Technical Textiles
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Lecture - 29
Ultraviolet Protective Textiles (contd…)

Hello everyone. So in UV protective textiles, we are now discussing different research studies, in last class we have discussed the effect of yarn twist and the yarn structure on UV protective performance of woven clothing woven fabric.

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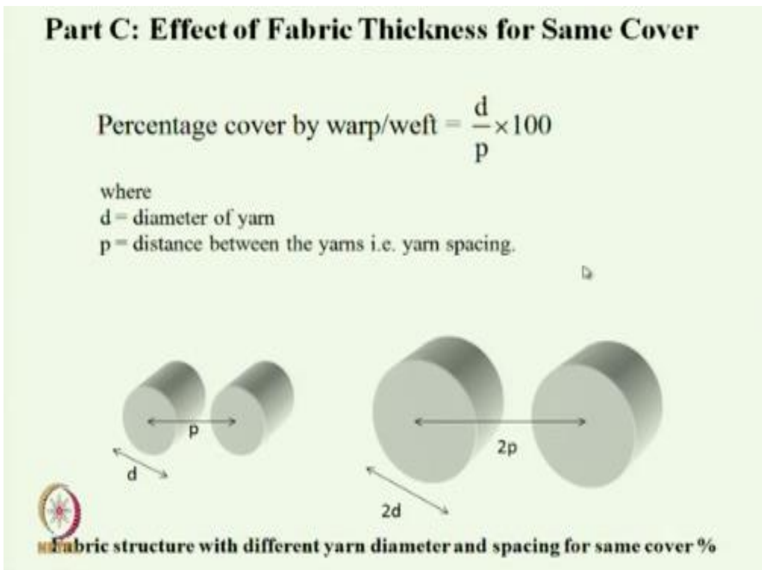

Today, we will discuss the effect of fabric thickness on UV protective textiles. Now, it has been reported that, both fabric thickness and fabric cover they affect the UPF of fabric. Here what we have tried to eliminate the effect of cover factor by keeping the cover same, only we have tried to reduce the thickness change the thickness and thickness change was obtained by changing the diameter of yarn, ok.

And percent cover we have kept constant and in the present study what we have done we have kept the warp density and warp count constant. So keeping the same warp cover what we have changed, the weft cover was changed. So d by p multiplied by 100 that it is the percent weft cover where d is the diameter of yarn and p is the distance between two yarns that is called yarn spacing.

So d by p is the total cover, if we see this portion it is a p and here it is a d. So p is the actual distance and covered distance is d by 2 and d by 2 cover distance is d, so percent cover will be d by p two types of yarns are produced if we see that finer yarn and it is a coarser yarn. So to keep the cover same for coarser yarn, we have to increase the distance, that is if it is 2d is the diameter is doubled then the spacing between yarn has to be doubled.

So that percent cover remains same but on the other hand what we will observe the thickness of fabric so if we with the simple calculation with the d yarn diameter fabric thickness will be typically 2d. If we see the simple theory it will be warp and weft diameter, so effectively fabric distance will be 2d here, the fabric this thickness will be 4d. So that is how keeping the same cover factor or percent cover the thickness of fabric can be changed.

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Experimental

Material: 100% cotton and 100% polyester yarn of 3 different counts.

Sample preparation: 3 fabric sets from both cotton and polyester yarns, keeping the cover % same

$$Fractional\ cover = \frac{d_1}{p_1} + \frac{d_2}{p_2} - \frac{d_1 d_2}{p_1 p_2}$$

$\frac{d_1}{p_1}$ = constant, d_2 and p_2 have been changed keeping $\frac{d_2}{p_2}$ = constant

Fixed parameter	Details
Weave	Plain
Warp count (Ne)	20
End density (inch^{-1})	50

And, if we measure the fractional cover which is given by d1 by p1, d2 by p2 - d1 d2 by p1 p2 where d1 by p1 they are constant, if we keep this constant and d2, p2 we have to change in a fashion that d2, p2 will also be constant keeping the d2, p2 constant, the fixed parameters warp count and ends density. So warp count in English count it is 20 and ends per inch was kept constant 50, so this is the fixed parameter.

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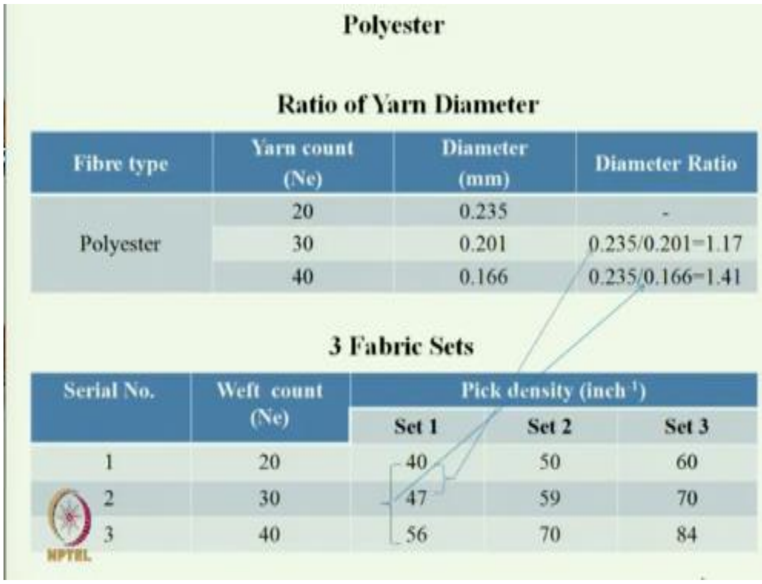

Polyester

Ratio of Yarn Diameter

Fibre type	Yarn count (Ne)	Diameter (mm)	Diameter Ratio
Polyester	20	0.235	-
	30	0.201	0.235/0.201=1.17
	40	0.166	0.235/0.166=1.41

3 Fabric Sets

Serial No.	Weft count (Ne)	Pick density (inch^{-1})		
		Set 1	Set 2	Set 3
1	20	40	50	60
2	30	47	59	70
3	40	56	70	84

We have developed two different yarns one is polyester and another is cotton. Now to keep the cover percent constant we have to adjust the pick density in such a fashion that d by p ratio remains constant. Now polyester yarn of three different linear densities were taken 20, 30, 40 English count and their diameters were measured. So 0.235, 0.201 and 0.166 respectively for 20s, 30s and 40s count.

Now for 20s count diameter is 0.235 with that the diameter ratio will be definitely 1 because we are measuring with the reference of 20s count. For 30s count the diameter ratio it is 1.17 that is the 20s count diameter is 1.17 times to that of 30s count and 20s count is diameter is 1.41 times of 40s count. So these are the diameter ratios and to keep this ratio constant and to keep the cover percent constant we have to keep the pick density ratio same.

For 20s count if we keep the pick density as 40 then for 30s count which is finer the pick density has to increase 1.17 times that is 40 multiplied by 1.17 it is coming out 47. Similarly for 40s count, which is finer in diameter to keep the same cover ratio so we have to multiply this 40 by 1.41 that is why we are getting 56, this is a set 1 means one set of cover factors average cover factors, this is the open structure with lower cover factor skipping the same cover factor here for different weft count.

Set 2 fabrics are with higher level of cover factors, but in set 2 the serial number 1, 2, 3 fabrics are having same cover ratio and the cover the pick densities were calculated based on the similar to the earlier that is 59 is a result of 50 multiplied by 1.17 and 50 multiplied by 1.41 it is 70. So similarly the higher level of cover was developed with the pick density 60, 70 and 80. But for this set 3, although the overall cover is higher than the set 2 but the cover percent within set 3 for these 3 fabrics are exactly same, so this is a cover ratio.

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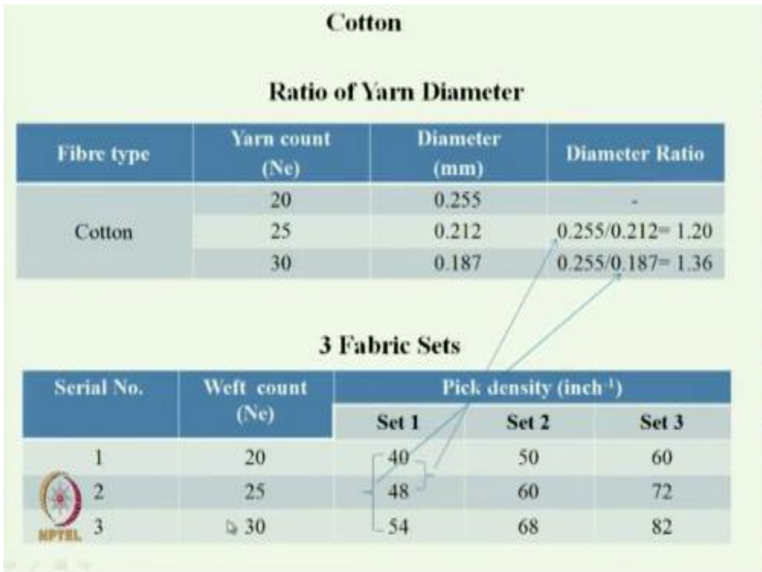

Cotton

Ratio of Yarn Diameter

Fibre type	Yarn count (Ne)	Diameter (mm)	Diameter Ratio
Cotton	20	0.255	-
	25	0.212	0.255/0.212= 1.20
	30	0.187	0.255/0.187= 1.36

3 Fabric Sets

Serial No.	Weft count (Ne)	Pick density (inch^{-1})		
		Set 1	Set 2	Set 3
1	20	40	50	60
2	25	48	60	72
3	30	54	68	82

Similarly for cotton yarn the pick densities were changed to 40, 48, 54 depending on the diameter ratio and set 2 with higher range of cover and the highest range is with the set 3 but within that within each set the cover ratios are same. Then what is the basically basic difference between this 3 within set 1, set 2, set 3? In set 1, set 2, set 3 here the in set within set 1 the serial 1, serial 2, serial 3 the difference here is that not by the cover, cover is same but the weft count.

So the weft yarn count is becoming finer, so effective thickness of the fabrics within set 1 will be different. So serial 1 will have the highest thickness in a set and serial 2, serial 3 will have least thickness. So we can see the effect of thickness for same cover.

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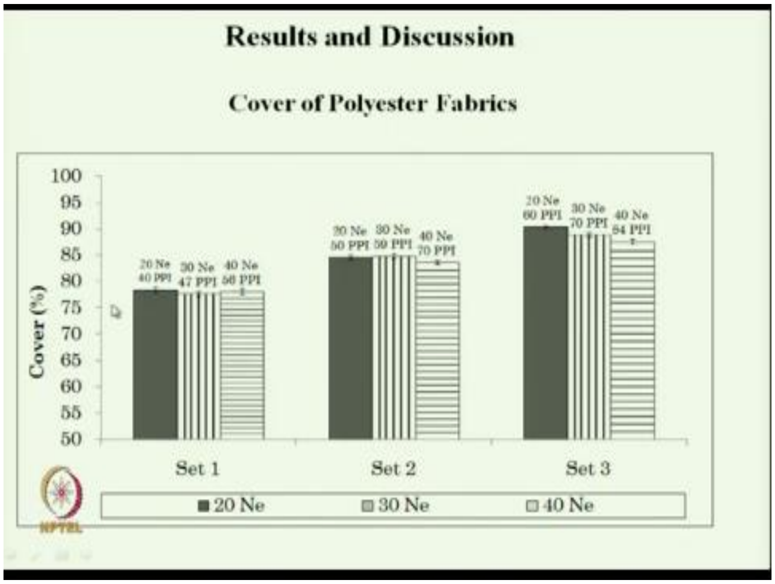

Now here set 1 with a least cover set 2 in a moderate cover and set 3 is higher cover, so this is actually we can see overall cover is increasing from set 1, set 2, set 3 but within the same set the cover is almost constant, that is what we have created there is no specific trend. So cover factor is constant for these 3 sets within the fabrics.

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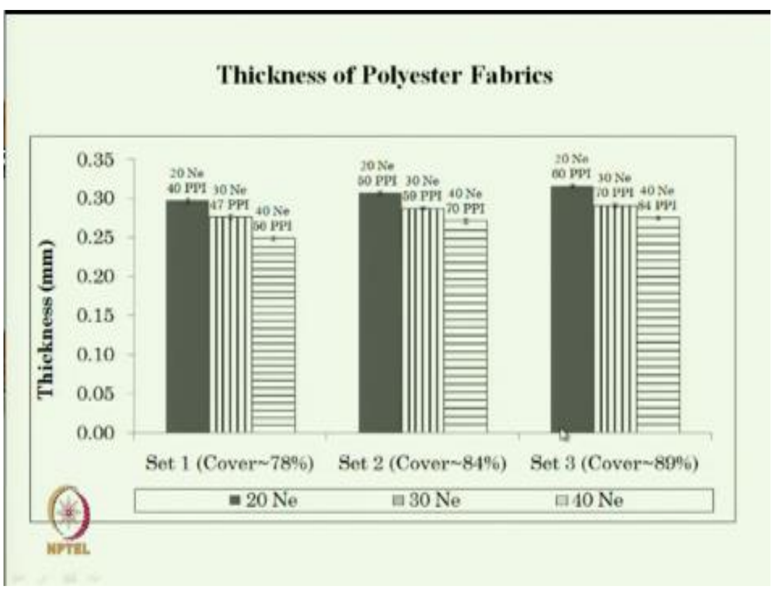

And what was tried the thickness is reduced with 20s count, 30s count and 40s count. So for polyester here thickness is low same cover factor for set same set here also thickness is reducing. So the fabrics within a set is having same cover but different thickness.

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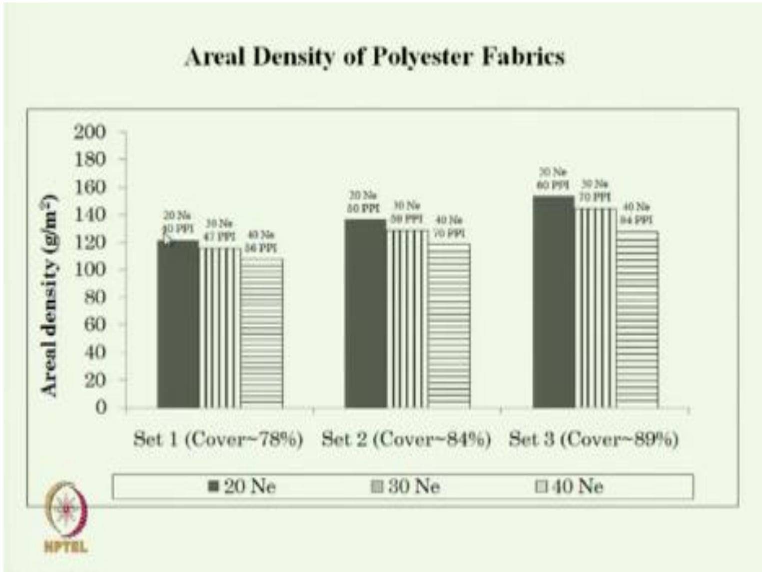

Areal density is observed to be little bit reduced here but with the increase in cover factor, they areal density is increasing but for with the reduction in thickness also areal density reduces to some extent.

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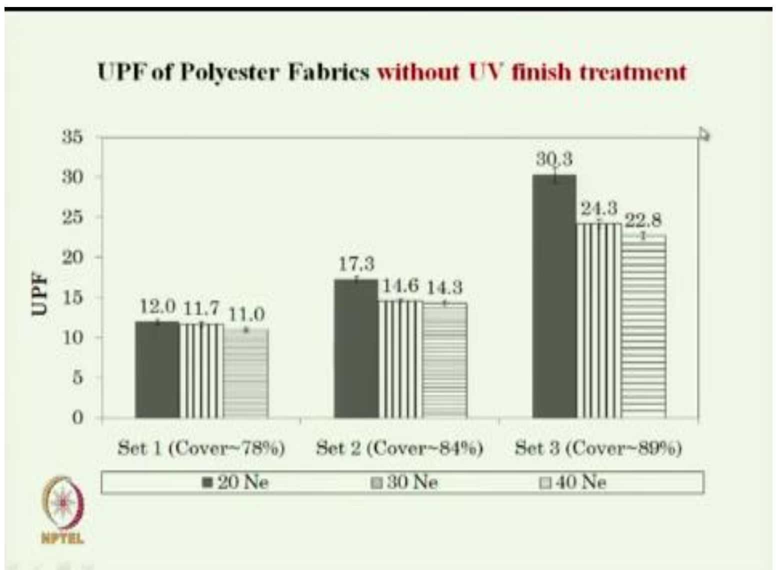

Now coming to the UV protective performance, UPF, here in polyester fabric if we see the cover percent at lower cover percent the UPF changes is not that significant for same cover percent the effect of thickness at lower level of cover it is not that significant, but at higher level of cover when the fabrics are more compact in that case the effect of thickness is visible here little bit, but with the increase in cover factor.

So 78%, 84% and 89% overall UPF increases gradually. So overall cover factor if we increase the fabric UPF increases, but for a keeping same cover the reduction in thickness also reduces the UPF value and this is evident at higher cover level and this is without UV finish treatment.

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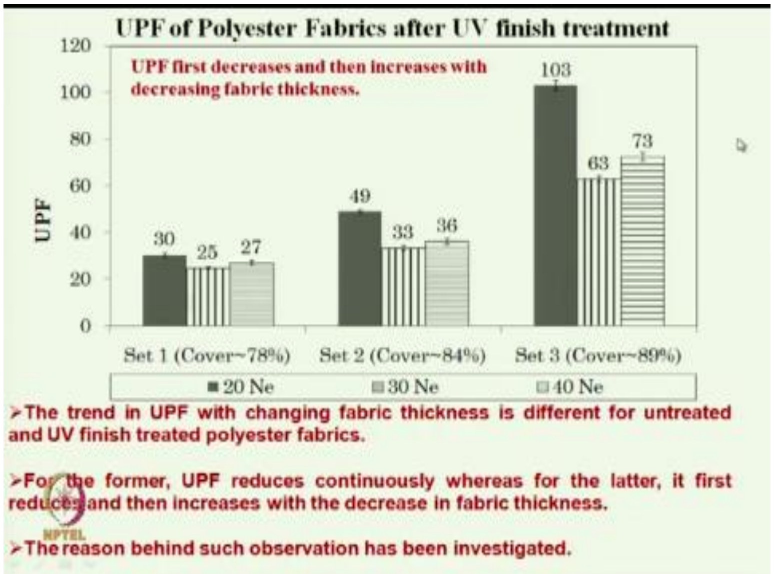

On polyester after UV finished treatment, so when we treat the fabric with UV finish the total behavior changes. UPF it has been observed for all the fabrics first decreases then increase with the decreasing fabric thickness, so first decreases then increases. So as the fabric thickness decreases the UPF first decrease then increase. The trend in UPF with change in fabric thickness is different for untreated and UV finish treated polyester fabric that we have observed.

The untreated case that is the former case UPF reduces continuously for the later it first reduces and then increases with the decreasing fabric thickness. So this reason we had investigated further. This is not any simple trend so there must be some other reason.

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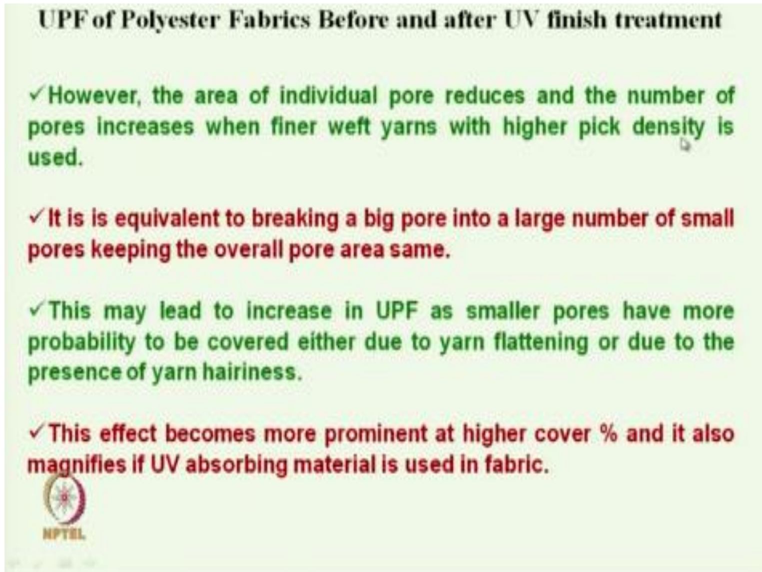

UPF of polyester fabric before and after treatment when we study the area of individual pore reduces and the number of pores increases when the finer wefts were used with higher pick density. So here what we have done effectively.

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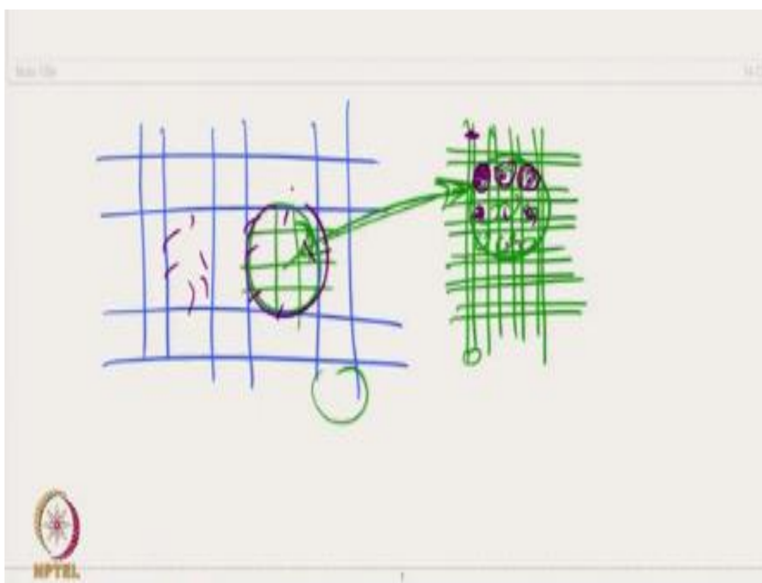

Effectively we have done we used coarser yarn with open structure and finer yarn with closure structure and to keep the effective cover that we have changed the pick density. So this effectively means one larger pore has been divided into many smaller pores because cover effective cover percents are same, just to change the yarn count, yarn linear density from thicker to thinner.

What we have done we have divided the larger pore to a many smaller pores that is what we have done this is that means, it is not only the thickness change here and keeping the pores constant, what we have done we have broken the big pores into large number of small pores keeping the overall pore area same and this may lead to increase in UPF, as smaller pores have more probability to be covered either due to yarn flattening or due to the presence of hairs.

So here if we see the hairs present but during the process the smaller pores will have higher probability to be covered further due to flattening of yarn and presence of this hairs, but larger pores will remain open. So this will lead to increase in UPF as smaller pores have more probability to be covered either due to yarn flattening or due to presence of yarn hairiness and this effect becomes more prominent at higher cover percent and it also magnifies if the UV absorbing materials are used. That we have seen here.

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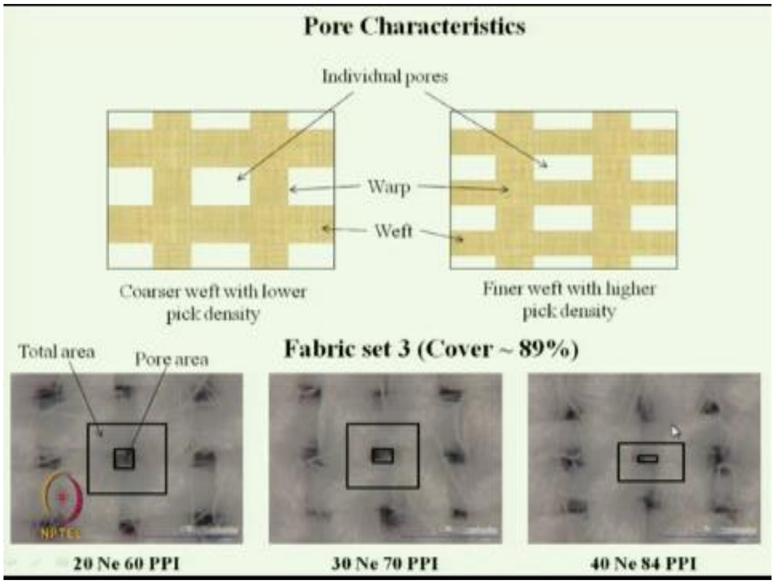

This is a larger pore and these pores with higher pick density, this is pore this one pore is actually divided into many pores. Total area fabric set with 89% cover factor. This is 20 Ne with 60 PPI, 30 Ne with 70 PPI, and 40 Ne with 84 PPI. So here pore size less number of pores, but pore sizes are higher here more number of pores with a smaller pore size, so here we can see the chances of flattening and covering of pores are more due to flattening and the hairs are covering the pores. So in this case, we will get more UPF value than the earlier.

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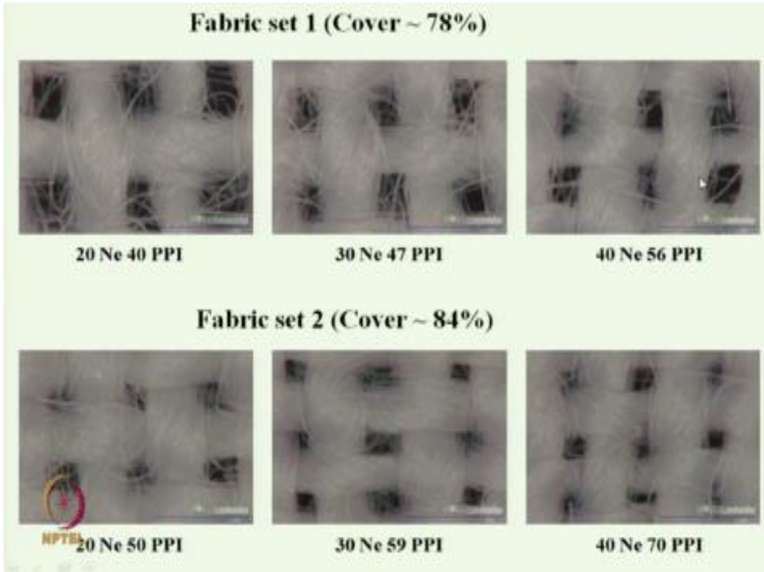

You can see here 20, 30, 40 and covering is probability of covering here is more similarly to fabric set cover with 84%.

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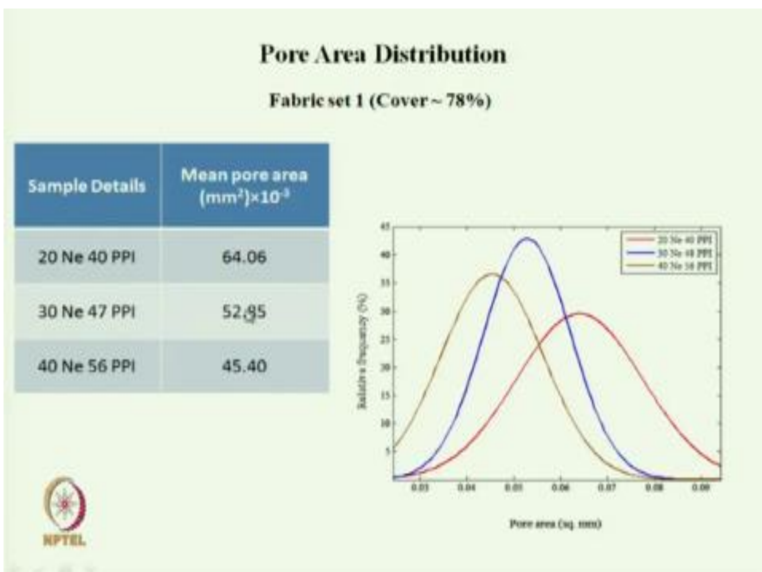

These are the mean pore area 64, 52 and 45 square millimeter multiplied by 10 to the power – 3, this much that means the 0.045 square millimeter.

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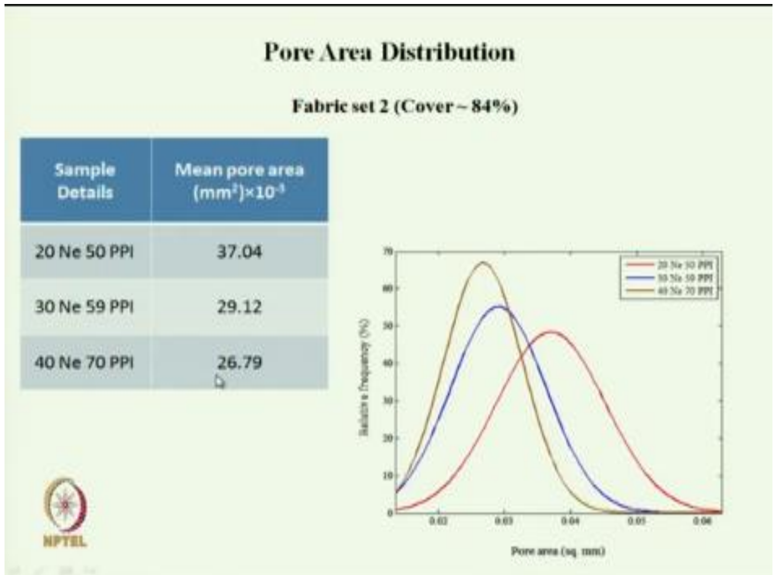

Similarly for set 2, 84% cover it was from 45 to 64 here 26 to 37. Now it is further reduced at the higher cover its 17 to 18 at that zone it is there.

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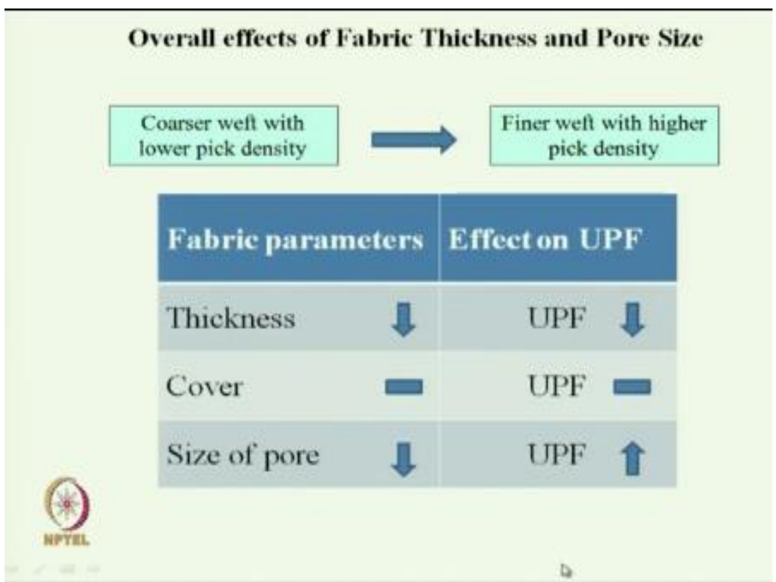

So as the fabric thickness reduces we have observed that UPF also reduces fabric cover was kept constant, as size of pore reduces the UPF increases. So that is why the pore size is also important along with the thickness, so if we try to reduce thickness keeping the cover constant we are at the same time reducing the fabric pore size. So these two effects here reduction in thickness and reduction in pores they are working in opposite fashion.

So as we are trying to reduce the thickness we are reducing the pore size so they are affecting in opposite direction that is why initially there will be one impact which will reduce the UPF then after that the pore size will come into picture and the application of UV finish will enhance this effect.

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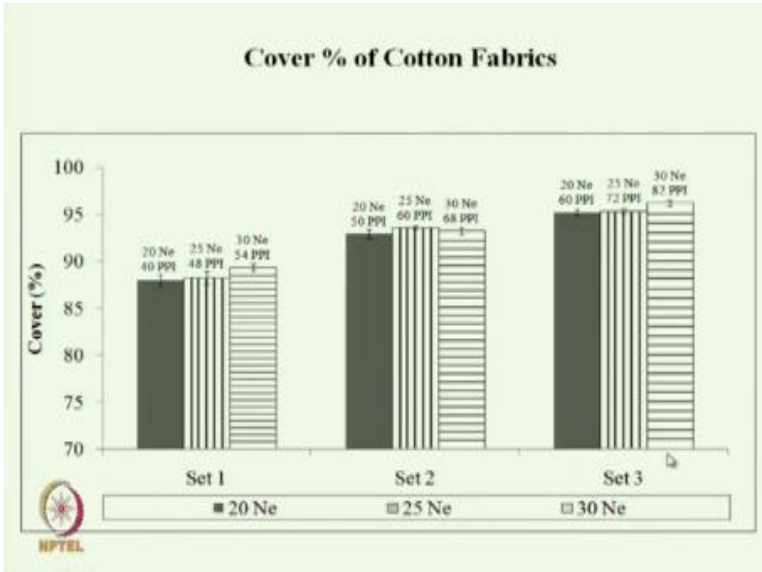

Now as far as cotton fabrics are concerned for set 1 as we increase the PPI, so there is no effect on the cover because we have tried to keep the cover percent constant. But with the increase in picks per unit length PPI, the overall cover has increased this is set1, set2, set3 that is why cover overall cover is increasing.

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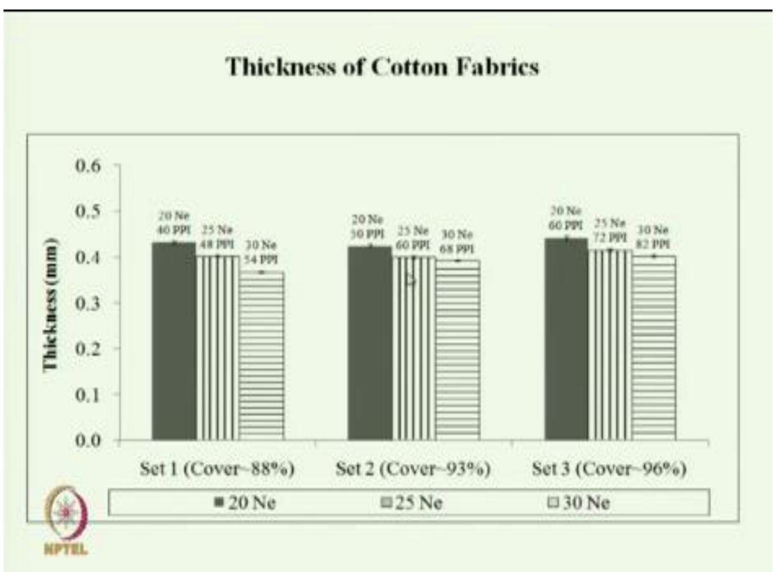

And thickness was absorbed its reducing that is what we have tried to reduce the thickness of fabric by changing the yarn count.

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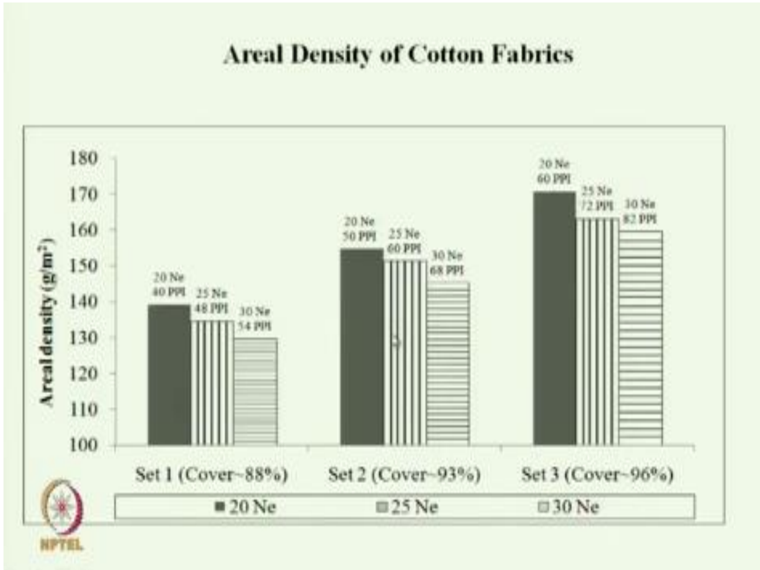

And areal density is also reduced here along with the thickness.

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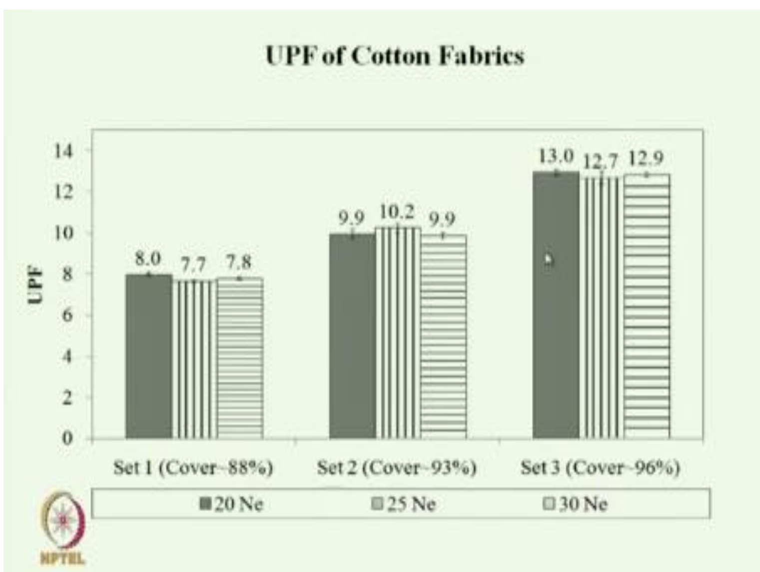

UPF without treatment it is showing there is no specific trend is observed here because of the facts we have discussed that is a reduction in thickness UPF reduces and with the reduction in cover percent UPF increases. So reduction in pores or reducing pore size UPF increases. So these two factors is coming into play together, that is why their impact on UPF is not that visible here for untreated cotton fabric.

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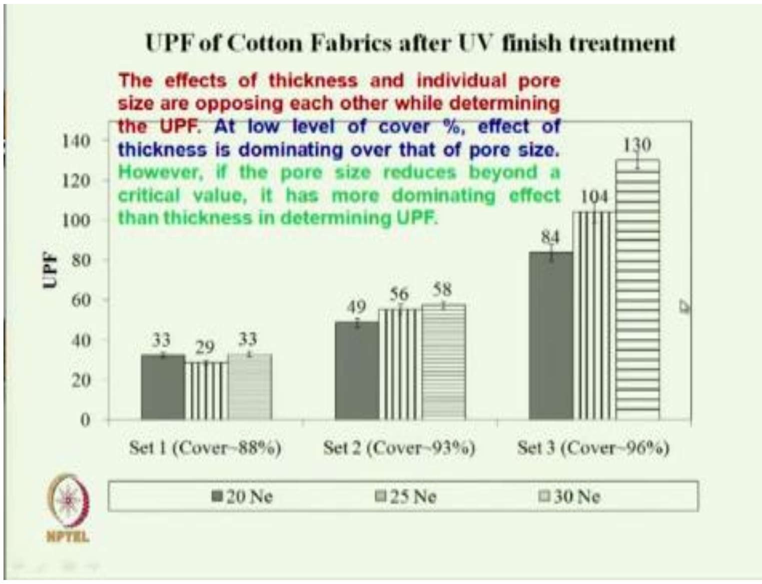

But for treated cotton fabric at least for higher cover the trend is that consistent increase in UPF this is very prominent here, UPF from 84 to 130 it is increasing. So the effect of thickness and individual pore size are opposing each other as I have mentioned, while determining the UPF at low level of cover percent the effect of thickness is dominating over the pores because pores are already a larger size.

However, if the pore size reduces beyond a critical value, it is more dominating effect than thickness in determining the UPF. So the critical value when it is a we are talking about 96% cover in that case, the change in pore size, here the change in pore size keeping the cover same we are changing the pore size the breaking the larger pore to smaller pore when we are using 20s count to 30s count. So this effect is prominent here from that pore size effect is dominating here.

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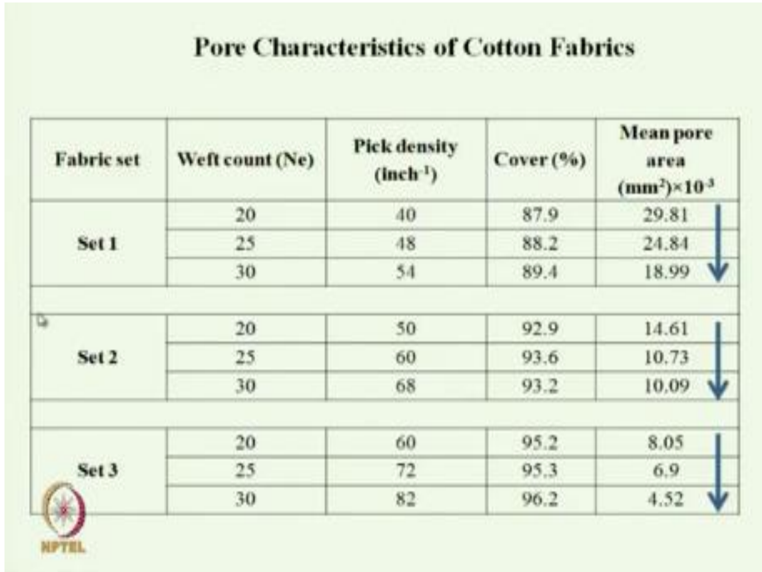

Pore Characteristics of Cotton Fabrics

Fabric set	Weft count (Ne)	Pick density ($inch^{-1}$)	Cover (%)	Mean pore area $(mm^2) \times 10^{-3}$
Set 1	20	40	87.9	29.81
	25	48	88.2	24.84
	30	54	89.4	18.99
Set 2	20	50	92.9	14.61
	25	60	93.6	10.73
	30	68	93.2	10.09
Set 3	20	60	95.2	8.05
	25	72	95.3	6.9
	30	82	96.2	4.52

So set 1 the mean pore size reduces.

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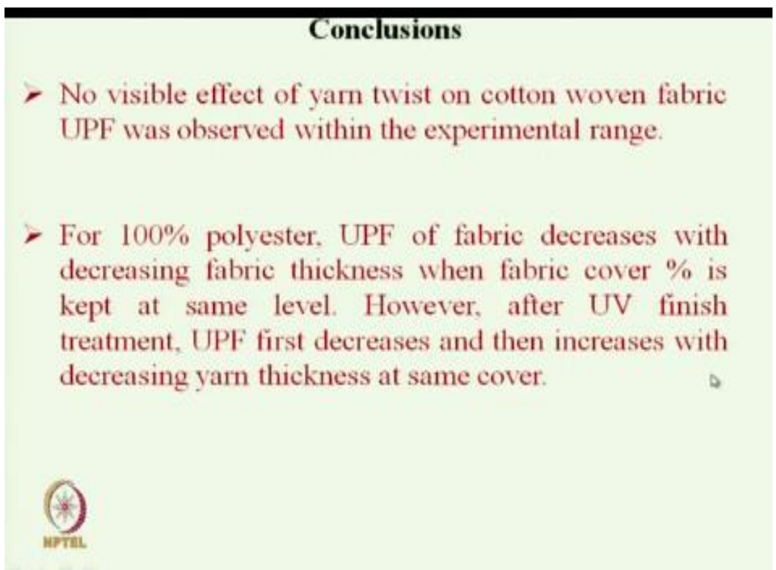

So the overall conclusions are the no visible effect of yarn twist on cotton woven fabric on UPF was observed within the experimental range. For 100% polyester UPF of fabric decreases with decreasing fabric thickness when fabrics cover percent is kept at the same level. However after UV finished treatment, UPF first decreases then increases with the decreasing yarn thickness at same cover.

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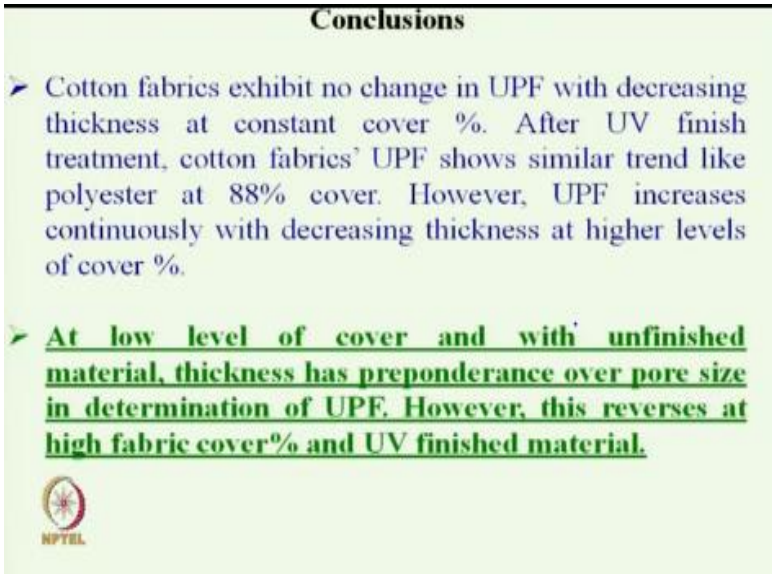

Cotton fabrics exhibit no change in UPF with decreasing thickness at constant cover, but after UV finish treatment, cotton fabrics UPF shows similar trend like polyester at higher cover factor that is 88% cover. However UPF increases continuously with decreasing thickness at higher level of cover, at low level of cover and with unfinished material, thickness has predominant effect on over the pore size.

Because at low level of cover that effect of thickness is predominant. But at higher level of cover the effect of pore size is predominant. Here, we will end our topic on UV protective textile, in next class will start one new area of technical textiles. Till then thank you.