Orientation of Fibers
Prof. Bohuslev Neckar
Department of Textile Technologies
Indian Institute of Technologies, Delhi

Yarn Strength as a Stochastic Process

Lecture No. # 20

In last lecture, we derived equations for characteristically diameter of pore, and we derived III variations, may be IV variants.

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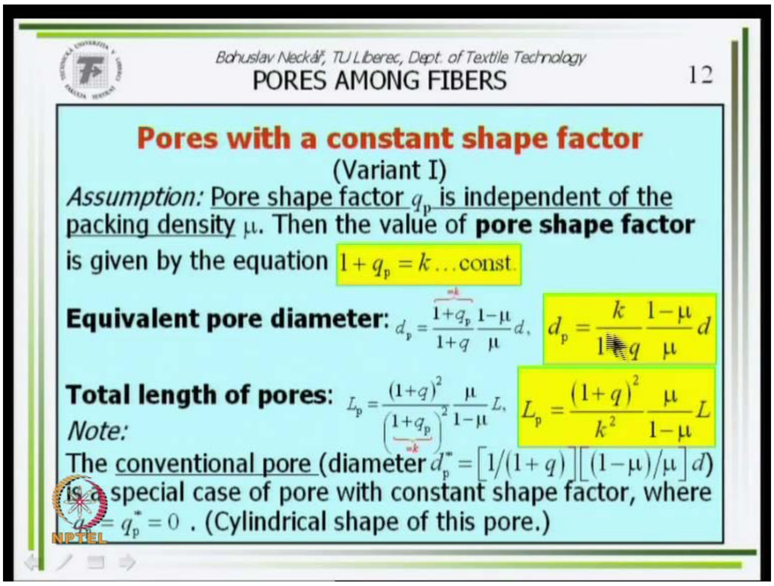

The first was a conventional pore, and then we derived the equation for the pore diameter, based on the idea of constant shape factor of pore, variation I.

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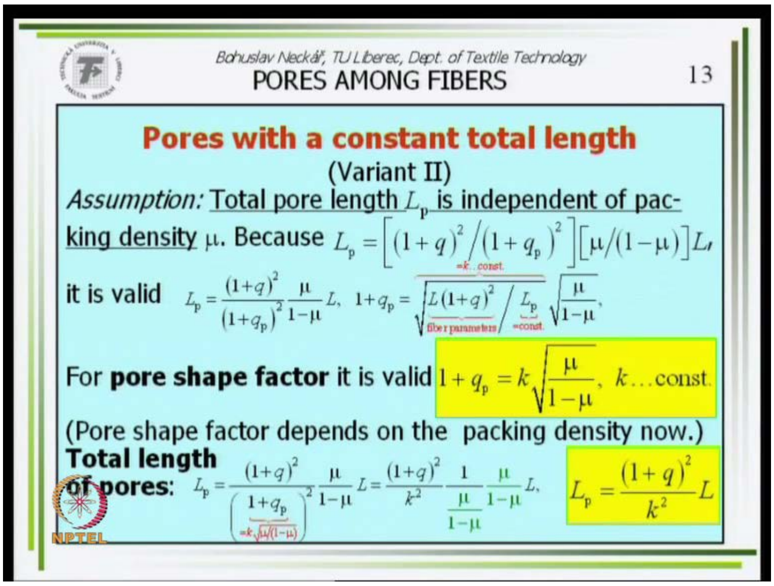

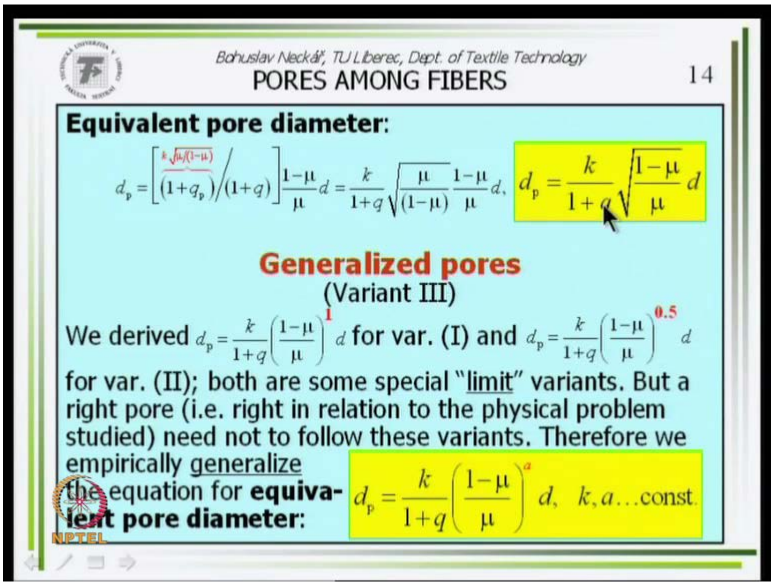

Second was the variation, two which give us the pore diameter for the idea of constant lengths of pores, and because some similarity because some similarity, between this two equations; the variations III, empirically generalized this two to the the equation, which is here as a diameter variation III.

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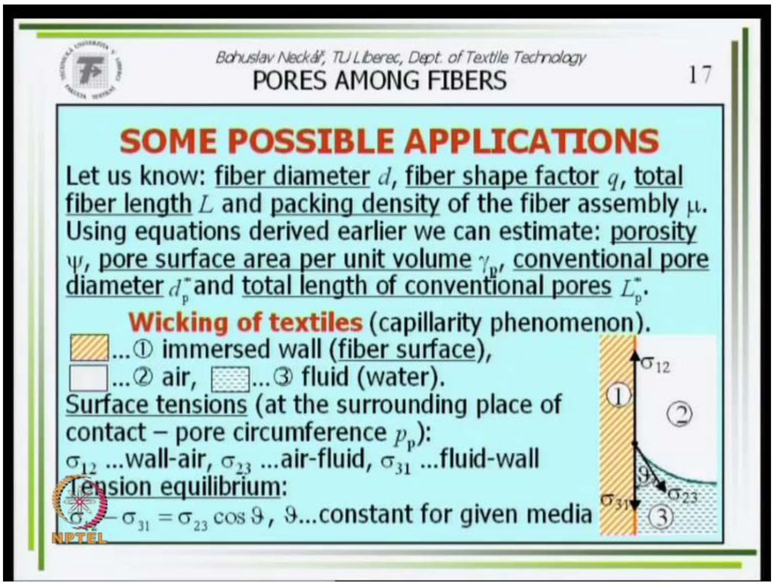

Today, I want to comment only short comment, in short comment some possible applications why because, I said that we must to to find our parameters in the relation to this or that process, physical process in last lecture. Independently independently to to physical process, use let us imagine that we know fiber diameter, fiber shape factor, total fiber length L and packing density of fiber assembly. And we can in each case to evaluate, porosity psi, pore surface area per unit volume gamma p, conventional pore diameter d p star, and total length of conventional pores L p start; his quantities are independent to this or that physical process used.

Now, let let us think about the first, process which is often used in textile and this are wicking of textiles or in textiles yes, it is principle its capillarity phenomenon, is it not. Similar picture you know from physic, one is an immersed wall, second white it is a air, and third some blue (()) is a fluid for example, let us imagine water. You know that exist a surface tensions at the surrounding place of contact, pore circumference P p is a part of of, this is a part of all some some some some capillar tube or pore. Sigma 1 2 sigma 1 2 it is a surface tension on the border wall-air; sigma 2 3 sigma 2 3 sigma 2 3 its air fluid air fluid here, and sigma 3 1 it is fluid-wall surface tension.

Using the equilibrium of forces in a vertical direction here, we can write that sigma 1 2 minus sigma 3 1 is equal sigma 2 3 times cos (()), this angle and this angle is a characteristical constant for given media, this all you know from physic.

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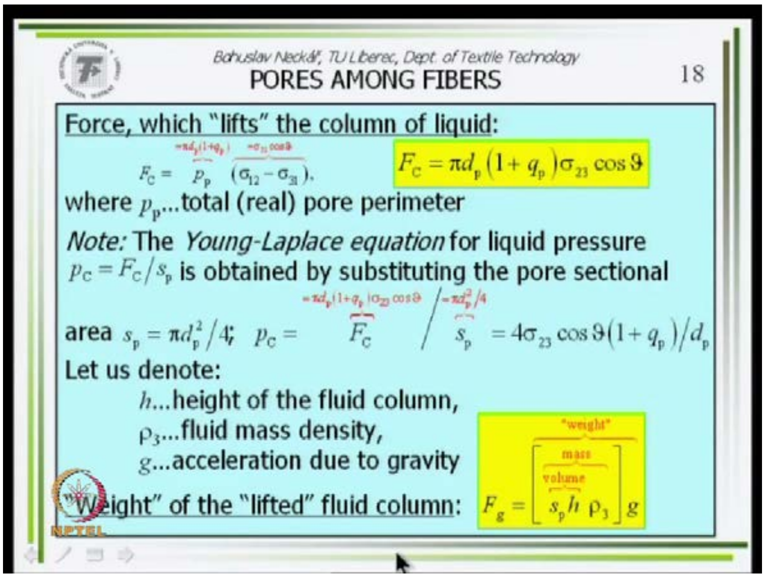

Force, which lifts, the column of limit of liquid over, it is perimeter of our capillary tube, times this force sigma 1 2 minus sigma 3 1, that is equal to sigma 2 3 times cos (()) theta, so that we can write this force is equal to this equation. Where P p is a total real pore perimeter, no effects above the evidence, by the way young Laplace equation for liquid pressure, obtained by substituting the pore sectional area S p it is only note, but this sentence is young Laplace equation is mentioned in the teaching book about, the physic or hydrodynamics and so on.

Well this is the force, which take our liquid over, why it is not so that the liquid, because it is force is going over over over to the end, to the top point of our capillar tube and then it is freed, down as a we have (()), it is not possible evidently why, because it is the first which is going in another direction, what is it intuitively say it, where it is wait of our rigid. Let us denote that h is height of the fluid column, (()) 3 is fluid mass density and g is acceleration due to gravity.

Then weight of the lifted fluid column is following, S p times h this is a volume, cross section times, height times mass, fluid mass density is a mass, times g gravity, acceleration and we obtained a force yeah.

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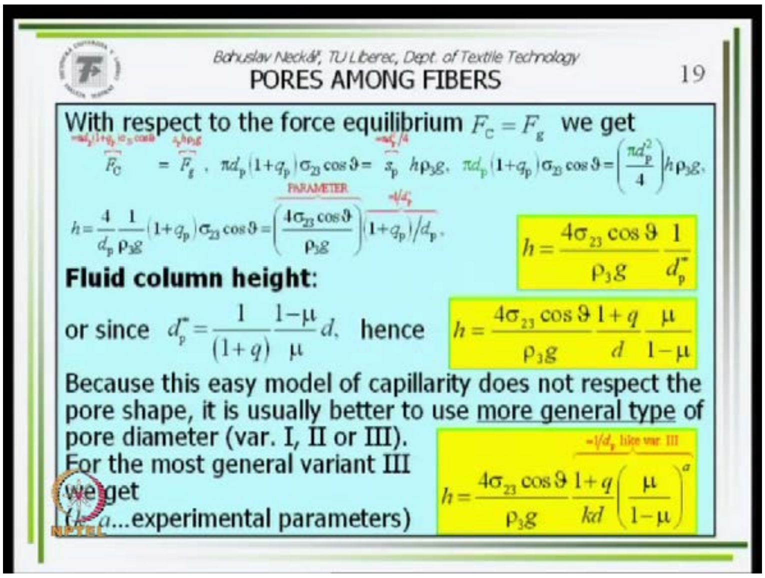

And the height with a respect to the force equilibrium, the height on which the rigid is stable is given by equivalence of these two forces, force which takes our rigid over, and force which take it down based on the gravity. So, is that F c is equal F g and using equations derived, we obtain this, then this, then this, then this it is only rearranging explicitly for h, it derived we rearrange our equation. And so, we obtain this equation this equation, but what is this here, this is 1 by conventional pore diameter.

So, we can say, that the that our our height which we measure in laboratory by wicking is proportional, because this is some consent of proportionality. Proportional to 1 by pore conventional, pore diameter yeah, it is a regular derivation (()) or 1 we use on the place of d p star our earlier derived equation; then we obtain this here, it related to the ratio mu by 1 minus mu h our h hey well. Nevertheless sometimes it is better, because this only idealized equation, we do not think about the shape of pore and so on, and so on.

Therefore, may be better is when on the place of conventional pore, we will use our our equation for pore according variant III, which is ritual this one this here, yeah because it can be more precise, so that we obtained for this h such equation, well this is material parameter, but mu by 1 minus mu is power to a a need not be just equal 1, it can be some other quantity (Refer Slide Time: 10:01). So, this is the in short idea, how to how to study the wicking process in a textile fibrous assemblies.

Of course, if some special influence is do not play role, when you will study for example, woolen fabrics then you must think about about the special character of this structure, about the between yarns and inside yarns and so on, and so on yeah. But, principally this is the way, how to how to go to the programmed of this wicking.

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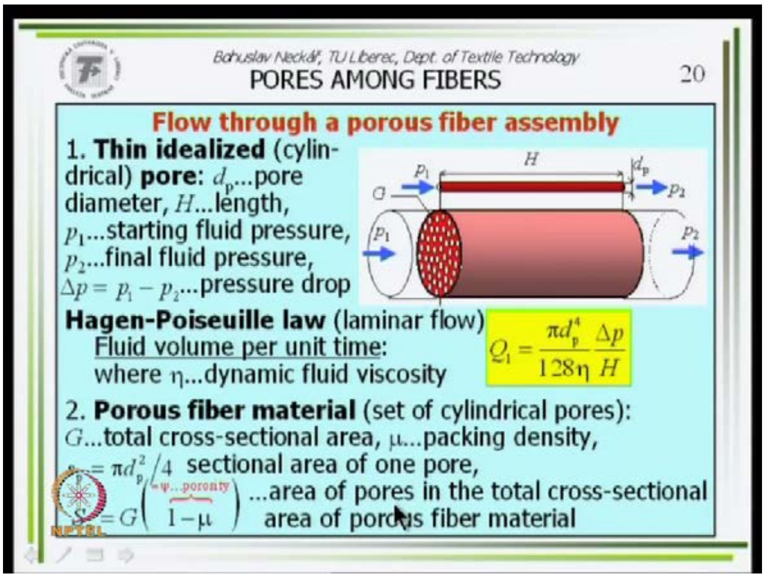

The second often used process, which I want to introduce here, is a flow to a porous fiber assembly, different filters filters are on similar flow to the porous material; we will now on a minute's speak about idealized porous material, then we will back to our textile structure. Let us imagine an idealized porous material like this here, some compact red material inside of which is set of thin cubes, it is also a porous material; it rather than our fibrous material, but it is also porous material.

One tube one tube is shown here, length is h starting pressure is P 1, pressure of the final pressure here is P 2 evidently, P 2 is smaller than 1, total area here is G and its and the diameter of 1, one thin cube is d p like diameter of pore; well P 1 starting fluid pressure, P 2 final fluid pressure, delta p P 1 minus P 2 is pressure drop. In a physics is derived some physical law, which is known as a Hagen-Poiseuille law; Hagen-Poiseuille law is one of known law in physics, you can find it in, how this derivation in in handbook of physics.

And it say that the that the quantity fluid volume per unit time fluid volume per unit time which is going through one this tube is given by the pi times d p power to 4 by some constants times eta, eta is dynamic fluid viscosity of our regulate delta p is is here pressure drop, and h you see is a length of our porous material, well G is for us total cross sectional area, mu is packing density in this cross section. So, that the and S p area, cross sectional area of our idealized, cylindrical pore is pi d p square by 4 is sectional area of one pore. So, total area of pores S p is whole area of this (()), this total area capital G times 1 minus mu, it is this white area inside is it not, it yeah well.

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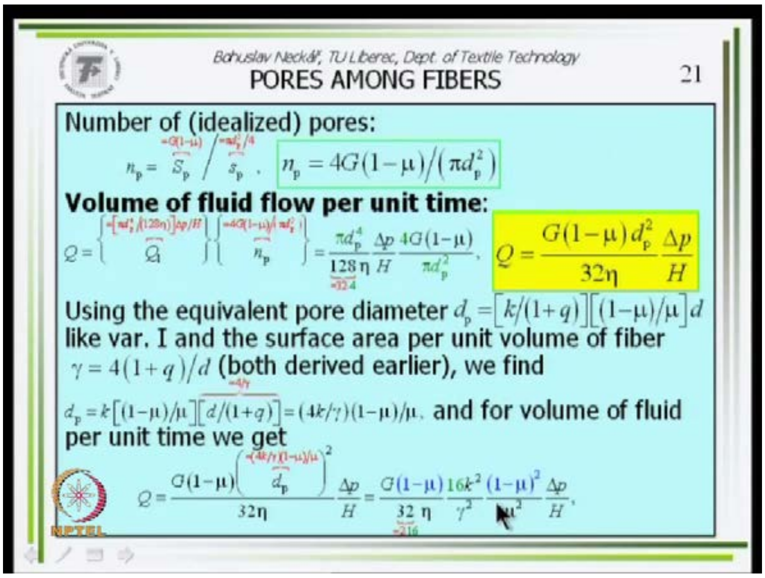

So, this is this S p, number of idealized pores n p in our cross section, it is this area divided by area pair 1 cube pair 1 pore. Using our equations we obtained that number of pores is this here, and volume of fluid flow per unit time, Q it is this volume per 1 cube times number of this cube this is pores, using equations we obtain this and after rearranging we obtain this here.

Using the equivalent pore diameter d p according the version 1, and the surface area per unit volume of fiber gamma is 4 times 1 plus Q by d both we derived earlier, we can rearrange d p, because to this ratio we use this here, so that we obtain also this structure, this formula this. And so that d p is our only rearranging, nothing new d p is also possible to explain using this this formula and using this, in this here we obtain this, and after rearranging finally this here (Refer Slide Time: 16:18).

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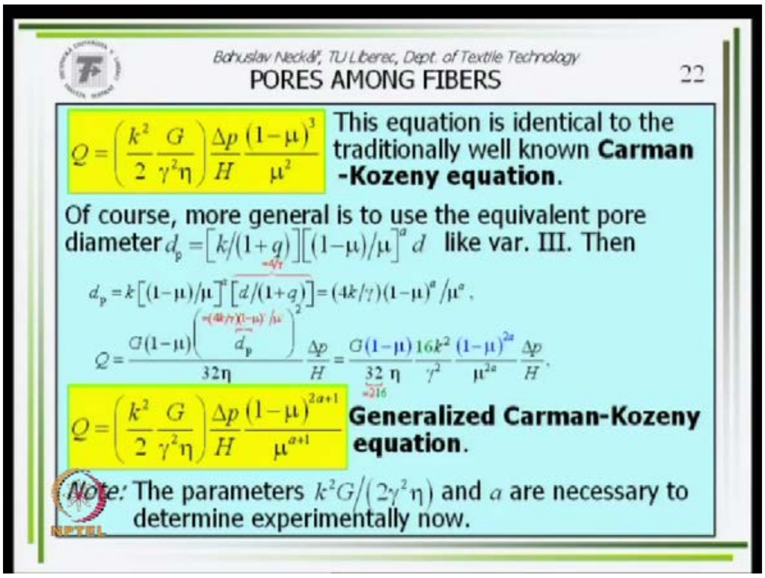

That is where (()) is it practically, no practically it is identical it is identical this, so called Carman-Kozeny equation Carman-Kozeny equation is very known equation, in hydrodynamic for flow through pores material. It is for example, used in textile for measurement of cotton fiber fineness (()) from (()) works based on this Carman-Kozeny equation. By the way Kozeny Kozenyis name, he was (()) do not know, but Kozeny means is the English ladder, from ladder, it is name it is name Carman-Kozeny are very known well.

So, this is the equation which can us say, how is the fluid through the pores material, but we used, what we used pore according variant number I, may be better is when we use the variant number III, which is more general of two parameters k and a yeah, which is more general. And then after rearranging using equations, which are known for us, we obtain such expression in a place to this here, is not 3 and 2 it is a plus 1 and 2 a plus 1 yeah. If a is 1, then it is required to the Carman-Kozeny traditional formula, but a can be also 1 half for another value, what is the best, we must study our structure by in laboratory by flow of some rigid, which is important for us yeah.

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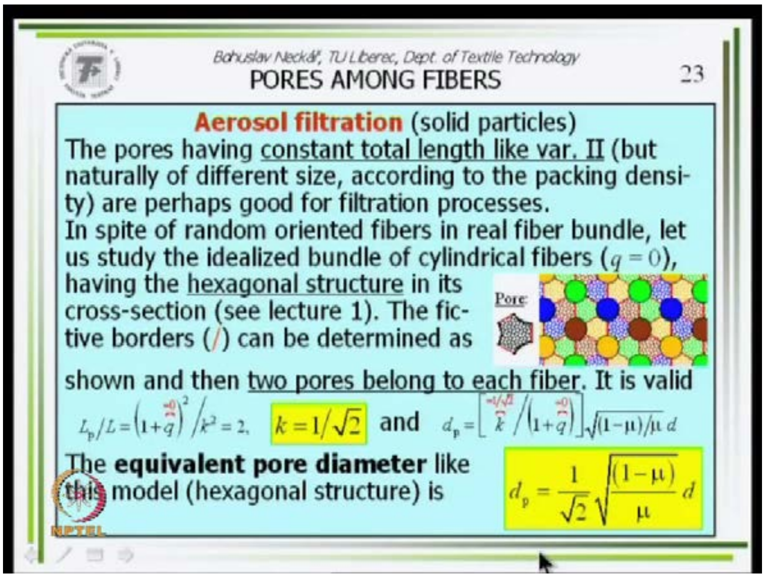

Well such example, which I want introduced in short is a aerosol filtration, let us imagine let us imagine an ideal structure which he was mentioned in lesson 1. So, called hexagonal structure well of fibers or the Para the cylindrical fibers aligned in such position, like the rings are here; let us imagine, then you have you are at (()) and you create this red lines. So, that to obtain the pores, then you obtain the pores having such shape and to and through this, the the filtration through this, like the cigarette filter, through this structure is going to such pores.

In this case, we can use the variant II, because lengths of pores is same, which of lengths of pores in relation along to fibers here, you can see therefore, it is a coloured that to each fiber related to pore for this blue fiber, this blue dotted pores; for brown fiber this 2 brown dotted pores here, to yellow to yellow dotted pores and then whole structure. So, that we can say, that in this special model, the the length of pores is two times higher than the length of fibers, because through 1 fibers 2 pores is coming.

So, that L p to L which is 1 plus q by k square is 2, so that k q for cylindrical fiber is 0, so k is 1 by square root of 2, and in this case according the the equation from d p in variant II and using k equal this we obtain d p according this equation.

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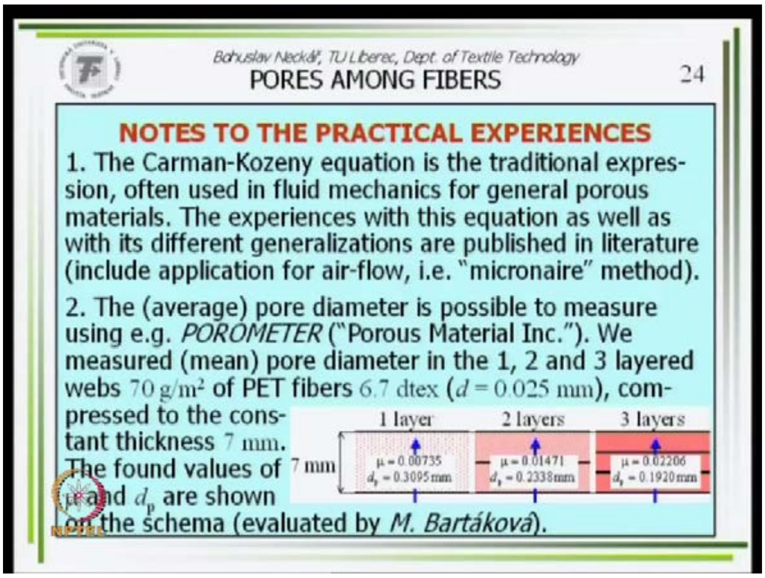

So, it was free example, how to apply, how to use our equation in different physical processes. I (()) to introduce one practical result, one experimental results, it is every times difficult to experimentally to measure the pore diameter. Nevertheless, it exist some instruments one produce some pores material in corporation, from (()) not Korean state university, some some some company by this university; they construct instrument name porometer, which is used also not only in US also abroad.

Nevertheless, it is very very expensive in (()) republic we have only one in an company near to town Vernon. Nevertheless because, we have it we based on some agreement this on the people from industry, and this company, we measure some materials on this little unique porometer; which of material, it was it was relative heavy, webs 70 gram per square meter from polyester fiber 6.7 dtex packs, it represent fiber diameter 0.025 millimeter.

The measurement is realized between two plates having distance constant, distance 7 millimeter, so the distance is 7 millimeter and we gave between this couple of plates 1 layer, 2 layers or 3 layers of our web. Therefore, we knew the packing density the starting packing density 0.007 to its two times 0.014 and the three time 0.022 packing density. This experimental organized for number one application, for number one textiles, before we preferred small values of packing density.

Yes and the this instrument, give us the mean value of pore equivalent pore diameter as its shown, this is what is it 0.3 millimeter, here it is 0.023 millimeter 0 to 0.19 millimeter evidently, what we (()) write it increasing of packing density bring smaller, characteristic of dimensional pore.

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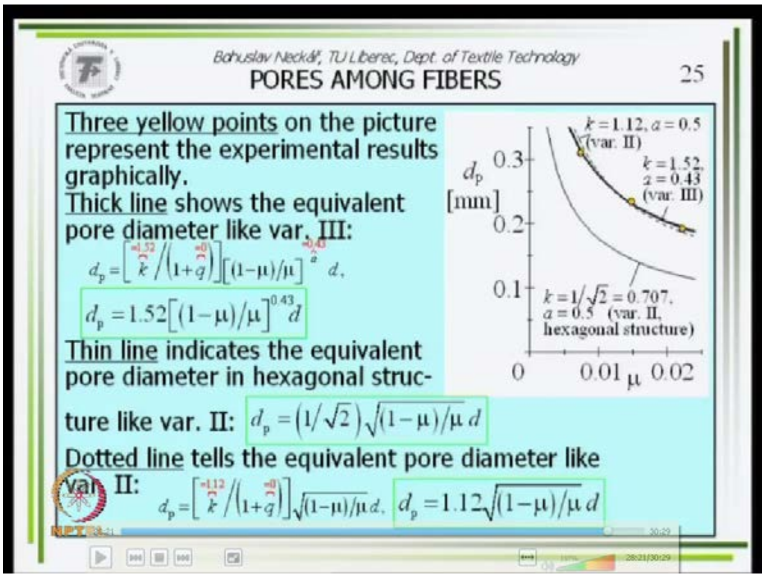

Let us show graphically our experiment, our three there are graph packing density, and diameter, equivalent diameter of pore, our free experimental values are here, this point, this point and this point. First step was what we derived, the best couple of parameters k and a based on statistical regression, what we obtained we obtained k equal 1.52 and a was 0.43, when we use this couple of parameters, we obtain curve the peak curve which is here; I think it is absolutely perfect.

But, interest it is interesting, that the value a was not too far from 0.5, we derived empirically based on statistical regression, 0.43 smooth differences 0.5. Therefore, we say lets to construct some is, some function the relation between pore diameter, and packing density based on our idea number two, variation II, constant length of pores. And we say yes a is 0.5 square root and how is the best k best k is now 1.12 and we obtain a dotted line, when you see the dotted line is also very near very very near to our experimental values.

What we can say you know, it means that the physical process, which used the instrumental porometer (()) based on the, it is a flow to some line, and it need something like same length of pores yeah, the length of pores is constant. It is also, because 0.5 yeah, our theoretical example for a hexagonal structure is very far, from our our results, so that this is not relevant for this for its results. One it is here according equation two or very near to version II, we have also say that it do not exist some universal instrument, principally do not exist and cannot also in future, there not be some instrument, for measurement of pore diameter which is universal.

Because, textile structure have not only one pore diameter, it has so much diameters yeah much physical processes you used, to its physical processes, corresponds another diameter is it not, by the same structure. Therefore, these instrument is good give representative results it is well, but it measured the diameter, pore diameter based on the physical process, which this instrument used yeah, so is that program is pores, in the in pore pores layers.

So, we started with from from effective border, your (()) and in the final, we must say this red pen we have not, this red pen owner of this red pen is the physical process; which used pores yeah. So, it is well, may be this is all for the pore, thank you very much for your attention.