Unit – 5 Machining Time Calculation

Part – A

1. Write steps involved in cutting time calculation (AU A/M ’18)

Step 1: Calculation of length of cut (L)
Step 2: Calculation of feed (f) and depth of cut
Step 3: Calculation of speed (S); [rpm (N) = 1000 S/π D]
Step 3: Calculation of machining time by using the formula ($\frac{L}{f \times N}$)

2. What are the typical data required for cutting time calculation in shaping (AU A/M ’18)

Shaping time T_m = [{L x B x (1+ k)} / (1000 v f)] x number of cuts
B = width of the work
N = Number of stroke/min
f = Feed/stroke in mm
V = Cutting speed m/min
K = Return time/Cutting time

3. Write short notes on tear down time (AU N/D ’17)

It is the time taken to remove the tools, jigs and fixtures from the machine and to clean the machine and tools after the operation has been done on the last component of batch. The tear down time is usually small. The tear down time occurs only once for a complete lot or batch taken for machining. Standard data are available for tear down time for various machines.

4. Give the formula for estimation of machining time for drilling (AU N/D ’17)

$$\text{Time for drilling} = \frac{\text{Depth of hole to be produced}}{\left(\frac{\text{feed}}{\text{rev}}\right) \times (\text{rpm})} = \frac{L}{f \times N}$$

5. Define cutting speed. List various factors affecting cutting speed. (AU N/D ’16) (AU A/M ’17)

Cutting speed is the speed at which the cutting edge of tool passes over the job and it is usually expressed in meters per minute. The cutting speed depends on the cutting tool material, the work piece material and the operation. Once the cutting speed has been selected, the revolutions per minute of job/machine are calculated as follows:

S = π DN/1000 or N = 1000 S/π D

Where S = Surface cutting speed in meters per minute
D = Diameter of the job in mm
N = r.p.m. of machine/job.

6. What is machining time? (AU N/D ’16)

It is the time for which the machine works on the component, i.e. from the time when the tool touches the work piece to when the tool leaves the component after completion of operation. The machining time depends on the type and extent of machining required, material being machined, speed, feed, depth of cut and number of cuts required.

7. Derive an expression for machining time in planning machine. (AU N/D ’11)

Planing time Tm = [(L + 250) (B + 50) (1+ k)] / (1000 v f)
B = width of the work
N = Number of stroke/min

f = Feed/stroke in mm
V = Cutting speed m/min
K = Return time/Cutting time

8. Derive an expression for machining time for plain turning in lathe. (AU N/D '10)

Turning, on a lathe, is the removal of excess material form the workpiece by means of a pointed tool, to produce a cylindrical or cone shaped surface. From cutting speed, r.p.m. of job are calculated by using the formula.

$$N = \frac{1000\ S}{\pi D}$$

where N = r.p.m. of job
S = Surface cutting speed in meters/minute
D = Diameter of the stock to be turned (in mm)
if *f* = Feed per revolution (in mm)
L = Length of stock to be turned (in mm)
T = Time required for turning (in minutes)

$$\text{Then } T = \frac{L}{f\ X\ N}$$

9. What are the different types of milling operations? (AU M/J '07)

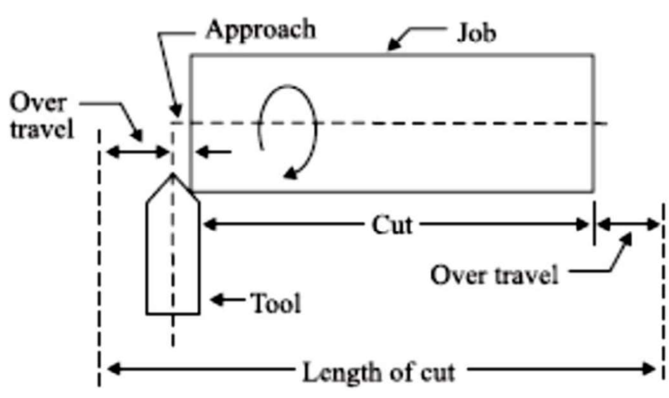
- Face milling
- Slab milling
- Profile milling
- Keyway cutting
- Slotting

10. Define tool approach and tool travel (AU A/M '17)

Length of cut : It is the distance travelled by the tool to machine the work piece and is calculated as follows :

Length of cut (L) = Approach length + Length of work piece to be machined + Over travel

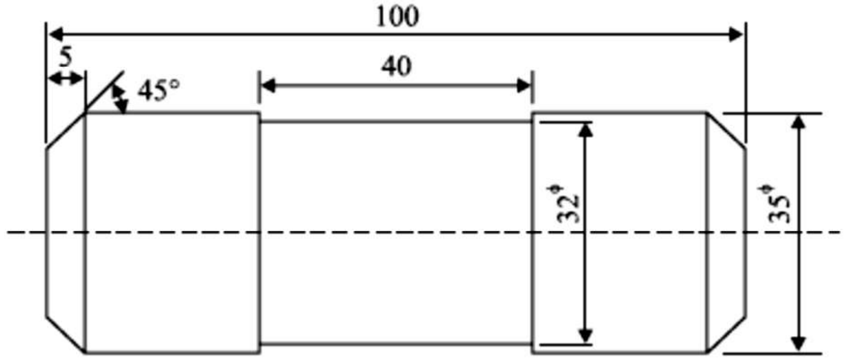
Approach is the distance a tool travels, from the time it touches the work piece until it is cutting to full depth. Over travel is the distance the tool is fed while it is not cutting. It is the distance over which the tool idles before it enters and after it leaves the cut. These terms are explained in the Fig. for a cutting operation on lathe.



Total tool travel = length of job + approach + over travel

Part – B

1. **A mild steel bar 100 mm long and 38 mm in diameter is turned to 35 mm dia. And was again turned to a diameter of 32 mm over a length of 40 mm as shown in the Fig. 5.23. The bar was machined at both the ends to give a chamfer of 45° × 5 mm after facing. Calculate the machining time. Assume cutting speed of 60 m/min and feed 0.4 mm/rev. The depth of cut is not to exceed 3 mm in any operation. (16 marks) (AU N/D'16) (AU N/D'17)**



Solution : *Ist operation* : Turning from f 38 mm to f 35 mm

$$S = 60 \text{ meters/min.}$$

$$D = 38 \text{ mm}$$

$$N = \frac{1,000\ S}{\pi D} = \frac{1,000 \times 60}{\pi \times 38}$$

$$= 503 \text{ r.p.m.}$$

$$\text{Time taken} = \frac{\text{Length of cut}}{\text{r.p.m.} \times \text{Feed/rev.}}$$

$$= \frac{100}{503 \times 0.4} = 0.5 \text{ min.}$$

2nd operation : External relief

$$L = 40 \text{ mm.}$$

$$D = 35 \text{ mm.}$$

$$S = 60 \text{ m/min.}$$

$$N = \frac{60 \times 1,000}{\pi \times 35} = 545 \text{ r.p.m.}$$

$$\text{Time taken for second operation} = \frac{\text{Length}}{\text{r.p.m.} \times \text{Feed/rev.}}$$

$$= \frac{40}{545 \times 0.4} = 0.18 \text{ min.}$$

3rd operation : Facing of both ends

$$L = \text{Length of cut}$$

$$= \frac{35}{2} = 17.5 \text{ mm}$$

$$D = 35 \text{ mm}$$

$$S = 60 \text{ m/min}$$

$$N = \frac{60 \times 1{,}000}{\pi \times 35} = 545 \text{ r.p.m.}$$

$$\text{Time for facing one end} = \frac{17.5}{0.4 \times 545} = 0.08 \text{ min}$$

$$\text{Time for facing both ends} = 2 \times 0.08 = 0.16 \text{ min}$$

4th operation : Chamfering 45° × 5 mm

$$\text{Length of cut} = 5 \text{ mm}$$

$$N = 545 \text{ r.p.m.}$$

$$\text{Time taken for chamfering on one side} = \frac{5}{545 \times 0.4} = 0.02 \text{ min}$$

$$\text{Time taken for chamfering on both sides} = 0.02 \times 2 = 0.04 \text{ min}$$

$$\text{Total machining time} = 0.50 + 0.18 + 0.16 + 0.04$$

$$= 0.88 \text{ min}$$

2. **Find the time required to drill 4 holes in a cast iron flange each of 2 cm depth, if the hole diameter is 2 cm. Assume cutting speed as 21.9 m/min. and feed as 0.02 cm/rev. (8 marks) (AU N/D '16)**

Solution

Depth of hole = 2 cm = 20 mm
Diameter of hole = 2 cm = 20 mm
Cutting speed = 21.9 m/min
Feed = 0.02 cm/rev,
Depth hole = l + 0.3 d
= 2 + 0.3 (2) = 2.6
Number of holes = 4

(i) N = (1000 V) / π D
= (1000 x 21.9) / 3.14 x 20
= 350 rpm

(ii) T_m = Depth of hole / (Feed x rpm)
= 2.6 / (0.02 x 350)
= 0.3714 min

(ii) Time for drilling four holes = 0.3714 × 4 = 1.486 min.

3. **A keyway has to be cut in spindle whose dimensions are 40 cm long 4 cm diameter with a 1 cm width. The cutter diameter is 10 cm. If the cutter is revolving at 120 rpm, what time will be required to cut one cm deep keyway at a feed of 0.05 cm/rev of cutter? (8 marks) (AU N/D '16)**

$$\text{Table travel} = \sqrt{d(D-d)} + 0.5 = \sqrt{1(10-1)} + 0.5 = 3.5 \text{ cm}$$

$$\text{Total table movement} = 40 + 35 = 43.5 \text{ cm}$$

$$\text{Time required} = \frac{\text{Total table travel}}{N \times \text{Feed}}$$

$$= \frac{43.5}{120 \times .05} = 7.25 \text{ min}.$$

4. **A 20 × 5 cm CI surface is to be faced on a milling m/c with a cutter having a diameter of 10 cm and having 16 tooth for the cutting speed and feed are 50 m/min and 5 cm/min respectively, determine the milling time, rpm, and feed/tooth. (8 marks) (AU N/D '15)**

$$N = \frac{1000 \times V}{\pi \times D} = \frac{1000 \times 50}{\pi \times 100} = 160 \text{ rpm}$$

$$\text{Feed/min} = f_t = n \times N = f_t \times 16 \times 160$$

$$\text{Feed/tooth } f_t = \frac{50}{16 \times 160} = 0.0196 \text{ mm}$$

$$\text{Milling time } T = \frac{L + \frac{1}{2}\left[D - \sqrt{D^2 - W^2}\right] + 7}{(f_t \times n) \times N}$$

$$= \frac{200 + \frac{1}{2}\left[100 - \sqrt{100^2 - 50^2}\right] + 7}{0.0196 \times 16 \times 160}$$

$$\boxed{T = 4.27 \text{ min}}$$

5. **A T-slot is to be cut in a C.I. slab as shown in Fig. Estimate the machining time. Take cutting speed 25 m/min, feed is 0.25 mm/rev. Dia of cutter for channel milling is 80 mm. (16 marks) (AU N/D '14) (AU N/D '17)**

Solution:

The T-slot will be cut in two steps :

***Step I* :** Cut a 20 mm wide and 35 mm deep channel along the length

Dia of cutter = 80 mm

Cutting speed = 25 m/min

Length of job = 260 mm

$$\text{r.p.m. of cutter} = \frac{25 \times 1000}{\pi \times 80} = 100$$

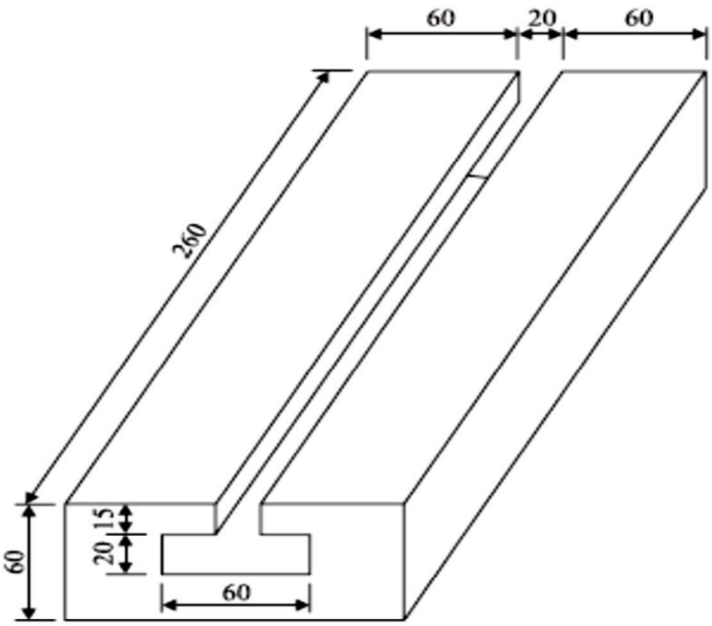
$$\text{Over travel} = \sqrt{Dd - d^2}$$

$$= \sqrt{80 \times 35 - 35^2} = 40 \text{ mm}$$

$$\text{Total tool travel} = 260 + 40 = 300 \text{ mm}$$

$$\text{Time for cutting slot} = \frac{\text{Length of cut}}{\text{Feed/min.}}$$

$$= \frac{300}{0.25 \times 100} = 12 \text{ min.}$$



***Step II* :** Cut T-slot of dimensions 60 × 20 with a T-slot cutter
Here dia of cutter = 60 mm

$$\text{r.p.m. of cutter} = \frac{25 \times 1{,}000}{\pi \times 60} = 133$$

$$\text{In this case the over travel of tool} = \frac{1}{2}\text{ Dia of cutter,}$$

$$\text{since} \quad \text{dia of cutter} = \text{width of slot}$$

$$\text{Over travel} = \frac{60}{2} = 30 \text{ mm}$$

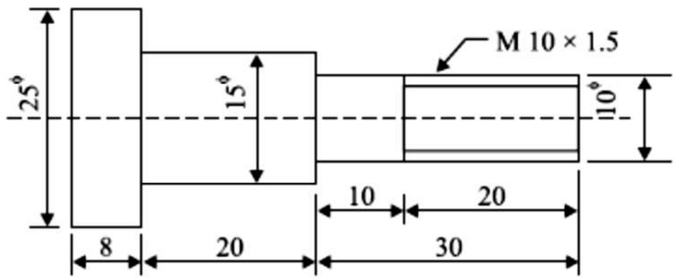
$$\text{Total tool/Table travel} = 260 + 30 = 290 \text{ mm}$$

$$\text{Time taken} = \frac{290}{0.25 \times 133} = 8.7 \text{ min}$$

Total time to cut T-slot = 12 + 8.7
= 20.7 minutes

6. **Calculate the machining time required to produce one piece of the component shown in Fig. given below starting from f 25 mm bar. The following data is available. (16 marks) (AU N/D '14) (AU N/D '13)**

   For turning:
   Cutting speed = 40 m/min.
   Feed = 0.4 mm/rev.
   Depth of cut = 2.5 mm/per pass
   For thread cutting:
   Cutting speed = 8 m/min.



Solution:

***Step I* :** Time for turning to 15 mm dia from 25 mm dia.

As depth of material to be removed is

$$\frac{(25-15)}{2} = 5 \text{ mm.}$$

it will be accomplished in 2 cuts.

$$\text{Average Dia} = D_{av} = \frac{25+15}{2} = 20 \text{ mm.}$$

$$\text{Spindle r.p.m.} = \frac{40 \times 1{,}000}{20 \times \pi} = 637 \text{ rev/min.}$$

$$\text{Time taken} = \frac{50}{637 \times 0.4} = 0.2 \text{ min.}$$

For 2 cuts time taken = 0.4 min.

***Step 2* :** Turning from 15 mm to 10 mm dia over a length of 30 mm in one pass

$$N = \frac{40 \times 1{,}000}{\pi \times 15} = 850 \text{ rev/min.}$$

$$\text{Time taken} = \frac{30}{0.4 \times 850} = 0.09 \text{ min.}$$

***Step 3* :** Threading

$$N = \frac{8 \times 1{,}000}{\pi \times 10} = 255 \text{ r.p.m.}$$

$$\text{Feed} = \text{pitch} = 1.5 \text{ mm}$$

$$\text{Threads per cm} = \frac{10}{1.5} = \frac{100}{15}$$

$$\text{No. of cuts} = \frac{25}{\text{Threads per cm}}$$

$$= \frac{25 \times 15}{100} = 3.75 = 4 \text{ cuts}$$

$$\text{Time for one cut} = \frac{\text{Length of cut}}{\text{Feed/rev.} \times \text{r.p.m.}}$$

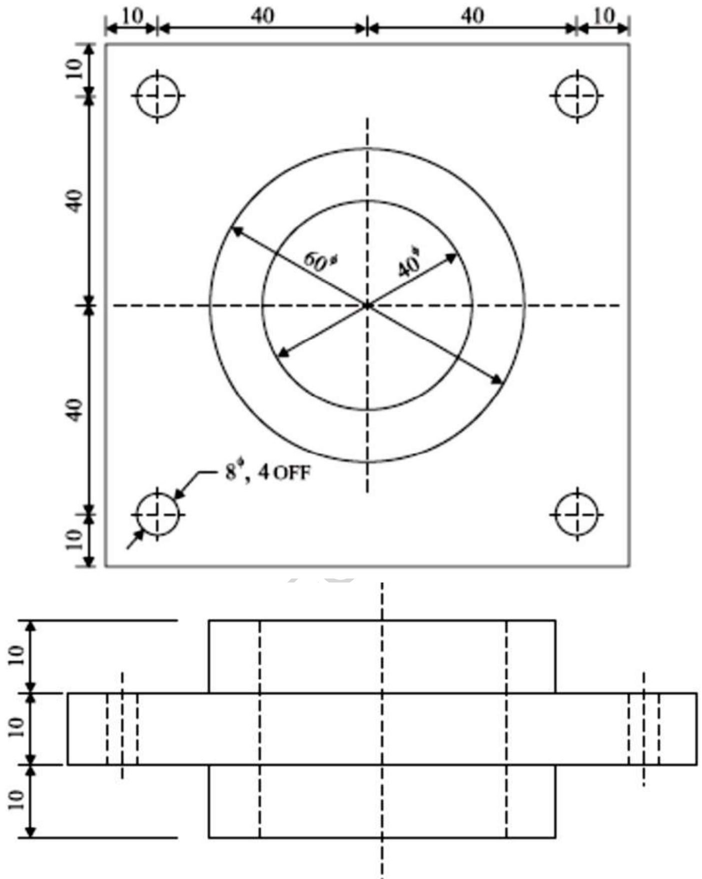
$$= \frac{20}{1.5 \times 255} = 0.05 \text{ min.}$$

Time for 4 cuts = 0.05 × 4 = 0.2 min.

Total time for producing one component = 0.4 + 0.09 + 0.2

= 0.69 min.

7. **Calculate the machining time to drill four 8 mm dia holes and one 40 mm dia central hole in the flange shown in Fig. 20 mm dia hole is drilled first and then enlarged to 40 mm f hole. Take cutting speed 10 m/min, feed for 8 mm drill 0.1 mm/rev, for 20 mm drill feed is 0.2 mm/rev. and for 40 mm f drill feed is 0.4 mm/rev. (16 marks) (AU A/M '17) (AU A/M '18)**



Solution :

(*i*) Time to drill four 8 mm dia holes

S = 10 m/min.

Dia of drill D = 8 mm.

L = 10 mm

f = 0.1 mm/rev.

$$N = \frac{S \times 1{,}000}{\pi D} = \frac{10 \times 1{,}000}{\pi 8}$$

$$= 398 \text{ r.p.m.}$$

$$\text{Time taken to drill one hole} = \frac{L}{f \times N} = \frac{10}{0.1 \times 398}$$

$$= 0.25 \text{ min.}$$

$$\text{Time to drill 4 holes} = 0.25 \times 4 = 1 \text{ minute.}$$

(*ii*) Time to drill one hole of 40 mm diameter :

This hole is made in two steps :

(*a*) Drill 20 mm £ hole — 30 mm long

$$N = \frac{10 \times 1,000}{\pi \times 20} = 159 \text{ r.p.m.}$$

$$\text{Time taken} = \frac{30}{0.2 \times 159} = 0.95 \text{ min.}$$

(*ii*) Enlarge 20 mm £ hole with 40 mm £ drill

Here $$N = \frac{10 \times 1,000}{\pi \times 40} = 80 \text{ r.p.m.}$$

$$f = 0.4 \text{ mm/rev.}$$

$$\text{Time taken} = \frac{30}{0.4 \times 80} = 0.94 \text{ min.}$$

Total time taken to drill all the holes = 1.0 + 0.95 + 0.94
= 2.9 min.

11. Find the time required on a shaper to machine a plate 600 mm × 1,200 mm, if the cutting speed is 15 meters/min. The ratio of return stroke time to cutting time is 2 : 3. The clearance at each end is 25 mm along the length and 15 mm on width. Two cuts are required, one roughing cut with cross feed of 2 mm per stroke and one finishing cut with feed of 1 mm per stroke. (8 marks) (AU N/D '17)

Solution :

S = 15 m/minute

Length of stroke = L = Length of plate + clearance on both sides
= 1200 + 2 × 25 = 1,250 mm.

Cross travel of table = W = Width of job + clearance
= 600 + 2 × 15 = 630 mm.

K =2/3 = 0.67

Cross feed for rough cut = 2 mm/stroke

Cross feed for finish cut = 1 mm/stroke

$$\text{Time for one complete stroke} = \frac{L(1+K)}{1000 \times S}$$

$$= \frac{1,250(1+0.67)}{1,000 \times 15}$$

$$= 0.14 \text{ min}$$

$$\text{No. of strokes for roughing cut} = \frac{\text{Cross travel of table}}{\text{Feed/stroke (Roughing)}}$$

$$= \frac{630}{2} = 315$$

$$\text{No. of strokes for finishing cut} = \frac{\text{Cutting travel of table}}{\text{Feed/stroke (Finishing)}}$$

$$= \frac{630}{1} = 630$$

Total no. complete strokes required = 630 + 315 = 945

Total machining time = 945 × 0.14 = 132 min.