Automation in Production Systems and Management

Prof. Pradip Kumar Ray
Vinod Gupta School of Management
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

Automated CAPP (Part-II)
Lecture - 58
Process Optimization and CAPP: Numerical Examples

During these lecture sessions on process planning, I will be discussing a few numerical problems related to basically process planning. One of the important steps involved in the process planning is Process Optimization.

Through process planning or using the process planning approach, you get a process plan for a given part and against different kinds of operations, against different types of processes involved, you need to define in explicit terms the optimal process conditions. Through application of the different techniques or different optimization tools, we can determine the process conditions or process parameters.

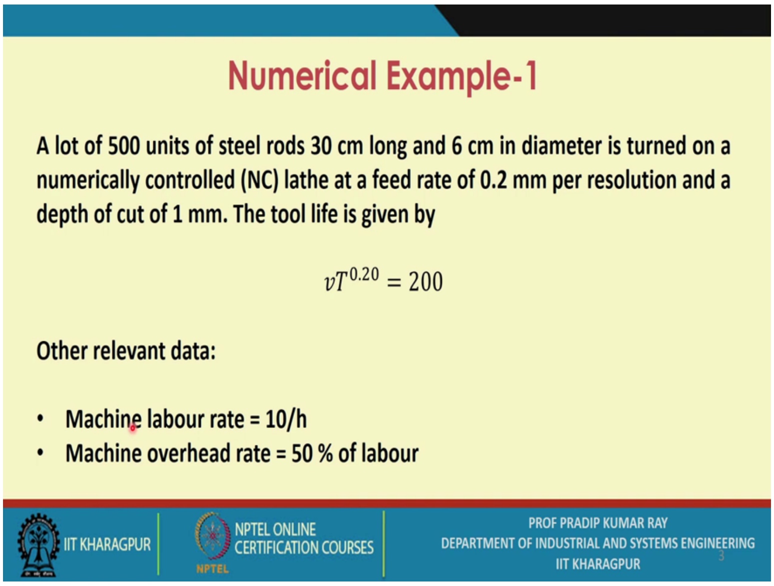
Given a particular operation and given all other the elements of a process you need to determine the process parameters. Ultimately, the best possible the process settings, you have to use for using a process plan.

As far as possible, when it is necessary and when it is feasible, you must use computer aided process planning. Under certain conditions, you also know that the computer aided process planning becomes an automated system.

Automated system of the generating the process plans has several advantages. You make sure that it becomes cost effective and when you get the item or get the part or get the product, using a particular process plan generated through an automated system make sure that the quality of the product of the quality of the part or the quality of the component getting produced, getting manufactured is conforming to its standards specifications.

There are 6 steps involved.

(Refer Slide Time: 04:31)



The second important aspect is the selection of the machine tool. Then the selection of the inspection equipment. Selection of the work holding devices. Work holding devices could be of different types depending on the shape and size of the object or shape and size of work part.

The last step is you have to determine the process conditions. While you determine these process conditions, three specific objectives you have to fulfill. The first one is-make sure that these process conditions are determined in such a way that unit component or product cost is held at minimum.

The second condition is-you need to assure that the production rate is maximum. In order to maximize the production rate, you need to the minimize the processing time and per unit at the minimum obviously, the production rate will be at the maximum level.

The third condition you have to satisfy is-you make sure that that manufacturing lead time should be at the minimum level.

At this point in time, you may not consider the waiting time or transfer time. You are focusing on the operations being carried out within the boundary of a machine tool.

We are basically considering the two-time elements. One is the setup time should be held at the minimum and the processing time per unit. Unit could be 1 or unit could be 1000 units. It depends on your production run and the type of component you are producing.

Machining conditions are determined in such a way that these three conditions are fulfilled.

Now, we will be referring to the first numerical problem.

A lot of 500 units of steel rods 30 cm long and 6 cm in diameter is turned on a numerically controlled (NC) lathe at a feed rate of 0.2 mm per resolution and a depth of cut of 1 mm. The tool life is given by

$vT^{0.20} = 200$

The other data are:

Machine labour rate = $10/h

Machine overhead rate = 50 % of labour

Grinding labour rate = $10/h

Grinding overhead rate = 50 % of grinding labour

Workpiece loading and unloading time = 0.50 min/piece

The data related to tools are:

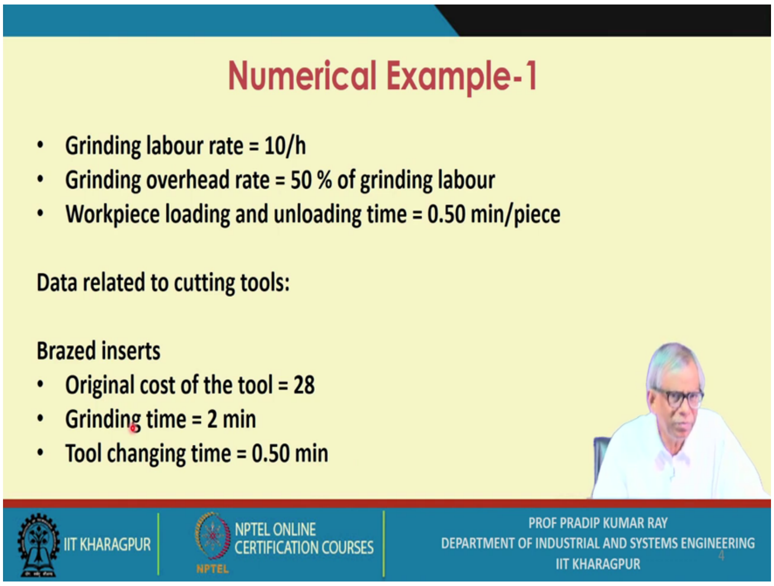
Brazed inserts

Original cost of the tool = $27.96

Grinding time = 2 min

Tool changing time = 0.50 min

(Refer Slide Time: 14:55)



The tool can be ground only five time before it is discarded.

Determine the following:

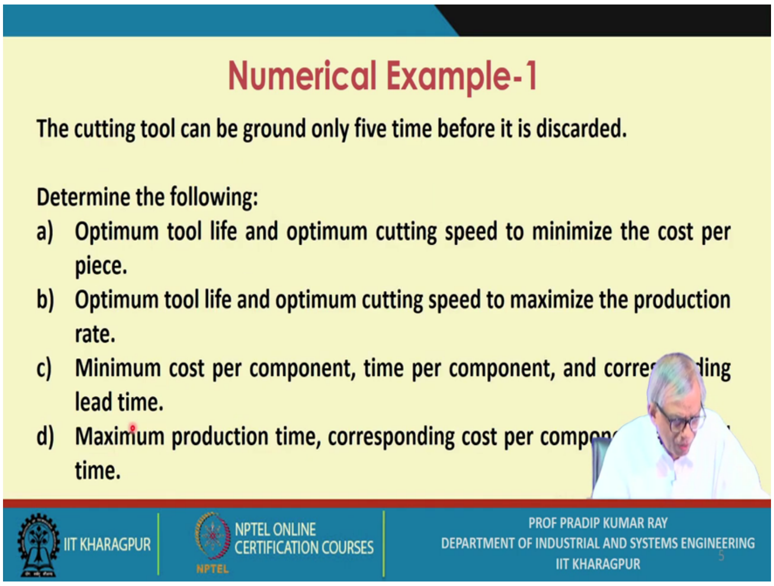
a) Optimum tool life and optimum cutting speed to minimize the cost per piece.

b) Optimum tool life and optimum cutting speed to maximize the production rate.

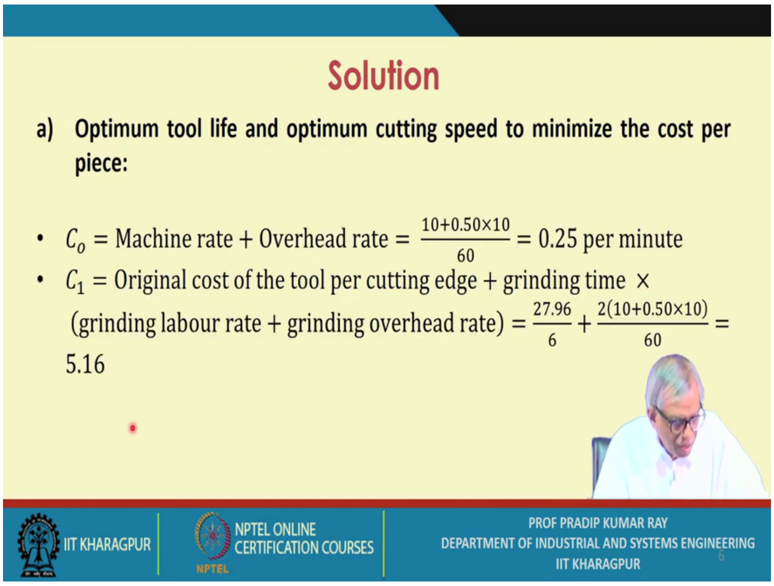
c) Minimum cost per component, time per component, and corresponding lead time.

d) Maximum production time, corresponding cost per component, and lead time.

(Refer Slide Time: 18:14)



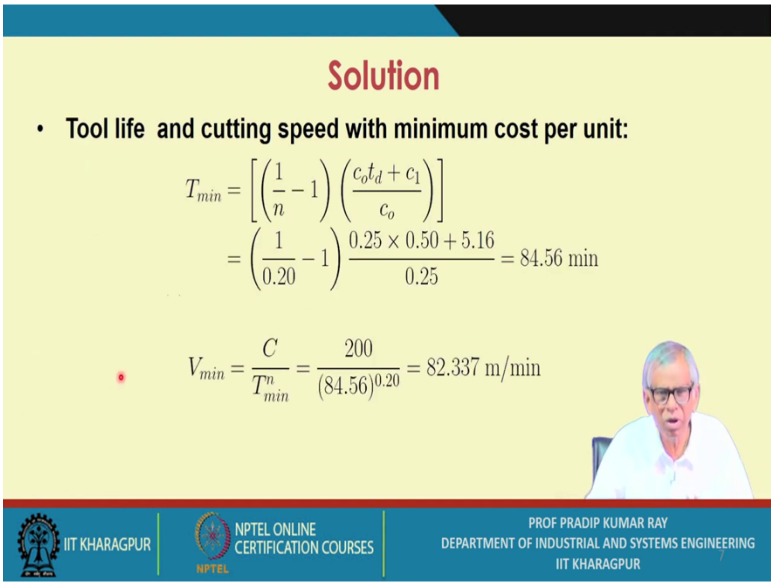
(Refer Slide Time: 20:56)



a) Optimum tool life and optimum cutting speed to minimize the cost per piece:

- $C_o = \text{Machine rate} + \text{Overhead rate} = \frac{10+0.50\times10}{60} = \$0.25 \text{ per minute}$
- $C_1 = \text{Original cost of the tool per cutting edge} + \text{grinding time} \times (\text{grinding labour rate} + \text{grinding overhead rate}) = \frac{27.96}{6} + \frac{2(10+0.50\times10)}{60} = \$5.16$

(Refer Slide Time: 23:05)

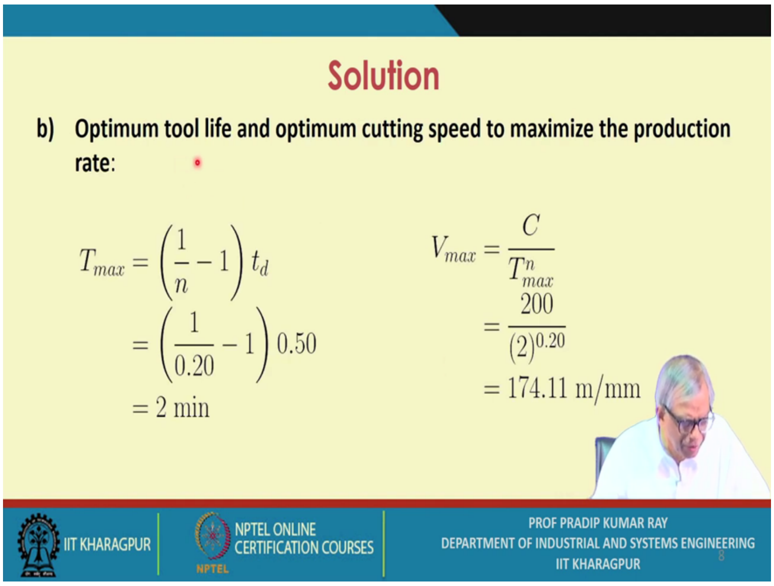


Therefore,

$$T_{min} = \left[\left(\frac{1}{n} - 1\right)\left(\frac{c_o t_d + c_1}{c_o}\right)\right] \\ = \left(\frac{1}{0.20} - 1\right)\frac{0.25 \times 0.50 + 5.16}{0.25} = 84.56 \text{ min} \quad (1)$$

$$V_{min} = \frac{C}{T_{min}^n} = \frac{200}{(84.56)^{0.20}} = 82.337 \text{ m/min}$$

(Refer Slide Time: 25:06)

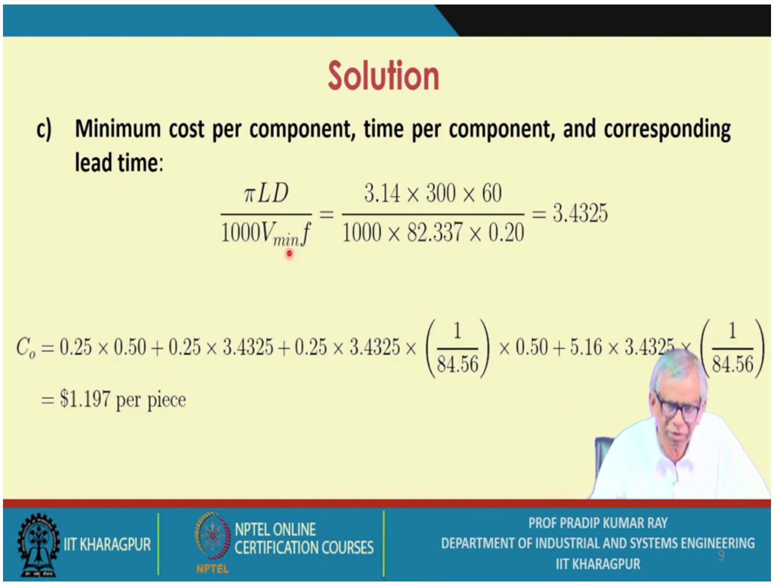


b) Optimum tool life and optimum cutting speed to maximize the production rate:

$$T_{max} = \left(\frac{1}{n} - 1\right) t_d \\ = \left(\frac{1}{0.20} - 1\right) 0.50 \\ = 2 \text{ min}$$

$$V_{max} = \frac{C}{T_{max}^n} \\ = \frac{200}{(2)^{0.20}} \\ = 174.11 \text{ m/mm}$$

(Refer Slide Time: 25:47)

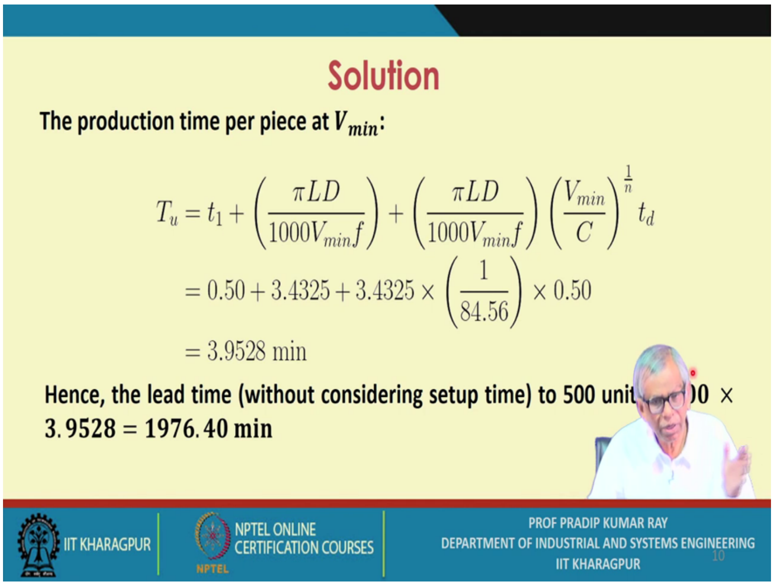


c) Minimum cost per component, time per component, and corresponding lead time:

$$\frac{\pi LD}{1000V_{min}f} = \frac{3.14 \times 300 \times 60}{1000 \times 82.337 \times 0.20} = 3.4325$$

$$C_o = 0.25 \times 0.50 + 0.25 \times 3.4325 + 0.25 \times 3.4325 \times \left(\frac{1}{84.56}\right) \times 0.50 + 5.16 \times 3.4325 \times \left(\frac{1}{84.56}\right)$$
$$= \$1.197 \text{ per piece}$$

(Refer Slide Time: 26:35)

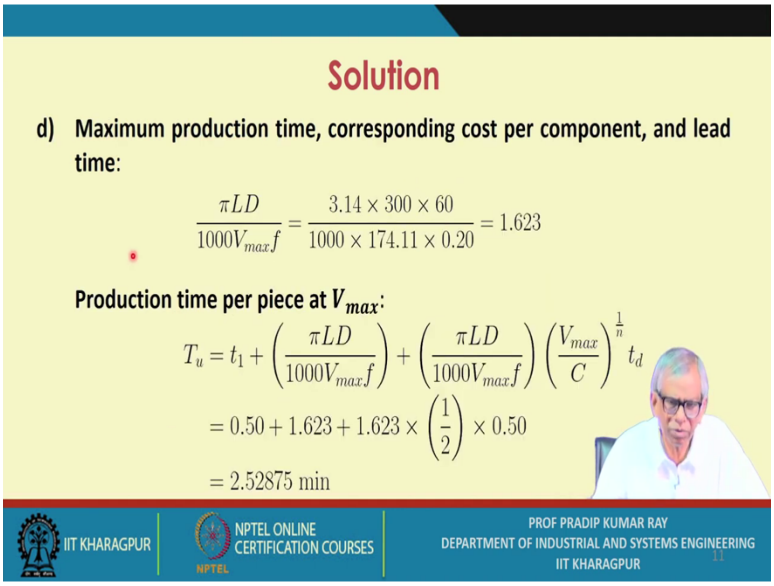


The production time per piece at V_{min} is

$$T_u = t_1 + \left(\frac{\pi LD}{1000V_{min}f}\right) + \left(\frac{\pi LD}{1000V_{min}f}\right)\left(\frac{V_{min}}{C}\right)^{\frac{1}{n}} t_d$$
$$= 0.50 + 3.4325 + 3.4325 \times \left(\frac{1}{84.56}\right) \times 0.50$$
$$= 3.9528 \text{ min}$$

Therefore, the lead time (ignoring major setup time) to 500 units is 500×3.9528 = 1976.40 min

(Refer Slide Time: 27:42)



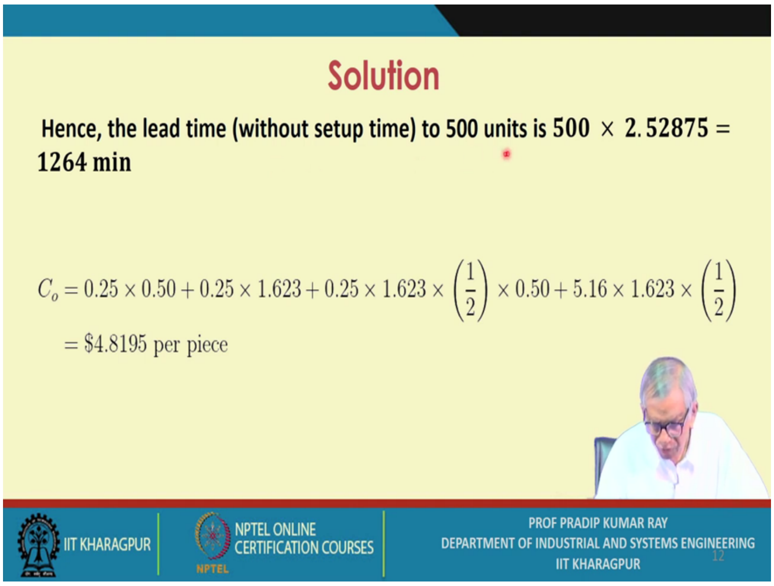
d) Maximum production time, corresponding cost per component, and lead time:

$$\frac{\pi LD}{1000V_{max}f} = \frac{3.14 \times 300 \times 60}{1000 \times 174.11 \times 0.20} = 1.623$$

The production time per piece at V_n V_{max} is

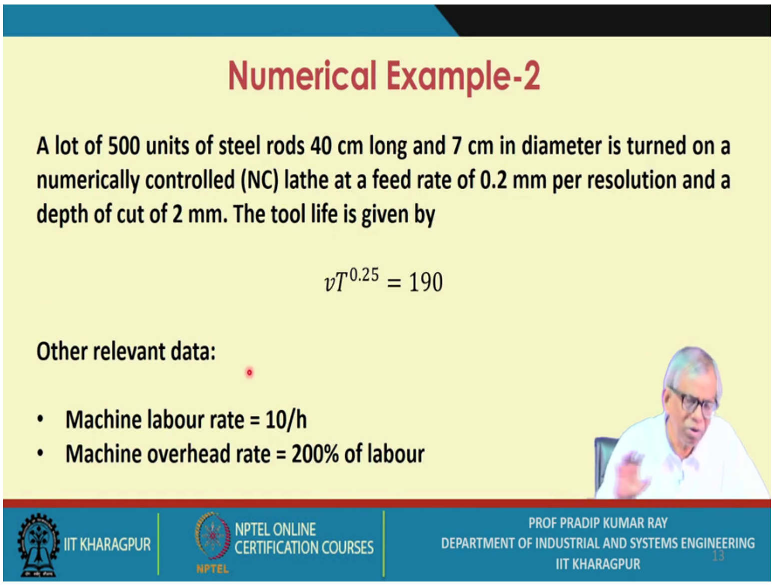
$$T_u = t_1 + \left(\frac{\pi LD}{1000V_{max}f}\right) + \left(\frac{\pi LD}{1000V_{max}f}\right)\left(\frac{V_{max}}{C}\right)^{\frac{1}{n}} t_d$$
$$= 0.50 + 1.623 + 1.623 \times \left(\frac{1}{2}\right) \times 0.50$$
$$= 2.52875 \text{ min}$$

(Refer Slide Time: 28:55)



Therefore, the lead time (ignoring major setup time) to 500 units is $500 \times 2.52875 = 1264.375$ min

(Refer Slide Time: 29:08)



$$C_o = 0.25 \times 0.50 + 0.25 \times 1.623 + 0.25 \times 1.623 \times \left(\frac{1}{2}\right) \times 0.50 + 5.16 \times 1.623 \times \left(\frac{1}{2}\right)$$
$$= \$4.8195 \text{ per piece}$$

Numerical Example-2

A lot of 500 units of steel rods 40 cm long and 7 cm in diameter is turned on a numerically controlled (NC) lathe at a feed rate of 0.2 mm per resolution and a depth of cut of 2 mm. The tool life is given by

$$vT^{0.25} = 190$$

The other data are:

- Machine labour rate = $10/h
- Machine overhead rate = 200% of labour

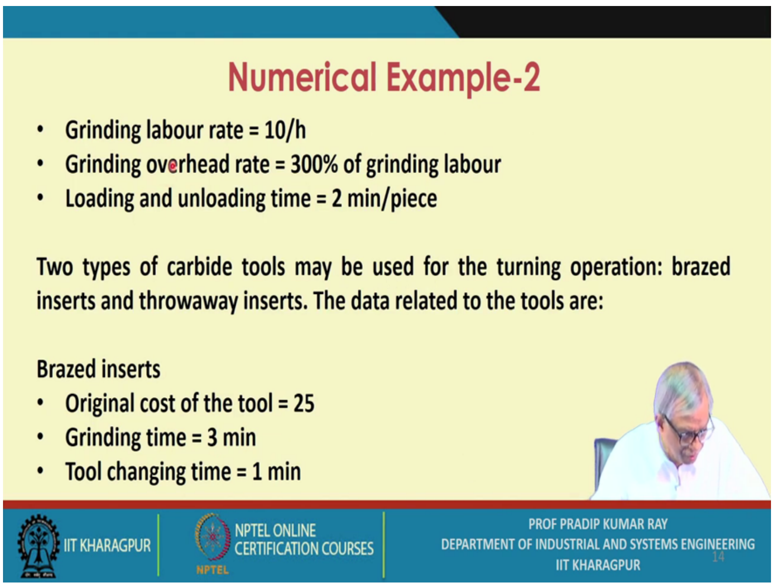
- Grinding labour rate = $10/h
- Grinding overhead rate = 300% of grinding labour
- Loading and unloading time = 2 min/piece

Two types of carbide tools can be used for the turning operation: brazed inserts and throwaway inserts. The data related to the tools are:

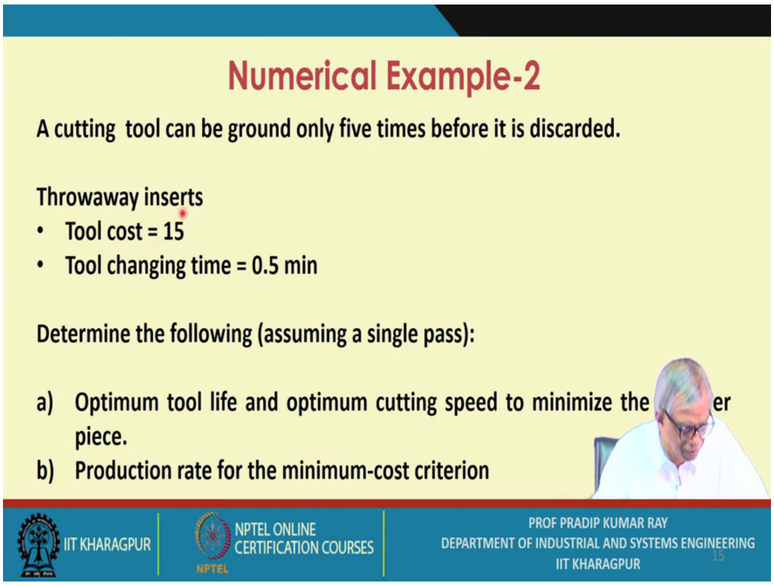
Brazed inserts

- Original cost of the tool = $25.00
- Grinding time = 3 min
- Tool changing time = 1 min

(Refer Slide Time: 29:57)



(Refer Slide Time: 30:33)



The tool can be ground only five times before it is discarded.

Throwaway inserts

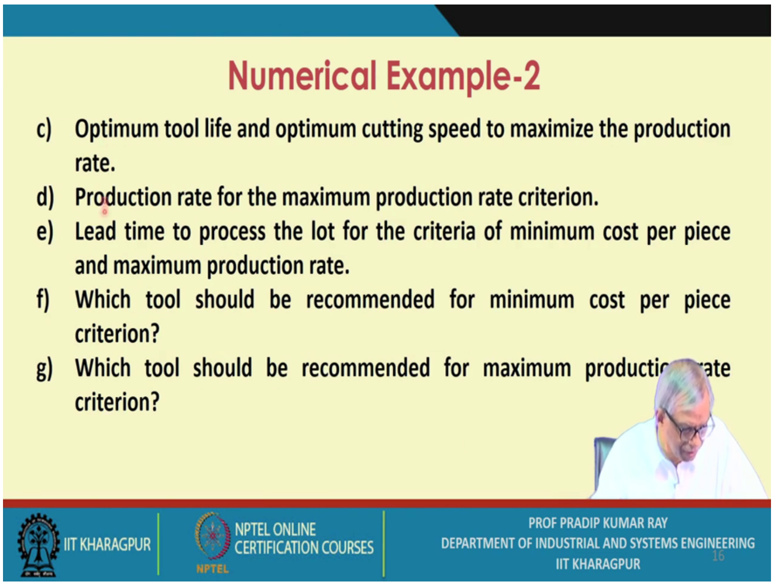
- Tool cost = $15.00
- Tool changing time = 0.5 min

Determine the following (assuming a single pass):

a) Optimum tool life and optimum cutting speed to minimize the cost per piece.

b) Production rate for the minimum-cost criterion

(Refer Slide Time: 31:11)



c) Optimum tool life and optimum cutting speed to maximize the production rate.

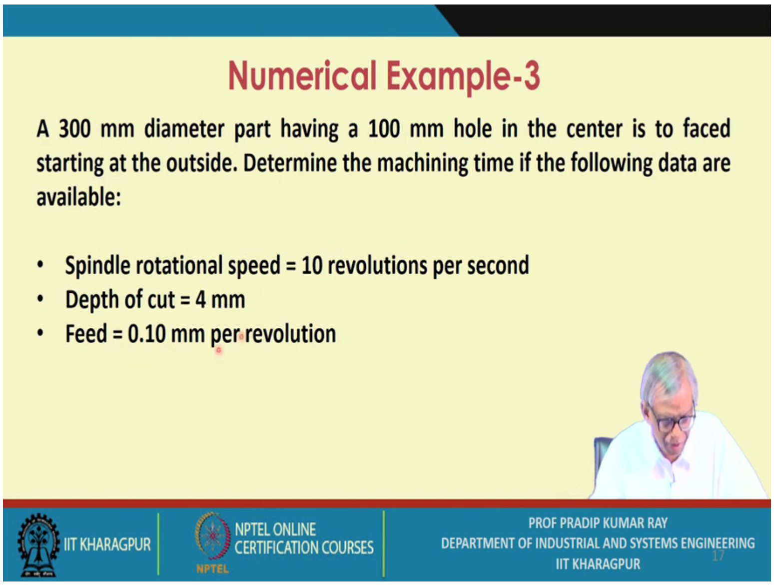
d) Production rate for the maximum production rate criterion.

e) Lead time to process the lot for the criteria of minimum cost per piece and maximum production rate.

f) Which tool should be recommended for minimum cost per piece criterion?

g) Which tool should be recommended for maximum production rate criterion?

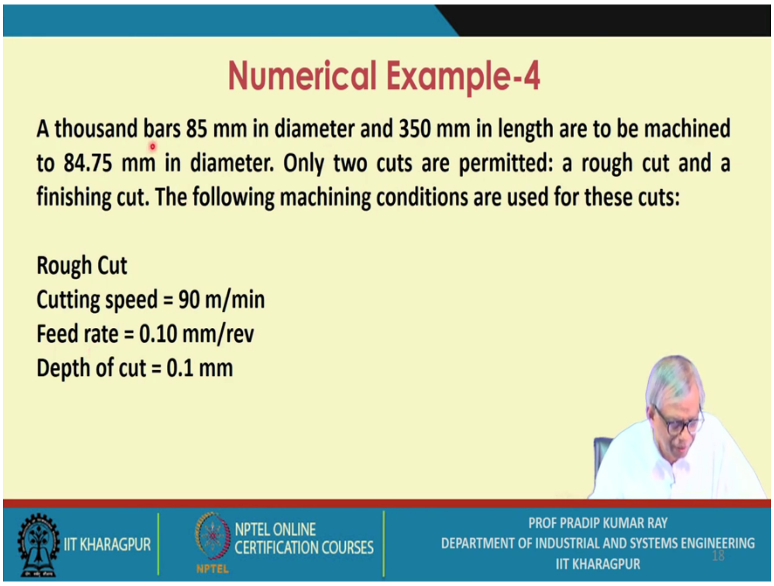
(Refer Slide Time: 32:25)



A 300 mm diameter part having a 100 mm hole in the center is to faced starting at the outside. Determine the machining time if the following data are available:

1. Spindle rotational speed = 10 revolutions per second
2. Depth of cut = 4 mm
3. Feed = 0.10 mm per revolution

(Refer Slide Time: 33:03)



A thousand bars 85 mm in diameter and 350 mm in length are to be machined to 84.75 mm in diameter. Only two cuts are permitted: a rough cut and a finishing cut. The following machining conditions are used for these cuts:

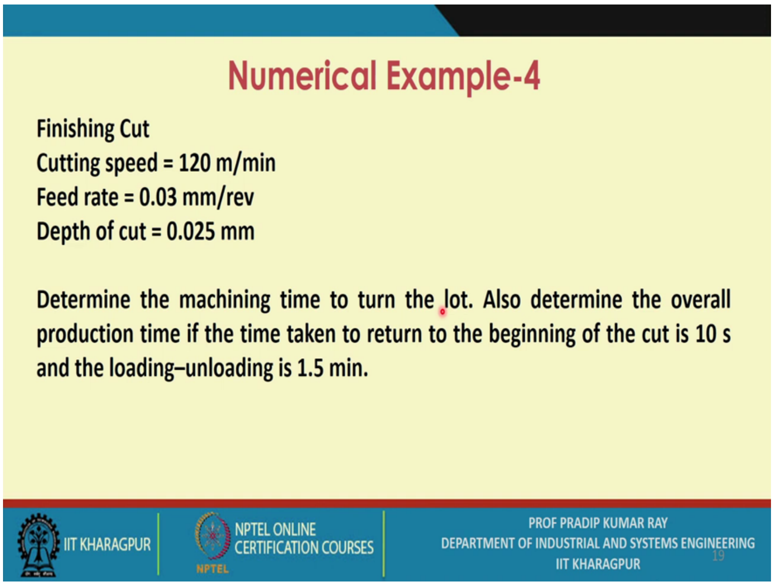
Rough Cut

Cutting speed = 90 m/min

Feed rate = 0.10 mm/rev

Depth of cut = 0.1 mm

(Refer Slide Time: 33:45)



Finishing Cut

Cutting speed = 120 m/min

Feed rate = 0.03 mm/rev

Depth of cut = 0.025 mm

Determine the machining time to turn the lot. Also determine the overall production time if the time taken to return to the beginning of the cut is 10 s and the loading–unloading is 1.5 min.