



IE-352

Section 1, CRN: 32997

Section 2, CRN: 5022

Second Semester 1431-32 H (Spring-2011) – 4(4,1,1)

MANUFACTURING PROCESSES - 2

Sunday, Apr 17, 2011 (13/5/1432H)

Exercise: Cutting Forces and Power

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Relative Energies in Cutting

In an orthogonal cutting operation $t_o = 0.13 \text{ mm}$, $V = 120 \text{ m/min}$.

$\alpha = 10^\circ$ and the width of cut = 6 mm. It is observed that $t_c = 0.23 \text{ mm}$,

$F_c = 500 \text{ N}$ and $F_t = 200 \text{ N}$. Calculate the percentage of the total energy that goes into overcoming friction at the tool-chip interface.

Indep. Variables
Depend. Variables

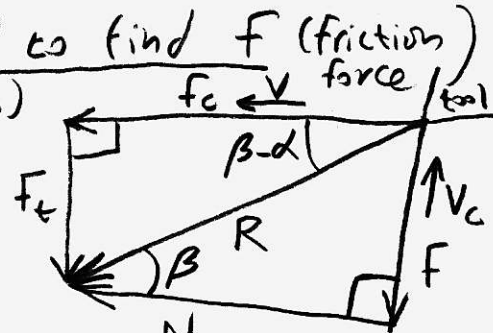
Given: SI units
 thicknesses: $t_o = 0.13 \text{ mm}$ (depth of cut)
 $t_c = 0.23 \text{ mm}$ (chip thickness)
 cutting velocity (velocities): $V = 120 \text{ m/min}$ (cutting velocity)
 angles: $\alpha = 10^\circ$
 forces: $F_c = 500 \text{ N}$ (cutting force), $F_t = 200 \text{ N}$ (thrust force)
 $F = ?$ (friction force), $F_N = ?$ (normal force)

Req: % of total energy in overcoming (ie against, ie = and opposite) to friction

(100) $\frac{U_f}{U_{tot}} = \frac{\text{Power}_f}{\text{Power}_{tot}} \times 100 = ?$
 also \downarrow
 $V_c/V = r$ (cutting ratio) = t_o/t_c

Solⁿ: $\frac{\text{Power}_f}{\text{Power}_{tot}} = \frac{F V_c}{F_c V} = \frac{F r}{F_c}$, where $r = \frac{t_o}{t_c} = \frac{0.13}{0.23} = 0.565$

Strategy: since we now have: r , F_c , we need to find F (friction) from force circle, we note that R (resultant) is common between F_c, F_t & F, N thus we can find R (from F_c, F_t) and use it to find $F \Rightarrow$



$R = \sqrt{F_c^2 + F_t^2} = \sqrt{500^2 + 200^2} = 538.5 \text{ N}$

Also: $\tan(\beta - \alpha) = \frac{F_t}{F_c} = \frac{200 \text{ N}}{500 \text{ N}} = 0.4 \Rightarrow \beta - \alpha = \tan^{-1}(0.4) = 21.80^\circ$
 since $\alpha = 10^\circ \Rightarrow \beta = 21.80^\circ + \alpha = 31.80^\circ$

Cont:

• Now consider Δ : R-N-F:

$$\begin{aligned} \sin \beta &= \frac{F}{R} \Rightarrow F = R \sin \beta \\ &= (538.5 \text{ N}) \sin 31.80^\circ \\ \Rightarrow \underline{F} &= \underline{283.79 \text{ N}} \end{aligned}$$

• subst. in Power eqⁿ \Rightarrow

$$\frac{\text{Power}_f}{\text{Power}_{\text{tot}}} = \frac{Fv}{F_c v} = \frac{(283.79 \text{ N})(0.565)}{(500 \text{ N})} = \underline{0.3208}$$

\Rightarrow % energy in overcoming friction = 32.1% ◀
