Manufacturing Processes - II
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Lecture No.25
Estimation of Machining Time

Friends, now come to our subject Manufacturing Processes – II Module - 4 the General Purpose Machine Tools.

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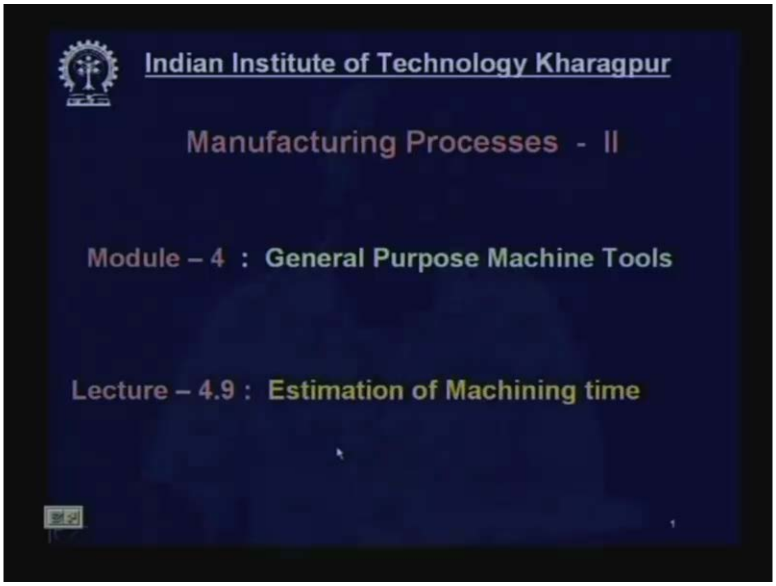

and today is the last lecture under this module that is ninth lecture Estimation of Machining time. Now what are the real contents within this topic? We have to learn necessity of evaluating the machining time requirement. Why it is so necessary to estimate the machining time required?

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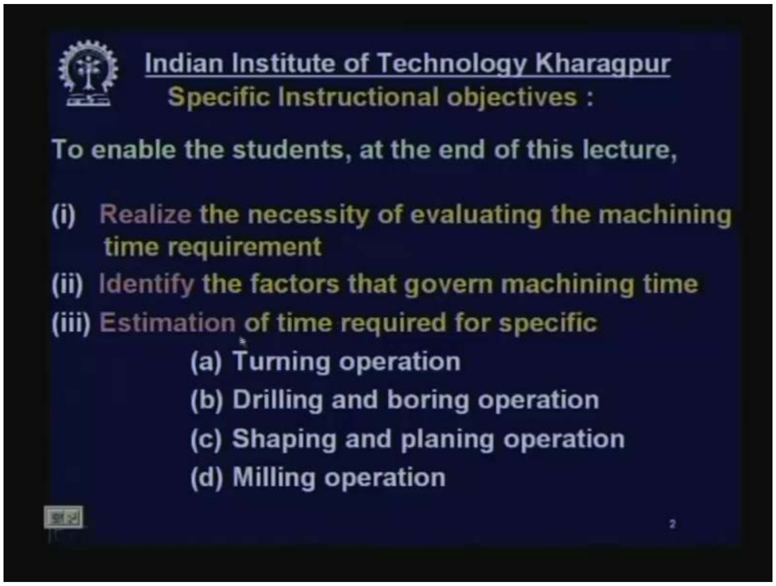

Next the factors governing machining time. This is very important then we can control the machining time and finally estimation or calculation of time required for specific turning operations, drilling and boring operation, shaping and planing operations, milling operations which are compressed in conventional machine tools, general purpose machine tools.

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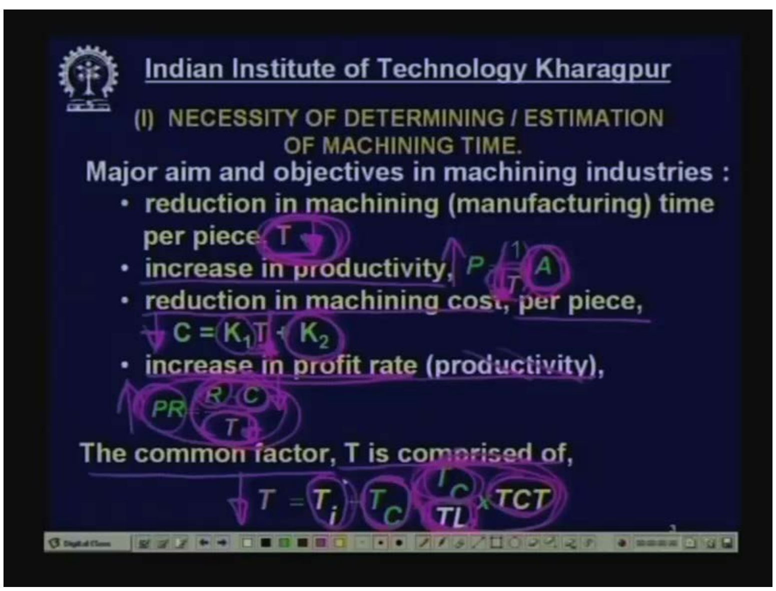

Now first let us discuss about necessity of the determining the machining time requirement. Why it is necessary? Please recall what are the objectives, aim and objectives in manufacturing say like machining. You remember the major aim and objectives in machining industries are reduction in machining that is total manufacturing time will be reduced if we can reduce that machining time which is a componential manufacturing. Now this time per piece suppose is denoted by T okay this is T. Now this time T required should we try to increase it or reduce it or maintain constant. Obviously we have to reduce the time as for as possible because more time is more wastages of time. We have to get the work done quickly and accurately all right.

So we have to try to reduce the time as for as possible but not at the cost of the quality of the product, quality of product has to be retained. Next objective is increase in productivity or material removal rate or productivity. What is productivity? Simply number of pieces produced per unit time. If time is T, then one upon T is the number of pieces produce per unit time. But whatever we machine are not acceptable may be 5 percent or 10 percent as a rejection. So 90 percent will be the acceptance level or 95 percent. So ‘a’ is a factor called acceptance level which may be 0.9, 0.95 and so on.

Now here we have to increase the productivity that can be obtained by reducing the time. Now in the previous case we have observed our target should be reduction in time. Here also we find our target is reduction in time so for as increase in productivity is concerned. Next objective is reduction in machining cost per piece. Now this has to be reduced okay as for as possible. Now this cost per piece has to be reduced, which is equal to K 1 into T, T is the time required per piece. K 1 is the man machine labour rate. Man machine hour rate that in to time is amount of rupees required and K 2 is a consumable cost. Cutting tool cost or say cutting fluid cost and so on. Now here we can see, if we want to reduce this cost per piece that time has again has to be reduced again I remind that okay.

We have to reduce the time but not at the cost of the quality that is dimensional accuracy and finish of the product. Now reduction of cost is not enough. What we are interested all with the profit? The owners or entrepreneurs or the industries are interested in the profit or other profitability increase in profit rate. What is profit rate? Amount of profit per unit time okay that has to be profited not productivity is wrong it has to be profitability. Now this profitability of profit rate is equal to R minus C. What is R? R is revenue cost of the price per piece say 20 rupees minus manufacturing cost 12 rupees. So what is the profit per piece 8 rupees?

Now profit per piece is not important if we make one piece in one month and make profit 10 rupees per month that has got no significance. We have to make profit per unit time that is the major like our salary so must 1000s of rupees per month. So per unit time again this profit per piece has to be divided by the amount of time required to produce that particular piece. So this gives the profit rate. Now here again we find, if we want to enhance the profit rate or profitability, we have to reduce the cost which can be possible by reducing the time again we have to reduce the time then this will be overall value of the profit rate will increase.

Now what we observe from these four objectives? Everywhere what is the most common factor that governs or influences the objectives? Amount of time required for machining each piece it is everywhere you see. Now this common factor T is comprised of several parts okay. This T has to be reduced that is okay that is understood. So this time per piece will have to be reduced. Now this is comprised of several components 'T i' that is called ideal time waiting time all right TCT tool change time. After doing one work side drilling, we have to do suppose boring that drill has to be removed and a boring tool has to be fitted. This tool change has to be done as quickly as possible this tool change time.

Normally it takes in ordinary industries particular in our country may be 5 minute to half an hour but this has to be reduced. Now friend this Ti ideal time, waiting time and this tool change time, the tool change time per tool. Now suppose if the cutting time is T C and life of the tool is only T L then how many times the tool has to be change T C by T L. Suppose the cutting time actual cutting time is 30 minutes, life of the tool is10 minutes. So how many times the tool has to be changed? Three times, 30 by 10 that every time you have to encore a tool change time say 5 minutes. So 5 into 3, 15 minutes will be wasted a lost because of the tool change for producing that particular piece.

Therefore our aim should be reduction of this ideal time and this TCT as for as possible.
Earlier this two together this total tool change cost and ideal cost comprised 70 to 90 percent and remaining 10 to 20 percent was invested for actual cutting action. Now this Ti and TCT of total tool change time have been drastically reduced by development and incorporation of very modern appropriate mechanization or what is called automation. Now after drastic reduction of auto TCT total tool change time and ideal time by automation. Next attempt was made to increase the tool life that is the denominator. If we increase the tool life then this value the tool change time will be reduced.

How these tool lives has been enhanced? Lot of research has been done carried out in the area of cutting tool material and geometry. As a result, tool life has been improved substantially then what remains is only machining time which was early hardly 10 to 15 percent of the total time. Now it has become it contributes 30 to 70 percent of the total time after automation and improvement in tool life of the cutting tool. So our target now is fixed to reduce this cutting time as for as possible again remember without sacrificing productivity, quality and overall economy.

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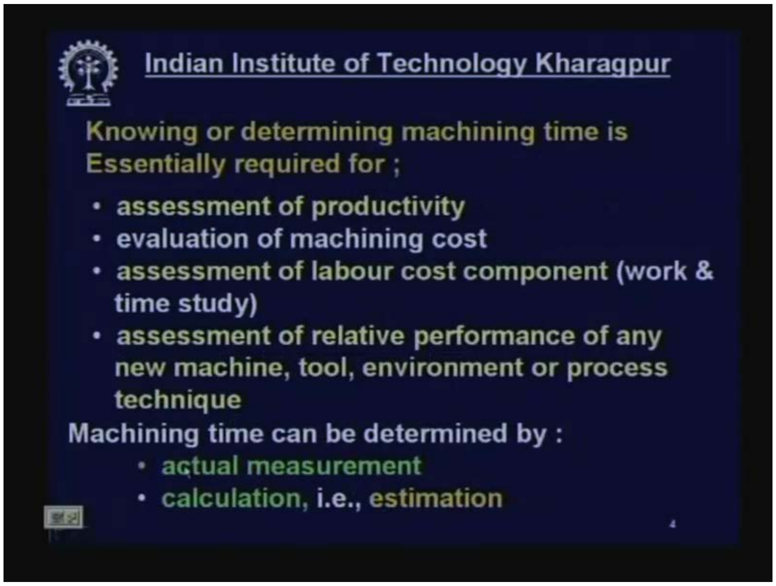

Now why do we need knowing this cutting time? Is it only for reducing? It has got many implications. This cutting time is an index of various objectives. Knowing or determining machining time is essentially required for now one by one see; assessment of productivity. Productivity means rate of production which will increase expectedly if the time is reduced. So the machining time or manufacturing time will tell us what is the range or level of productivity? Evaluation of machining cost in the previous. Previously you observed that machining cost is a function of time. Time is money, a more time is invested the more labour rate, more machine hour rate will be invested and there will be lot of un-economy.

Therefore now the machining time will help us reducing the machining cost. Assessment of labor cost component; now we do we try to know what is the labor contribution in a manufacturing based on which the incentives or salary of the laborers or workers will be decided. We do work study, time study and so on. So by actual experiment or machining contest we find out the machining time. Of course this can be done theoretically also by calculation. Next assessment of relative performance of any new machine, new tool, new environment or cutting fluid or a new process or technique:

Now we suggest, we develop, we create various types of or modifier improve technology, process, tool materials, tool geometry or say cutting fluid. But how do we assess the performance of the new? Tools system techniques, relative to the existing once. Now this is decided whichever tool machine or environmental process will enable reduction in machining time, keeping quality on altered we shall accept those new techniques and environments as a success and that have to be welcomed. So, machining time now again machining time can be determined in two ways.

What are those two ways? One is actual measurement. You know you just ask one operator, average operator or an expert some expert to carry out the machining work a particular machining work with a very average speed, feed, depth of cut certain conditions and you take a stopwatch and you measure the actual time. Now this is very precise, very accurate but this takes lot of time and this is expensive and wastage of material also. Now this can also be done by calculation simply by using simple equation or relations we can estimate or theoretically determine by calculation that time that will be required. This estimation by calculation may not be very correct may be approximate. But this will be very quick in expand inexpensive and very easy without any wastage of time, wastage of effort and wastage of materials. So calculation of estimation of machining time is very very important and useful for several purposes. Now next is measure factors that govern machining time.

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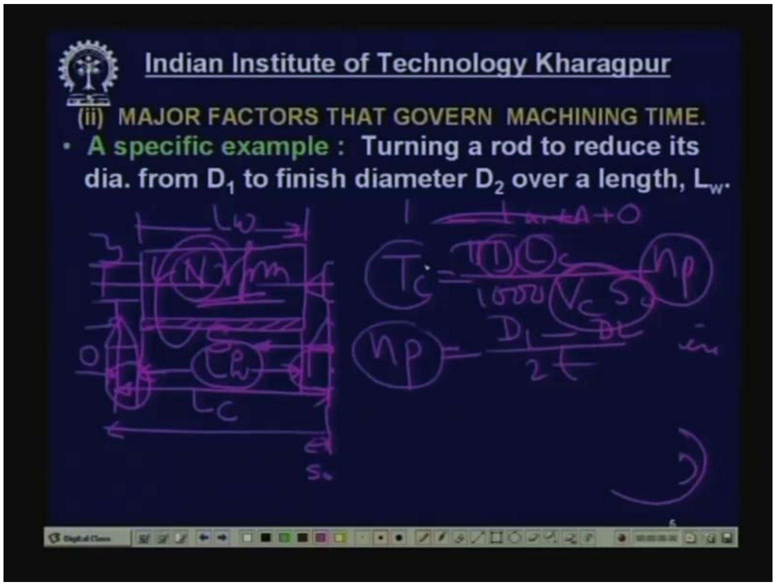

Now friend what is our target? First of all to know the machining time involved or required for a particular machining operation that will enable us to estimate the total manufacturing cost of any product all right a volume of production. This estimation of machining time will also help to think how this time can be reduced to reduce the cost or enhance the economy of machining. Now now there are several factors which govern or influence or effect the machining time. So see if you simply say hello machining time, you come down it is not possible you have to see what are the factors that are involved in machining time and we have to select those parameters, control those parameters in a such a way that machining time comes down or becomes rational. Now to understand this let us take a specific example to start with to understand how what is the basic principle of estimating time and what factors are involved in it.

Let us take an example turning a rod to reduce its diameter from D 1 to finish diameter D 2 over a length L w. Now let us sketch it show it. Here is a job, a rod held in the centers and on the other side by chuck and the diameter of this rod has to be reduced say by one pass or number of passes. But nowadays only one pass is used. Mainly maximum 2 passes; one roughing and one finishing. Earlier days, people thought that number of passes will be required not necessary. Now suppose the length of this job is L w, this L w okay. Now if we want to remove a layer of material to reduce the diameter, you have to utilize a cutting tool and this cutting tool has to be placed at a distance from the job and after completing the tool has to come to a position away from the job.

Now this distance is called approach for easy and simple engagement. These are engagement and this is called overrun. So the tool has to slightly to moved up away to clear the tool for the job and this is the L w. So what is length of cut total length of cut? This is the total length of cut L c okay. Now L c is the total length of cut L w plus approach plus overrun. Now usually the approach and overrun they are taken conveniently depending upon the operator the job configuration of the machine cutting tool geometry shape etcetera. It can vary from say 2 millimeter to 5 millimeter. Some time it can go to as low as 1 millimeter, sometime it can go as 10 millimeter but 2 to 5 millimeter is a very rational.

So this is a length of cut; now how much will be required to go this cover this length by the cutting tool at a feed rate say 'So' is the feed rate. What is 'So'? 'So' is the feed rate. The length of travel of tool per revolution of the job. This is the revolution of the job. Suppose the speed is N rpm of the job. Now how much time will be required? T c is equal to total length of cut say L c divided by 'S o'. Total length that has to be travelled by the tool from this point to this point, that is L c and in one revolution of the job that tool advances by a small distance called feed 'S o'. So 'L c' by 'S o' means total of number of revolution that be required to complete the job. Now what is the speed? Speed is N.

So many revolutions will be required L c by S o but how many revolution we get one minute 'N' called rpm, revolution per minute. So how many minute will be required L c by 'S o' divided by 'N'. So this is the real formula to determine the machining time in turning but the question is the feed 'S o' has to be assumed reasonably. Depending upon several factors which I shall tell you shortly, but what about the speed? The speed is available in the machine. Which one you will select? That question comes. Now the cutting velocity V c is equal to phi D N by 1000 meter per minute okay. Now from here 'N' is equal to 1000 V c divided by phi D. Now the problem is, this V c has to be first selected. Now the selection of V c requires lot of knowledge and experience and awareness okay.

It is not that easy to select cutting velocity that will depend upon several factors. Now form if you can select the cutting velocity considering all the relevant factors you can you know the diameter of the work piece the largest diameter of the work piece and you can determine the speed 'N'. Now remember by calculation, this speed may be around say 429 rpm. Is it available in the machine? It is a step drive. If it is a step place you can decide 429 but if the machine tool general purpose machine tools are step drive, so the 429 rpm may not be available that nearest lower rpm which is available may be only 400. So you have to adopt this nearest standard nearest lower standard rpm.

Now put this value in to this equation here, feed is assume say 0.2 millimeter per revolution. ‘L c’ is known because this is equal to ‘L w’ length of the job known approach you assume to 5 millimeter, overrun O, 2 millimeter. So you get ‘L c’ and you get the total value of ‘T c’. This is the basic principle of determining the time. Now briefly what is the equation stands then? ‘T c’ is equal to phi D L c divided by 1000 V c cutting velocity and feed for a single pass. If number of passes are required, then each has to be multiplied by number of passes and number of passes you know that will be determined by initially diameter minus final diameter by twice depth of cut okay. This formula is known but generally np is equal to one in case of turning may be maximum two for roughing and finishing. Now what we observe from this that to determine T c for a given job of diameter D and length L the velocity and feed have to be very carefully judiciously reasonably selected that part has to done.

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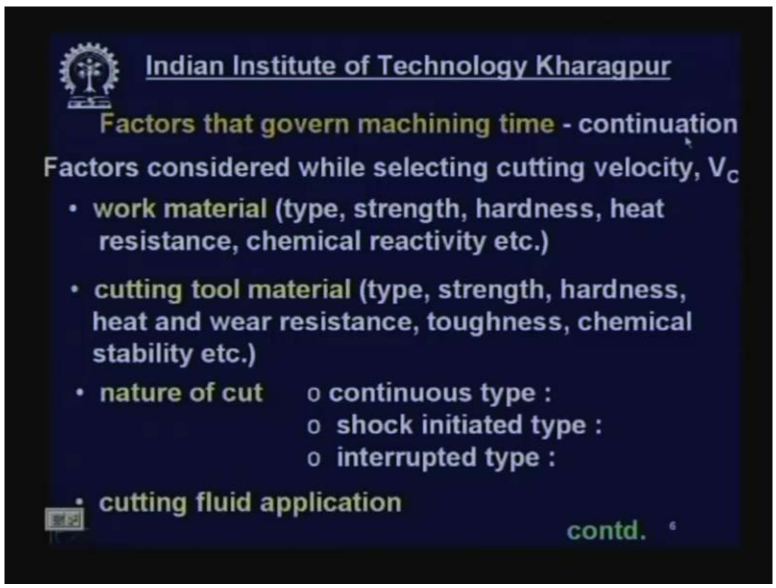

Now we can let us come to factors that govern machining time continuation factors. Now what we see that machining time is governed mainly by the cutting velocity and feed in simple machining like turning okay. Now the factors considered while selecting the cutting velocity V c in meter per minute. Now friend you can see, how many factors come into picture? Work material the work material what aspects of the work material we have to consider type. Is it ductile? Is it brittle or it is a sticky or it is a nonmetal alloy or exotic like that strength, the shear strength of the material, hardness, heat resistance chemical reactivity, stickiness, softness, etcetera that means if the work material is hard, strong, chemically reactive, heat resistant then it is very difficult to machine such a material even by good cutting tool material.

So the cutting velocity has to be low in such kind of materials but other way if the work material is very soft, ductile and non sticky like say aluminum or brass, then you can machine the same material at very high speed. Now the cutting tool material yes that also plays very vital role in deciding the cutting velocity what aspect of the cutting tool material important type is a brittle grade or ductile grade or tougher grade or it is you know special materials like cBN and diamond, then strength transverse structure strength shear strength compressive strength tensile strength etcetera hardness of the tool material heat and wear resistance toughness of the tool material chemical stability etcetera all these things have to be taken into account when you select the cutting velocity. For example, if you want to machine say mild steel turn mild steel by high speed steel cutting tool which is not very strong and heat resistive and chemically stable.

So the cutting velocity should be reasonably low around 40 meters per minute without cutting fluid and 50 meter per minute with cutting fluid. But, if you machine same work material by carbide tools you can go up 120 per minute. If you use ceramic cutting tools then you can go up to 400 meter per minute and so on. Nature of cut; you know that there are three basic three types of cut; continuous type of cutting where the chip load remains constant like turning, boring, drilling, etcetera. Shock initiated type like jerk like say shaping, plaining, gear shaping, broaching. Interrupted type or intermittent type milling where the chip load varies and the force fluctuates. Obviously you understand if we machine by a given material by a given tool tool material, if it is a continuous type we can go for high speed. If it is shock initiated type, we have to reduce the cutting velocity and if it is intermittent type or interpreted type milling then the cutting velocity has to be even lower.

Suppose for turning mild steel by carbide, even it is a turning 120 per minute. If it is shaping or plaining 80 meter per minute. If it is say milling that 60 meter per minute. Cutting fluid application; yes, the cutting fluid application is it is applied for you know lubrication and cooling. With increase in cutting velocity, why we cannot give high velocity? Because it creates high temperature and rubbing tool wear. So cutting velocity is kept low but if we are allowed to use cutting fluid for lubrication and cooling, then we can easily go for higher speed.

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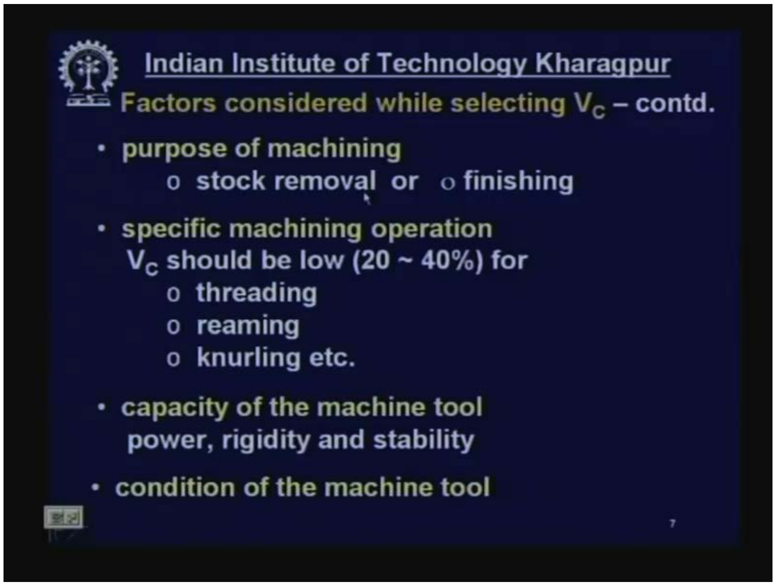

Now the other factors the purposes of machining. For what purpose really we are machining? Is it stock removal or high metal removal rate or finishing purpose that will also govern what should be the cutting velocity for saying work-tool combination. If it is stock removal at high depth of cut and high feed, cutting velocity should be moderate or low. If it is finishing operation on the same tool material, same job by same tool material at low feed and low depth of cut cutting velocity has to be very high we can take high speed. Another case specific machining operation; what kind of operation we are going to we are going to do? Velocity for turning by a given tool work material may be say 100 meter per minute. If it is a threading operation by the same tool material of the same work material the velocity should be drastically reduced on 20 to 40 percent. If it is reaming, it has to be reduced. If it is knurling, it has to be done at slow speed for same tool work combination.

So depending upon the kind of the operation, this specific critical operation like threading, reaming and knurling etcetera the speed should be low. The velocity selection will also depend upon the capacity of the machine tool. If the machine tool is not powerful, not rigid, not stable then even for a good work material and very strong tool material, we cannot go for speed, high velocity. Because high velocity means high speed high speed means you know lot of eccentricity and other problem may arise. But if the machine is powerful, rigid, stability, you can exploit the fullest capacity of the cutting tool and you can go for high speed.

Next is condition of the machine tool. Machine tool may be apparently powerful, rigid stability. But if it is old and attain lot of defects like misalignment back lash, then you cannot go for high speed. So speed has to be sacrificed accordingly. If it is a new machine, you can go safely for high speed. If it is over all type of machine repaired number of times, then you should sacrifice cutting velocity. So now you have heard that so many factors are essentially considered while selection of the cutting velocity for a particular machining operation like turning, drilling, boring and so on. Now come to factors considered while selecting the feed. Now friend you know the increase with increase in feed, what are the problems? With increase in feed, force increases proportionally, temperature raises, tool wear increases, surface becomes rough. So all this problem arise because of increase in feed okay, but increase in feed means more productivity that has to be how shall we select them this feed, which on one hand creates problem and on the other hand it is essentially for high productivity.

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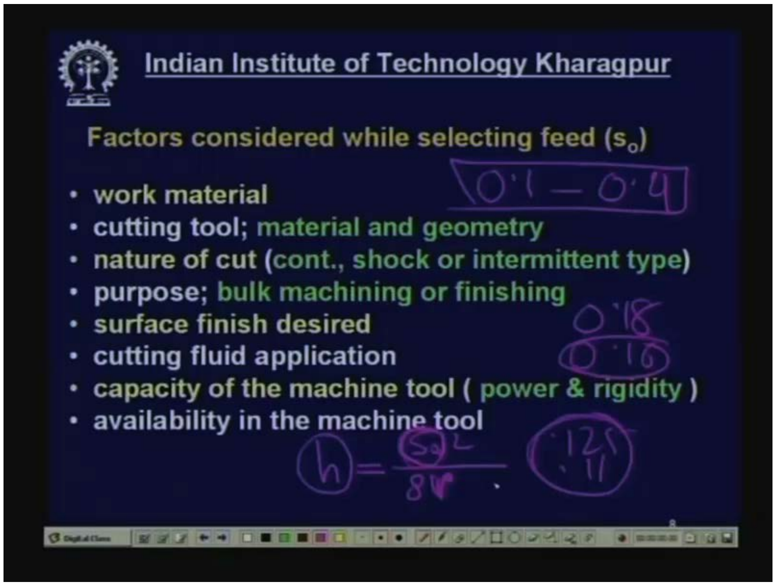

Work material - If the work material is soft, easily go for high feed because the force will not be high. Cutting tool; If the cutting tool material is tough, strong and heat resistive then geometry is favorable. Then you can go for high feed say first, if it is a ceramic, ordinary ceramic, very brittle, then you cannot take high feed. But if it is a high performance ceramic, tougher grade ceramic or cBN you can go for high feed. Nature of cut; Continuous cut you can safely go for large depth of cut. If it is shock initiated type shaping, plaining you have to reduce the depth of cut. If it is intermittent type then the feed per tooth has to be much low. Purpose; bulk machining or finishing. Bulk machining you can go for you have to go for high feed because high productivity. In finishing where only small amount of material is removed to get the surface finish and dimension that feed should be very low.

Surface finish desired; now the surface finish or the surface roughness you know edge is a surface roughness for turning kind operation is ‘S o’ whole square by 8 r okay. Now this equation shows that the surface roughness is proposanal to the square of the feed. So if you want good finish or less roughness,, then feed has to be low and the reduction in feed or reduction in productivity because of reduction in feed has to be compensated by increase in cutting velocity. Cutting fluid application; yes, if cutting fluid applied you can go for higher feed capacity of the machine tool more powerful and rigid machine tool will allow more feed availability in the machine tool. Now you may select 0.125, 0.11 but cannot that because all the feeds are not available. You can decide what should be range of feed? So 1 to 0.4 but all the feeds in between are not available in the machine if it is a step drive. So you have to first decide the near value say point 0.18, but this is not available. What is available? Next row of that 0.6 is the standard feed which is available in the machine and you take that. This is how it is selected.

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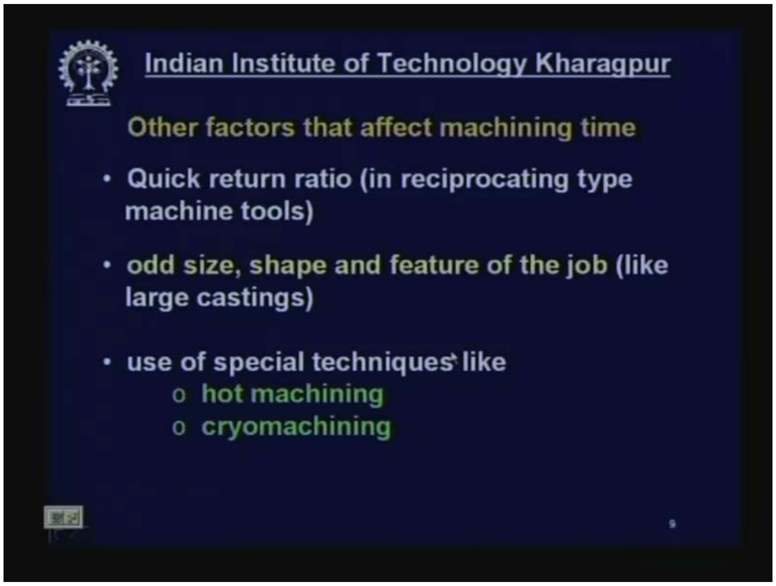

The other factors that affect machining time: Quick return ratio; now you know in shaping machine, reciprocating type machine tool like shaping machine, plaining machine, the forward stroke is the cutting stroke that is very useful but the return stroke is the simple ideal wastage of time. So we should try to keep this return strokes as fast as possible. Return time should be low and this ratio quick return effect or quick return ratio that is return time by the forward time will also influence the total machining time in shaping and plaining machines. Odd size, shape and features of the job; Now suppose you have got a large casting okay.

Large casting which has got irregular size shape and surface are hard and irregular all right and you have to machine some part, a turn a part of it in a lathe. So this has to be some how fixed into the lathe on a face plate and you machine it because of this eccentric mass, heavy mass and eccentricity of lot of there and hard surfaces you have to keep the cutting velocity very very low. Use of special techniques; now some materials say Inconel, mnemonic, this kind of materials are very very tough and hard difficult to machine. If you try to machine this material by carbides or coated carbides or similar materials the cutting velocity it will be very low because it is very difficult to machine but if you adept or you are allow to adopt hot machining then you can go for four five times higher speed. Cryo-machining that also allows you know increase in cutting velocity in machining steels.

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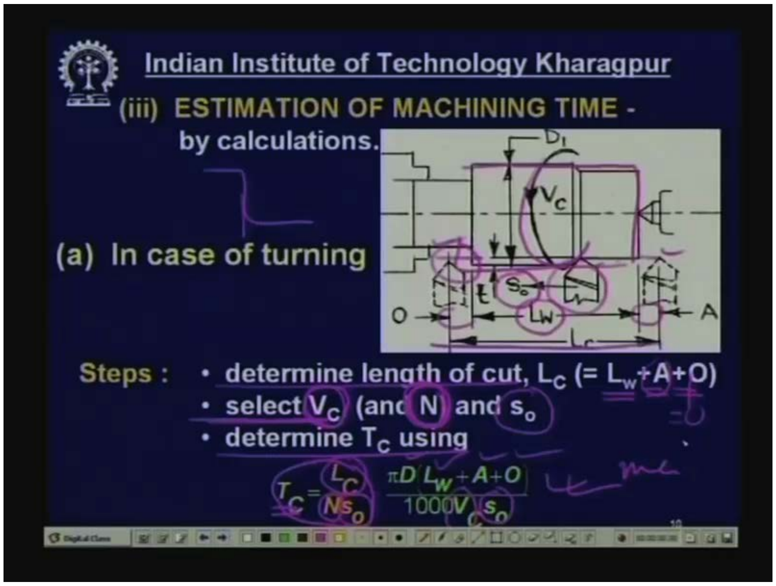

Now come to the real process. How really the machining time is estimated by calculations. We are not going into measurement. Estimation of machining time by calculations; because nowadays we have got gathered lot of experience, lot of knowledge and lot of equations are available. Simple and we can easily utilize them to estimate the cutting time which will be very very close to you know almost close to or equal to the actual time. Now in case of turning, how we shall do that? Now this is the diagram okay. This is the rod, this is the length of the job where the material has to be removed by one pass. These are length of the job L w which I already described and this is the approach. This is overrun. This is amount overrun and approach. Total length is L c that length of travel has to be completed by this cutting tool from this point to this point.

Now this is the feed rate per revolution of this job the tool advances by only ‘S o’. Now what are the steps? Determine the length of cut first. How do you determine? You know the length of this job or length of cut to be made, approach you assume, overrun you assume. Now friend this over one sometime may not be required if it is the free machining here overrun has to assume but it is the step machining like this then you need not consider approach. Sorry overrun which will be zero. Approach will be always there, but overrun may zero or may not be, it can be 2 to 5 millimeter.

Now next is most important part see that cutting velocity and from the cutting now you consider all the metal aspects. Work material, tool material, cutting fluid in environment, the condition and the power of the machine tool and all these things. Then you very carefully judiciously decide cutting velocity. With the help of the simple equation, you determine the corresponding value of speed. Now this speed calculated may not be available. You take the nearest available speed in the machine tool which are standard and you also assume the feed, then you determine the cutting time utilizing this equation. Cutting time, turning time is equal to the total length of traveler cot divided by feed and N rpm. So this is the equation, final equation. If you note D w diameter of the job, length of the work piece approach and over on you assume and velocity you select, feed you select carefully and judiciously you can easily determine T c in minute. These are basic principle all right.

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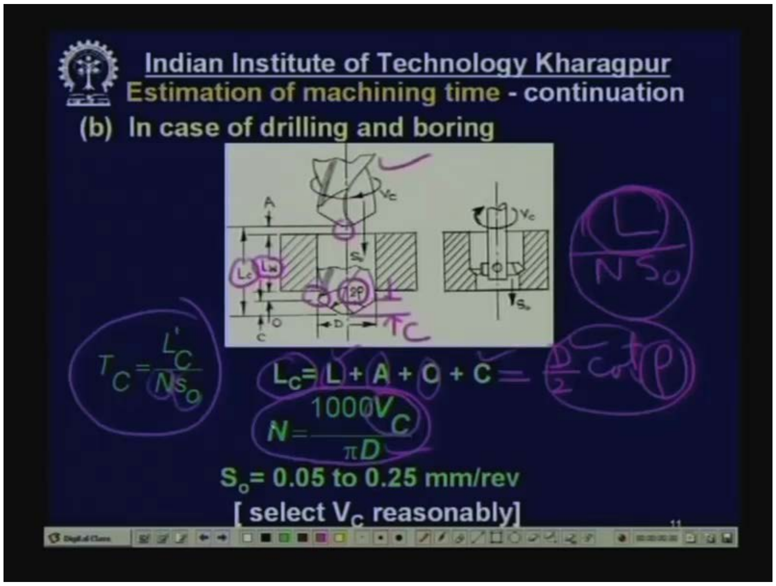

Next come to Estimation of machining time by continuation in case of drilling and boring. Now this is one example, this is an example of drilling. So this is the work piece, a plate or a block in which a hole has to be made a through hole. Suppose a through hole has to be made okay by a cutting tool namely drill. Now how much the drill has to travel? Now actually we have to determine how time is calculated length of travel divided by feed which decide the number of revolution that to be required they are divided by N which is nothing but number of revolutions per minute we get the time in minute. So first of all we decide what is the length of travel required for the tool or job? According to the case in drilling the job remains stationary and the travel and that drill which rotate as well as moves axially okay.

Now here from the diagram you can see that length of the hole or thickness of the plate is L w. There should be an approach, a gap, there should be an overrun a gap between the end point of the tool from the end point of the job. Beside that, this amount has also to be considered which is equal to C. Now this L c is equal to length of the hole, approach overrun and this C. This cone, length of the cone which is approximately equal to D diameter of the drill by 2 co-tangent row. This is 2 row point angle half of that is row. So row is known of the drill. These are known diameter of the drill. So you can easily determine the C. After you determine C, an assume approach and overrun for a given length of a job or hole you determine ‘L c’. Now this ‘T c’ is equal to ‘L c’ divided by feed and rpm.

How to determine rpm? Rpm will be decided from this equation. Here D is the diameter of the drill known but what about cutting velocity that has to be selected again based on the tool material, work material and the cutting condition. Surveys one is desired machine tool condition all these things and you also assume feed for drilling. It may vary from 0.05 millimeter for finishing and 0.25 per revolution for roughing. So you select accordingly and put into this equation L c is determined from this. N is determined from this and 'So' is assumed you get that time. Now the selection of velocity has to be done most carefully.

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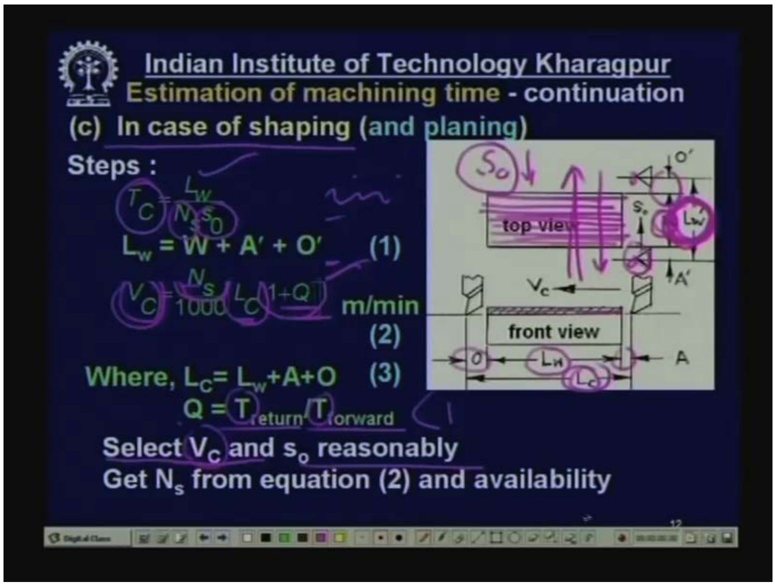

Now come to shaping. Shaping and planning, even slotting are more or less same. It is a reciprocating type shaping machine the tool reciprocate job remains stationery almost on to the feed motion is given to the job. Job moves very slowly but the cutting tool reciprocates. In case of planning, the job reciprocates and the tool moves slowly that is feed motion per stroke and its slotting machine. It is very alike shaping machine but vertical shaper. Now if we understand or no how to estimate the machining time in shaping, we can easily do for planing as well as slotting. Now let us take this example; in case of shaping, this is a job, this is the front view of the job, a plate a metal plate where from this layer or material has to be removed in one spell. Top view of the job is shown over here which has got a definite length L w and width W.

So a layer of material of say thickness 1 or 2 millimeter and area L w by W length and width have to be removed. This is amount of material that is to be removed. Now this is the cutting tool which will reciprocate from this point to that point. This is the length of the job and this is approach and this is overrun. So what is the total length of travel of the tool L c which is equal to L w plus approach plus over run. Now in one stroke, it will remove only a thin layer of the work material. So in one stroke, suppose this is tool this will remove a thin layer from here then layer by layer this will remove the materials okay. So how many strokes will be required to cover the total width. What is the width W and here also you have to consider approach and overrun. So this is the amount of now this tool has to travel. Actually the tool travels in this direction cutting velocity but in these directions the tool does not move rather this job moves on the work travel.

Anyway relative to the job the tool moves from this point to this point and the distance is equal to L w prime and L w is equal to width of the job approach in this way here and over run. We know width of the job we assume A and O we get the total length of travel of the work piece through feed. Then basically remember what the basic equation is? Basic equation remains more or less same like turning and drilling. L w is the length of travel it is length of travel okay. This much has to be travel gradually by the job. Stroke per stroke and in every stroke they cut job advances by a feed say ‘S o’ this is called millimeter per stroke. For every stroke, the job advances by ‘S o’. So how many strokes will be required? The total length of travel divided by ‘S o’ then so many strokes how many strokes we have in one minute N s number strokes per minute. So this is the actual machining time in minute.

Now L w; here has to be determined from this equation V c, this N s. How you determine this N s? Stroke per minute, this comes on the cutting velocity again cutting velocity in shaping is equal to length of stroke and number of stroke that gives the total length of travel per unit time okay that divided by 1000 is a meter per minute. But, you know that in shaping or plaining there is a return stroke which is ideal and but that is faster. So this velocity will be actually given by this product of number of strokes per minute in to length of cut multiplied by 1 plus Q, where Q is called quick return ratio and this quick return ratio means the time required for return and time required for the forward stroke or cutting stroke.

This is less than one it is less than one may be 0.5 or 0.4, 0.6 depending upon the length of stroke all right. So if we know this Q, which is normally known or if not it has to be evaluated for the different length of stroke L C is determine from the length of this job. Here length of this job and approach and overrun we have to determine and V C has to be selected ‘So’ has to reasonable assumed, depending upon the work material, tool material and also remember since it is shaping and shock initiated, the velocity should be lower than normal speed used for continuous cutting. If it is for turning, say 60 meter per minute for shaping it has to be taken say 40 meter per minute. Now this way you get N s number of strokes per minute put this value number of strokes per minute into this equation. L w is known, N s is known, ‘S o’ is assume you get the cutting time T c. So this is how machining time in shaping, plaining, slotting can be determined.

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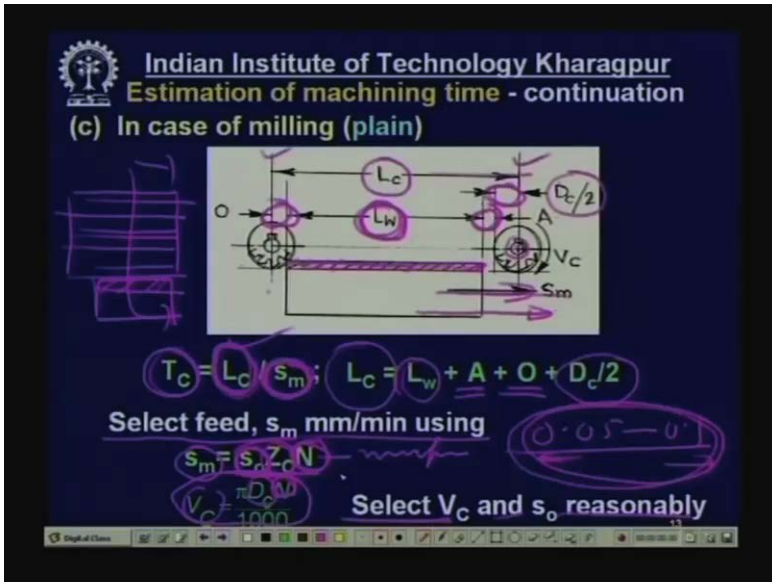

Now next is Estimation of machining time in milling in a milling process. Now milling is a very common, general purpose machine tool milling machine and it does surfacing and various other applications are there which have been discussed in my previous lectures you have that again before we going to estimation of milling time let us recall that there are different types of milling cutters and milling process. What are the different types of milling cutters? One is plain milling cutter or slide milling cutter. These are hollow cylindrical having teeth cut on thus periphery and these are hollow which are mounted on the arbor of milling machines. These are called plain milling machine or slab milling machine do which may say 4 to 8 or 12 number of cutting edges which can be straight, which can be helical.

Another case called end milling cutters the solid end milling cutter with a shank which is fitted in to this spindle through socket or collet and these are small generally and vertically there is another milling cutter generally call face milling cutter which are very large in size having number of cutting teeth mounted at equal space on the periphery of the stub or the solid body. Now let us consider at this moment plain milling or slab milling with a cutter slab milling cutter which is nothing but a hollow cylinder having a kiwi cut inside and there are teeth on the periphery like this. If you take the cross section this will look like this okay.

This is enhance suppose this is the work piece mounted and you have to remove a layer of material, then this cutter has to move along this surface of the job. Now this is the work piece suppose of length L w a layer of material has to removed in one pass okay and then this is the milling cutter which is mounted on the milling arbor and keeps on rotating in a particular direction in same position, but the job will travel gradually in this direction apparently job remains stationary. The tool moves from this point to this point say from this point to this point practically the tool remains keeps on rotating in one position on the but a job mounted on the travel moves against the cutting tool. Any way so total length of travel of the job required or total length of travel relative to the job will be L c total length of travel which will be equal to length of the work piece approach that is gap an overrun, another gap after clearing and beside that since is a rotatory cutter at initial stage this should not foul with the job. So another gap this is maintained, that is half of the diameter it can be slightly less than that also but normally for convenience or simplicity we take that diameter of the cutter by 2.

So this is the total length which is comprised of L w approach overrun and half of the cutter diameter. Now come to the basic equation like any machining process T c is equal to total length of cut or total length of travel of the tool relative to the job. It can be travel of the job, it can be travel of the tool depending upon the process. But anyway these are relative travel of the tool with respect to the job and S m is the feed or rate of travel that is rate of travel which is expressed in millimeter per minute. Unlike millimeter per revolution, in turning or millimeter per stroke in shaping, plaining and so on. Then it is very easy more easy total length of time divided by velocity gives the total machining time.

So simple where L c has to be determined, total length of cut, length of the job 'w' work piece approach 2 millimeter or 5 millimeter to 5 millimeter overrun 2 to 5 millimeter and D c by 2. This is the diameter of the cutter known available and so you can easily get L c. Put here. Now what remains is S m that is the feed of the job in millimeter per minute. This has to be selected, but how will you select it. This S m is equal to S o Z c N. So is the feed per tooth, Z c is the number of teeth on the cutter and N is the rpm. So this is S o is the feed per tooth So into Zc means feed per revolution and multiplied by N, feed per minute that is millimeter per minute. So you assume 'S o' say this will be around 0.05 to say 0.1 or even less than, slightly less than this or slightly hard than this depending upon the work material, tool material, machine tool condition, surface finish desired and so on.

Then you get a 'S m' but how you get 'N' the speed rpm of the cutter that will be again decided from this expression. Cutting velocity is equal to phi Dc by N this is the diameter of the cutter in the rpm. Now this cutting velocity has to be selected. Select velocity and feed reasonably taking all factors in consideration I told you, then you get N and this standardize the N speed according to availability in the machine tool and put in to this equation, into this equation and this equation you get the value of the machining time. This is how you can get the machining time. Now if it is end milling, it will not be much difference. In end milling, the milling cutter will be like this solid and suppose you want to machine a surface like this. So this is vertical. Now if you just rotate it, imagine rotated by ninety degree then the cutter becomes horizontal like this just like plain milling cutter and the work piece is this. So the principle of calculation estimation will be more or less same. All the question is whether overrun is required or not? If required, you have to select depending upon the situation but not less than 1 millimeter and not more then 5 millimeter that's all.

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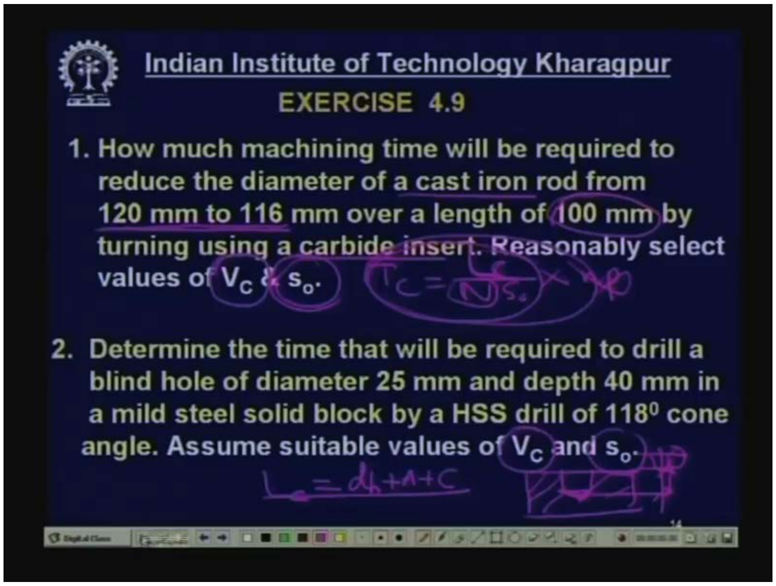

Now friend here I have given you 4 exercises under the lecture number 4.9. There are 4 problems I have given. How much machining will be required to reduce the diameter of the cast iron rod from 120 millimeter to 116 millimeter over a length of 100 millimeter by turning in a lathe using carbide insert? This is the problem. Reasonably select valves of velocity and feed. Now I shall give you the hint; only selection of cutting velocity equation is very simple. Equation you remember T c is equal to L c is equal to Length of cut by rpm and feed. Rpm has to be selected from cutting velocity multiplied by number of passes.

Now here you see the diameter has to reduce 120 millimeter 216 millimeter only 4 millimeter has to be reduced that is 2 millimeter on radius. So that is the depth of cut so one pass is sufficient. So this is the sufficient you know only one pass. L c length has to be determined. What is the length of this job given? 100 millimeter that has to be with that approach and overrun say 10 millimeter has to be added then cutting velocity has to be selected and what is the work material, cast iron and what is the tool material, carbide using carbide. So cutting velocity will be around 60 meter per 60 to 100 meter per minute.

Now since it is not mentioned what is the cutting fluid of course in machining cast iron cutting fluid is not used but machine tool condition and all these things, you can assume say 80 meter per minute okay. If the machine tool is powerful enough and feed since it is not mentioned it is bulk material or say finishing, you can take around say 0.2 millimeter put into this equation you get the value. Similarly determine the time that will be required to drill a blind hole. Now here is a blind hole that means in a plate, you have to make a hole up to certain depth up to certain depth not to the full depth okay. So here you have to consider the length of depth of the hole approach. But overrun is not required but the cone length has to be considered.

Here ‘L c’ length of cut of the drill will be the depth of the job, depth of the hole plus approach plus the cone like this okay which is equal to D by 2 diameter of the drill by 2 the co-tangent I have wrote that you know. So this is how you will determine rpm will come from the cutting velocity. If not given you assume it reasonably, some time in problem velocity or rpm feed or given suggested you can take that. If not, you have to assume it. An assumption is more difficult, it has to be very carefully done. Now the other problems, there are two more problems.

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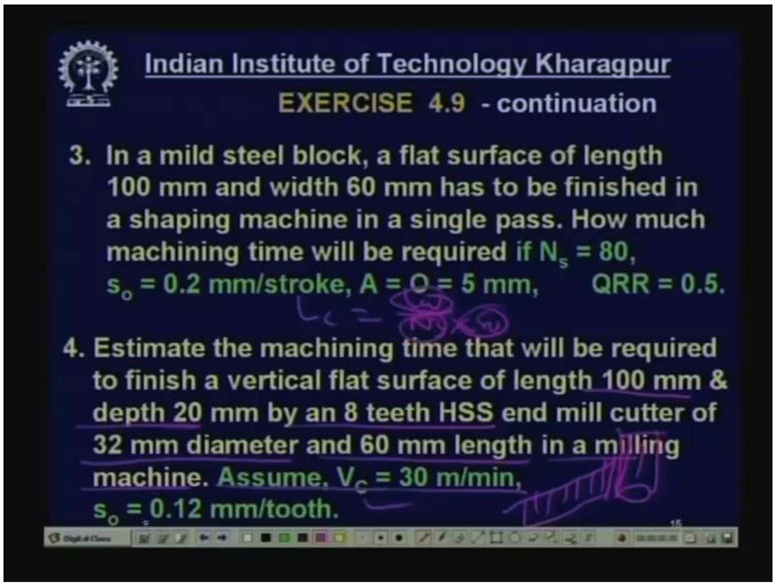

Third problem in shaping, but you can follow the same principle that I described in a mild steel block, a flat surface of length 100 millimeter and width 60 millimeter has to be finished in a shaping machine in a single pass. How much machining time will be required? ‘N s’ is given. So problem is very very simple, feed is also given, approach overrun are given then what remains? Everything is given. So the equation will be like that L c will be equal to ‘L w’ by number of strokes per minute into feed. So you have to determine L w from the length of the job ‘N s’ is given. ‘S o’ is given. So you determine. Fourth estimating estimate the machining time that will be required to finish a vertical flat surface of length 100 millimeter and depth 20 millimeter that is 100 millimeter length and depth this much and this is the vertical surface and the cutter will also be end milling cutter.

But, if you can consider it is very similar to slide milling cutter. Only 90 degree rotated vertical or horizontal. But the basic principle will remain the same. So the width of job is known ten length of the job is known and number of teeth is known and then the 32 diameter of the cutter is known. Length of the cutter is known. So the width of the job is less then length of the cutter. So, one pass is sufficient in a milling. Now you have to determine the time, the velocity it has been suggested velocity you can assume 30 meter per minute and feed even. So, all the values are given. So you can easily determine this time. Of course you can solve this way also.

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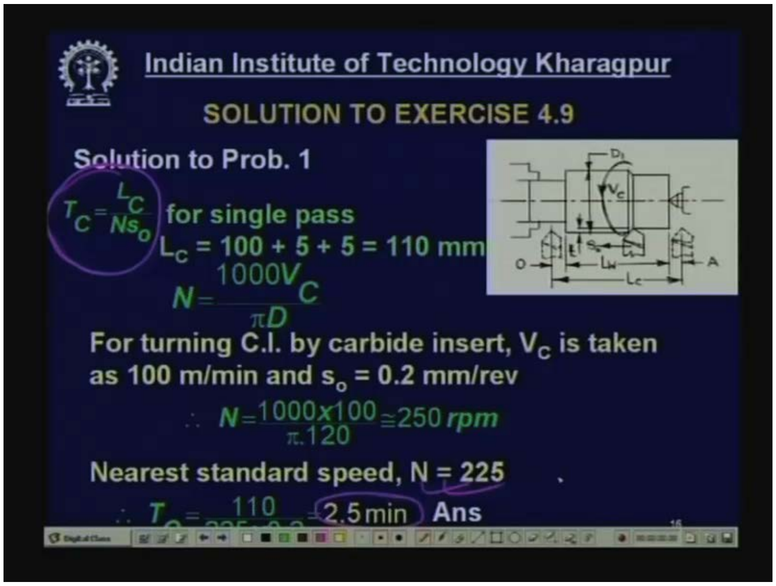

The solutions are given here step by step. For problem number one, you have to determine the time required turning a rod over a length L w and velocities assumed and all you have to follow the same equation and the basic equation is T c is equal to the same equation. You have to start from this equation and follow the basic principle which already described and come to this value and you know person to person the time will vary depending upon how much cutting velocity and feed approach and overrun he assumes or he selects. So this will vary.

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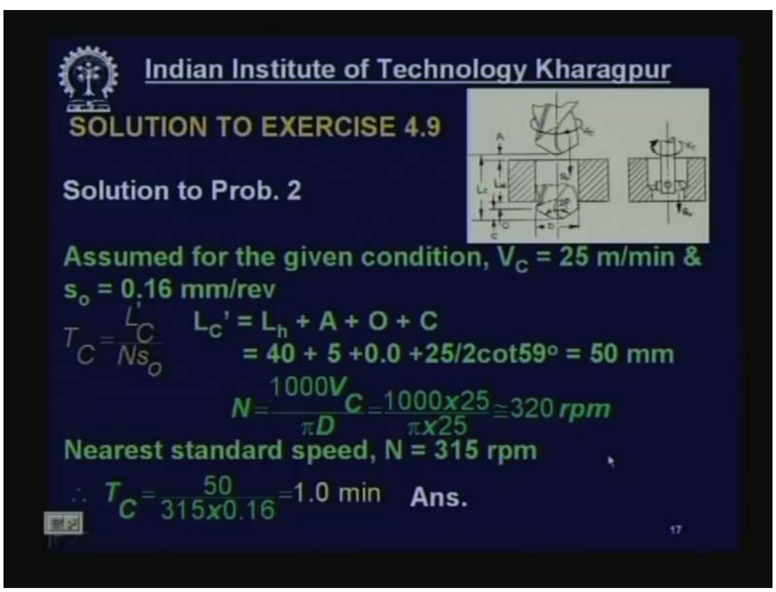

Similarly the solutions of the second one; Solution of the third problem

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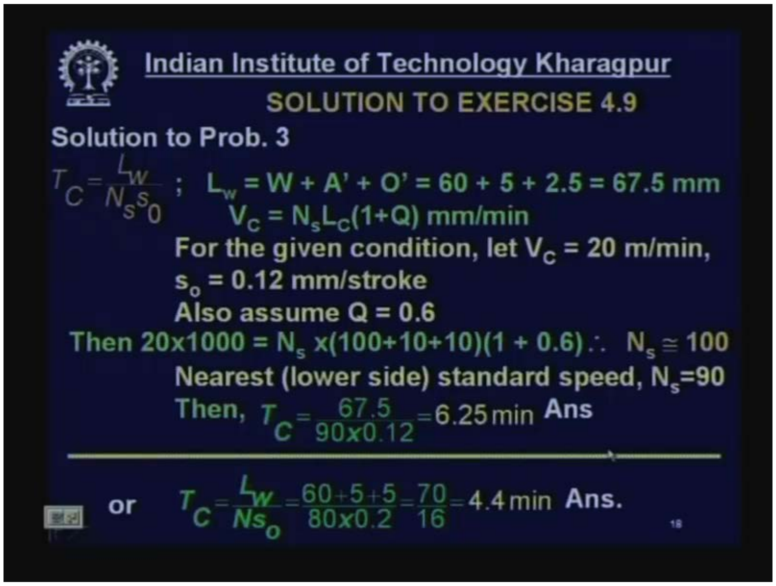

and solution to the fourth problem these are all given.

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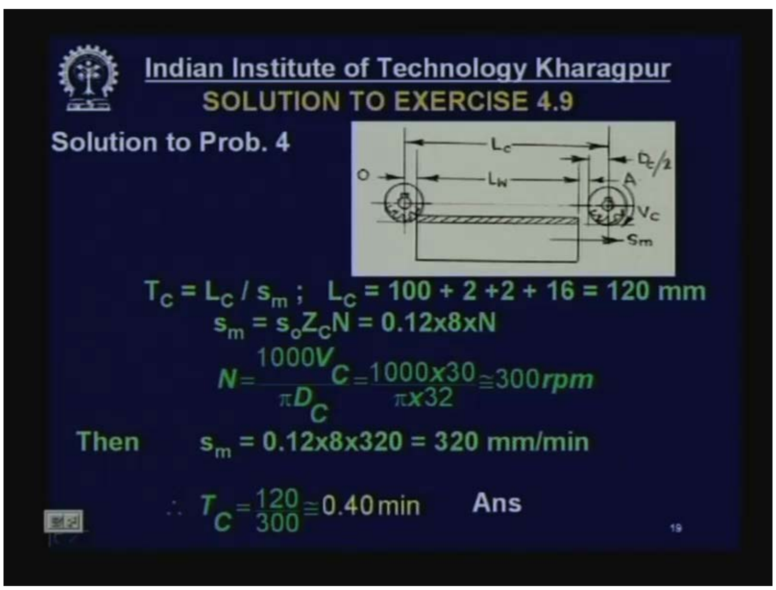

So you can practice.

Thank you.