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**Theory and Practice of  
Non Destructive Testing**

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**PENETRANT TESTING –PART 2**

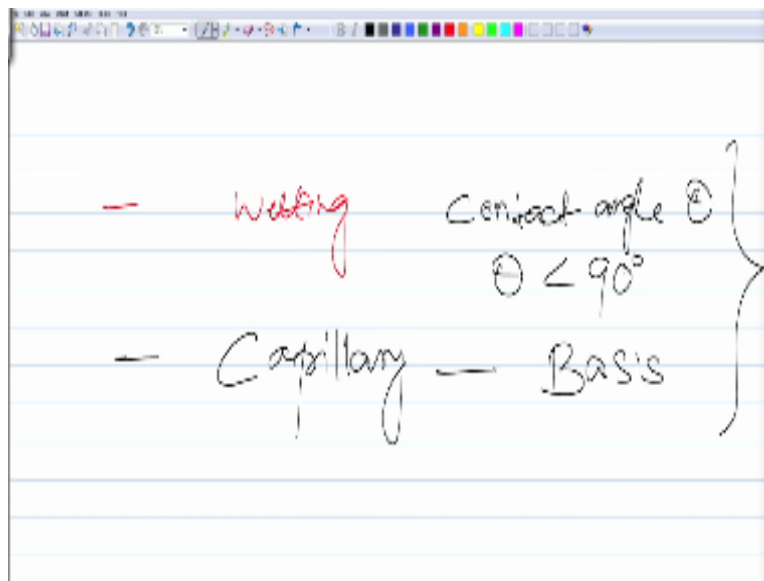
Hello we'll come back to this lecture series on NDT this is the third lecture in the last class we just started our first topic on entity which was on dye penetrant testing and in that we discussed about the basic principle of this particular method and then we saw what is the basis for this particular technique okay so we will quickly take a recap of last class what you did and then we will proceed okay but before that at this point in time.

I should tell you that these penetrant testing is one of the earliest methods to be used as an entity technique okay, and it was perhaps used for the first time by the railways for inspecting their rails and fields okay, so what they used to do at that point in time for inspecting their fields they used to take some kind of oil in a big tank in which they can immerse their wheels so they will immerse the wheel in that tank which contains the oil and allow sometime to soak it and then after some time.

They will take it out and after that they will apply chalk dust on the surface after soaking it in the oil chalk dust either dry chalk dust or some kind of suspension of chalk dust in some volatile liquid okay, so this chalk dust what it will do if there is any crack or any such discontinuity it will soak out or it will suck out the liquid from the cracks and it will make some kind of visible indications so in this form the railways used to apply this particular technique for inspecting their rails.

And wheels to find out any defect okay, so over the years it has been influenced and today we have in the current form okay, and that is what we have been talking about in the last class and in today's class also we are going to continue on that okay, so let's take a quick recap as to what we learned.

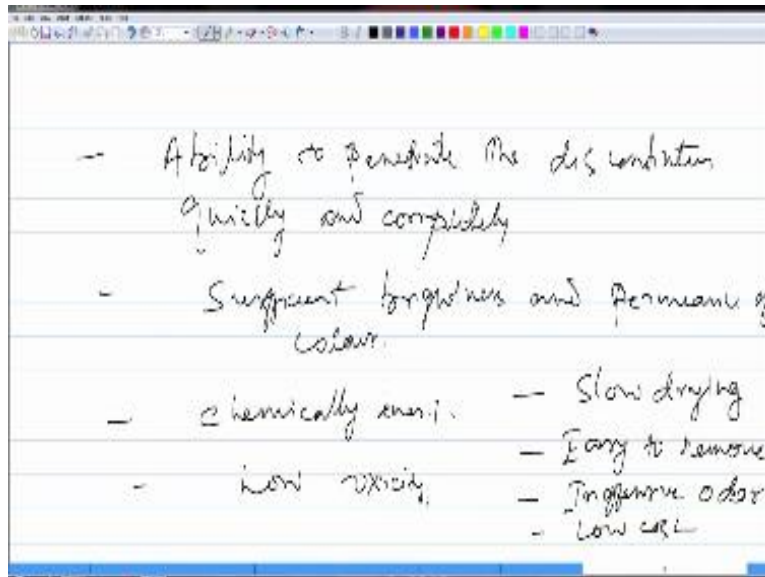
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In the last class so what I said for this particular method is that first you need to have wetting okay, so you are you are having this liquid dye you are applying on a solid surface so it should spread over the surface and wet the surface so that is the first requirement okay, and for this the main parameter which controls this is the contact angle  $\theta$  and for wetting to happen  $\theta$  should be less than 90 degree okay this is what we saw now the next thing.

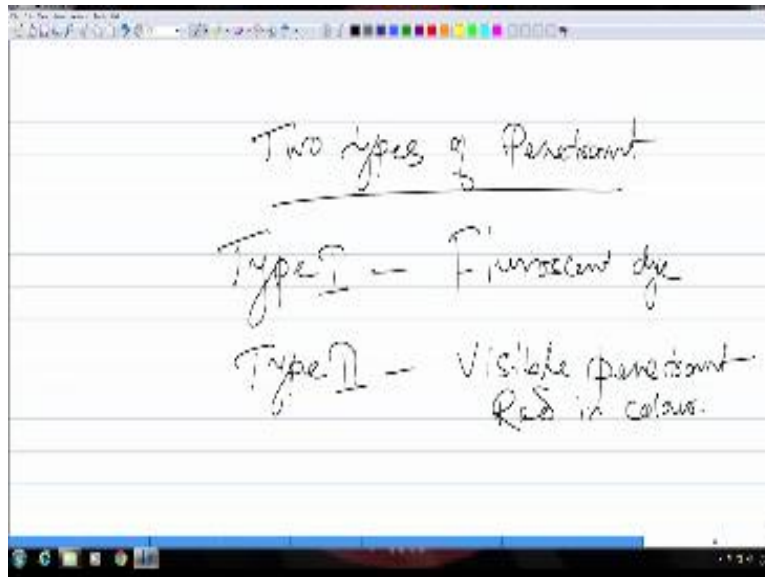
We saw was the basis or the driving force behind penetrant testing is this capillary which is developed due to the surface energy or surface tension of the liquid okay, so this is the basis for this particular method of dye penetrant testing or this is the main driving force the capillary is the main driving force behind dye penetrant testing so this is what we saw in the last class okay, so let us continue on this and I have also talked about the kind of liquid which is used that is the properties.

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Of the dye which can be used as a liquid penetrant in this case so these are the typical properties that you need in a dye for it to be used as a penetrant in dye penetrant testing okay.

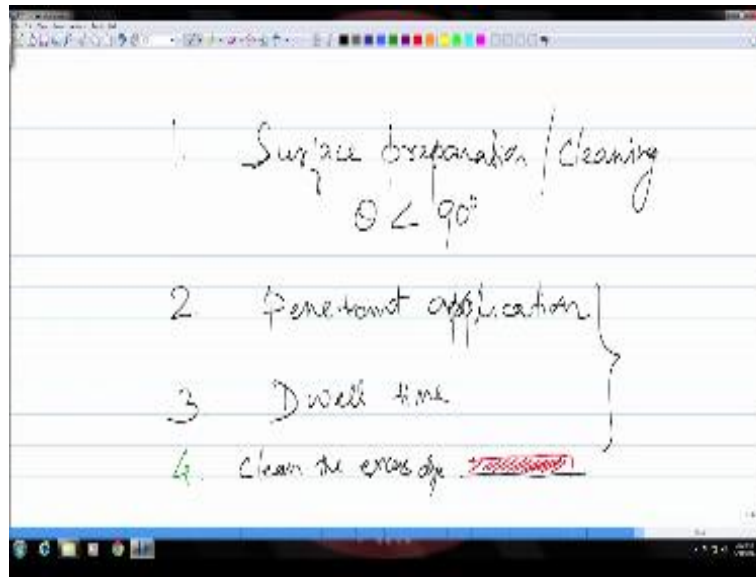
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So continuing on that there are two types of dye's the first one is type 1 so it is just these are just known as type 1 and type2 okay, type 2 is the normal visible dye which is normally red in color and this is what most of the time we use and type 1 is sometime used based on the requirement this is a fluorescent dye so sometime you may want to use a fluorescent dye but in that case you need to do the final inspection under UV light in a dark room in which case.

This fluorescent dye will fluoresce and if there are any cracks or defects they will make visible indication and they will also glow because you are using a fluorescent dye okay, so sometimes this kind of fluorescent dye is also used so these are the two different types of penetrant which are in use most commonly used as I said is the visible red colored I now coming back to this method if you see the different step.

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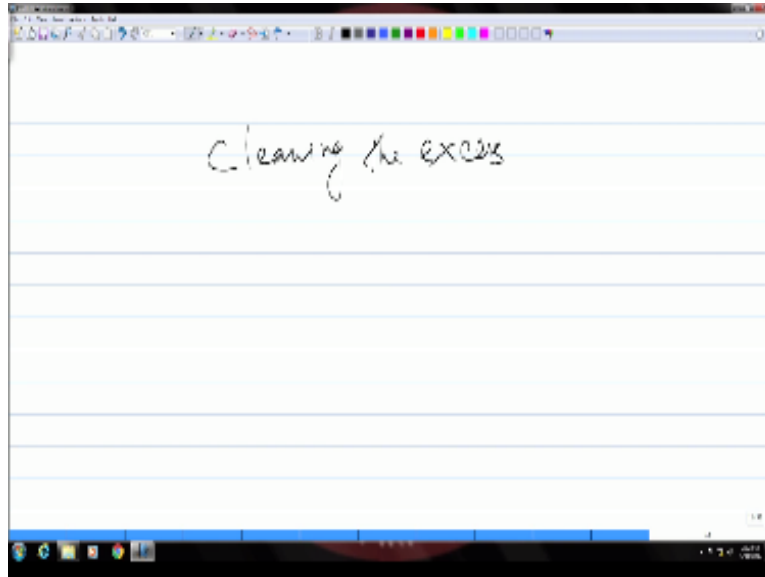
The first one as I have already mentioned in the last class is such surface preparation or surface cleaning and this is to ensure that  $\theta$  is less than 90 degree as I would have said before also so you clean the surface remove all the grease oil dust or any scale which might have found on the surface and keep it clean so that it provides a contact angle which is less than 90 degree and in that case the liquid will nicely spread over the surface second is penetrant application.

So you apply the penetrant after the surface is cleaned okay, and this we have talked about in the last class and then third is dwell time so you have to allow some time for the liquid to go inside the floss if there are any and this dwell time will depend on the part size or the kind of floss you have the size of the floss and so on so you have to allow some time for the liquid to go inside the floss.

Now once you have done this too okay, so now you have a part the surface of which is completely covered by a red color liquid okay, so this red dye is now all over the place and if there are flaws it might have gone inside the floss also but now the surface will look red because the dye has spread over the surface ok so that means at this point you cannot start the inspection

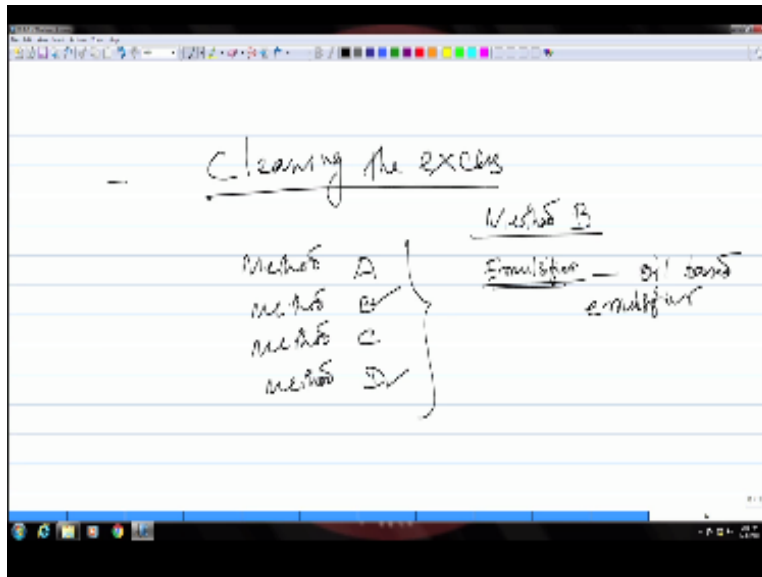
unless you clean the excess dye which is spread over the surface ok that means the next step would be to clean the excess dye.

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And this may be bit tricky because you need to ensure that you clean the surface in fact the surface should go back to the condition as it was in the beginning so it should go back to the initial condition as it was okay, but at the same time you need to ensure that if there are any flaws and if the liquid has gone inside those flaws you have to be careful not to remove the liquid dye from the defense okay, so you need to first make sure that the surface is totally clean as it was but at the same time you need to ensure that the dye which is their inside the flaws is not removed okay ,so that is why it could be tricky and you should do it carefully.

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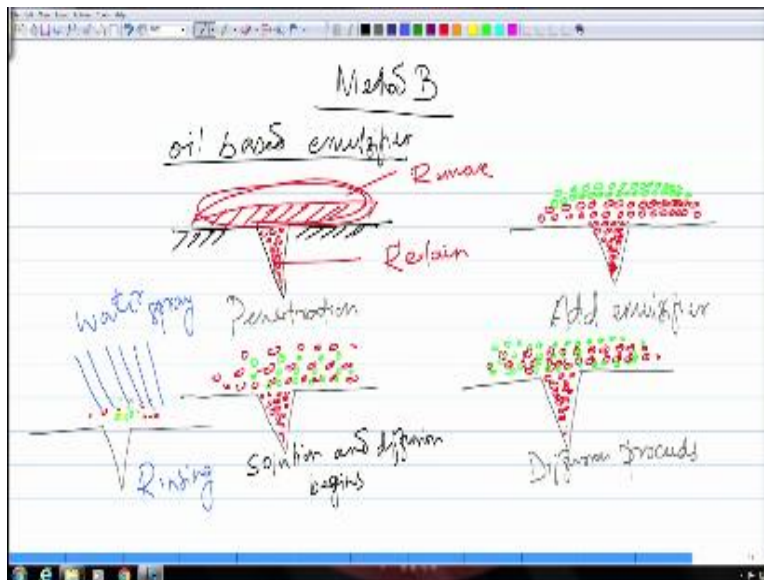
And that is why a particular process is recommended for this that you need to follow a particular method to clean the excess time okay, and these methods are given some names like in terms of four letters method A method B method see and method D so these are the four methods of cleaning the excess dye and these methods are well established and you need to follow them with as I told you this could be tricky and you need to take care you need to do it carefully.

So let us have a look what these methods are and how they are done first we will pick this too because this involves something and you know a particular mechanism so in cleaning the dye if it is already not water washable and that could be the case many times that the dye itself is not what are washable so you need to render this die you need to make this dye water washable so that you could easily clean it by a water rinse okay.

So you can rinse it with water you can apply water spray carefully and you can clean the entire surface okay so the purpose of following this method B or method D is to make the dye water washable so that it can be removed by washing okay so in that case you need to use an emulsifier which will emulsify the dye as it gets mixed with the dye and once it is emulsified then it can Be easily removed by water so it becomes water washable.

Once it is emulsified okay, so in case of method B this is an oil-based emulsifier and let us see how does it work when you apply this emulsifier on the surface which is completely covered by the dye so it works by a particular mechanism okay, so let us see that.

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So this uses an oil-based emulsifier okay so this is how let us say there is a crack like this okay and this is your solid surface so once you apply the dye so it will spread over the surface the liquid dye and it will also go inside the crack due to the capillary force as we have already discussed so what I said you need to ensure that this particular part which is on the surface okay this has to be removed and the dye which is inside the flaws that has to be retained and that is where you need to be careful so this is in the beginning.

Where the entire surface is covered by the liquid dye and now we are taking the help of an emulsifier to make it water washable and then you are going to clean it with the water spray so let us say now we have applied this emulsifier also okay so let us say these are the dye molecules we will indicate them by red color okay and now you have used an oil-based emulsifier so we will indicate them the molecules of the MLC phi by a different color.



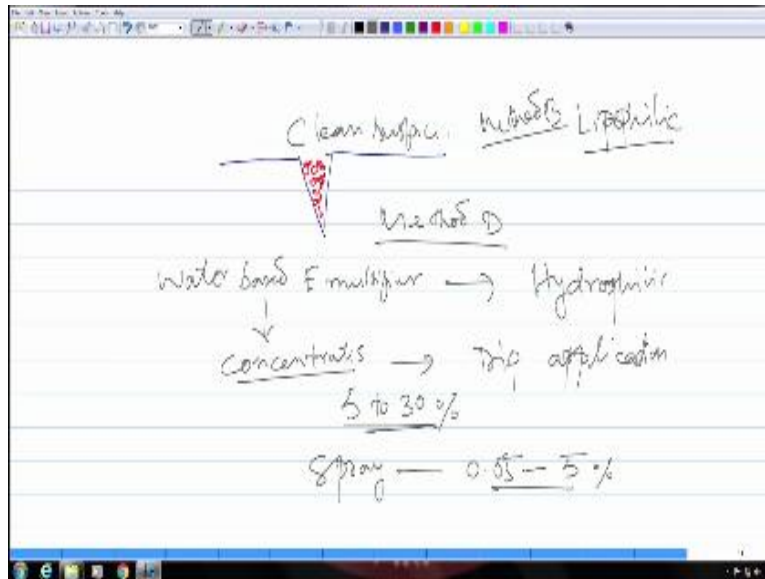
So let us say this green color is the emulsifier so you have applied it on the surface so if you see the steps in this case the cleaning step so the first one is this is die penetration the die has gone penetrated inside the flaw then you add the emulsifier and then allow the emulsifier to act okay, so let us see what happens after that after you apply the emulsifier so in case of an oil-based emulsifier which is method be the emulsifier is going to diffuse and get mixed with the dye okay, so that means in between this dye molecules now you have these emulsifier molecules also so they are diffusing into the dye molecules and getting mixed okay.

So that means once we apply that the solution of the emulsifier with the dye begins the solution and diffusion begins at this step so this will continue further because finally as I said you need to make this dye emulsify able you have dye emulsify it and then you can wash it by water so this will continue so the diffusion will proceed as you allow some more time so that means more and more emulsifier molecules will be makes take the dye molecules.

But remember all that should happen on the surface but not inside the floss so you have more and more emulsifier molecules being mixed with the dye molecules, so this will call as diffusion proceeds okay and then once there is enough mixing between this emulsifier and the die then the dye itself will be emulsifier and then at that point in time it becomes water washable okay, so then next you need to wash it with water so you can apply water spray and arrange it.

So now that everything is mixed okay so what you do you now rinse it with water so that you can do by using a water spray or a water gun because now at this point in time the dye has become water possible because it is emulsified okay and once you do this after this particular step of rinsing with water your surface should look exactly how it was in the beginning okay.

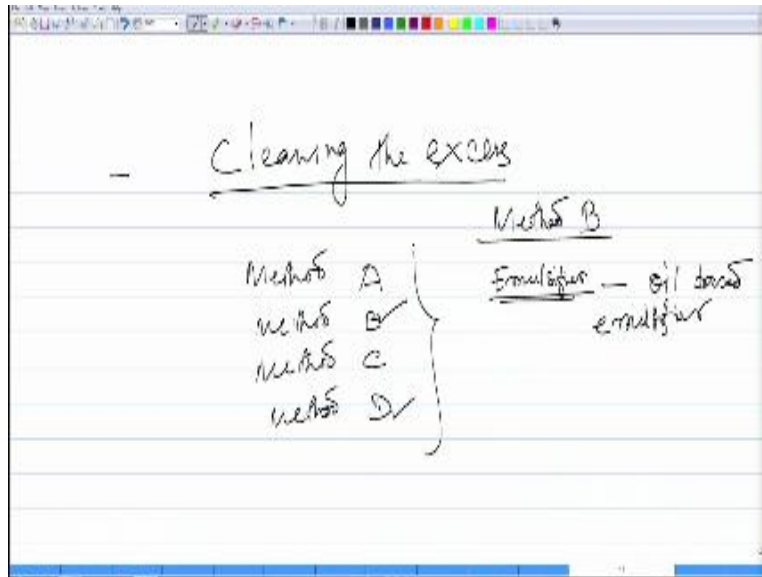
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So that means it should on the surface of course it should look like this that means the surface would be free of any dye and it should look as clean as it was in the beginning but the dye would still be inside the flaws otherwise your purpose is lost okay that is why it could be tricky as I told okay. So this is how it should look like at the end of the cleaning process at the end of the cleaning the excess type okay, so the dye is there inside the flaws but the surface looks clean.

So that means at this point in time you do not see anything so that means if you go back to the steps that we have.

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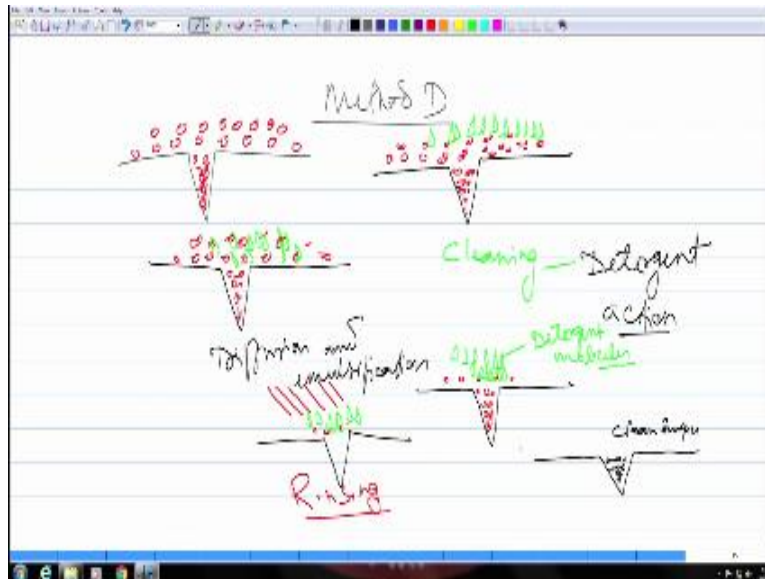


Okay fine but before that let us talk about the other methods also so we just now talked about method B wherein you use an oil-based emulsifier to emulsify that died the excess dye and clean it and in case of method d so this is the last step of cleaning my method B so you should have a clean surface now let us have a look at the method d so in case of method d the emulsifier that you have these water-based okay.

So that means this can be called as a hydrophilic and in case of method B we saw that it is oil-based so that is why that is called lipophilic okay, so this water based emulsifier it comes has a concentrate so you need to evaluate it so you could depending on how you are applying it so this comes as concentrates if you are applying it by dipping the part so the part which is covered by the excess dye you can take it and dip it inside this emulsifier.

So in that case you need to use 5 to 30% of this concentrate so you need to evaluate it up to that extent and if you are using it by spray then you can take this in the range of 0.5 to 5%, so this is the this is how it is used and let us see once you use it what happens like what we saw in case of method B.

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So there again in the beginning you have the surface is covered entirely by the dye and it is there inside the defect also, okay then you apply the now you apply the emulsifier so we will again indicate that with a different color so let us say these are the emulsifier molecules which now you are applied on the surface okay, so here also the emulsification will begin so as you apply the emulsifier and allow some time or apply some more then this emulsification will begin okay.

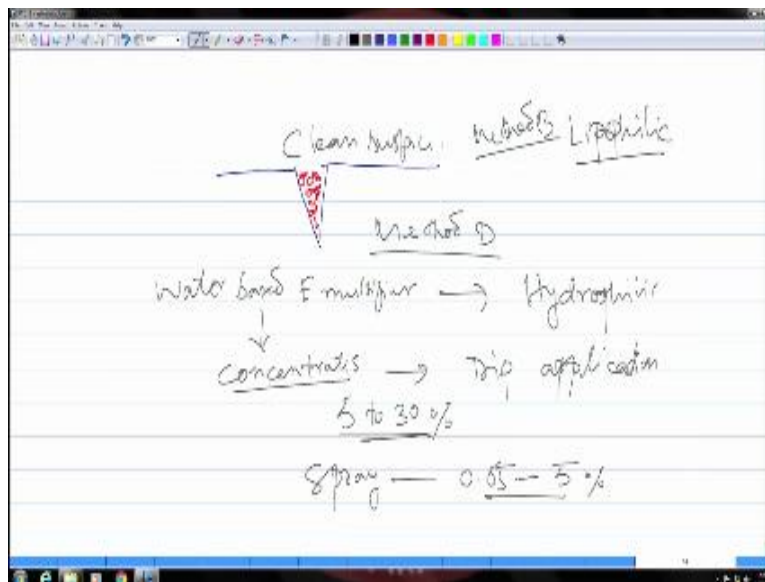
But in this case there is no not really like what you saw in case of method d it was complete mixing between the dye and the emulsifier and then it becomes water washable or thud it is emulsified but in this case the cleaning happens by a detergent like acts like how a detergent remove dark particles from a piece of cloth so here also the action is similar okay because it is a water-based emulsifier so once you let this emulsification happen then it will act like a detergent and clean the surface in the surface and remove the excess dye.

So that means as you proceed you will have legs of dye molecules on the surface as these dye molecules are being removed by these detergent molecules are the emulsifier molecules so this will act by a detergent kind of action okay, so once this happens then now you can use a water

ins to clean the entire surface by like what we did in case of method B so now at this point in time this is suitable for using a water spray and then clean the surface.

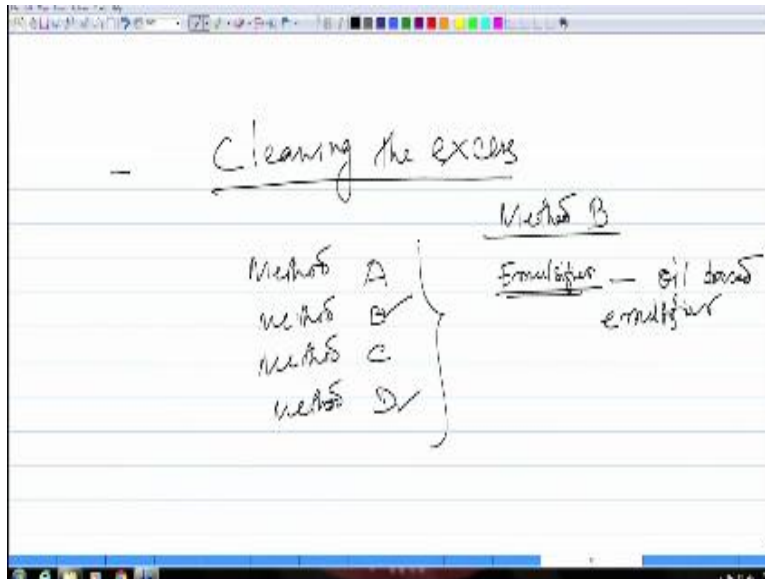
So you know there are few emulsifier and then the dye is emulsified so now we can use a water rinsing to clean the surface okay and at the end of it like the previous case again it should go back to the initial condition so you should have a clean surface okay. And your dye would remain only inside only inside the floss so you still have the dye inside the flaw but the surface should be entirely clean like how it was okay, so these are the two methods wherein you need to use an external emulsifier to make the dye water washable and then using a water spray you can clean the surface okay but there are other two methods also.

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So this is method B and D but if you see we have listed two other methods.

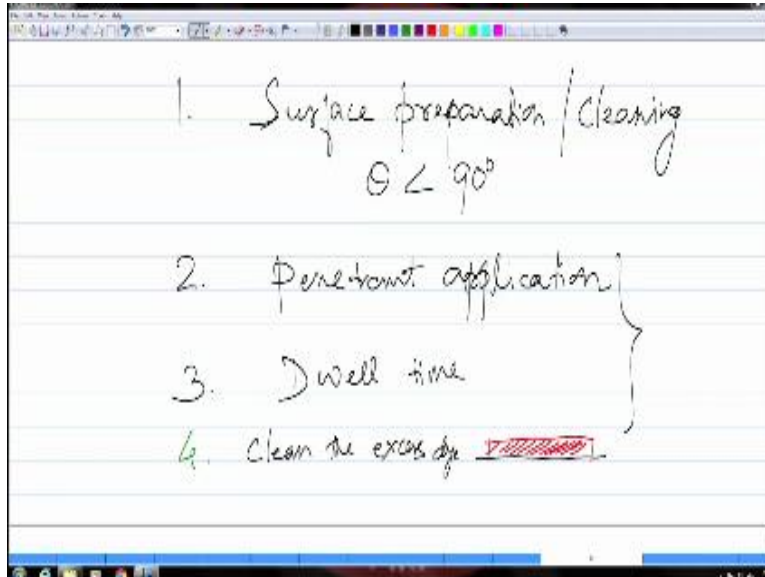
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Which are method a and method c method a and method c are the simplest ones in case of method a the dye itself is water washable that means this kind of dyes contain an inbuilt emulsifier okay so you can easily remove it by using water and method c is about using a solvent to remove the excess type so in this case what you do you take the solvent in a piece of cloth if it is a small part you can take it in a piece of cloth take the solvent on that and nicely rub it over the surface and cleaning it is bigger part.

You may want to use some other application process for example you can use a spray and things like that and then again you clean it with a cloth or things like that okay so these are the different methods of cleaning the excess dye because before you start the inspection the surface should look like as it was in the beginning okay.

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So this was the fourth step of the steps that we have in this process okay so for today I will stop here and then we will see after you clean the excess dye in the next class we will see how these indication is made I mean after this what is that you need to do to make visible indications of the floss by sucking out this dye which is inside the flask okay so that is what we are going to do in the next class for today this is all I have thank you for your attention.

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