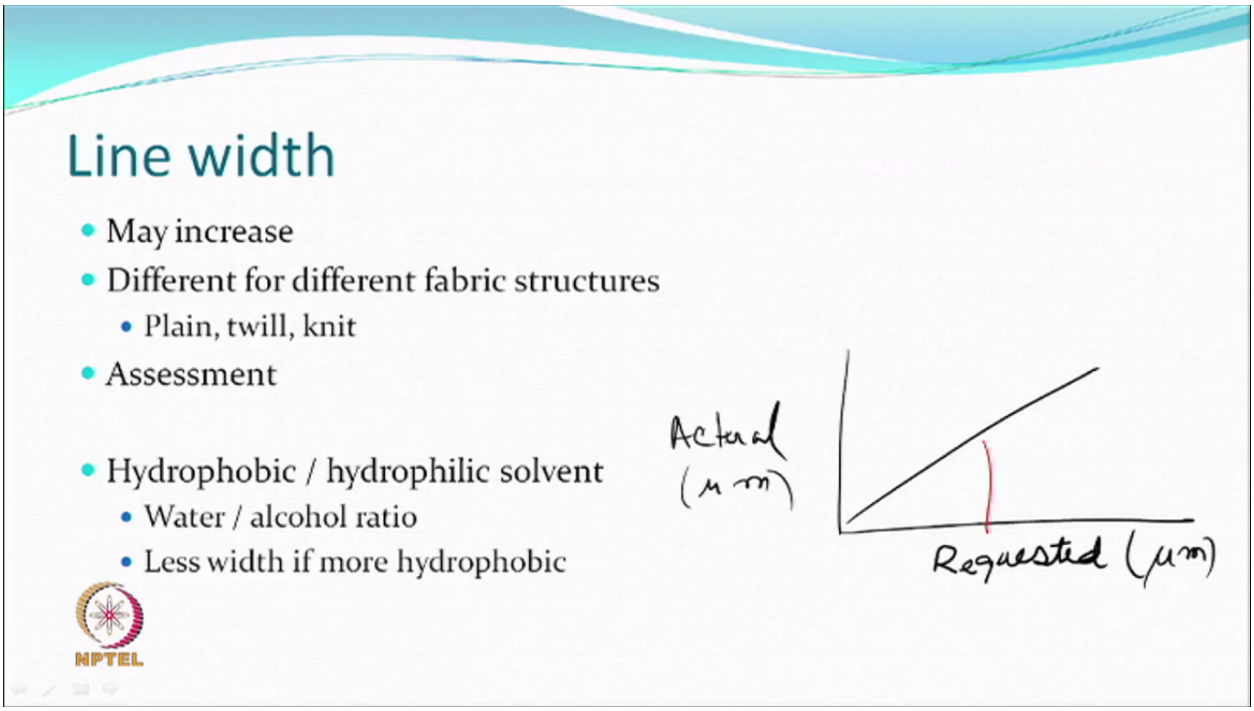
we do and we always love the absorbency to be very high and if that is so then spread takes place.



So if the spread takes place uniformly in all directions this is one thing and if it does not spread to the extent that crosses and merges with the other drop you are still there except that as you remember the drop size changes, the gray value will appear to change but that's one part but if for some reason absorption on one side is more than the other let's say this was material which has more cotton on that side and then was a polyester rayon and if that happened certainly becomes no more spherical, it may be taking some shape which is not sphere. It could be any direction. So it is not equal. If it's not equal from image point of view you are not reciprocating what you wanted. So you have done a good job but you're not reciprocated what you wanted. And every time you do this may not be same. So that means you are also saying that I cannot really reproduce what I did last time in some sense because how do you ensure that when the drop falls wherever it falls that hydrophobic part will be always that much on this side. No control in that. so you're only hoping everything is clean, everything behaves the same which in true sense may not take place. Theoretically every equipment that we have in every system there is error and we only have to worry about the error how much is error. If the error is less than what we can perceive then it's okay but when somebody say well I want to, you have printed I want to really go and measure the drop size. I want to make the gain in the drop size then you have to satisfy this which is you say well this is the preparatory guy not my problem but that is where it is.

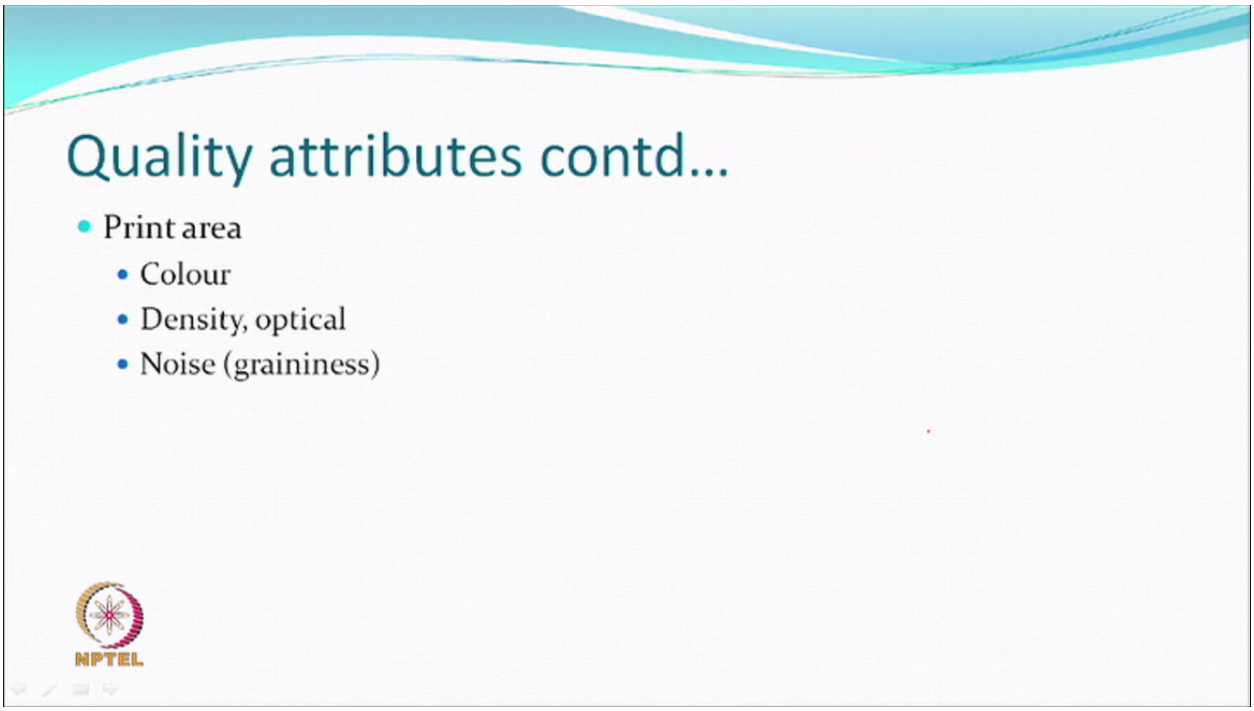


So sometimes you draw lines so they also have a that you actually draw a line and you see does it like a line. You see when your test prints which come when you do a first printing you have changed the ink in a cartridge, cartridge you have changed and exit printer then the first thing you just give a command and then you see all the lines sometimes you know the test print comes the lines are there, the bars are there the thick thin different colors just to say well if it looks as if as it is when we thought it should look then it must be okay. So one is the drop size and center there that is the line itself you draw a line does the line width is exactly same as you wanted? It's very easy on a computer screen to do that this is the width I want but when it gets printed is it the same? Is the sharpness same? Particularly the edges do they appear really clean or they don't appear clean. The density, the optical density was supposed to be very black it is not really so black. So does that matter? So people will like to measure these also. Let me just check whether whatever you are doing is same or not. So what I am only saying that you are making the life of a people who are making ink and who want to print more difficult because these systems are meant initially for paper. Paper was relatively a very different thing and if you remember that the photographic paper is still very different than a normal paper. So when I say I want to photograph then you have photographic paper which has been really properly coated with making a uniform surface everywhere.

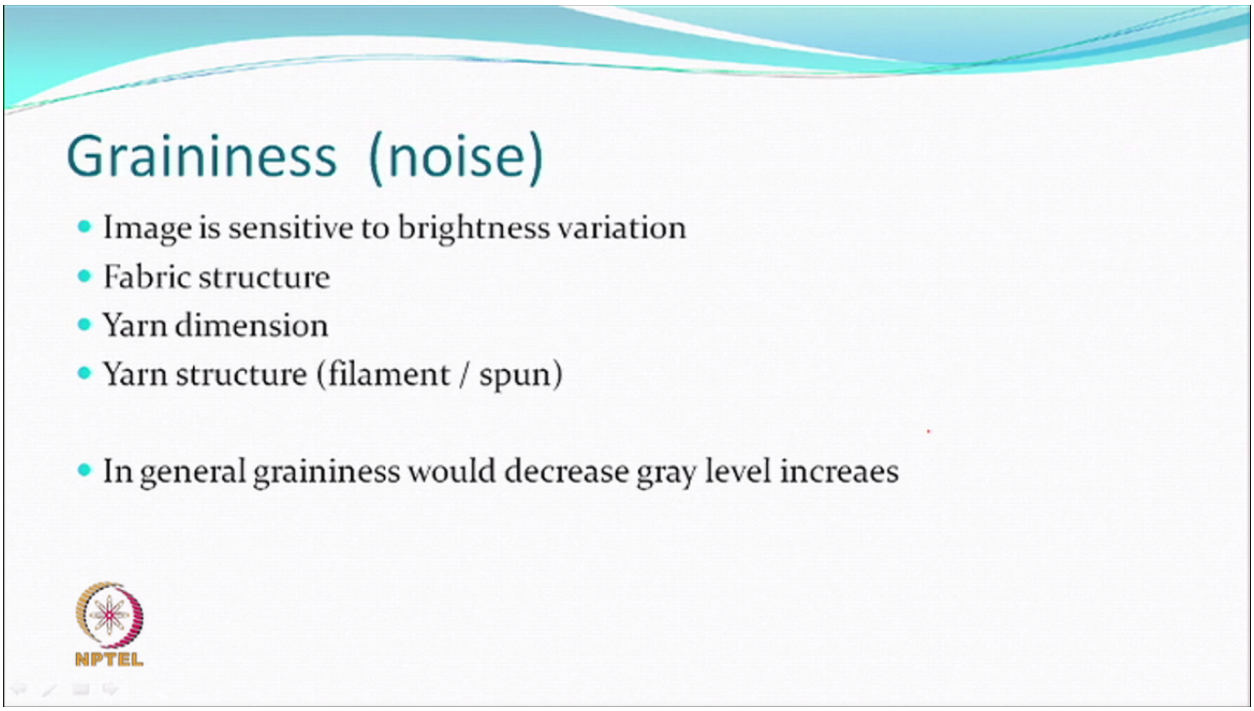


So just the paper itself is not good enough if you take the same photograph on a normal paper versus a photographic paper the impression is different and so now we are looking at a textile which obviously has got all kinds of surfaces and you want that. You don't want a textile to be like a film and within that you are supposed to do this as well. So this line width depending upon the condition like a fabric structure people have studied this also. There is a plain V, or a 12 V or a inter fabric the same intended thickness is not the same intended thickness and so you like to do the assessment or you tell the people look your fabric is different. It will not be exactly same. If he accepts it it's good. So it will change.

So one should know that will change. You can't say that nothing will happen. So some assessment will have to be made. The solvent as we say co-solvent other things have been generally added and things like that. So if you have a hydrophobic and hydrophilic solvent ratios in the ink. Let's say the water and alcohol so alcohol we can consider the hydrophobic. The line width is less or less change shall we put it if it's a hydrophobic portion is more or the hydrophobic fiber is more. So we're spreading it doesn't take place so much. So wherever there is a possibility of spread then these lines changes. So you will say quality of the image has changed. This is not the same quality. So they would measure actual requested width of the line versus the requested width versus the actual width of the line and they will draw a curve and see is it linear non-linear what is it different. It may be linear but you may have wanted one value and you may get a different value.

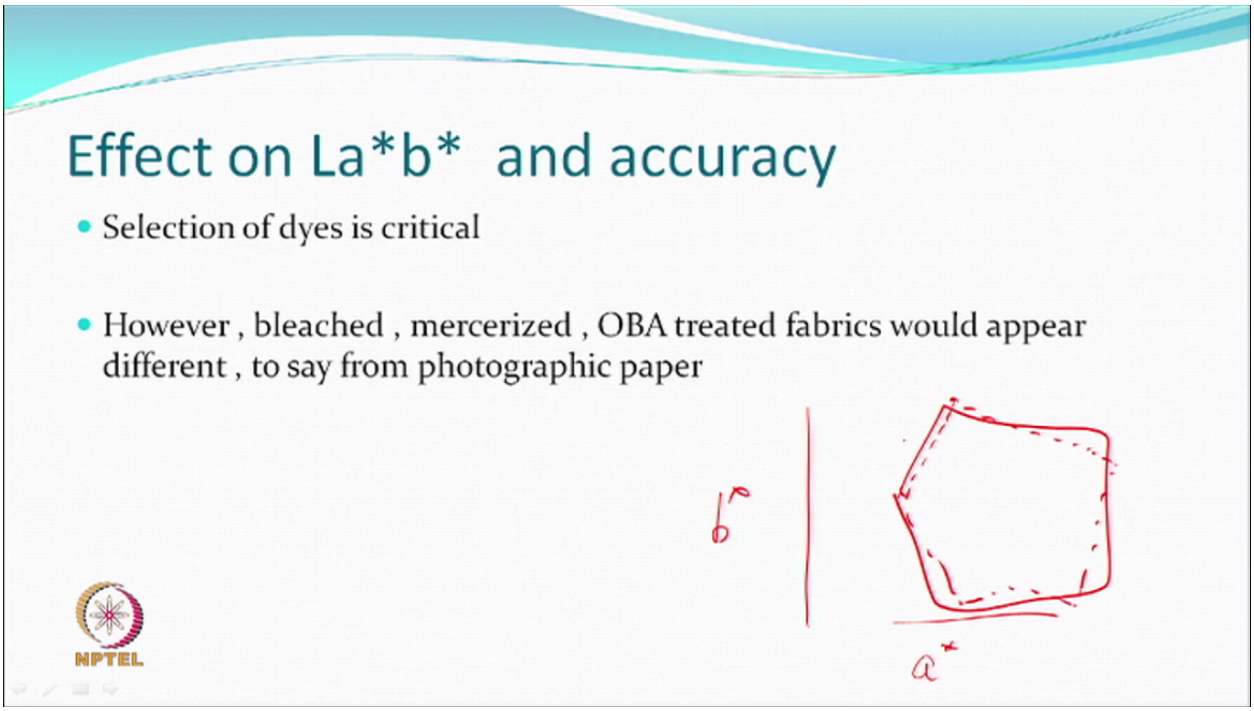


So printed area so you have people look at the color. So you wanted a magenta to appear. Is it magenta is appearing or not. So this is omething do more with do with the choice of the dye which obviously they would have taken care but it's quite possible that your fabric which is cotton and also must mercerized but after that some people have done OBA treatment on this to make it look whiter which actually means some blue component coming. So you're adding a blue component to the perception. So the whole picture may say as if the blue tint has been given on the picture like you have filter. So like your filter. So you have image. You can put a filter to get a CPI image you put a filter to give a blue image. So it might appear is something else has happened which is not exactly what was on the screen. Then density obviously is how much is on the surface how much have gone down. the noise is for various reasons based on what is the depth of color or the lightness color or a grayness of the color, the graininess may appear which is not really considered. If you have a deep color the graininess may not appear. The lighter color or medium shade you might just see somewhere.

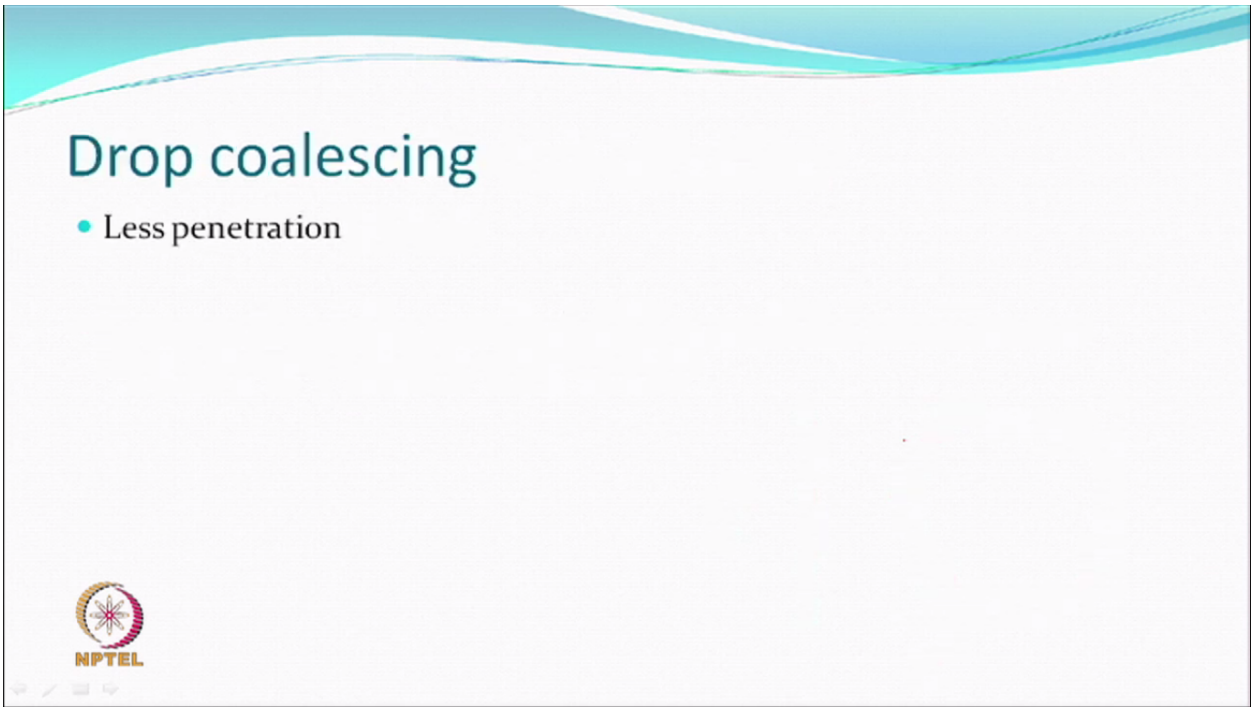


When you really see with more focus then you might find that there is some graininess. These are attributes as far as the print area is concerned. People may like to measure them. So but say graininess or a noise is because of the brightness variation. So brightness means what? Either the surface reflection or a scatter or it has something to do with as I said you put OBA, you do more bleaching, less bleaching, double bleaching, chemistry is same. You have done you're singeing also very well but still some of these things are inherent to the fabric. You see what happens is like a fabric structure is inherent to the fabric you have coated. After coating you've done fixed but then finally done washing also so this so-called uniform surface is gone out which is you are happy with it but then it is the same surface. The dye is somewhere on the top of the yarn, then the side of the yarn. So this impression cannot be same as a flat surface. So this could be so people had look at fabric structure as we said the plane, the twill setting which is shines anyway or a knitted fabric which is relatively whatever dull would not give you the same effect. It will be different. Then the yarn dimension, the denier particularly very-very fine versus the relative coarser will also give you something else which may give you noise. The yarn structure spun or filament and within spun also you have different kind of spun yarns. They can also make a difference. So people studied these also and found that they will definitely have an impact which may appear to be common sense but then you have to convince your customer.

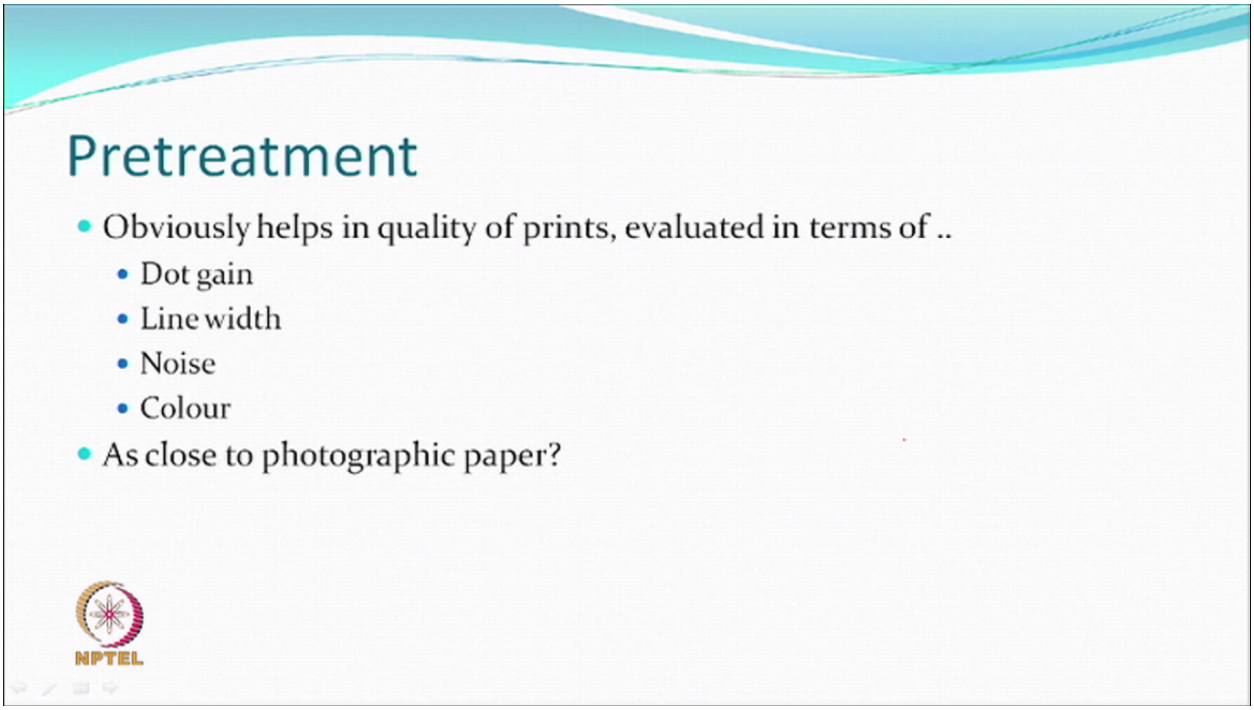
So gray level also has some role to play and the graininess or a noise of a design and quality.



So LAB value we expect it to be exactly same, they may not be. So here the selection of dye may be very critical and which people obviously do but then you change the surfaces you would not be able to get exactly same impression as on the screen or as you might get on a photographic paper if you have treated your fabric differently. So these are inherent things and that also is in a kind of an accuracy. So you make curves of a star versus b star and you make a gamut of one. The other with you wanted this maybe you get slightly different and if you get different then it's different.



You will still say it is acceptable but it is not same and this also happens if you have too much of a hydrophobic material drops have not been absorbed and if they are too near they may two of them may become one which will obviously give you a different kind of image. So these are possible errors which would happen despite all the good intentions.



So why do we do pretreatment? We do pretreatment to help improve the quality of the prints which is evaluated in terms of dot gain, line width, noise, color with an aim that to say we will do whatever you can do so that it comes very close to photographic paper it may not come but doesn't matter. Still it will be much much superior compared to any other method of printing as far the image quality is concerned because here you are actually trying to control every pixel. So you're better off then doing segments in square centimeters.

So that's all we will work today. so what we have understood is that the aqueous inks have their own issues as far as design and quality is concerned and all the systems that have been developed have their own advantages and disadvantages and the efforts are obviously being made to make sure that these errors are as less as possible and this remains a challenge which we cannot say with confidence that we have been able to meet all the challenges.