Orientation of Fibers.

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Lecture No. # 16.

Relations amongYarn Count T, Twist Z, Packing Density, and Diameter D

Well, good afternoon, everybody. Last lecture we spoke about Pierces's model.This model introduced the general logic ofthe problem of strength distributionin differentgaugelengths; YarnStrengthdistribution (( ))

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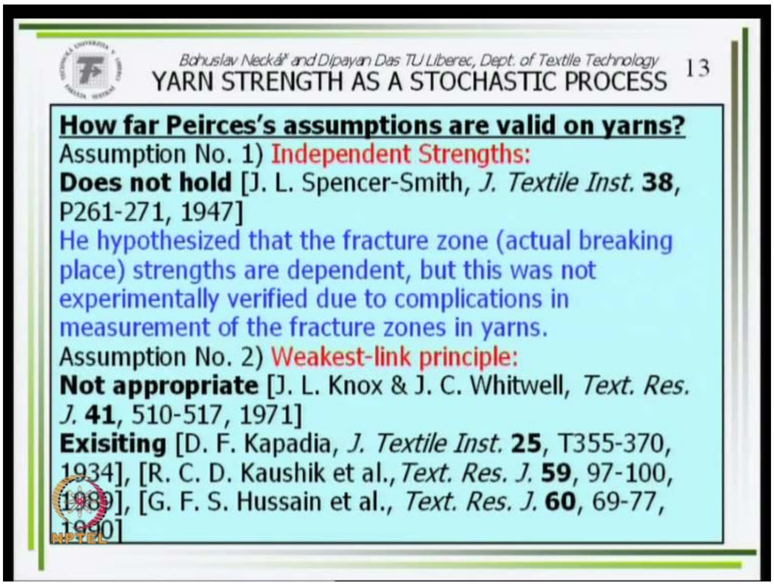

Nevertheless,Mr.Pierces use some set of assumptions.Oneof his assumptionswas on independent strengths. Based on the idea of Pierces, each short fiber portion, the strength of each short fiber portion is independent to each other; each is independent.During the experimental works, he was doing,the results wereharder.Thestrengths of shortsegments are not independent.Ifonesegment or one part lengths is 0,have relatively high value ofstrength, the probability that the neighbor will have also a little higher than the mean, than the averagevalue of strength. The probability is higher,and thenthis isabsolutely independent. You can imagine also intuitively that this relation is possible good to see, because if this yarn isgood oriented fiber then its neighbor also, the fibers will be good oriented and somethingso.

So, the independency, this is a problem which is not valid. Weakest-link principle,(( ))of which I spoke it in the lastlecture;of course, we must work on whichgauge length higher thanlongest fiber lengths.When we use the shorter, then the Weakest-link principle is absolutely out, because we measure something other.Nevertheless, when we use such, then different authors have different meaning.At most, they mean it that we can accept Weakest-link principle as a goodtheoretical assumption for our modeling.

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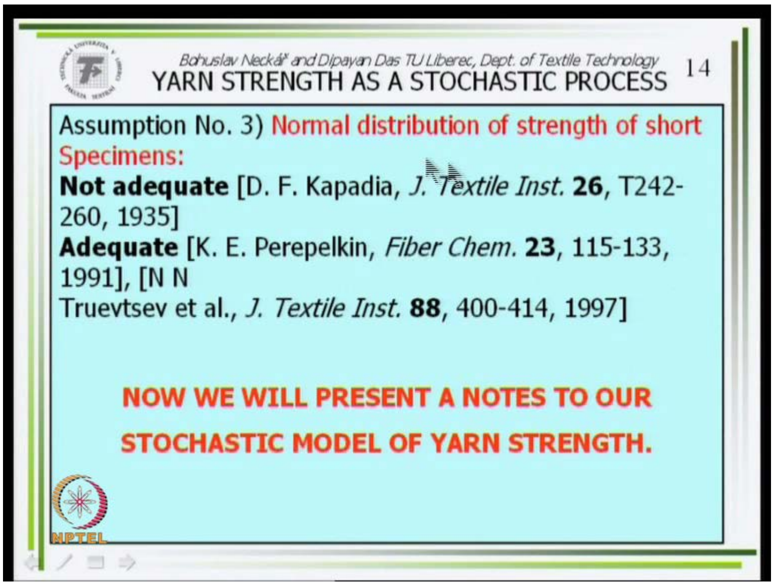

The third isnormal distribution ofstrengths of short specimens. In short specimens,the experiments results showthat often this assumption is acceptable;not every time,but very often it is yes. So, what are the highest differences?It is the point one, which means the independent strengths, no theyare not independent (Refer Slide Time: 04:37).

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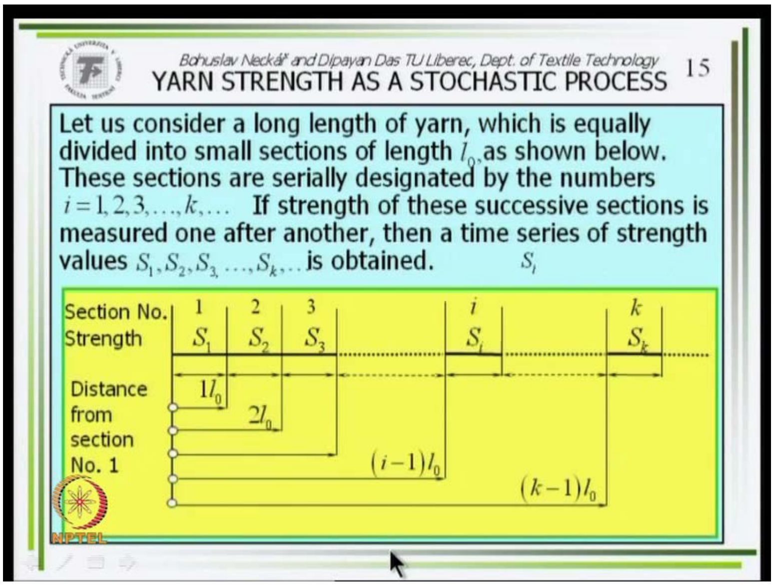

So, it was necessary to create some more general model in which among the short fiber portions, I mean the strength of the short fiber portions,had some dependency.Let us imagine a yarnsymbolically divided into some portions lengths like *l* 0.The distance from here isonetimes*l* 0,twotimes*l* 0,threetimes *l* 0,till iminus 1 timesof *l* 0and so on. Each portion, each segmenthas its own strength as S 1, S 2,S 3 and so on.So, we obtain someseries of quantities like S 1, S 2,S 3, up to Sk and so on.

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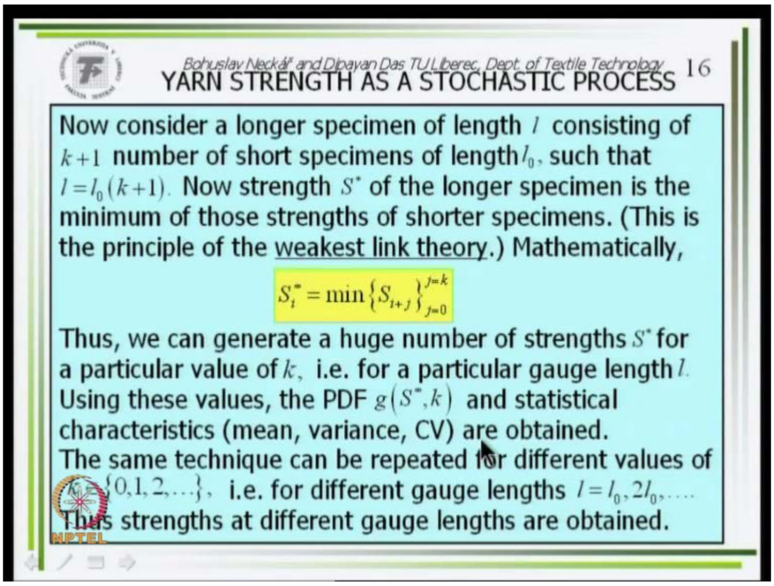

What is the strength ofsome fiberlengthsin which are the segmentsfromith segments toith plus k?Let usimagine some lengths, in which we have k plus 1 segments, from subscriptitoiequalsorry j equal 0to j equal k.How is the strength?It is theminimum from strengths, from all thestrengths.Is it not? Automatically, say this isminimumof this strength set.Is it clear?

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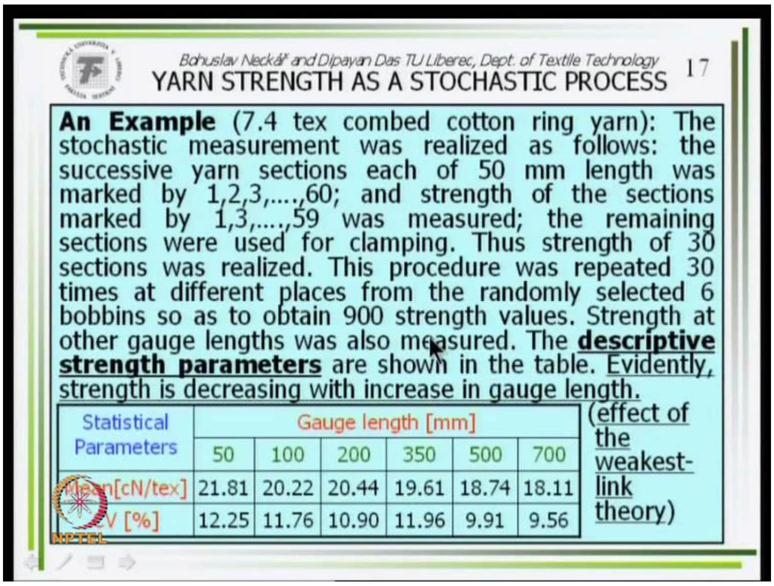

Our experimental work is as following. The table illustrates experimental values.We have some instrument which helps us to usefivecentimeter gaugelengths; *l* 0equals 5centimeter, and we measure strength, then secondfivecentimeter was a technical lengths because summons is necessary, because in bothjaws we must clamp the yarnsegment.Is it not? So, in our system it was sothatthe jaw was here and here and we measured strength of S 2 (Refer Slide Time: 07:35).Then the jaw was here andI think here, and we measure the strength of S 4 and so on.So,onebeside the other, we knew the distances between neighbor portions is length offivecentimeter.

Then weevaluateon how the strength of longer lengths are, because we had this small. We obtain experimentally;experimentally we obtain this. This is immediately measured and it is from different gauge lengths.It is on breaking machine.For the same yarnand we obtain such values like the mean value andcoefficientof variation.Forfivecentimeter, it was 21centi-newton per tex, and CV is 12 percent.By 77centimeter, which waslongest possible in our breaking machine, we obtain 18centi-newton per texand9.5percentas

CV.You can see that really, in reality, the strength is decreasingas gauge lengthsin increasing. This is the gauge lengths. The mean value of strength is decreasing and CVcoefficient variation of this quantity is decreasing to.

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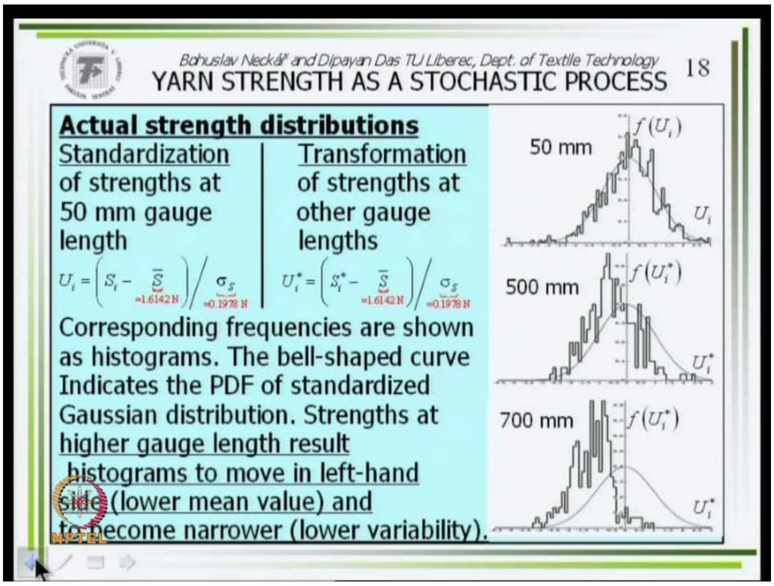

You can see how the distribution is by 50 centimeter, by 500 and by 700 centimeter.It was sameyarn but differentknow how for measurement; One time it is 5centimetergauge length,then 500 mm andthen 700 mm. Can you see this histogram, how is going on thisleft hand side? This histogram is recalculated to thestandardize values.So, you can seethis with linear transformations, which we did sothat you can see it, is going to left, more and more to the left hand side in opposite to this;that isGaussian standard probability density function.

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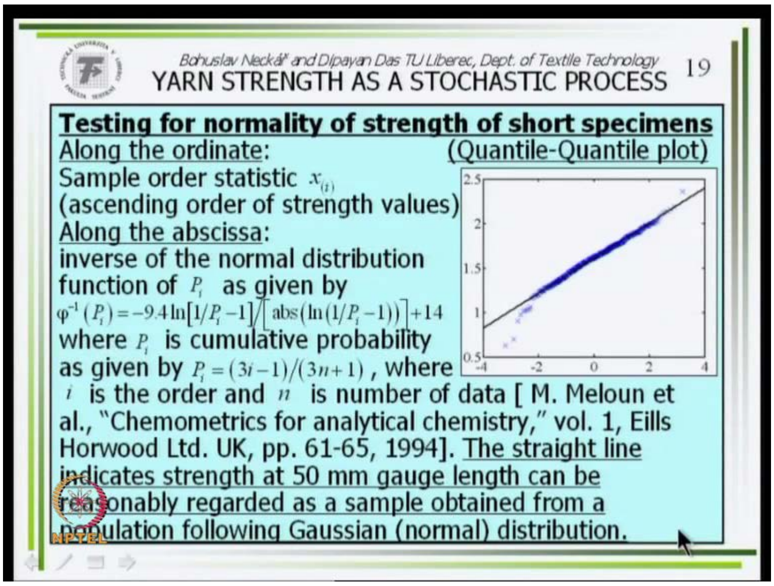

Gauss, the idea of Gaussian distribution in short lengths, in this caseis five centimeters lengths arerelatively good.As shown,inthis example, it is thesame yarnand Quantile-Quantile plot, may be you know what it is.It is some graphical system through which you canwatch if this or thatdistribution is or notGaussian.You can see that the dominant part of points are lying on straight line,which say us that this distributions is practically very good comparable withthe Gaussian distribution.So, the idea of Gaussian distribution can be… But,how it is with dependency or independency?We use socalled auto correlation function.Do you know what the auto correlation function is?May be you know what is the coefficient of correlation, you know what is the coefficient of correlation, you know it, yeah.So, it is good.

Let us imagine our yarn. (Refer Slide Time: 11:46)We measure,let us imagine theoretically,we measure, we have the set of quantities S 1, S 2,S 3. We can create some couples; S 1 and S 2as second couple, S 2and S 3asthird couple, S 3plus S 4 and so on. Every time, this couple of quantities,represents two parts in which the distance isonetimes *l* 0.Well from these couples, we can evaluate a coefficient of correlation.Is it possible?Yes,we evaluated and we say this is the coefficient of correlation for distance of this couples of strengthsonetimes *l* 0.Nevertheless, from the same set of experiments we can evaluate,we can create other couples; S 1 and S 3, S 2and S 4,and so on. Thetwovalues in each couple have the distance on the yarnof twotimes *l* 0.Is it not?Is it imaginable?We evaluate coefficient of correlation and we can say this is the coefficient correlation for the distance 2*l*0.Similarly, from the distancethree times*l* 0,to all possible distances.

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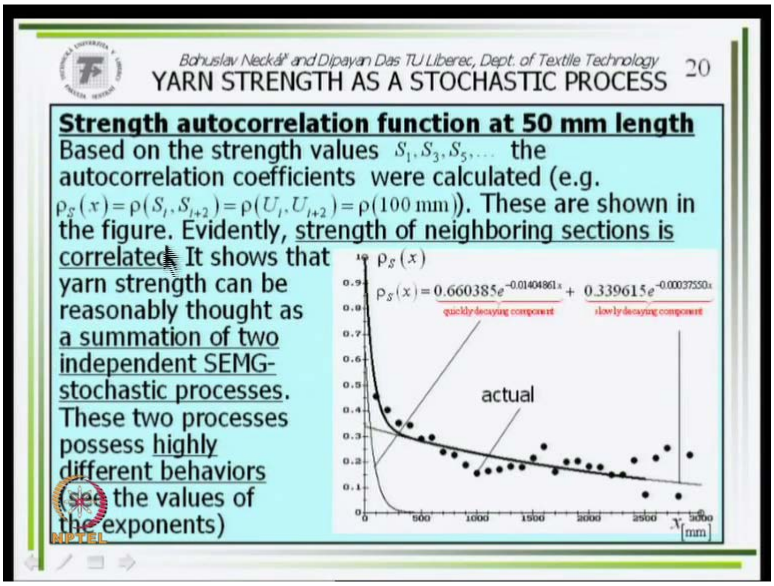

Like this and we can create some graphs.On theabscissa, we can give the distance between our couple values likeonetimes*l*0ortwotimes*l* 0orthree times*l* 0;this is distance.On the ordinate is the value of coefficient correlation,and we obtained such points like this which are here.This is one real example.Can you imagine this way? I hope yes, it is possible.Evidently, the coefficient correlation at the distance 0must be one,because when you have couples from onevalue and the same value, the second value and the same value, then the correlation of couples where both values are every time the same, then it is 1.Is it not?So, this point is also one, ofpoint from this coefficient of correlations.

Thefunction, which saysushow, is the change in the coefficient correlation in relation to the distance is the correlation function.We callit as a correlation function; nothing more.And because both these values are from the same yarn, when we speak about other yarnit can be quite out of problem. Now, from the sameset here means in orderfrom the same yarn.Not the first from the blue yarnand the second from the yellowyarn.Here, they are the same yarn.Therefore, we must call these functionsasauto correlation function.It is correlation in the same yarn.

For this auto correlation function and the experimental trend of auto correlation function is given by this black points here is real experimental results;this is experimental results.Now, how to formulate the model;mathematical model,stochastic model of this auto correlation function?We use set of ideas; I want only here to present the name of these assumptions, which we used.We think that the series of our quantities, like those S 1, S 2and S 3andso on, it is this seriesrepresents of some stochastic; represents of stochastic process.

In the theory of stochastic processesareknown in following trends like stationarity; stationary process, stochastic process. I want to explain it only very vaguely or very intuitively. So, if somebody of you wants to know it in the mathematicallyprecision then please forgive me.Stationary is the process whenit is a random process, but it oscillates around some quantities, around some value.For example, processes, which are permanentlyin random and by general, the strength is increasing then it is not stationary.

So we assume it as the stationary process.Thesecond isergodic process;ergodic is intuitively is very difficult to say; very intuitively, I can say it is a normallyimaginedas what we understand, what we feel under the termstochastic process. Markovian process, it means that the influence of the following value in our series, the influence of following value have only thevalue which is immediately before.So, the strength of twelfthsegment of the yarnis influenced through the strength of the eleventh, butnot influenced throughsegment number three,for example.Only the neighbor can influence the following, the probability or the following value.Similar processes are named asMarkovian processes.

And final is Gaussian;it means that we will usedistribution according or normal distribution according to Gauss.Using this type of process, and using the set ofdifferent mathematical tools, we can derive (Refer Slide Time: 19:02) that the auto correlation function must be exponential curve; oneexponentially decreasing curve.It is a mathematical result of process, which are Stationary,Ergodic,Markovian and Gaussian.Nevertheless, our experimental results do not correspond with exponentially decreasing function.Therefore, we say it is not well.In reality,it is a little harder. The situation or the real situationseems little harder.

We start to think abouttwoindependent; such twoindependent processes having another parameter and then we obtained very goodresult.It is shown in this example on this picture (Refer Slide Time: 20:04).Oneprocesshas this character of auto correlation function.It is, in this moment, I do not know,is roughly 35 percentof this process plus65 percent at the second process, which is going from here to here.The auto correlation function is slowly decreasing inonecase and quickly decreasing from the other case.Sum of both together give the resulting thick curve, which could explain our strengths measured in our laboratory.

What it means from point of view of logic?The variability of our strengths in short ones is S 1, S 2,S 3,which was in our first pictureis a result oftwoindependent influences.Oneinfluence decrease very slowly and second decrease very quickly in autocorrelation function or the correlation decreases slowly in the second case.How is the physical sense of thesetwoinfluences?Nobody knowsto this time.Nevertheless,oneof them, may be thismore quickly downgoing part is a result ofvariability of a mass variability of the yarn.We compare it with the result which we obtained from(( )) (Refer Slide Time: 21:54), we recalculatethe primary valuesfrom(( ))to auto correlation function; it is also difficult. Ok,jump these difficulties.

We obtained something which was similar to this curve (Refer Slide Time: 22:16), butwas the sense of thisinfluence;nobody knows. We can have lot of hypothesis, butno oneis verified. Ineach case, it existsof two independence influences, which create both together the resulting variability ofstrengths of our portions on the gauge lengths *l* 0.Based on evaluation of such experimental curve, we obtained parameters through which it is possibleto calculate all other equations and as finally, to calculate the probability density functions orstandardizedfor different(( )) (Refer Slide Time: 23:19). We use the simulation method because the analytical version is verydifficult.

Therefore, we use the computer simulation.We simulate the strengths S 1, S 2,S 3like this here, using computer.We give in to the computer,the correspondingequations and parameters and in computers;it is possible to producethe strengths S 1, S 2,S 3with the same distributions S in original yarn, with this computer simulation.Then we can evaluate also the distributions of strengths for longerlengthseasy from lengths 10 times of *l* 0. Now, we produce by some our software, we simulate the first 10 values and minimumnext link…Minimum of these 10 valuesis the strength of lengths, the first lengths is ten times *l* 0;second 10 values generated from computerrepresent the second long lengths and minimum value, it is the strength of this one.So, using this way, using this simulation way,we can obtain, we can simulate the set of values of strength values for different lengths.

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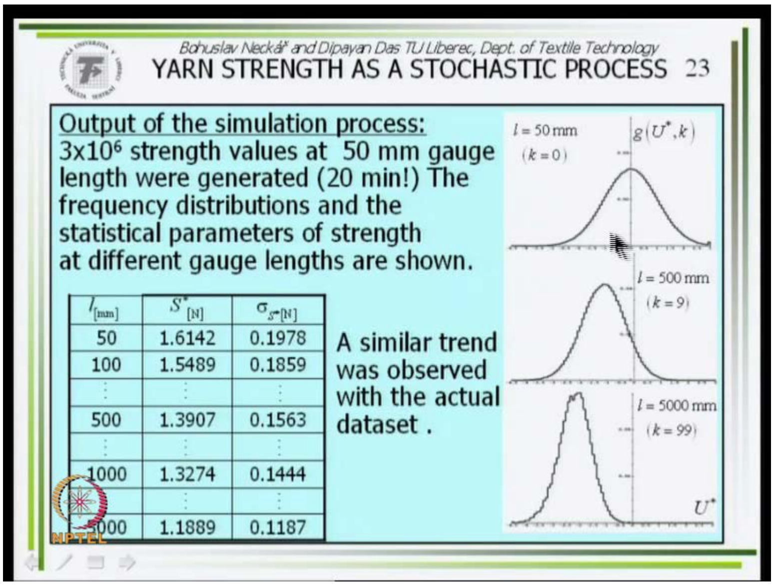

$l_{[mm]}$	$S^*_{[N]}$	$\sigma_{S^*[N]}$
50	1.6142	0.1978
100	1.5489	0.1859
⋮	⋮	⋮
500	1.3907	0.1563
⋮	⋮	⋮
1000	1.3274	0.1444
⋮	⋮	⋮
5000	1.1889	0.1187

Andthere are the probability density functions for such. For 50 millimeter it is here.For 500millimeter it is here, from computer, and from 5000 millimeters, 5meters, it is here.You can see similar effects as byPierce’s model.Now, when we have this set ofvalues, which are obtained from computer using the simulation; using these set of simulated values, we can evaluate from this set,the same way as in laboratory,the mean value, standard deviation, coefficient correlation; allthese standardstatistical characteristics.

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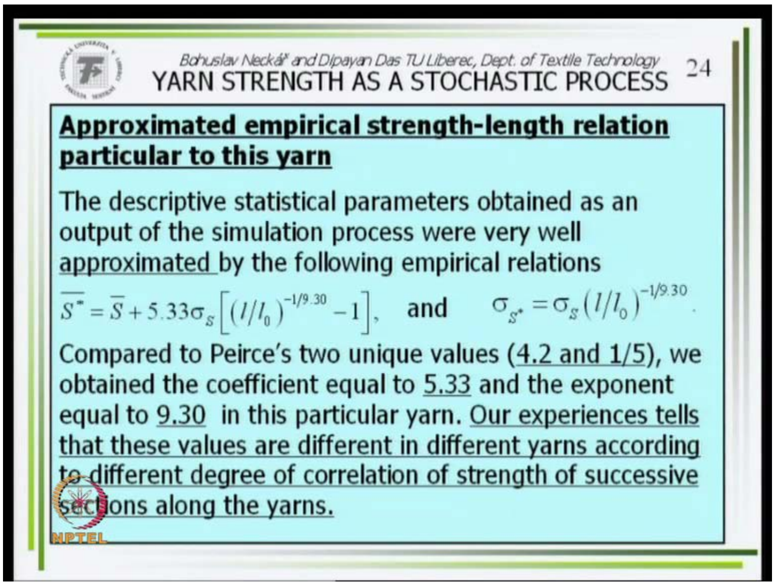

And when we had this, we prove to apply also similar equation then toMr.Pierces and we obtainedthe followingexpressions.They are based on our experiences for yarn.They are good, we can use it.Nevertheless, the exponent here is now 1 by 5,then 1 by9.3, and this co-efficient is5.33and was4.2.Pierces derived it for his model, individualindependent fiber,independentyarn portions.Now, it is for independent, we call itSEMG-stationary ergodic,Makovian and Gaussianprocess or dependent, so that we obtainanother parameter, which can approximate the resulting values like here.

What is interesting? ProfessorRurek,veryrenowned name in the theory of yarn, he is veryold man in Poland in the townLodz,in University of Lodz.He derived, he measured this problem toand he derived empirically.The value of this exponent is 1 by 7. (Refer Slide Time: 28:08) Based on our experience, we have 1 by 9.Now, it is written the reality have higher value, when he approximate the reality to this equation, and the reality need to use higher exponents than is thePeirce exponentwhich is 1 by 5derived theoretically only.Some story, when Professor Rurek was 70, may be 75,I do not know.No,70 maybe, it wasan international conference in LodzandI presented here some contribution that whyRurekvalue 1 by7 is better than earlier Peirce numberwhich is 1 by 5,because this story, say ittheoretically.

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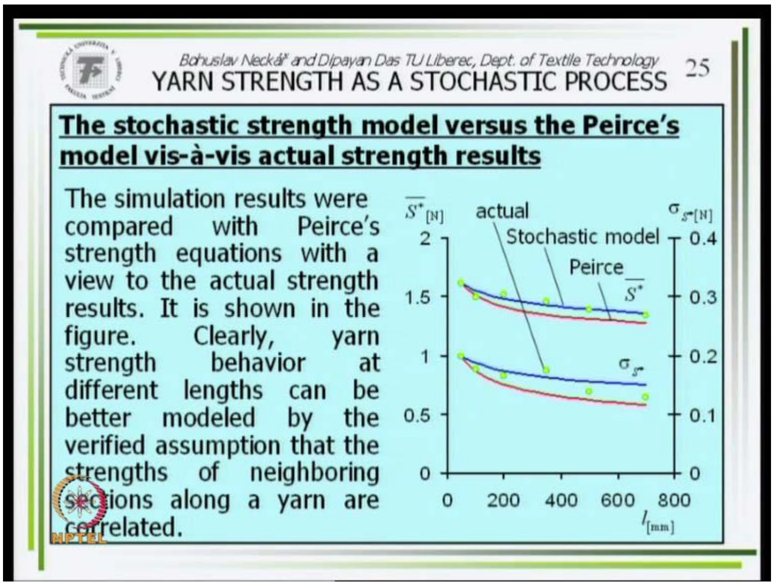

Now is the resulting; the examples of the results,points are same as earlier, points are experimental points.Mean value and standard deviation,in earlier Peircemodel; it is the red curve here, this and this.Now, when we use our model,which accepts the mutuallydependence of yarnsegments, we obtain here the blue curve.You can see that there is blue curve islittle better than theearlier red curve.

So, it is a short overview, nothing more.Short overview over this model of yarnstrength is a Stationary, ErgodicMakovianGaussian process.We call it SEMGprocess, which bring a little better result.Nevertheless,full derivation is relatively long and need to usequite…No easy methods for derivation.Therefore, I want to recommend you when such problem will be especiallyto somebody of you,I actuallyrecommend you to call or inviteDrDipayan Das from IIT D, and ask him, because he has3yearsof works on this theoretical, as well as these experimental concepts.He is in each detail very good informed.This is all for the program of yarnstrength or for the problem of all textile questions about which was my set of lectures.My last words are my acknowledgements.

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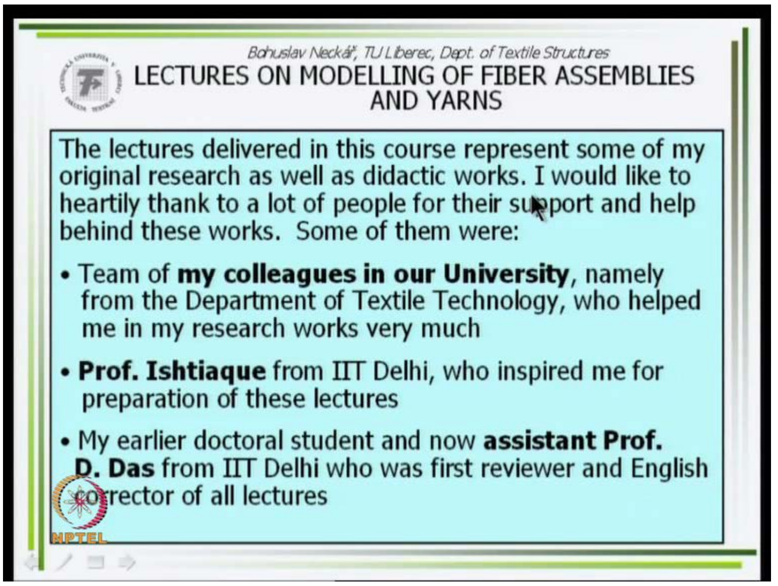

I want to thank. At first to my colleagues from our university namely from the department of Textile technology,who helped me in my research works very much.Then I want to thank to Professor Ishtiaque,your known professor from department of Textile on Indian institute of technology,Delhi, because he inspiredme for preparation of this set of lectures.And third I wanted to thank toDrDipayan Das, to this assistant professor of the sane department, who was first reviewer and English corrector of all of my lectures.

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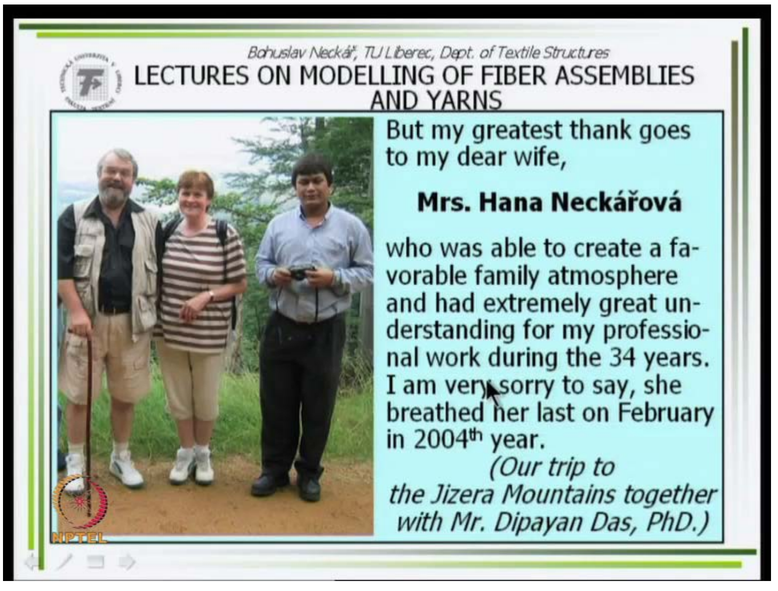

Well, my greatest thank goes to my dear wife, sorry, I am very sorry to say that she breathed her last on February 2004.Sheinspired the whole of myprofessional work and whole my life.Here, this woman is my wife,this person is known to you; it isDrDipayan Das. I am here today. You see myonly my professor mask today.This is my nature face here and is for our trip to JizeraMountain, which are the mountains by our town, where I am living and where is our university.This trip was when I was 60 years.Is it not?Then I was sixty years. So, this is my thanks. I thank also you,because you wasvery good auditorium for me. I wish you good luck, successful study and all good what youwant.

Thank you.