Metal Cutting and Machine Tools

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Lecture – 12
Wear and life of cutting tools – II

Welcome viewers to the 12 lecture on of the course Metal Cutting and Machine Tools, and today we are going to take up the last part of the discussion on wear and life of cutting tools. On the previous day, we have understood how a wear and tear can reduce the working life of a cutting tool and ultimately make it render it to be unusable.

What exactly happens is wear takes place mainly on the principal flank and on the rake surface; on the rake surface it you know it manifests as a creator and on the flank surface it removes part of the top of the flank. So, that a landforms and when this the average wear extent of this land reaches around 0.3 millimetres, we name that tool I mean we state that that tool has become unusable due to wear and tear.

So, it gives rise to an expression of tool life and we have already studied about Taylors tool life equation not the extended one the simple one, Taylors tool life equation we have already studied in which a relation is established between the cutting speed in meters per minute and the tool life in minutes, so that if a tool is used at different velocities we can establish a relation between all of them. So, let us go on to the solution of few problems, so that we understand how the operation how problems can be solved in this particular direction.

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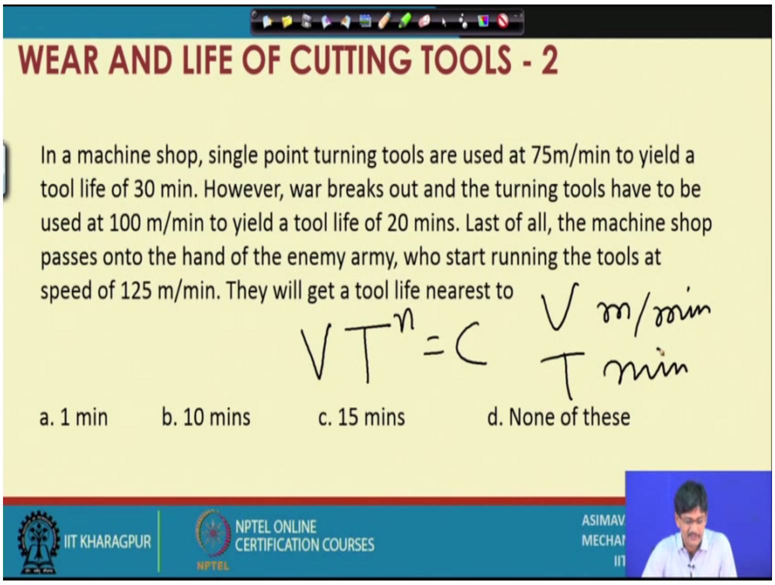

Let us see in a machine shop single point turning tools are used at 75 meters per minute to yield a tool life of 30 minutes. So, you are using it at 75 meters per minute and the tool life is 30 minutes. However, war breaks out and the turning tools have to be used at 100 meters per minute to yield a tool life of 20 minutes, last of all the machine shop passes on to the hands of the enemy army oh my god who start running, the tools at a speed of 125 meters per minute, they will get a tool life nearest to some options are given.

So, what exactly is the case? First data we get a set of values, I mean a pair of values of velocity and tool life 75 meters per minute and 30 meters per minute. So, war accelerates a number of activities, you need more you know spares maybe for different equal related equipment and for that you have to get them fast.

So, you do not really care about economy and you know meaningful to lives and therefore may be due to some government applied you know command sort of they have to be operated 100 metres per minute; so obviously, the tool life will be less and we will be operating with the Taylors tool life equation so let us just write it down. So, that we are remind sorry yeah that is all right V is equal to sorry V into T to the power n is equal to constant and V is in meters per minute and T is in minutes.

Now war breaks out, so you have to make you get things done fast and you increase it to 100 meters per meter. So, another set of values they are given. Last of all the machine shop passes on to the hands of enemy army, if this happens very frequently in the second world war what happened was that the Germans took over some countries very fast you know almost overnight and I remember having read somewhere that in Czechoslovakia the machine tools were of high repute and the Germans started using them.

So, what did the Czechoslovakians do? They put sand into the cutting fluid at all the machines were rendered useless. So, this thing will happen very frequently enemy army will use them not even bothering about you know how much expenses are incurred, but they just have to get some of their parts made and the earliest. So, another value is given 125 meters per minute the velocity, but the time is not given what is the tool life and the tool life has to be decided. So, the tool life options are 1 minute, 10 minutes, 15 minutes and none of these, so let us see how we can proceed.

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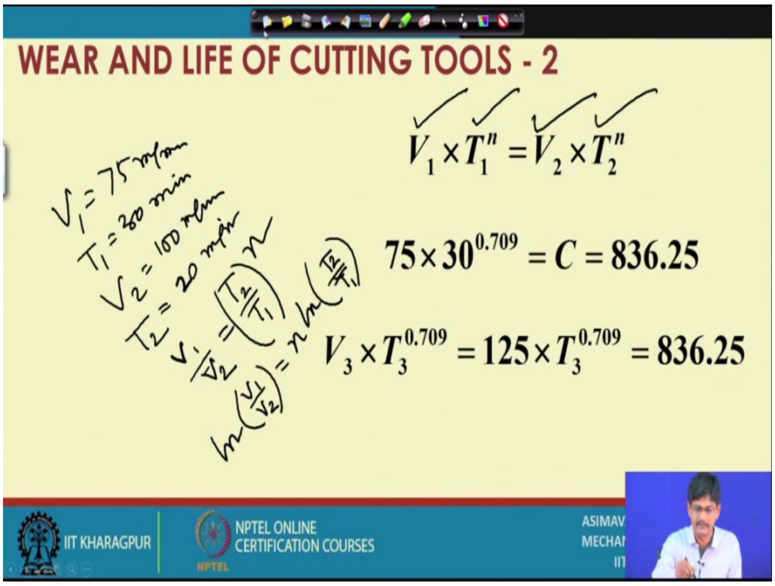

So, first of all what we have written here is V into T to the power sorry V 1 into T 1 to the power n is equal to V 2 into T 2 to the power n. Let us see what are the values that we know; do we know V 1 yes, V 1 is equal to 75 meters per minute do we know T 1 yes we know T 1, T 1 is equal to 30 minutes, do we know V 2 yes, V 2 is equal to 100 meters per minute. So, this also we know T 2 do we know yes.

So, what is to be found out n we do not know. So, T 2 is equal to 20 meters per minute sorry 20 minutes. So, in that case what we can do is, that we can write V 1 by V 2 is equal to T 2 by T 1 to the power n; and after that we can find out natural log of V 1 by V

2 is equal to n natural log of T 2 by T 1 does it seem to be all right yes. So, V1 by V2 what is V1? V 1 is 75, V2 is 1000 a 100, so just a moment I think better.

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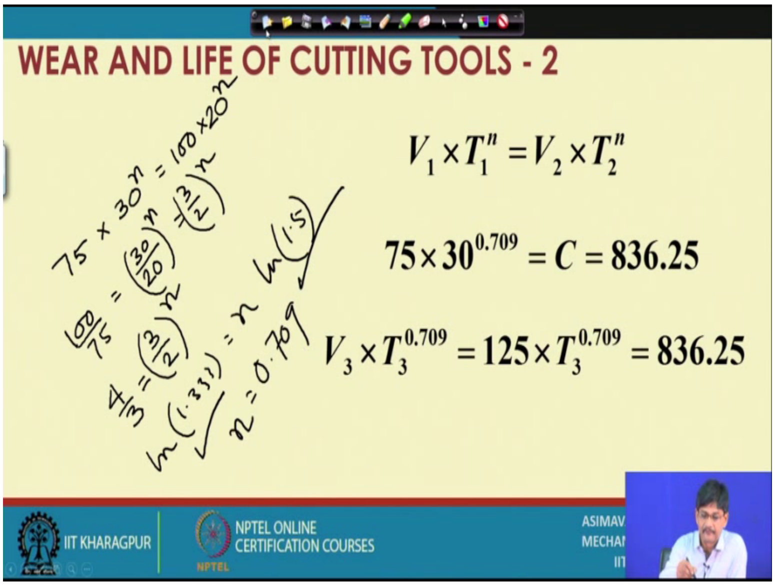

Let me just clear it let us put in the values actually 75 into 30 to the power n is equal to 100 into 20 to the power n, which means we can write 100 by 75 is equal to 30 by 20 to the power n, which means 3 by 2 to the power n and this is 4 by 3. So, 4 by 3 sorry is equal to 3 by 2 to the power n and after that we can take ln 1.333 equal to n into ln 1.5.

We can find out these values very easily and n can get solved. So, I have found n to be 0.709. So, please check n comes out to be 0.709 does this solve our problem? No, it does not solve our problem because if we try to find out T 3.

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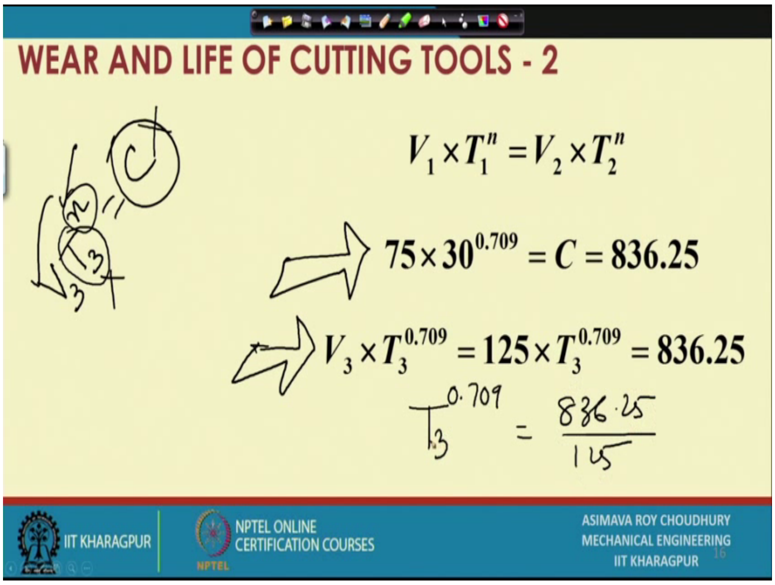

If we try to find out T 3 suppose we put V into V 3 into T 3 to the power n is equal to C, I do not know C till now but I do know n, I do not know T 3, I know this; I do not know this so it still cannot solve my problem.

So, what we need to do is, we need to find out C and that is what we have done here, in one of the known cases say the first case we know all the values and therefore C can be found out 75 velocity into T to the power n, n is known now is equal to C and therefore C comes out to be 836.25; I just you know at this moment I am not draw (Refer Time: 10:10) units, I think for all you know for this problem you can still this will be clear to you.

So, C is equal to 836.25 so that, now if I apply it in case of the third equation; that means, V 3 and T 3 we have 125 meters per minute multiplied by T 3 to the power 0.709 is equal to 836.25, which means I will have T 3 to the power 0.709 is equal to 836.25 divided by 125 and therefore, once again by taking log I can solve it. That means, it will be 0.709 log T 3 is equal to log of this value ok and therefore, I can send 0.709 to this side and then take antilog and solve for T 3, let me see what value I had obtained sorry.

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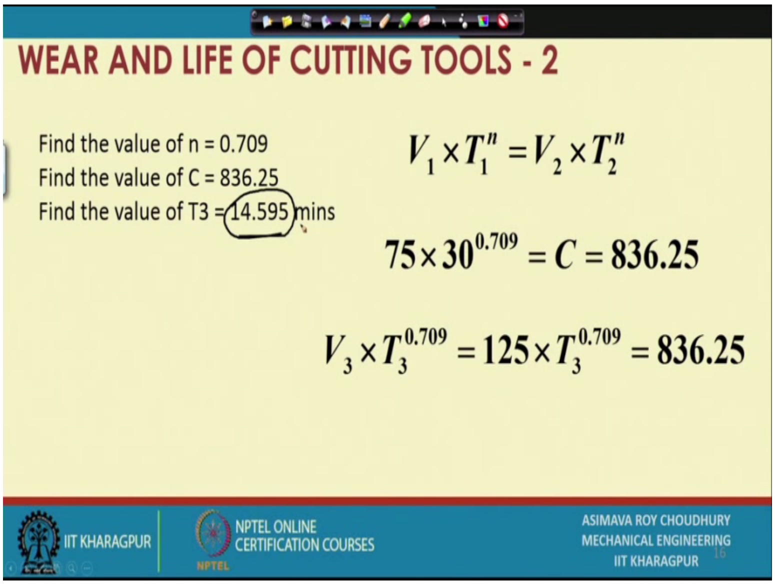

I obtained a value of 14.595; I obtained this particular value of 14.595. So, if we look at the solutions 15 minutes, this is then the correct answer. 14.595 that is as good as since we have given they will get a tool life nearest to this will be taken as the correct answer ok. Now, let us pass on to the next problem.

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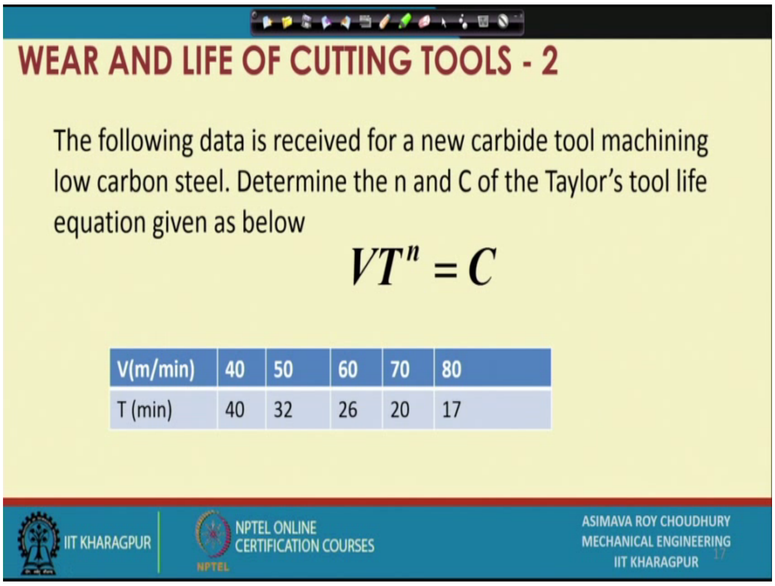

So, the following data is received for a new carbide tool machining low carbon steel. Jelly carbide tools are not used for you know steels because, diffusion wear can take place and it can you know destroy the tool within a few minutes of it is first run. So, generally we take precautions like we can put a coating say titanium nitride coating is put there, so that it deters any such diffusion wear. So, in this case we assume that some problem, if it is occurring like that it is not existing here.

So, we are now supposed to determine n and C of the Taylors tool life equation given as below. What is the data given get to us? That is it has been run at several cutting velocities and we have the corresponding tool lives in minutes. So, what is the problem we will say that yes just put these values in and find out n and C there is a problem, what is that just a moment.

If we so let us quickly have a look at the data 40 meters per minute gives a tool life of 40 minutes 40 meters per minute give a tool life of 32 minutes 60 meters per minute give a tool life of 26 minutes. So, as the velocity is increasing the tool life is decreasing that is understood?

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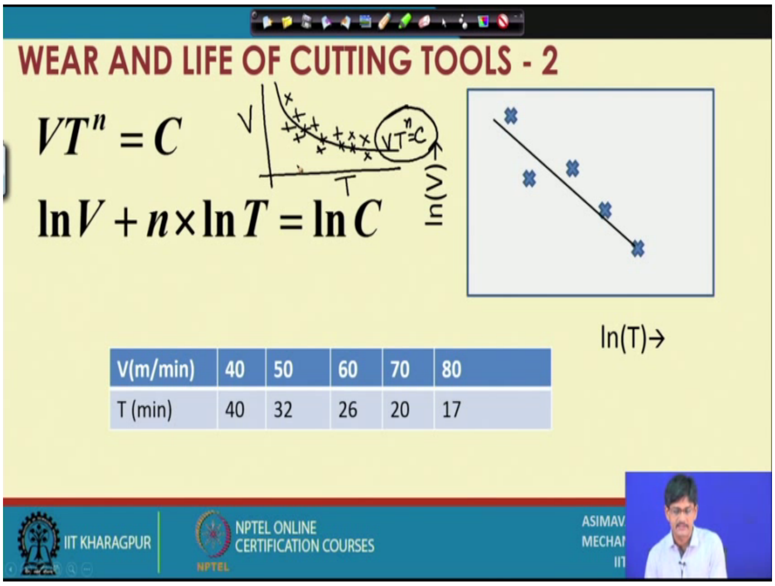

Now, let us see what is the way in which n and C can be determined. N and C you know if we plot if we plot the values of n and C in an ordinary paper, let us say this is our graph paper and on this side I have tool life, on this side I have velocity, I am supposed to have a curve which obeys V is V into T to the power n is equal to constant, but you know this is a relation between velocity and tool life in a sort of generalized manner, a single point might not be lying on it, a point might be here you will say why it is supposed to you know obey this particular rule.

But this rule is a sort of fitted behaviour to you know general data, the points might be clustered around it and then the general behaviour has been predicted by fitting a curve, this is fitted curve and all sorts of data points experimentally obtained it will be clustered around it, because of which this particular you know behavioural pattern has been identified and mathematically expressed.

So, if we have this data it is not always true that all the points will be very comfortably lying on a curve which will be obeying this 1 no, rather it will be like this. So, in that case how do we find out n and C in that case first of all what we can do is, once we notice this particular form of the equation, we can write it out as taking log on both sides I have you know log a b is equal to log a plus log b.

So, log VT to the power n is equal to ln V that is natural log V plus n log T is equal to log C, I have taken natural log. So, I might be using log directly please understand that I am always referring to natural logarithm; if this happens we quickly notice that this represents nothing but a straight line in what way we might say Y minus m x equal to C.

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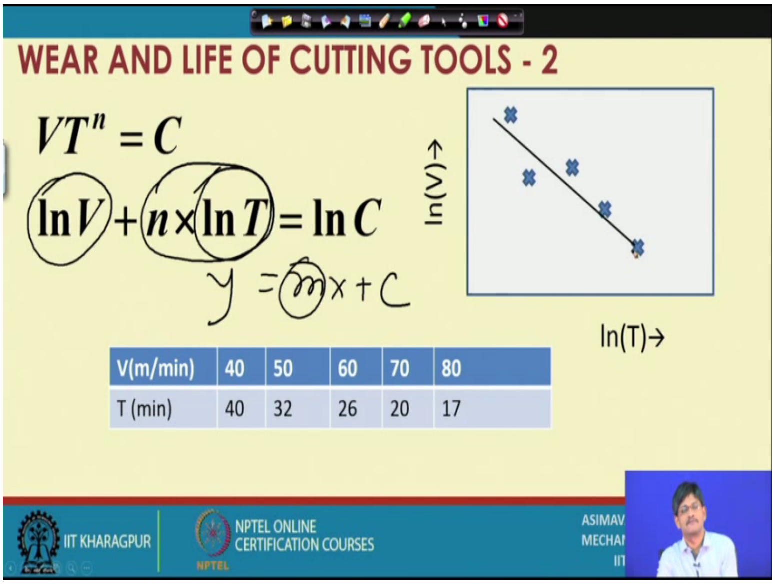

Which means it corresponds to sorry y is equal to m x plus C this m x term happens to be on this side, but we write it here it will gain 1 minus sign, but that is m x I mean that is the general form of the straight line.

What is y? We will say y is nothing but the natural log of velocity, what is x? X is nothing but the natural log of tool life in minutes, what is n? N must be equal to m if it is going to that side there must be a negative sign let it be no problem. So, we have here if n log T sorry if natural log of time is you know this axis if natural log of velocity is this axis and if the points did obtain experimentally fall like this we can draw a line which is sometimes called the best fit.

Now, what is the best fit mean? It means that whatever errors we are incurring from the actual experimentally obtained points and the curve drawn by us that error will be minimum, why not 0 will seems to be the best fit best fit. It might not come out to be 0 that is what you can reduce this error to a minimum, but it might well not come out to be 0, so that is why this concept of you know best fit curves have arisen. So, let us try a best fit here and get the corresponding values of n and C for that best fit.

Generally best fit is obtained if you are trying out say by hand we used to do it on log paper and best fit ultimately construes to this case, that these errors that we are incurring between the curve and the y coordinates they are you know sum of the squares of these errors; that means, y 1 minus y whole square. So, that we always have squares. So, that they do not negate each other by being plus and minus. So, experimentally obtained value y 1 y 2 y 3 y 4 y 5 and you know the fitted curve, so these y values have a difference. So, this 1 delta y ones delta y 1 square, plus delta y 2 square plus delta y 3 square this way, if we sum up sum of the squares of these errors will be equal to will be minimized. This thing can be done very elegantly by mathematical manipulation, so let us quickly do that and obtain the answer to this question.

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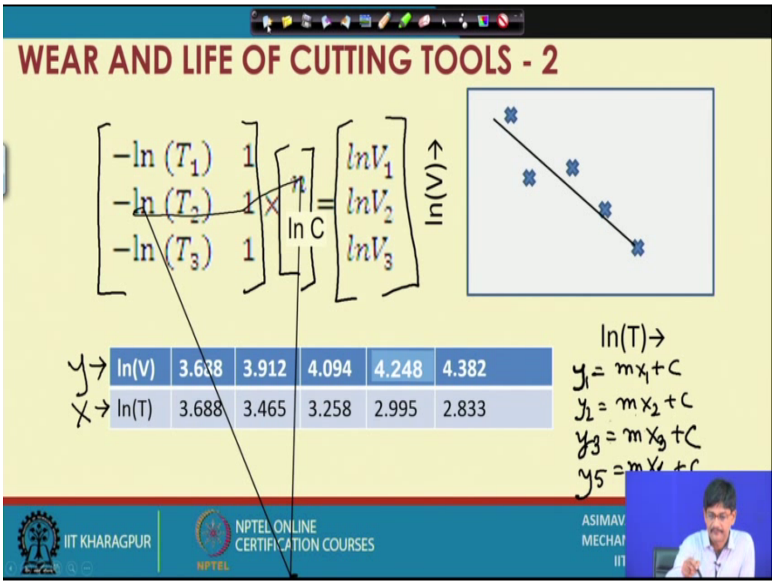

So, I hope you can read it, basically what I have done is I have expressed this in matrix form, here I have a matrix. So, what we have is, if we are having y is equal to mx plus C, we are actually having y 1 is equal to mx1 plus C, y 2 is equal to m x 2 plus C, if we had add 2 points we would could have drawn exactly a line between these 2 points, but the problem is we have more data than we actually required to draw a line here, a number of such points are here. So, m and C these are remaining constant, but y 1 and x 1 they are going on changing.

So, let us say here we are having 1 2 3 4 5 such values, sorry x4 plus C and what are these y 1 is nothing but these values y values and x is nothing but these values, it will come with a negative sign that is why remember that if it is coming going to the other side it develops a negative sign that is why I put negative sign. So, if we express it in matrix form taking out m and C in a separate matrix oh sorry m is the gradient and in our case it comes out to be the index of I mean Taylors index the index of t. So, n and c so if we multiply this way that is minus l n T1 into n that is log natural T1 into n plus 1 into C is equal to log natural V1 this 1 into sorry this one into this one is equal to second one this one. So, row by column multiplication yields this these things ok.

Now, in these matrices it can be noticed that as the matrix is not square it cannot be inverted, therefore we cannot get a direct solution naturally because, if we have more equations than the number of unknowns these are the 2 unknowns.

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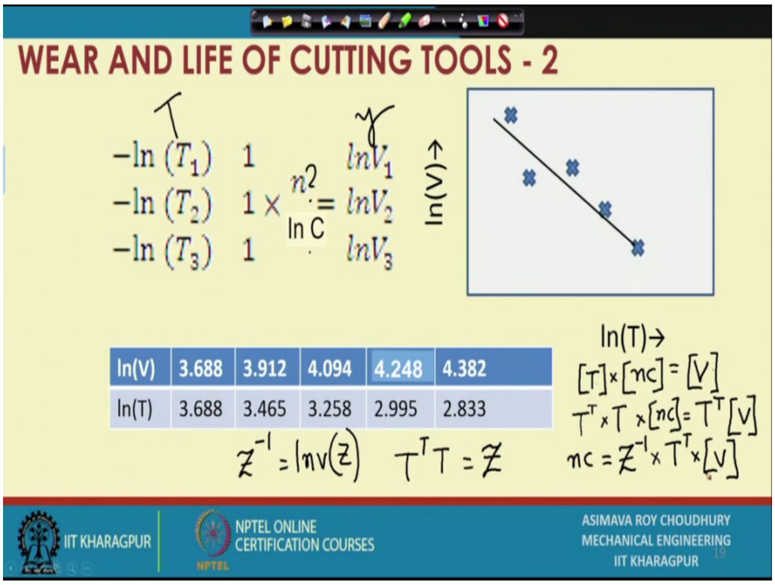

And how did have they been 2 equations we would have been able to solve it; if there are more such equations you cannot directly solve it. So, what we do in this case I can write it here, that is if I have the matrix the coefficient matrix as if I write it as x, multiplied by the matrix I need to find out let us write it as n c is equal to y, shall we use more relevant terms T matrix let us call it. So, we will easily remember this is the T matrix and this is our y matrix and therefore, we call it velocity matrix.

Now, all that you know operation of getting least square feet can be mathematically done this way, we multiply the transpose with T on two sides that is good. So, this becomes square then inverts it and sends it to the other side. So, that n c can be solved as this one let us give a name T star T is equal to say what Z x we have used Z.

So, we write now Z inverse let us write minus 1, so we also add here Z inverse means inverse of Z. So, this n c will now be solved as that is it by the multiplication of these 3 transpose of T and Z inverse which is the inverse of you know from here, it will be clear inverse of T transpose multiplied by T. N c can be directly solved this way and this is the same as least square fit and it can be used in any such similar problems, where the number of equations they are more than the number of unknowns, and the problem is solved in a general sense; that means, the solved line does not necessarily pass through all the points, but the error incurred will be the least. What I will do is I have solved the problem you can check it up and I will also send you a mat lab program through which this same operation can be done, so that it will be useful to you.

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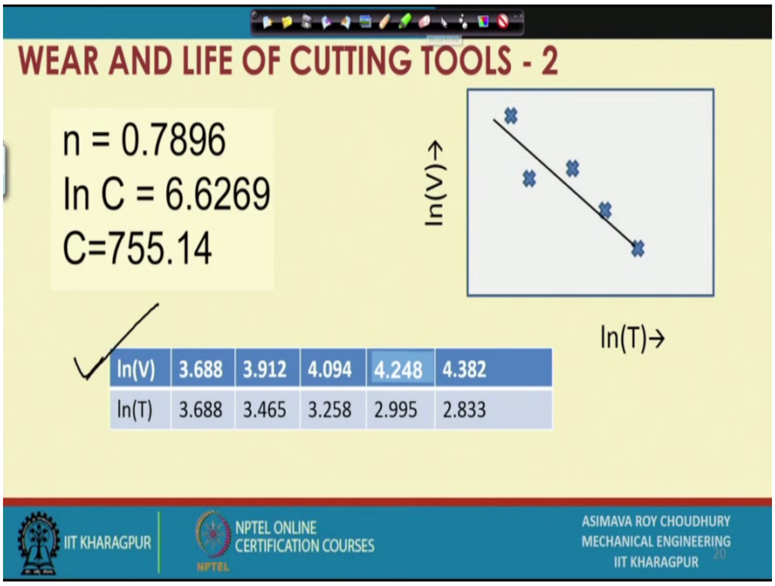

So, let us move on to the solution. So if we are given such values of velocity and time, first what we have to do is, we have to convert them into l n values make up the matrices in what form? In this form, make up the matrices in this form where you know just these will be used from the table, invert this matrix that means only this one first get it is transpose multiplied on both sides then inverse the transpose multiplied by this matrix send it to the other side and you can solve for ln c.

So, with this we come to roughly the discussion on tool wear, there are many aspects which are we are leaving behind because as you can well understand, if we have metal cutting and machine tools covered in a lecture Cs spanning only 10 hours there will be many things we will be leaving by the side of the of our, you know movement forward, and the only way in which we can make use of such information never discussed in the class is that by uploading by my from my side, by uploading some textual notes with some numerical examples. And if you can make use of those notes and ask me questions if you come across something which is difficult to understand; only that way we can get a you know balanced knowledge based on metal cutting and machine tools, otherwise it is extremely difficult. Otherwise we cannot cover all the aspects of all these things spanning a vast you know literature so.

Thank you very much.