Module-8

Machining time & Economics of M/cing

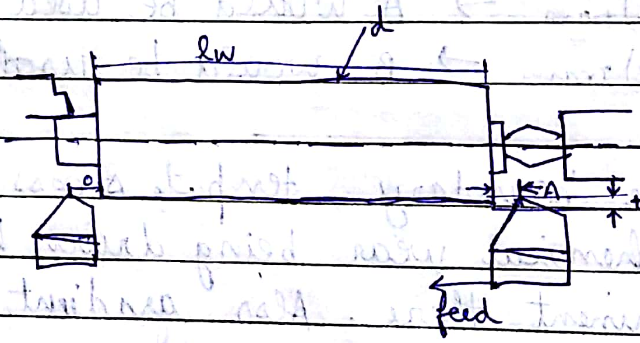
→ how much time is required to machine
↳ machining time (t_m)

→ how much time is required to machine a component → cycle time (t_p)

→ how much cost is involved in m/c ing a component.

Estimation of machining time (t_m):

a) straight turning:



t_m = machining time = $\frac{\text{distance travelled}}{\text{feed rate or speed}}$

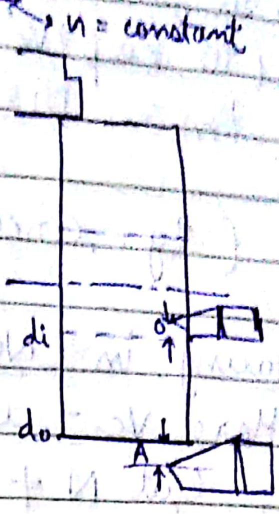
A : approach distance
O : overtravel distance
l_w : length of w/p
S : feed
V_c : cutting speed
n : rotational speed

$$\Rightarrow t_m = \left(\frac{l_w + O + A}{S \cdot n}\right)$$

b) Facing (in a central lathe) :

$$t_m = \frac{\left(\frac{d_o - d_i}{2}\right) + O + A}{S \cdot n}$$

(In central lathe, n is constant)



→ We have to give some amount of approach ($A \neq 0$). They should be as less as possible. similarly for O.

→ For expressing t_m in terms of MRR, we need to account for some air swept vol. ($\pi d A$). [If A & O = 0, then volume = MR]

$$t_m = \left\{ \frac{\text{air swept vol}}{MRR} \right\} \rightarrow \text{complete volume}$$

$$t_m = \frac{\frac{\pi}{4}(d_o^2 - d_i^2) \cdot t}{V_c \cdot S \cdot t} \quad \left(\text{assuming } A = O = \text{zero}\right)$$

V_c → not constant

X

⊛ Facing in a CNC turning centre or lathe
→ V_c can be kept constant.

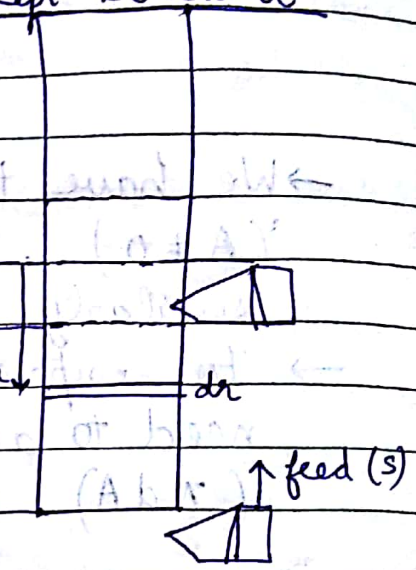
Thus, $t_m = \dfrac{\text{total air swept volume (including actual material removed)}}{MRR}$

$$= \frac{\frac{\pi}{4}(d_o^2 - d_i^2) \times t}{V_c \cdot S \cdot t} = \frac{\pi}{4}\left(\frac{d_o^2 - d_i^2}{V_c \cdot S}\right)$$

→ In such approaches where N is varying (to keep V_c constant), we cannot use $t_m = \frac{\text{Dist. travelled}}{s \cdot n}$, as the N is changing (eg. circular interpolation)

Facing in CNC → V_c can be kept constant

→ Here V_c = constant
but $N \neq$ constant



$$t_m = \int \frac{dr}{s \cdot n}$$

$d_i = 2r_i$

$d_o = 2r_o$

$V_c = \pi d n$ → in appropriate units

V_c → mm/min

$$n = \frac{V_c}{2\pi r}$$

$$\therefore t_m = \int \frac{dr}{s \cdot \frac{V_c}{2\pi r}} = \frac{2\pi}{sV_c} \int r\,dr$$

$$\therefore t_m = \frac{2\pi}{sV_c} \frac{1}{2} r^2 \Big|_{r_i}^{r_o}$$

$$= \frac{\pi}{sV_c}(r_o^2 - r_i^2)$$

$$= \frac{\pi}{4sV_c}(d_o^2 - d_i^2)$$

V_c → mm/min

Date
Page

Qu) Straight turning

$V_c = 100\ m/min$

$d = 100\ mm$

$t = 0.5\ mm$

$l_w = 500\ mm$

$O = A = 5\ mm$

$s = 0.1\ mm/rev$ → estimated t_m ?

$$V_c = \frac{\pi d N}{1000} \Rightarrow N = 318.309\ RPM$$

$$\text{so } t_m = \frac{l_w + O + A}{s \cdot N} = 16.022\ min$$

↳ If tool life < t_m → you need to change tool ∴ you will take some time to change the tool. ∴ There exists some difference b/w actual m/cing time (cycle time) and t_m.

Cycle Time : $\boxed{t_p = t_m + \frac{t_m}{T_L} \times t_{CT}} \boxed{+ t_i}$

t_{CT} → (time required to change tool)

Even if $t_m < T_L$ on an avg you change the tool (for more than 1 tool).

t_i :- tool setting or idle time

↳ Tool would be set ; some settings are to be made (if you need to change tool 5 times, you need not set it 5 times) (Eg. $t_m = 10$, $T_L = 26$, you need not change tool in 1st and 2nd product but for 3rd ✓ ∴ That time is distributed to all 3 to get avg t_m)

Qu) $TL = 7$ minutes

$t_{c/T} = 1$ min

$t_i = 2$ min

Machining cost per component

$$C_p = K_1 t_p + \boxed{K_2 \frac{t_m}{TL}}$$

capital cost of equipment (Rs/hr)

[cost of one tool change per tool or CE] (possible in inserts)

no. of times Tool is changed

$$C_p = K_1 \left(t_m + t_i + \frac{t_m}{TL} t_{c/t} \right) + K_c \frac{t_m}{TL}$$

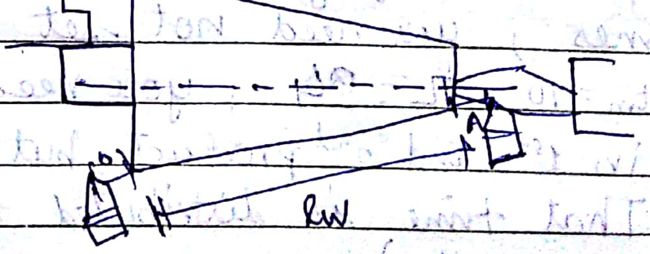
For TL : $VT^n = K$

$T = \frac{K_1}{V_c^x s^y t^z}$; depend on process parameters

$\therefore$ C_p can be minimized by optimizing certain parameters.

→ Profit rate $= \frac{\text{Revenue}}{t_p}$

Taper Turning (centre lathe):



$$t_m = \frac{l_w + O + A}{S \cdot n}$$

not valid for CNC $\because n \neq$ const

→ We need to know the eq^n of arc. to know l.