MACHINING TIME

◉ TITLE: Estimation and measurement of Machining time in facing in a CNC turning centre using constant spindle speed and constant cutting velocity.

◉ OBJECTIVES: ➤ To estimate and measure the machining time in facing of a disc in a CNC turning centre using (i) constant spindle speed and (ii) constant cutting velocity

➤ To determine the increase in productivity by employing constant cutting velocity over constant spindle speed

◉ THEORY:

◉ Derivations of expressions:

A. CONSTANT SPINDLE SPEED

when performing facing operation at constant spindle speed

$$t_m = \frac{\text{Distance travelled by tool (mm)}}{\text{Feed rate (mm/min)}}$$

$$= \frac{\text{approach} + \frac{d_o - d_i}{2} + \text{overtravel}}{SN}$$

If we neglect approach and overtravel,

$$\boxed{t_m = \frac{d_o - d_i}{2SN}}$$

where $d_o \rightarrow$ outer diameter (mm)
$d_i \rightarrow$ Inner diameter (mm)
$S \rightarrow$ Feed (mm/rev)
$N \rightarrow RPM_{spindle}$ (rev/min)
$t_m \rightarrow$ machining time (min)

B. CONSTANT CUTTING VELOCITY

$$t_m = \frac{\text{Total material removed}}{\text{material removal rate}}$$

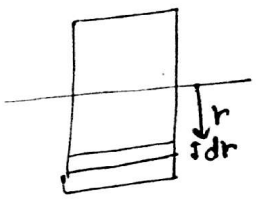
$$= \frac{\frac{\pi}{4}(d_o^2 - d_i^2)t}{stV_c}$$

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

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

where $d_o \rightarrow$ outer diameter (mm)
$d_i \rightarrow$ inner diameter (mm)
$s \rightarrow$ feed (mm/rev)
$V_c \rightarrow$ mm/min (Cutting velocity)

2nd Method :



$$dt_m = \frac{-dr}{sN}$$

$$\Rightarrow dt_m = \frac{-dr\,\pi r}{500\,V_c s}$$

$$\Rightarrow t_m = \int_0^t dt_m = -\frac{\pi}{500V_c s}\int_{r_o}^{r_i} r\,dr$$

$$\Rightarrow \boxed{t_m = \frac{\pi(r_o^2 - r_i^2)}{1000\,V_c s}}$$

$r_o \rightarrow$ outer radii (mm)
$r_i \rightarrow$ Inner radii (mm)
$V_c \rightarrow$ Cutting velocity ($\frac{mm}{min}$)
$s \rightarrow$ feed ($\frac{mm}{rev}$)

$$V_c = \frac{\pi DN}{1000}$$

$$\Rightarrow N = \frac{1000\,V_c}{2\pi r}$$

$$\Rightarrow \boxed{N = \frac{500\,V_c}{\pi r}}$$

OBSERVATIONS

Outer diameter of the workpiece (d_o) = 84.7 mm
Inner diameter of the workpiece (d_i) = 32.95 mm
Work Material : C60 steel
Tool Material : TiN Coated WC Insert
Tool geometry: VBMT 16,04,08
Depth of cut (t) : 0.5 mm
Cutting Velocity (V_c) : 100 $\frac{m}{min}$ (Constant V_c case, Initial V_c for constant spindle speed case)

#	SPINDLE SPEED N RPM	FEED S mm/rev	ESTIMATED TIME t_m (min)	MEASURED TIME t_m (min)
1a	376	0.05	1min 22.57s	1min 23.16s
2a	376	0.10	41.28 s	44.00 s
3a	376	0.15	27.52 s	27.30 s
1b	376 @ t=0	0.05	57.35 s	58.70 s
2b	376 @ t=0	0.10	28.68 s	27.37 s
3b	376 @ t=0	0.15	19.11 s	19.11 s

DATE

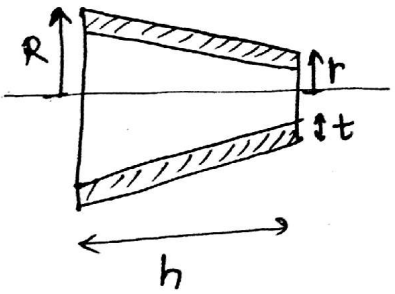
SHEET NO.

CALCULATIONS

TABLE: INCREASE IN PRODUCTIVITY (%)

#	FEED S mm/rev	ESTIMATED	MEASURED
1a 1b	0.05	30.54%	29.41%
2a 2b	0.10	30.52%	37.79%
3a 3b	0.15	30.55%	30%

MACHINING TIME FOR TAPER TURNING @ CONSTANT VELOCITY



∴ Volume of the material removed

$$= \frac{\pi h}{3}(R^2+Rr+r^2) - \frac{\pi h}{3}((R-t)^2+(R-t)(r-t)+(r-t)^2)$$

$$= \frac{\pi h}{3}(R^2+Rr+r^2 - R^2 - t^2 + 2Rt - Rr - t^2 + Rt + rt + r^2 - t^2 + 2rt)$$

$$= \frac{\pi h}{3}(3Rt + 3rt - 3t^2)$$

$$= \pi h t (R+r-t)$$

∴ Machining time, t_m = $\frac{\text{Volume of Material removed}}{\text{Material removal rate}}$

$$= \frac{\pi h t (R+r-t)}{s t V_c}$$

$$\Rightarrow \boxed{t_m = \frac{\pi h (R+r-t)}{s V_c}}$$

where R → Outer Radius, r → Inner Radius, t → depth of cut, h → height, s → feed, V_c → cutting vel.