Manufacturing of Composites

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Lecture - 06
Continued.
Selection of Materials

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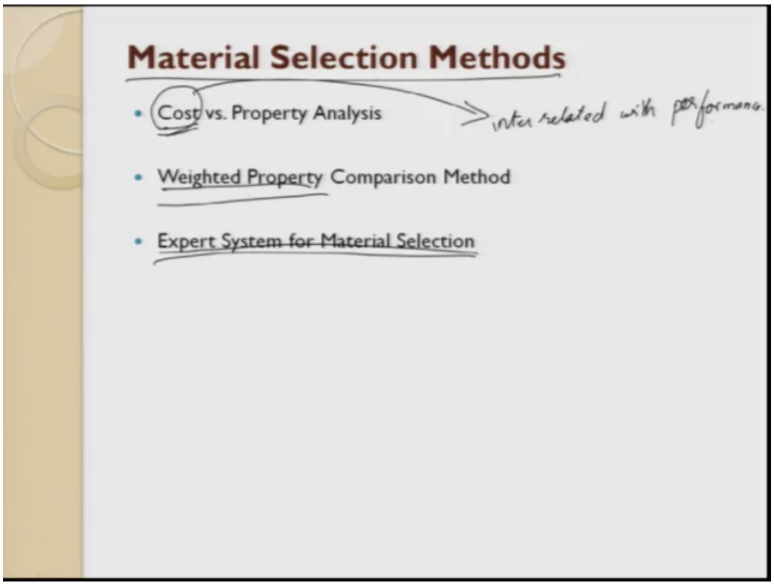

So, there are different ways of selecting the materials, so material selection method. The major thing is based on cost as I told early, then comes weight, and then finally it is expert system which are available today in doing it. Cost is a term which is interrelated with performance then is weightages, weighted properties comparison. So, that is what we do first we said we will look at different properties. Then we look for each property what is the weightage, and then we will try to do a selection of the product.

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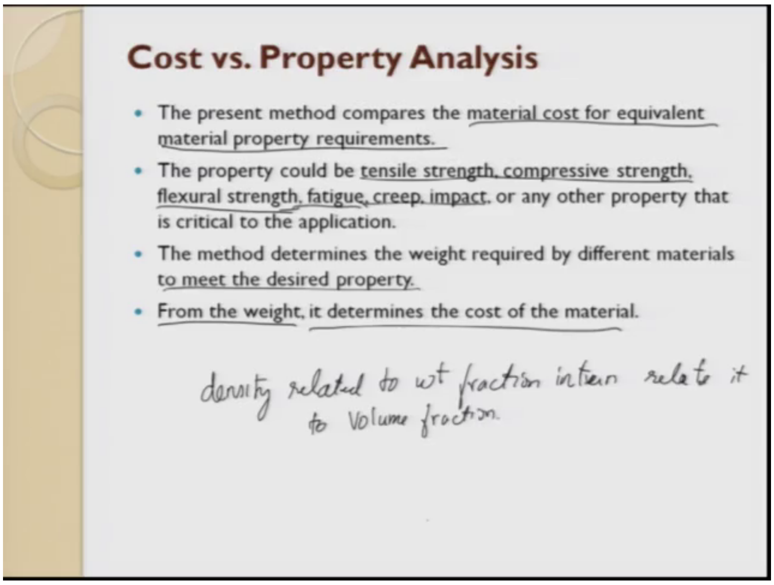

The cost versus property analysis is the present method we are going to discuss a method. In the present method we compare the material cost for a e material cost for equal material property requirements.

For example we take 2 different materials. Take 50 kilos of load. So, how do you choose a as compared to that of b? So, the property generally we generally talk about is tensile compressive, flexural, fatigue, creep impact and many more things to do. So, the method determining the weight required for different materials need to meet the desire property. So, from the weights it determines the cost of the product. We last class we saw density related to weight fraction, and that intern you can intern you can relate it relate it to volume fraction. So, this is what we saw in the last class, last derivation which I did.

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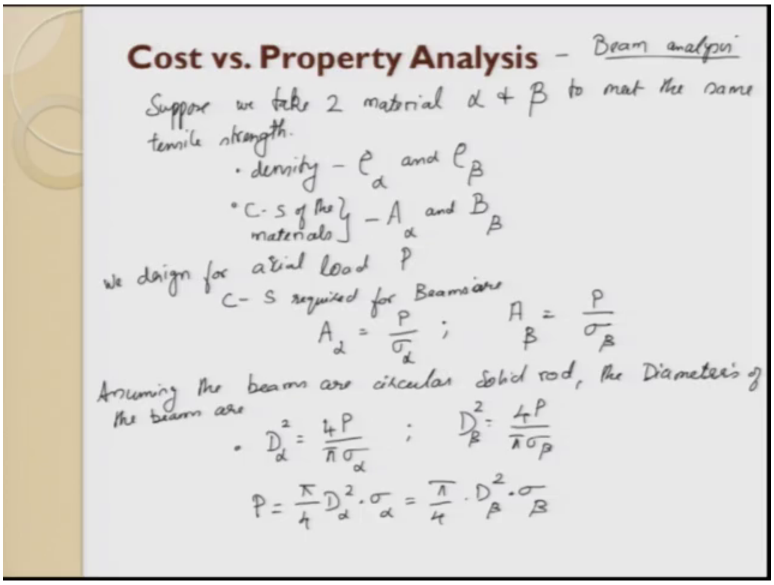

So now, let us try to take a simple example and start working. Suppose we take 2 materials alpha and beta to meet the same tensile strength. So, we need to understand density will be rho alpha and rho beta. So, since I want to find out the tensile strength. So, I need to know the cross sectional area. So, the cross section area of the material will be A alpha and B beta. So, if we if we design we design for axial load P.

So, the cross section area of beam so we are trying; what are we trying to do? We are trying to do beam analysis beam at beam analysis with respect to cost. So, the cross section area the C S required for beam is at most to say beam is like for a alpha you try that is load by sigma alpha. And beams I will make this as r. So, A beta what we have is this is load by sigma beta, this is beta sigma beta.

So, the assuming the beams are circular solid rods, because these are very easy to fab manufacture. So, so then what is the biggest thing which comes? The diameter we have to the diameter diameters of the beams are one D alpha square equal to load by area that is nothing but 4 P by sigma into alpha a. Then d square equal to 4 P which is nothing but pi beta. So, here it is for beta material. So now, what we have to do is we have to reconvert this. And then because I said it is for finding out for the same load; so for the same load. So, if I want to write the equation rewrite the equation like this.

I can say it as it is pi by it is pi by 4 D alpha square into sigma alpha that equal to pi by 4 D beta square into alpha beta. So, what are we trying to do? We are trying to take 2 different materials 2 different materials 2 different materials you will have 2 different densities, but the cross section area we assume to be the same, the loads are the same. So, we are trying to find out what is the relationship between them.

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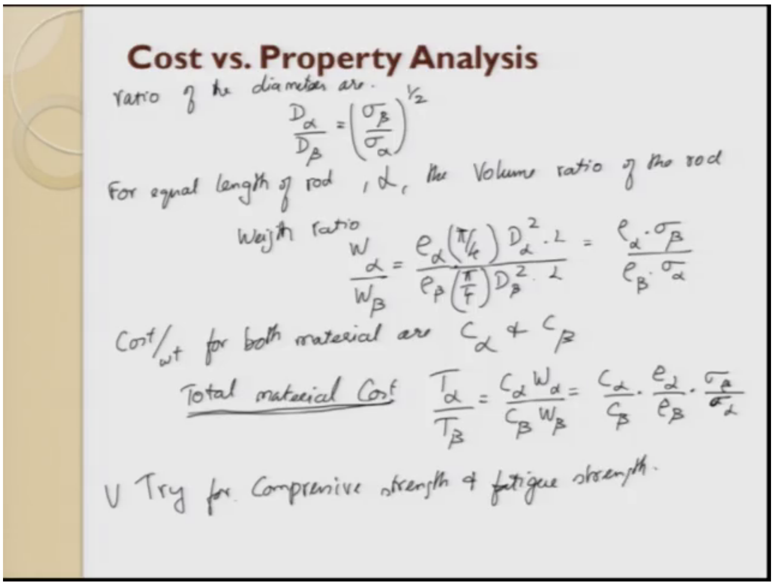

So the ratio of the diameter are, so it becomes D alpha by beta diameter is nothing but A beta by a alpha sigma alpha by 1 by 2. For equal length for equal length of rod L the volume ratio first, then we have to find out the volume ratio of the rods will be same. So, the weight ratio what happens to the weight ratio? Weight ratio is nothing but w by alpha by w by beta is equal to rho alpha by rho beta.

So, through this is pi by 4 D alpha square into L that divide by pi by 4 D beta square into L. So, that is nothing but rho alpha into sigma beta by rho beta into sigma alpha. So, assuming the costs per unit area per unit weight cost per weight for both materials are c alpha and c beta. So, the total cost total material cost will be t alpha by t beta, which is nothing but c alpha weight w alpha by c beta by w beta, which is again this weight.

Again you can convert it into density. So, alpha by beta into rho alpha by rho beta into alpha is that is stress eta. So, you can do a cost comparison. A cost comparison is done? keeping what did you keep? You kept tensile strength for 2 different materials. So, in the similar way you can try you try for you try for compressive test. Compressive strength you try for compressive strength. And the dynamic analysis what we were talking about is a fatigue strength, you can try this right.

So, this is for tensile we have done? So, what are we done in step one density, then we found out the area then we to the cross section is the same because when you try to change the this things. So, we always try to take cross section area same then we diameter same. So, from that we try to find out the load. So, from the load we try to find out the diameter ratio say then weight ratio, weight ratio is directly proportional to the cost we saw the cost. So, with this you can try to find out the total cost for any 2 given materials how do you compare? So, this is only one property.

So, if you have in reality you will always have combinations of several properties. And the biggest challenge is; what is the weightage you give for each combination carries importance.

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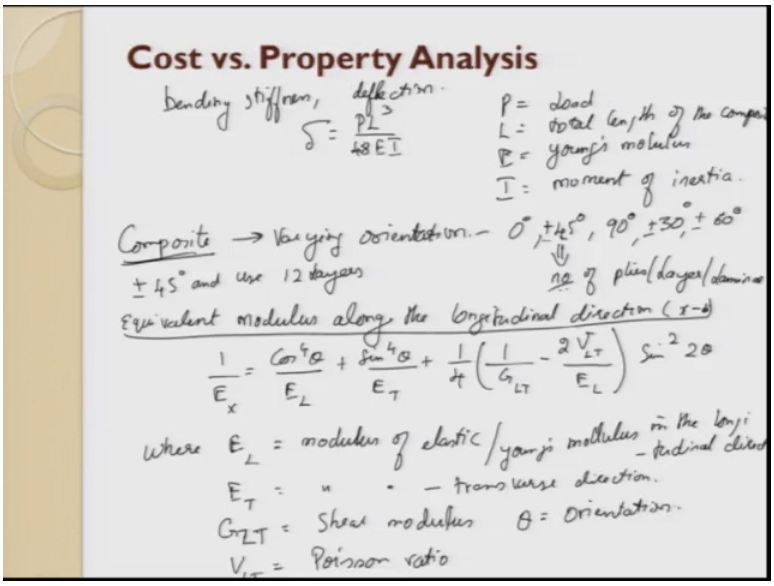

So in the similar way we can try to dif we can also try to do for designing stiffness. If you want to do for bending stiffness, then what do we do? Bending stiffness then what we try to do we try to find out the deflections? So, how do you do the deflections? Deflections can be done by load L cube by 48 E I. So, where P is the load. L is the total length of the composite, and then E is the Young’s modulus. And I is the moment of inertia, moment of inertia. So, we can try to do this. So, generally we know in composites I was trying to tell you that it can be made with varying orientation. For example, I said it can be made out of 0 degree orientation; it can be made out of 45 degree orientation plus or minus. It can be made out of 90 degree orientation. It can be made out of 30 degrees plus or minus 60 degrees plus or minus.

So, all these things are orientation, so each one in a lamile, so several of thing start together forms a laminate. So, if I wanted to determine for a composite material with varying orientation. So, if the and then varying orientation. So, here what is that? Is I just telling this information does not end. So, I have to also try to say number of plies I use. So that means, to say number of plies or number of layers, what is a layer number of lamine.

So, number of layers I also have to say this. So, let us assume that there are a there is a composite which is made out of plus minus 45 degrees, and then we use 16 or 12, 12 laminates 12 layers, 12 layers for construction. So, if we find wanted to find out the equivalent, equivalent modulus along with the longitudinal direction, because yesterday I told you there is a difference in property between the longitudinal and the transfers direction longitudinal direction, let us assuming x alone equal and modulus along the longitudinal direction x direction ok.

So, the end formula will be something like this, E x equal to cos 4 theta divided by E L plus sine 4 theta divided by E T plus 1 by 4, we can have 1 by G L T minus 2 times poisons ratio, poisons L in the L T. 2 poisons ratio divided by E L divided by E L into sine square 2 theta, where E L is the modulus of elasticity. I have been using 2 terms Young's modulus and modulus of elasticity it is the same.

So, I will write it down it can be also called as Young's modulus in the longitudinal direction, longitudinal direction. Then E T is going to be the Young's modulus in transverse direction, transverse direction. Then you will have G L T, which is nothing but the shear modulus. Now you see now new terms come into existence shear. Shear modulus of the composite. V L T is the poisons ratio is the poisons ratio, is the poisons ratio. And the theta what we talked about is the orientation. So, you see the orientation also plays an important role as for as the cost as for as properties are concerned.

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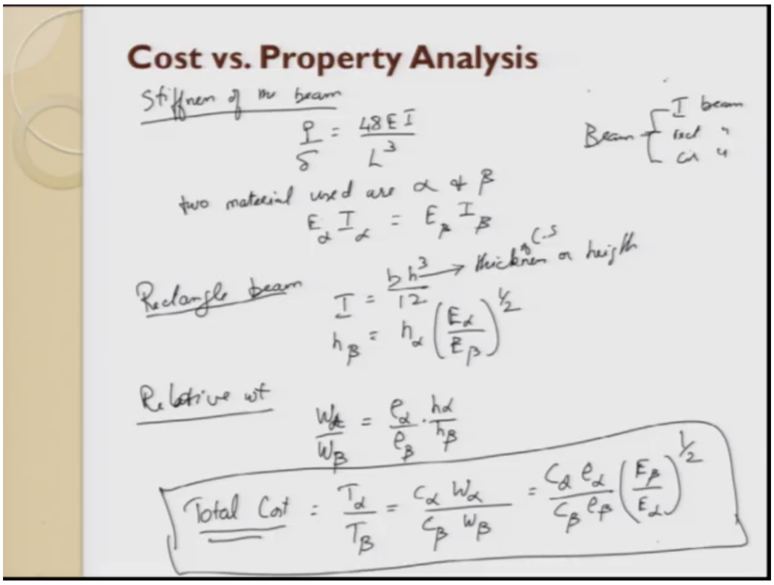

We will try to see the stiffness of the beam, the stiffness of the beam how do you find out the stiffness of the beam? Stiffness of the beam can be found out by this way it is 48 E I by L cube. So, where the stiffness is proportion the stiffness is directly proportion to E I. So, the 2 materials which we use the 2 materials, 2 materials used for 2 materials used are alpha and beta. So, E alpha I alpha equal to E beta I beta. So, the beam now what we have done? It can be I beam it can be rectangular, it can be circular beam.

So, depending upon this you can try to change and try to find out the deflection. Just for your information rectangular beam as I is nothing but b h cube by 12. So, if you want to do the height here, it is the height or the thickness you can take. Thickness or you can take the height of the component height or the length of this thing you can take height or the thickness of the cross section. So, if you take 2 different materials. It can be h beta equal to h alpha E alpha E beta into half. So, what have we done here? We have done the stiffness of the beam we have tried to find out the 2 different materials, and just for rectangle I have given it.

So, if you want to do it for other beams you can try and what we have done is we are trying to find out the thickness, thickness of the cross section area we are trying to find out that. And this relationship can be used for comparing 2 different materials. So now, if you want to compare it with initially we were trying to work on relative weight. So, this is for the relative weight. And finally, what we get is the total cost for this given a components. So, there are 2 ca materials, we are trying to compare and try to find out the stiffness.

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So, next is the weightages of properties what is a weightages? Weightage first we have now figure out 2 different materials 2 different properties, and we know what is the impact of each other. So, we are now trying to give weightages for individual properties you just maximum and minimum, and then we try to come with the non quantitative scaling property for the same.

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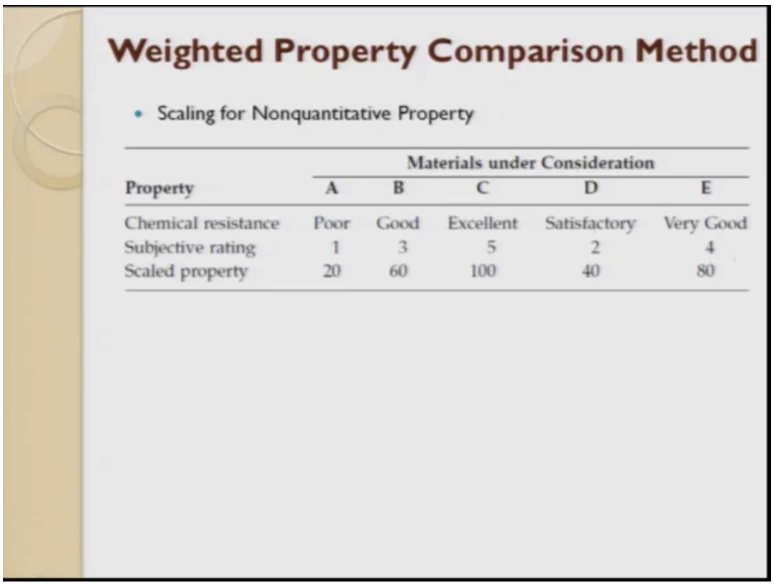

So, if you look at the property A B C D or these are the properties and what we are trying to do is we are trying to compare materials. So, for example, you will see a chemical resistance poor. Then it is good for B material it is good for c materials it is excellent, for D materials it is satisfactory E material is good. Now what did we do? We converted all these qualitative terms in to our subjective to term; that means to say this is extremely poor this is extremely rich. Then what we get was we try to multiply it with a factor and get these scaling properties. So, how did we do that? So, we will try to see for Maximum property.

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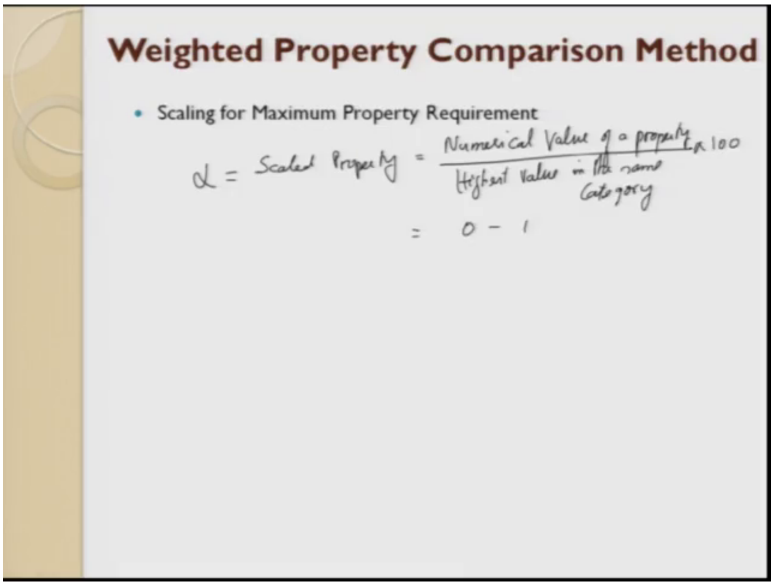

So, maximum property is defined as a term called as A alpha, which has a scaled property which is equal to numerical value numerical value of a property divided by highest value in the same category multiply by 100. So, you always get to know. So, multiply by 100.

So, what basically you do is you take a value from 0 to 100, and try to get this value by this what we get is we try to get the scaling for maximum property, in the same way you can also do the minimum property. So, minimum property is again alpha it has nothing but scaled the property, which is nothing but lowest value lowest value in the in the same category divided by the highest value in the same category, highest value in the same category.

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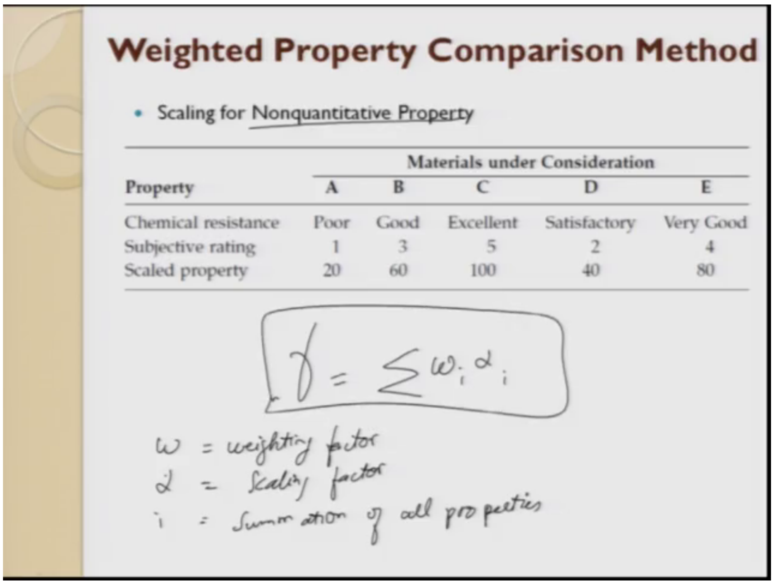

So, bay basically what are you trying to do? You have done for maximum you have done for minimum and then you multiply it with 100s. So, you get the value. So, here scaling for the non equal to. So, finally, what it happens is it comes to a new term called as gamma, which is put a summation of wi into alpha I. So, where w is the weighting factor weighting factor then alpha is the scaling factor scaling factor I is nothing but the summation of all properties, summation of all properties which you have considered.

So, we get a term called as gamma. So, this is a non qualitative property. So, you can do all these things, otherwise today we have standard expert Systems which are available.

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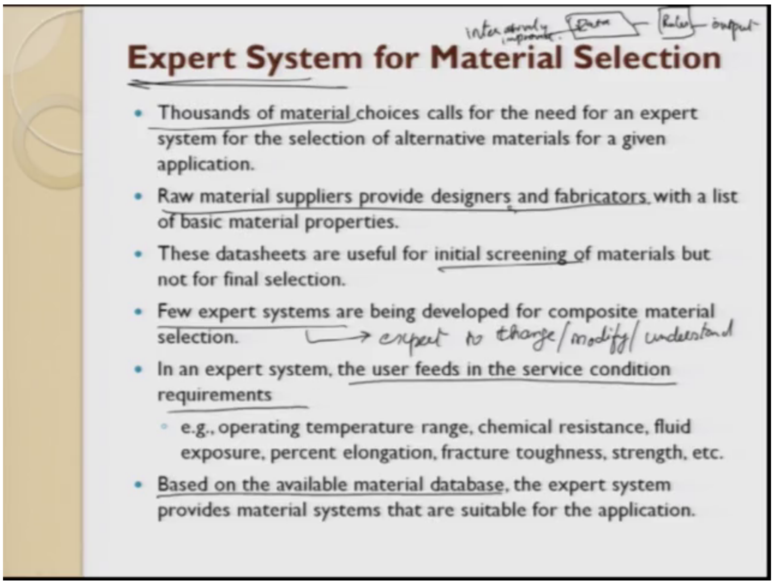

Where and which in expert system what we have is we have here database, we have a data and then we have this rules whatever you have framed. If and else rules and then you get the output you get the output whatever you want you just put all the queries whatever you want and other things. There is a huge set of database. This database is getting iteratively improved iteratively improved. So, what people have done is people have started building expert system. The expert system is used for material selection in an expert system you will have thousands of materials available, the raw material supplier provides designer and a fabricator whatever information they want, and initial screening of the material can be done very fast.

There are only few expert systems which are available, again in this expert system whatever comes you need an expert to tweek to change or to modify or understand, all these terms you can understand a solution. And then start doing if an expert system is very good the user feeds in the service condition required and also gets the best output, based on the available material data the expert system are also used for selection of materials.

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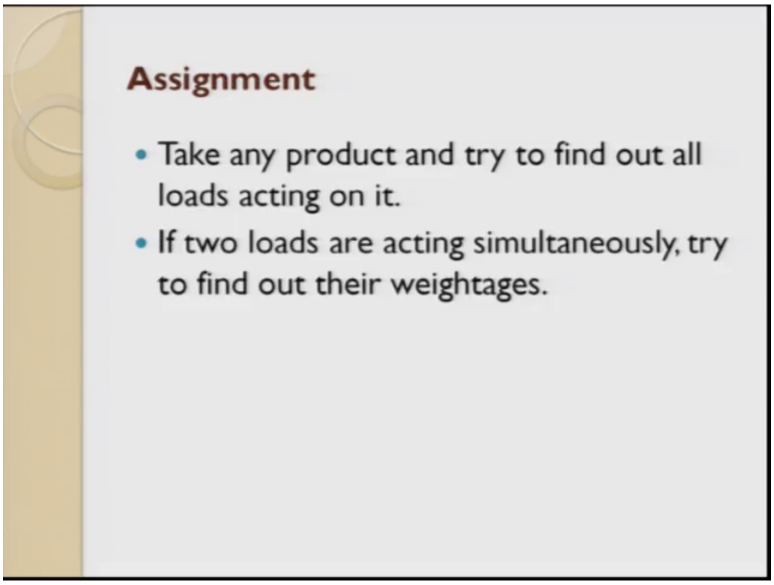

So the assignment for today's lecture will be you can take any polymer product, take any polymer product right and then try to find out what are all the loads getting acted on it is it only one load or is it multiple loads getting acting on it. And then if you find out there are multiple loads acting on it what weightage will you give for is load, and then you will take that as a base matrix to select a polymer. And here we are not considering cost we are just considering only loads which are getting applied. So, the loads can be tensile compressive shear fatigue whatever it is right.

So, with this we will try to come to an end to lecture 6.

Thank you.