Basics of Mechanical Engineering-2

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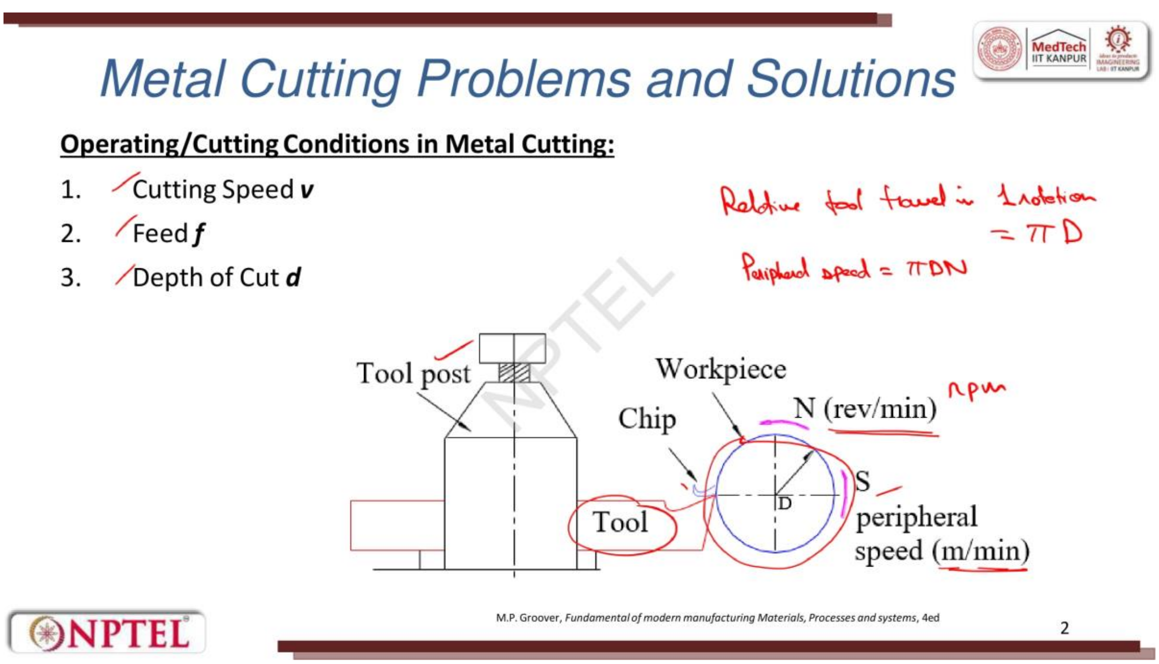
Week 10

Lecture 40

Tutorial-5 (Part 1 of 2)

Welcome back to the course Basics of Mechanical Engineering II, where we were discussing manufacturing processes. In the last week and in this week, we have discussed machining. In the machining, we have discussed about single point cutting tool, then lathe machining operations, then some of the milling operations because milling is a versatile process, versatile machining system, in which we do end-mill, we do a lot of kind of the operations that happens on the face, happens inside cutting slots, etc. Then, we also discussed about grinding operations. I will now try to take some problem statements, that is the tutorial session is on the machining, the points that we have discussed in the last week and in this week. So, this is tutorial session on machining. I am Dr. Amandeep Singh Oberoi.

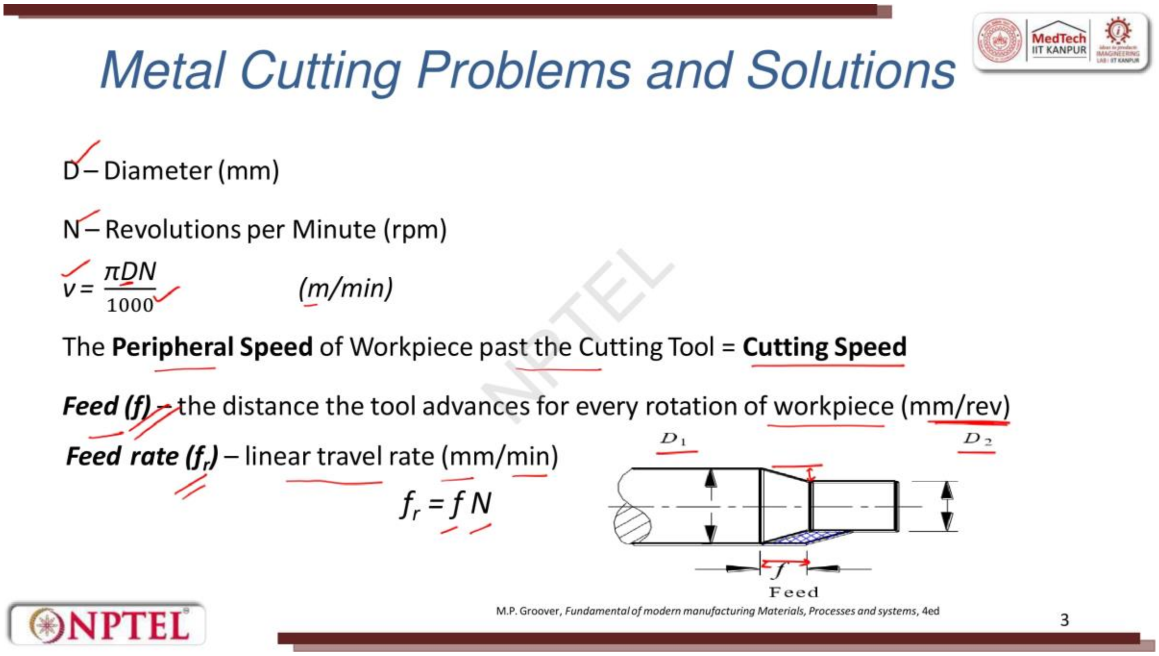


Just to recall the concepts that we have discussed in the last week about the cutting speed feed and depth of cut. Because generally when we have a specific dimensions of the material, we have a specific machine in which the machining speed is specifically defined. There are variable speeds in the CNC systems when we talk about there are machines for example, if the speed variations between 0 to 10,000 rotations per minute.

We can set even 9992. We can set even 8884 something. The operations even up to the variation of 1 meter per minute speed could be put as an input there. But in the conventional machining setups, the machining speed is sometimes generally fixed. For example, first variation is 100 meters per minute, second could be 120, third could be 140, then it could be 200.

So, based upon those only, we can have the cutting speed. And feed and depth of cutter are also generally fixed accordingly so that the surface roughness and the overall machining time are minimized, and the quality that you need is appropriate. So, in a lathe machining setup, you can see this is a tool post that is holding the tool, and the tool is cutting.

This is how the chip is coming out, and this is revolutions per minute, that is, rotations (RPM), and s is the peripheral speed, which is in meters per minute. So, this is RPM, and this is meters per minute, as given here. Relative tool travel in one rotation could also be expressed as πD, which is the whole periphery of the workpiece taken in one rotation (πD). Then, peripheral speed could also be expressed as πDN.

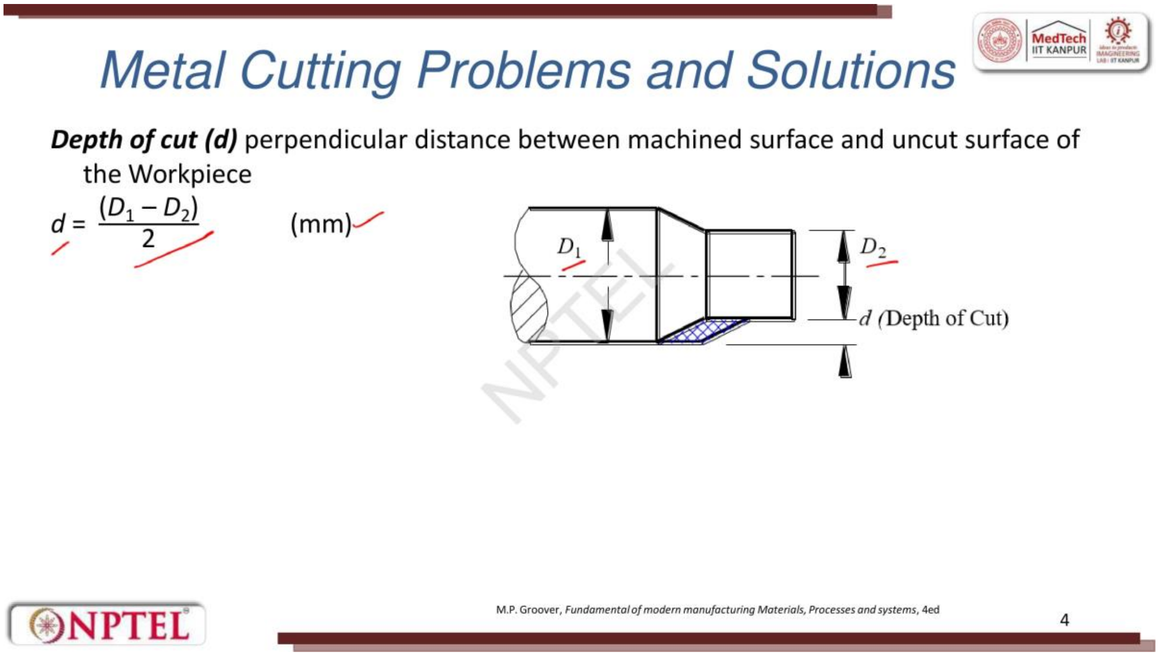


Now, if we are given the diameter and the RPM (rotational speed), we can calculate the cutting speed or the peripheral speed using $v = \frac{\pi DN}{1000}$. The factor of 1000 comes into play because we are converting the diameter into meters, as meters per minute is squared, and the diameter is generally given in millimeters.

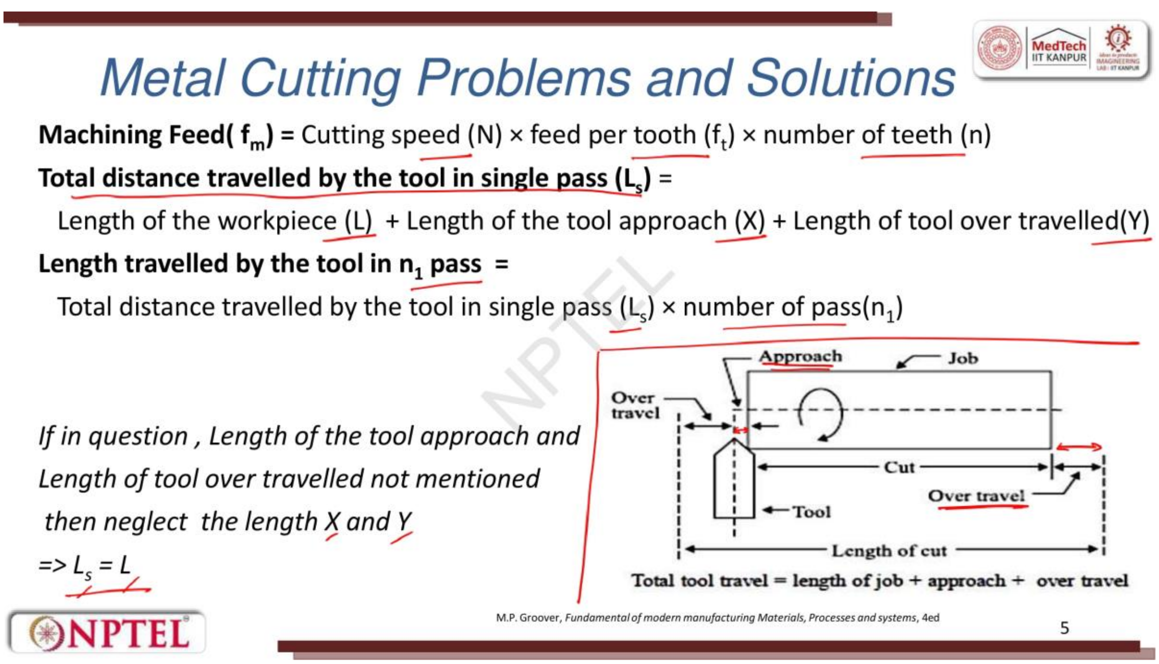
So, N is your rotational speed, that is, revolutions per minute. This is how we get the peripheral speed of the workpiece past the cutting tool, which is equal to the cutting speed. Feed: the distance the tool advances for every rotation of the workpiece.

After each rotation, it advances. In the second rotation, it advances. So, after each rotation, it is millimeters per revolution. So, millimeters per revolution is also the unit of feed. Feed rate: it is linear travel.

It is mm/min. This is equal to feed into the RPM. So, this is the feed that is getting into the workpiece. And this is my the initial diameter and final diameter, this becomes my depth of cut.



Now, depth of cut that I have given in the next slide, depth of cut is $d = \frac{(D_1 - D_2)}{2}$ this is the depth of cut which is also given in general in millimeters.

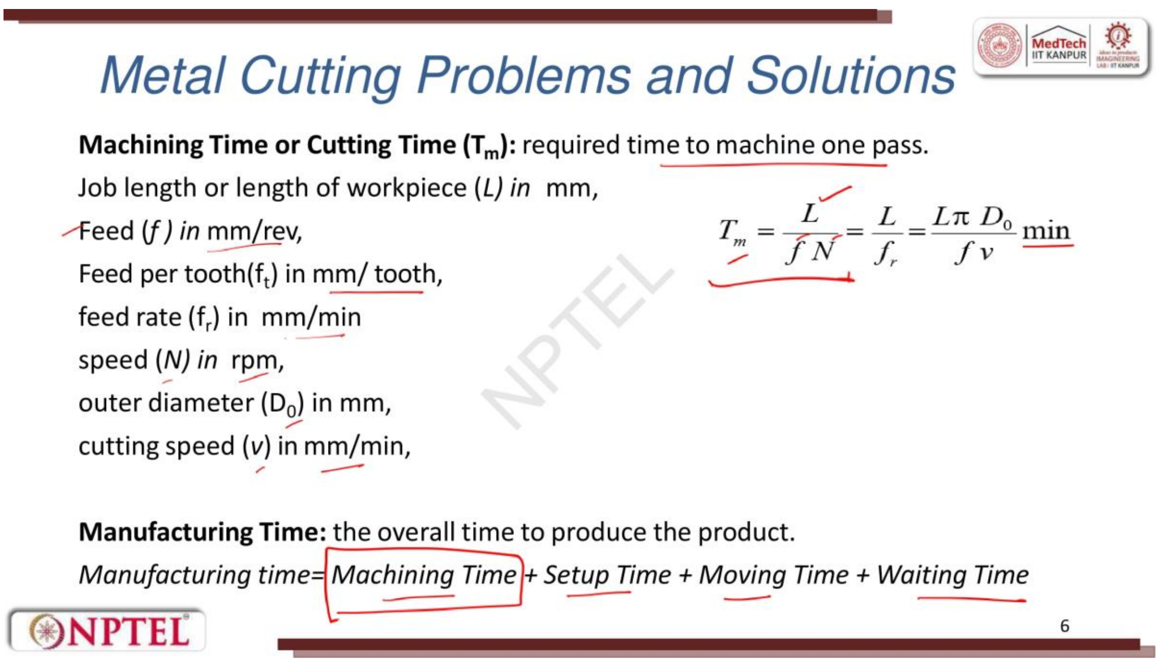


Before embarking upon the problem statements, let us try to see some more relations because these are important. In this figure that you are looking at, we have the tool when it approaches the workpiece. So, there is a reach of the tool towards the workpiece. When the tool comes very close to the workpiece, the tip has just reached close to the workpiece face here. This distance is known as approach.

And after the cutting, the tool also goes over and beyond the workpiece's contact. This is known as over travel. Then, the total distance travelled by tool that is length of single pass in a single pass when the tool has to come there is work piece tool has to approach it this approach length plus work piece length plus over travel length.

So, this becomes my total length of pass, this is Length of the workpiece (L) + Length of the tool approach (X) + Length of tool over travelled (Y). Now, Machining Feed(f_m) = Cutting speed (N) × feed per tooth (f_t) × number of teeth (n)

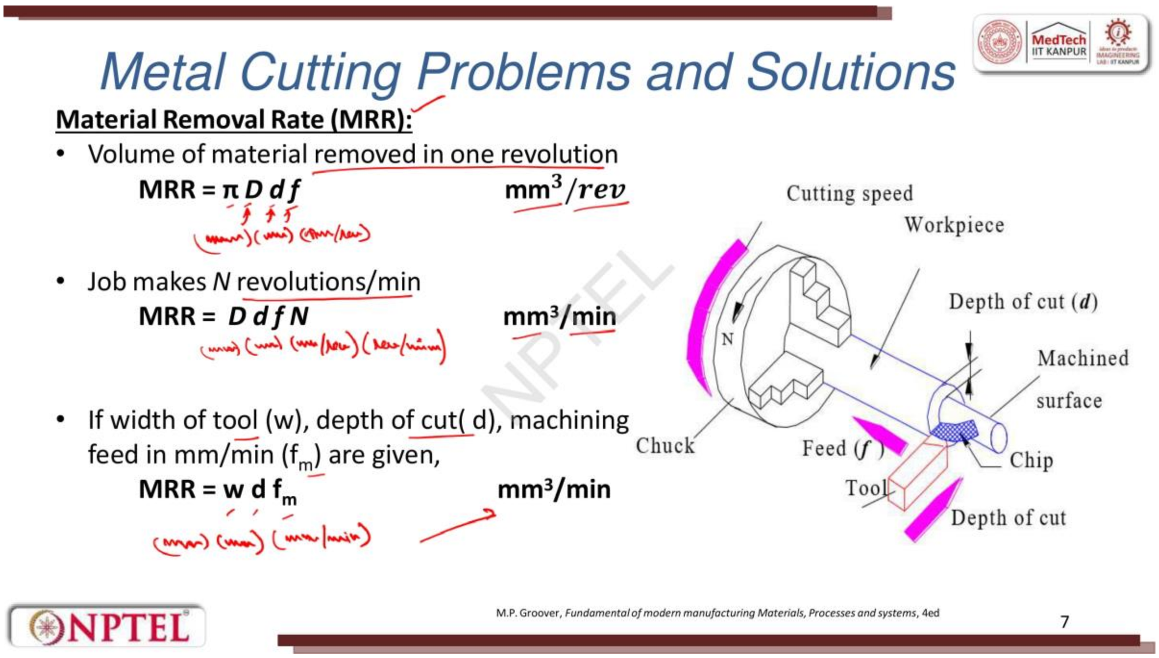
So, if in question the length of the tool approach and the length of the tool overtravels are not mentioned, then neglect X and Y, and the length of the single pass = length of the workpiece.



Then, machining time would also have to be calculated sometimes. Machining time or cutting time is the time required to machine one pass of the job or the length of the workpiece in millimeters. That is,

$$T_m = \frac{L}{f\,N} = \frac{L}{f_r} = \frac{L\pi\ D_0}{f\,v}\ \text{min}$$

Manufacturing time is the overall time to produce the product, which is machining time plus setup time plus moving time plus fitting time. That is a different scenario. We are only trying to talk about the machining time majorly here.

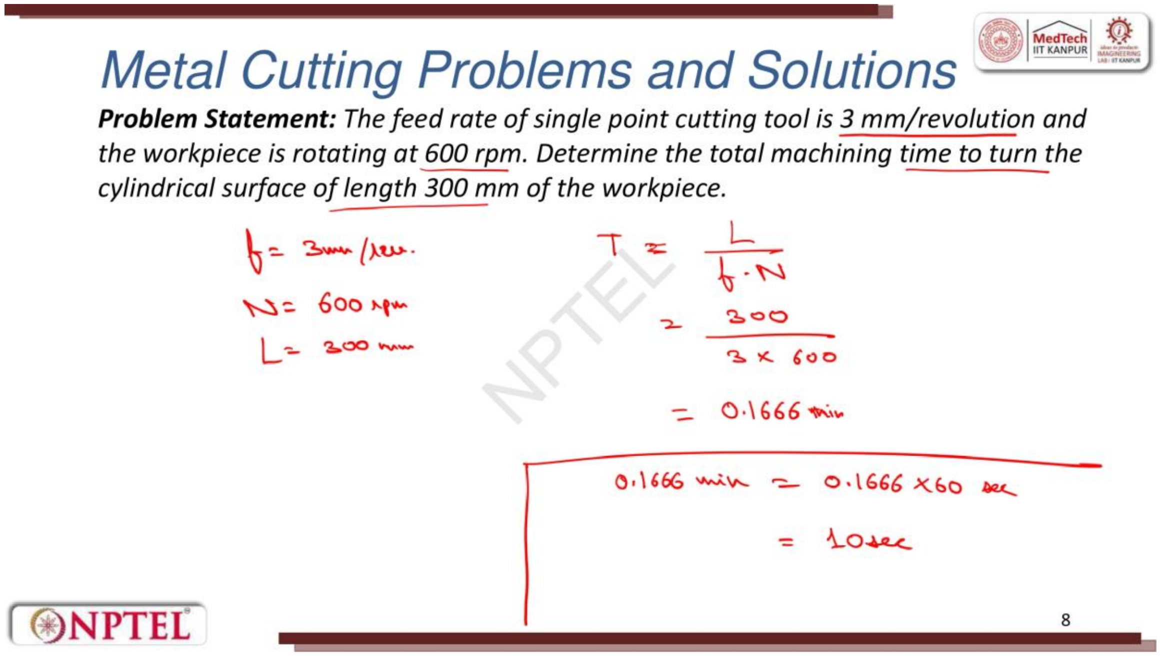


Then, we sometimes have to calculate the material removal rate. Material removal rate is in three forms. That is, material removed in one revolution, Then, N rev/min, then depending upon the width of the tool and the depth of cut, this is also calculated.

First is the material removal rate per revolution, which is MRR = π D d f. This is the diameter of the workpiece, this is the depth of cut, and this is the feed per revolution. So, this becomes mm^3/rev. That is the volume removed per revolution. The job makes N revolutions per minute.

Then, MRR = *D d f N***.** The depth of cut is also in millimeters. This feed is in millimeters per revolution. And N is revolutions per minute. So, this becomes the volume removed per minute.

If the width of the tool, depth of cut, machining feed in millimeter per minute are given, then it becomes MRR = w d f_m which is w in millimeters, depth in millimeters, and fm is millimeters per minute. For this, it turns to be millimeter cube per minute.



Let me now come to a problem statement, a very simple problem statement. The feed rate of single point cutting tool is 3 mm/revolution and the workpiece is rotating at 600 rpm. Determine the total machining time to turn the cylindrical surface of length 300 mm of the workpiece.

Given:

F = 3 mm/rev

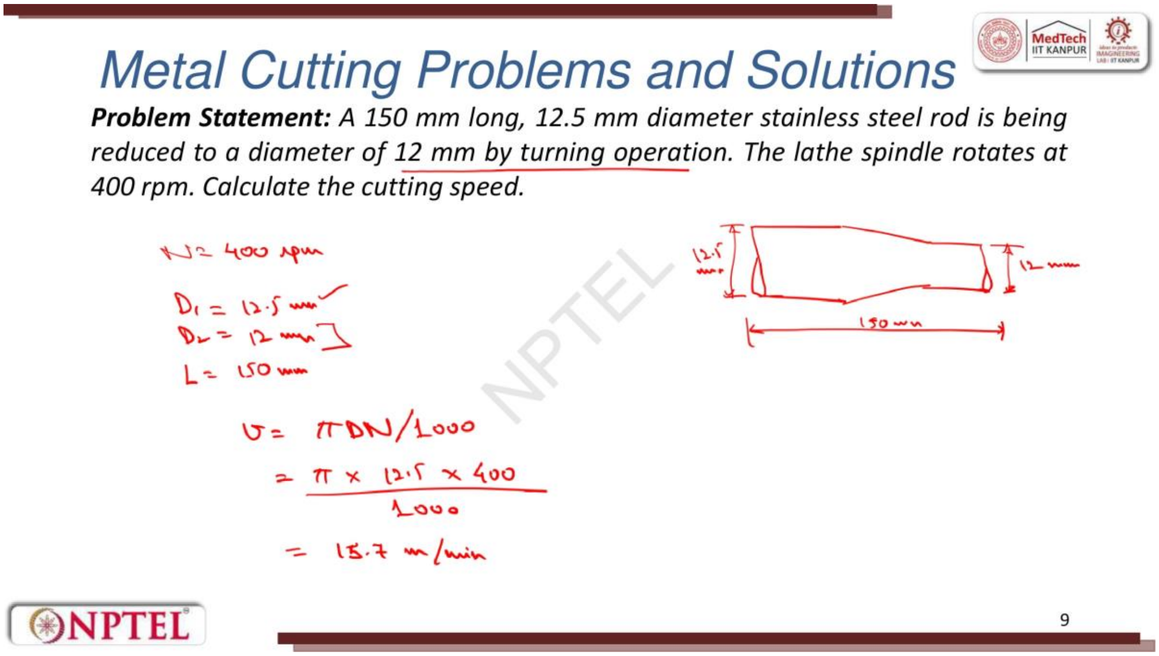
N = 600 rpm

L = 300 mm

Solution:

T = L/fN = $\frac{300}{3 \times 600}$ = 0.1666 min

0.1666 min = 0.1666 x 60 sec = 10 sec (ans.)



A 150 mm long, 12.5 mm diameter stainless steel rod is being reduced to a diameter of 12 mm by turning operation. The lathe spindle rotates at 400 rpm. Calculate the cutting speed.

Given:

N = 400 rpm

D1 = 12.5 mm

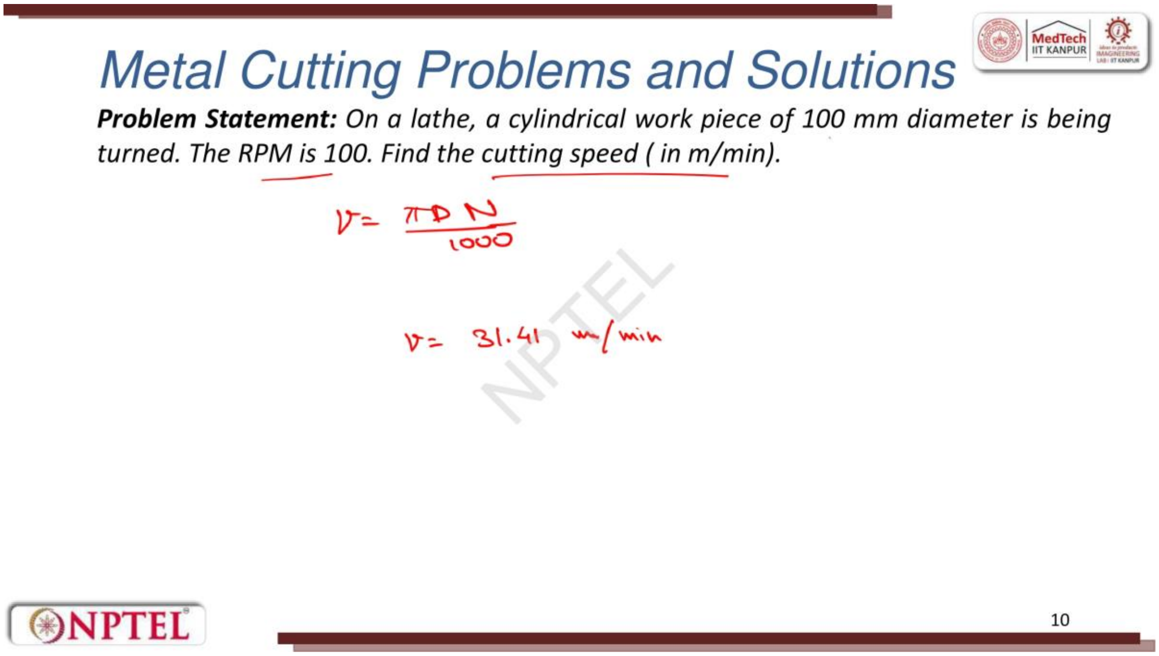
D2 = 12 mm

L = 150 mm

Solution:

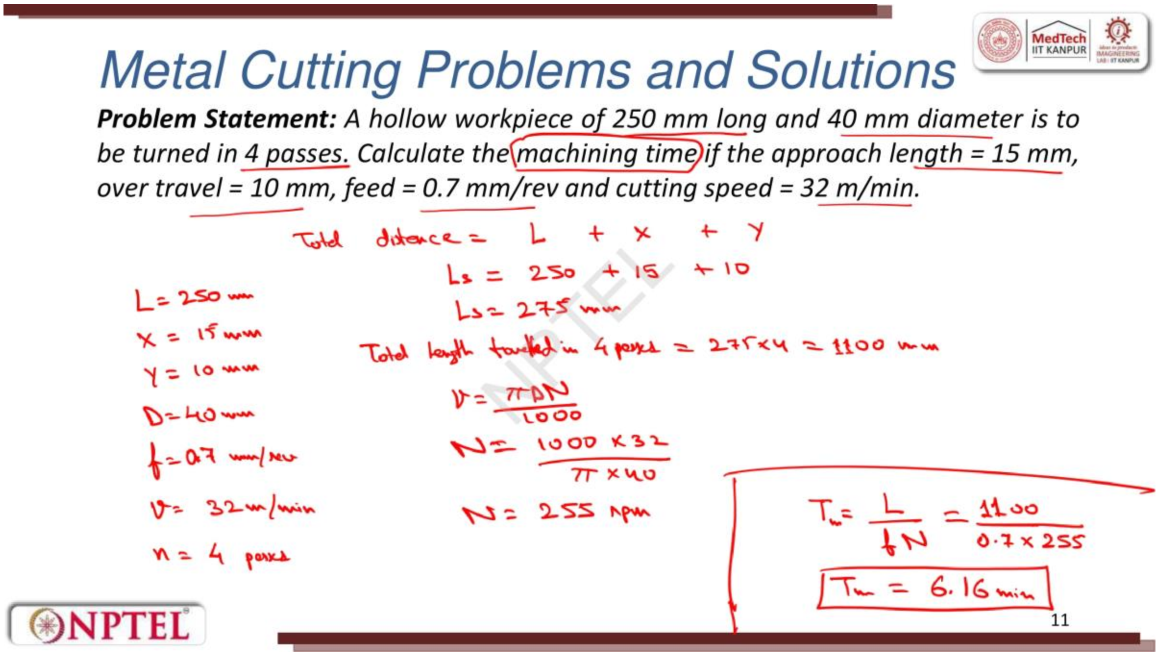
v = πDN/1000

$= \frac{\pi \times 12.5 \times 400}{1000}$ = 15.7 m/min (ans.)



On a lathe, a cylindrical work piece of 100 mm diameter is being turned. The RPM is 100. Find the cutting speed (in m/min).

You can calculate it by yourself. I will just give you the solution. The solution will give v = 31.41 m/min.



A hollow workpiece of 250 mm long and 40 mm diameter is to be turned in 4 passes. Calculate the machining time if the approach length = 15 mm, over travel = 10 mm, feed = 0.7 mm/rev and cutting speed = 32 m/min.

Given:

L = 250 mm

X = 15 mm

Y = 10 mm

D = 40 mm

f = 0.7 mm/rev

v = 32 m/min

n = 4 passes

Solution:

Total distance = L + X + Y

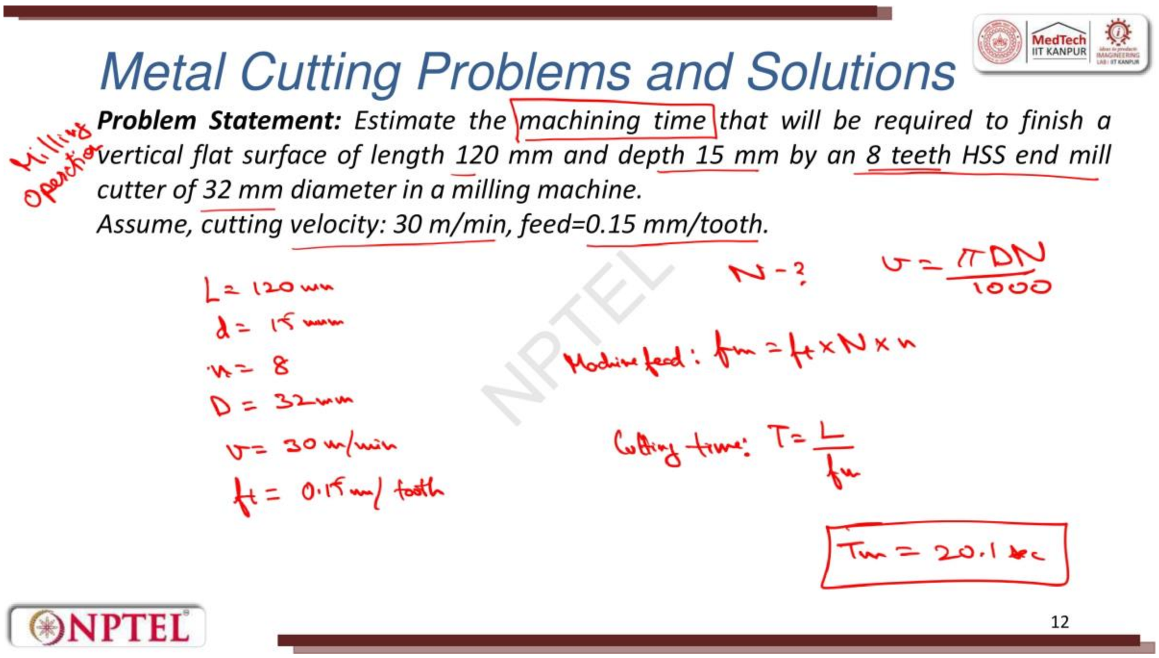
Ls = 250 + 15 + 10 = 275 mm

Total length travelled in 4 passes = 275 x 4 = 1100 mm

v = πDN/1000

N = $\frac{1000 \times 32}{\pi \times 40}$ = 255 rpm

Tm = L/fN = $\frac{1100}{0.7 \times 255}$ = 6.16 min (ans.)



Estimate the machining time that will be required to finish a vertical flat surface of length 120 mm and depth 15 mm by an 8 teeth HSS end mill cutter of 32 mm diameter in a milling machine.

Assume, cutting velocity: 30 m/min, feed=0.15 mm/tooth.

Given:

L = 120 mm

d = 15 mm

n = 8

D = 32 mm

V = 30 m/min

ft = 0.15 m/tooth

N = ?

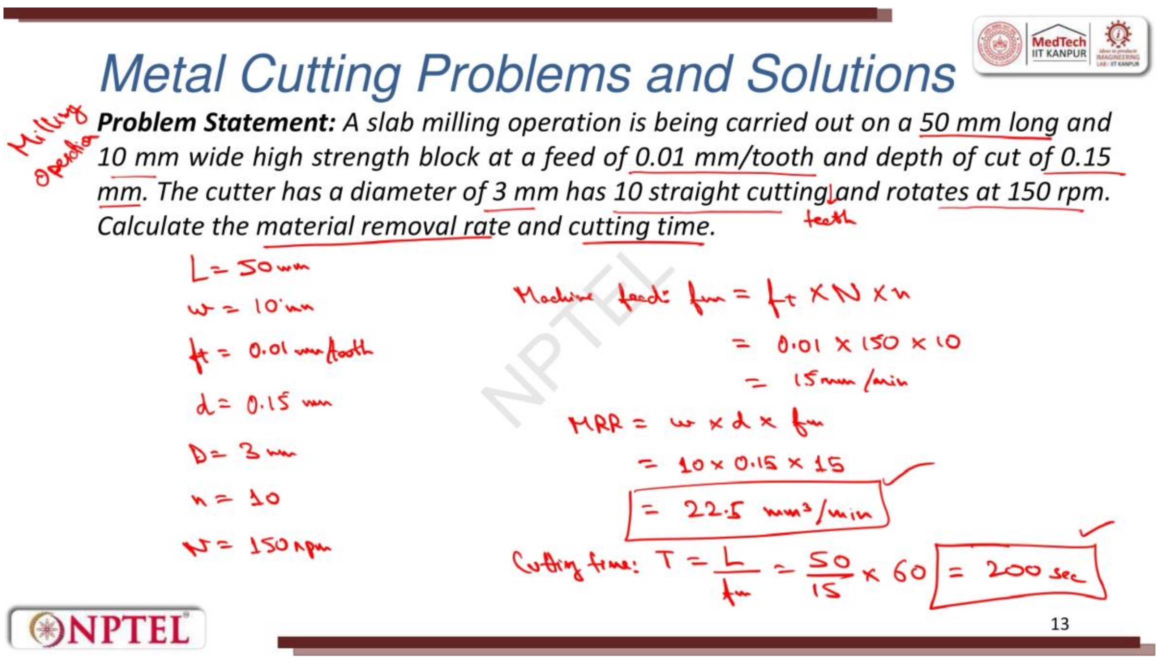
Solution:

v = πDN/1000

Machine feed: fm = ft x N x n

Cutting time: T = L/fm

Tm = 20.1 sec (ans.)



A slab milling operation is being carried out on a 50 mm long and 10 mm wide high strength block at a feed of 0.01 mm/tooth and depth of cut of 0.15 mm. The cutter has a diameter of 3 mm has 10 straight cutting and rotates at 150 rpm. Calculate the material removal rate and cutting time.

Given:

L = 50 mm

W = 10 mm

ft = 001 mm/tooth

d = 0.15 mm

D = 3 mm

n = 10

N = 150 rpm

Solution:

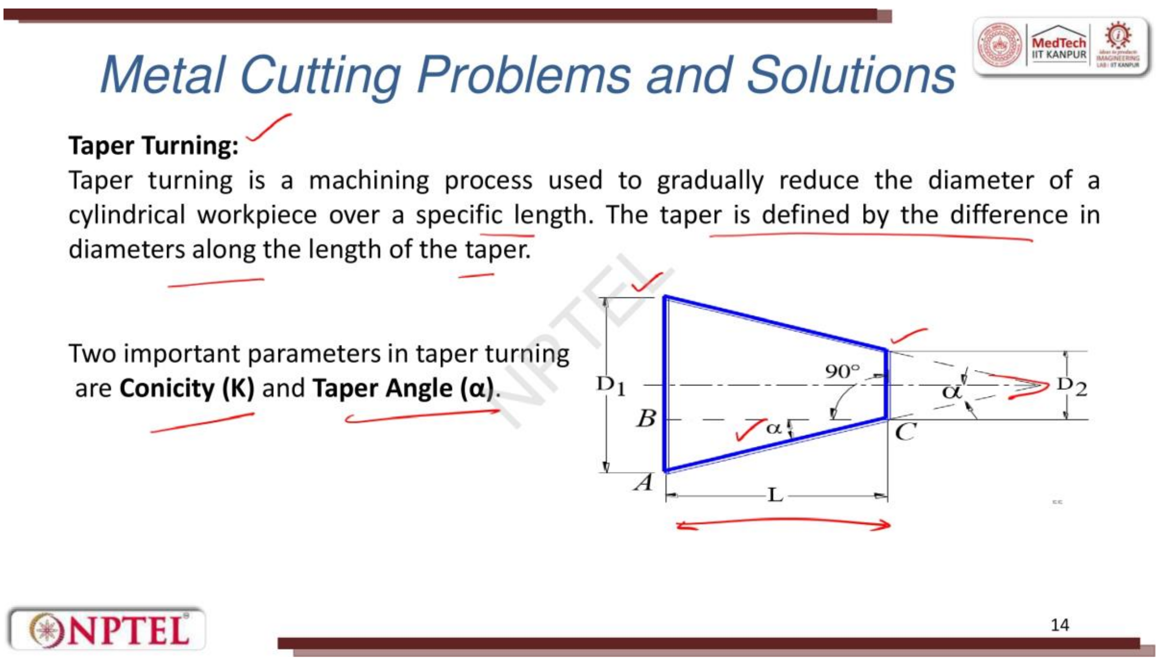
Machine feed: fm = ft x N x n = 0.01 x 150 x 10

= 15 mm/min

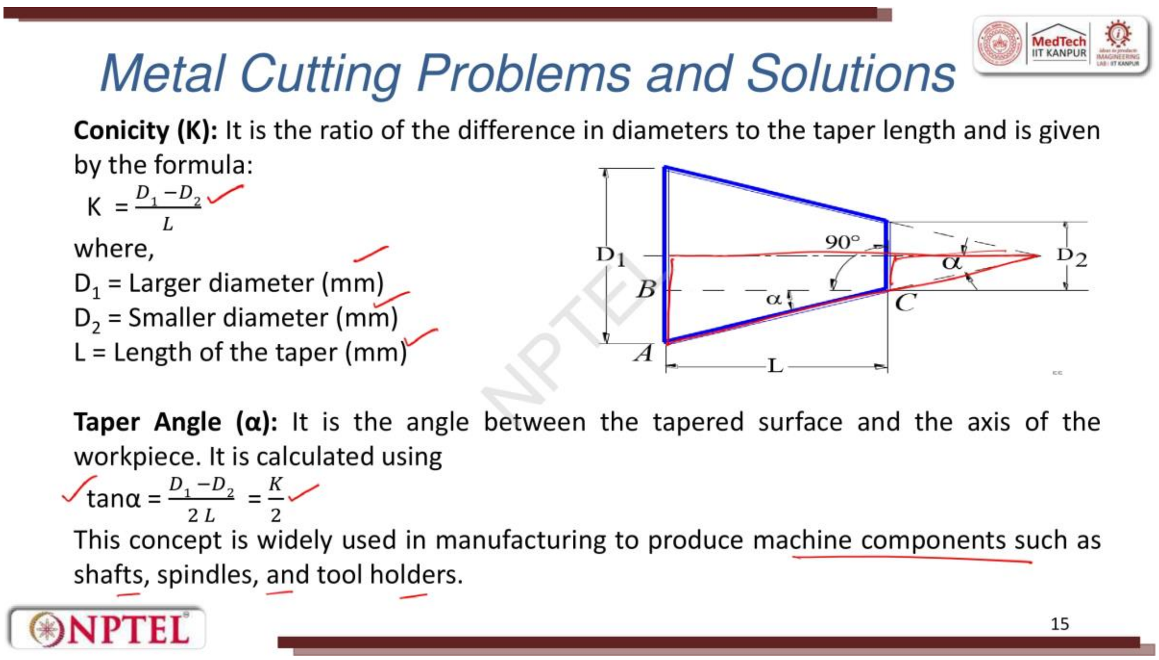
MRR = w x d x fm

= 10 x 0.15 x 15 = 22.5 mm^3/min (ans.)

Cutting time: T = L/fm = $\frac{50}{15}$ x 60 = 200 sec (ans.)

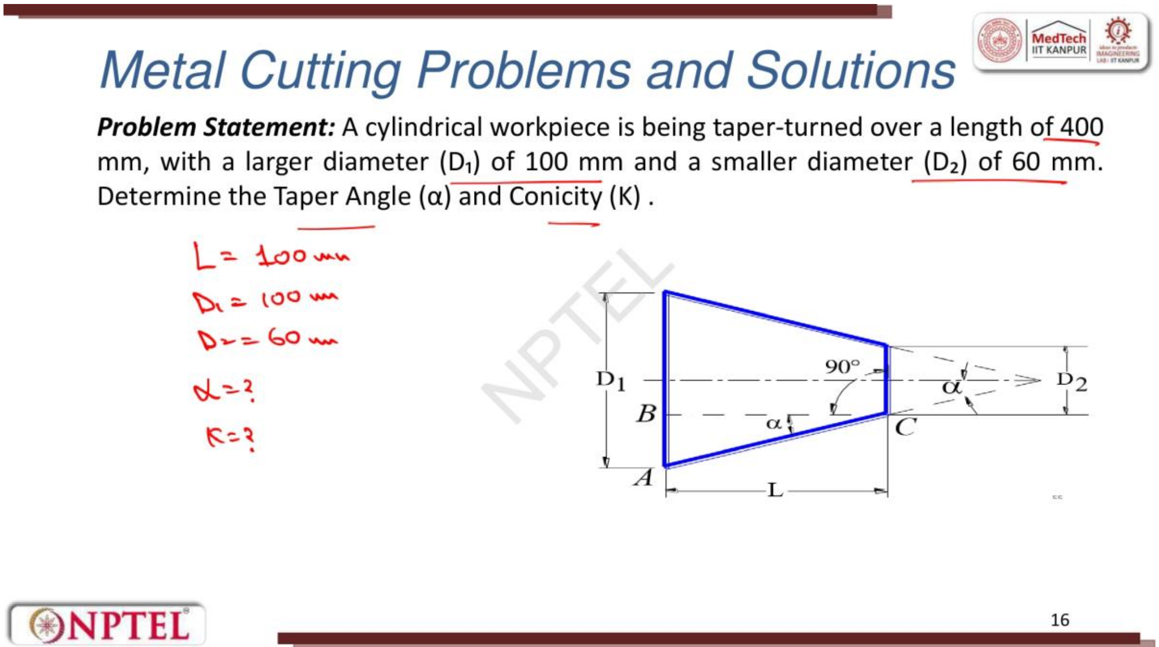


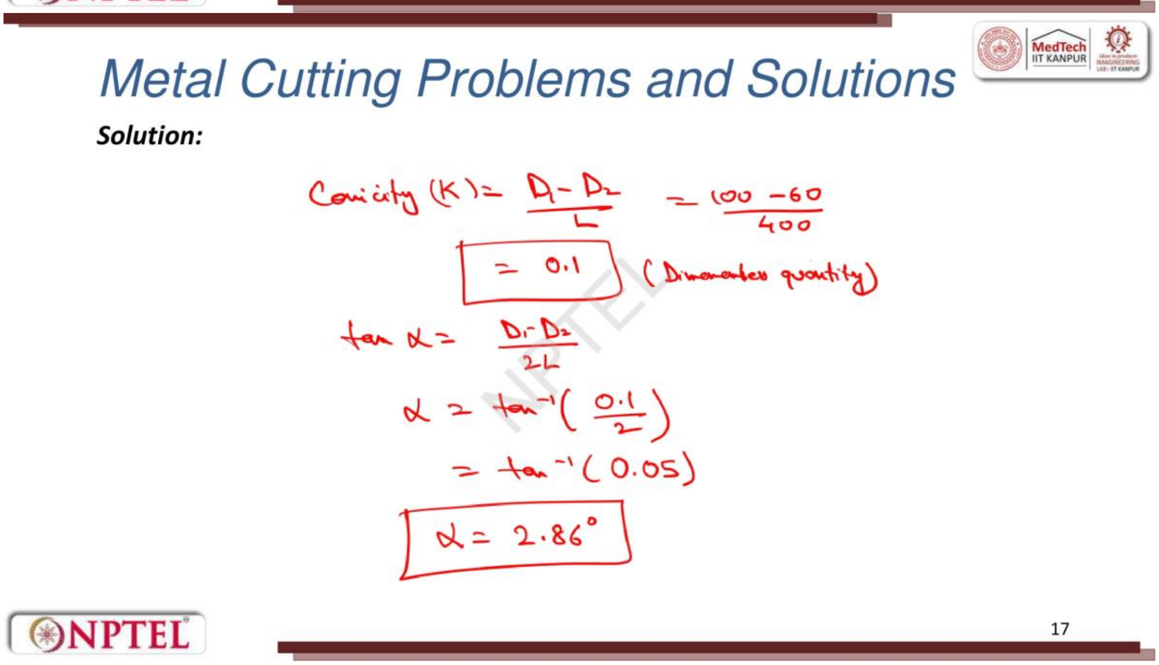
Next is the concept of taper turning. Taper turning means on one side diameter is larger, other side the diameter is smaller. The D1 is a larger diameter, D2 is a smaller diameter and there is a length that has been turned from the larger to the smaller diameter. And here we have multiple parameters here, we have taper angle alpha here, we have conicity K, By the definition, taper turning is a machining process used to gradually reduce the diameter of a cylindrical workpiece over a specific length. A taper is defined by the difference in the diameters along the length of the taper. So, here this alpha is half of this angle, total angle. And conicity is also calculated. How is K calculated?



Let us see here $K = \frac{D1 - D2}{L}$, that is conicity D1 is a larger diameter, D2 is a smaller diameter and L is the length of the taper. We can also calculate the taper angle that is $\tan\alpha = \frac{D1 - D2}{2L} = \frac{K}{2}$

So, here we can develop a triangle here. This is one triangle, and that triangle, using the triangle relationship, $\tan\alpha = \frac{D1 - D2}{2L}$, which is conicity by 2. This concept is widely used in manufacturing to produce machine components such as shafts, spindles, tool holders, etc.





A cylindrical workpiece is being taper-turned over a length of 400 mm, with a larger diameter (D_1) of 100 mm and a smaller diameter (D_2) of 60 mm. Determine the Taper Angle (α) and Conicity (K).

Given:

L = 100 mm

D1 = 100 mm

D2 = 60 mm

α = ?

K = ?

Solution:

$K = \frac{D1 - D2}{L} = \frac{100 - 60}{400} = 0.1$ (Dimensionless quantity)

$\tan\alpha = \frac{D1 - D2}{2L}$

$\alpha = \tan^{-1}(0.1/2)$

$= \tan^{-1}(0.05)$

α = 2.86 degree (ans.)

With this, I am taking a break here. And the second part of the tutorial will cover the other problems. This was just a simple machining system. Now, we will also try to see the tool, the shear angle, and the nose radius of the tool. How do we calculate those? Also, the tool life equation that you saw in the 3D lectures will also be covered in the next part of the tutorial.

Thank you.