IE-352
Section 3, CRN: 48706/7/8
Section 4, CRN: 58626/7/8
Second Semester 1438-39 H (Spring-2018) – 4(4,1,2)
"MANUFACTURING PROCESSES – 2"

Sunday, March 11, 2018 (23/06/1439H)

Turning Exercise: Tool Wear ANSWERS

Name: AHMED M. EL-SHERBEENY, PHD	Student Number: 4

Turning and Tool Wear Exercise

The outside diameter of a cylinder made of titanium alloy is to be turned. The $starting\ diameter = 500\ mm$ and the $length = 1000\ mm$. Cutting conditions are $f = 0.4\ mm/rev$ and $depth\ of\ cut = 3.0\ mm$. The cut will be made with a tungsten carbide cutting tool whose Taylor tool life parameters are $n = 0.23$ and $C = 400\ m/min$. Compute the cutting speed that will make the tool life equal to the machining time.

Given:

- Workpiece material: titanium alloy
- Turning process
- $D_o = 500\ mm$
- $l = 1000\ mm$
- $f = 0.4\ mm/rev$
- $d = 3.0\ mm$
- Tool material: tungsten carbide
- $n = 0.23$
- $C = 400\ m/min$
- $T = t$ (T: tool life; t: cutting/machining time, aka T_m)

Required: V, cutting speed

Solution:

- cutting speed, $V = \pi D_{avg} N$
- Since this is a light cut, we can take V to be V_{max}, i.e. $D_{avg} \approx D_o = 500\ mm$

  Otherwise, we can use the following to find $D_{avg} = \frac{D_o + D_f}{2}$

  D_f can be found using: $d = \frac{D_o - D_f}{2} \Rightarrow 2d = D_o - D_f$

  $\Rightarrow D_f = D_o - 2d = 500\ mm - (2 * 3.0\ mm) = 494\ mm$

  $$\Rightarrow D_{avg} = \frac{D_o + D_f}{2} = \frac{500\ mm + 494\ mm}{2} = 497\ mm$$

- We now need to find N

  We will take advantage of the relation between t and N: $t = \frac{l}{fN}$

  $$\Rightarrow N = \frac{l}{ft}$$

- We have the values of l $(1000\ mm)$ and f $(0.4\ mm/rev)$, now need to find t, taking advantage of the given relation $T = t$.

  We know from Taylor's Tool Life equation:

  $$VT^n = C$$

  $$\Rightarrow T^n = \frac{C}{V}$$

  $$\Rightarrow T = \left(\frac{C}{V}\right)^{1/n} = \frac{C^{1/n}}{V^{1/n}}$$

  $$\Rightarrow t = \frac{C^{1/n}}{V^{1/n}}$$

- Plugging back in the relation for N:

  $$\Rightarrow N = \frac{l}{ft} = \frac{l}{f \cdot \left(\frac{C^{1/n}}{V^{1/n}}\right)}$$

- Plugging this back in the original relation for V:

$$V = \pi D_{avg} N = (\pi)(D_{avg})(N) = (\pi)(D_{avg})\left(\frac{l}{f \cdot \left(\frac{C^{1/n}}{V^{1/n}}\right)}\right)$$

$$V = (\pi)(D_{avg})\left(\frac{l \cdot V^{1/n}}{f \cdot C^{1/n}}\right)$$

Collecting terms containing V (noting that $\frac{1}{n} > 1$) :

$$V^{\left(\frac{1}{n}-1\right)} = \frac{\left(f \cdot C^{1/n}\right)}{(\pi)(D_{avg})(l)}$$

Realizing that $\frac{1}{\left(\frac{1}{n}-1\right)} = \frac{1}{\left(\frac{1-n}{n}\right)} = \frac{n}{1-n}$

$$\Rightarrow V = \left[\frac{\left(f \cdot C^{1/n}\right)}{(\pi)(D_{avg})(l)}\right]^{\left(n/_{1-n}\right)}$$

Now, we can simply plug the values of all the variables as follows (noting that both C and V have to be in m/min):

$$\Rightarrow V = \left[\frac{\left(0.4\, \cancel{mm}/rev \cdot 400^{1/0.23}\right)}{(\pi)(500\, \cancel{mm})(\cancel{1000\, mm})} \cdot \frac{\cancel{1000\, mm}}{1\, m}\right]^{\left(0.23/_{1-0.23}\right)}$$

$$\Rightarrow V = 202.18\, m/min$$

► $\boldsymbol{V = 202.2\, m/min}$

Note, if we had substituted D_{avg} as $497\, mm$:

$$\Rightarrow V = \left[\frac{\left(0.4\, \cancel{mm}/rev \cdot 400^{1/0.23}\right)}{(\pi)(497\, \cancel{mm})(\cancel{1000\, mm})} \cdot \frac{\cancel{1000\, mm}}{1\, m}\right]^{\left(0.23/_{1-0.23}\right)}$$

$$\Rightarrow V = 202.55\, m/min$$

► $\boldsymbol{V = 202.6\, m/min}$

Thus, our assumption in taking $D_{avg} \approx D_o$ was a sound one.