Questions 1-8. In an orthogonal cutting operation using a ceramic tool ($n = 0.7$), $t_o = 0.25\ mm$, $V = 400\ m/min$, $\alpha = 15°$, and $w = 8\ mm$. It is observed that $t_c = 0.45\ mm$, $F_c = 600\ N$, and the mean coefficient of friction in the cutting zone is 0.83.

E

1. **What is the value of the *chip-compression factor*?**

   A. 0.56

   B. 0.25

   C. 0.45

   D. 0.11

   E. 1.8

$$\boldsymbol{chip - compression} = \frac{1}{r} = \frac{t_c}{t_0} = \frac{0.45\ mm}{0.25\ mm} = \mathbf{1.8}$$

$$r = \frac{1}{1.8} = 0.5556$$

A

2. **What is the value of the *shear angle*?**

   A. 32.1°

   B. 57.9°

   C. 72.8°

   D. 49.3°

   E. 17.2°

$$\tan\phi = \frac{r\cos\alpha}{1 - r\sin\alpha} = \frac{(0.5556)(\cos 15°)}{1 - (0.5556)(\sin 15°)} = 0.6267$$

$$\boldsymbol{\phi} = \tan^{-1} 0.6267 = \mathbf{32.1}°$$

C

3. **What is the value of the *shear strain*?**

   A. 3.27

   B. 1.72

C. 1.90

D. 3.54

E. 2.22

$$\boldsymbol{\gamma} = \cot\phi + \tan(\phi - \alpha) = \frac{1}{\tan 32.08°} + \tan(32.08° - 15°) = \mathbf{1.90}$$

B

4. **What is the value of the *shear velocity*?**

A. 222 m/min

B. 404 m/min

C. 108 m/min

D. 1314 m/min

E. 723 m/min

$$\boldsymbol{V_s} = V \cdot \frac{\cos\alpha}{\cos(\phi - \alpha)} = \frac{400\ [\frac{m}{min}] \cdot \cos 15°}{\cos(32.1° - 15°)} = \mathbf{404\ m/min}$$

D

5. **What is the magnitude of the *thrust force*?**

A. 1305 N

B. 80.2 N

C. 4488 N

D. 276 N

E. 545 N

$F_t = F_c \tan(\beta - \alpha)$

$\tan\beta = \mu = 0.83$

$\beta = \tan^{-1}\mu = \tan^{-1} 0.83 = 39.69°$

$\Rightarrow \boldsymbol{F_t} = 600\ [N] * \tan(39.69° - 15°) = \mathbf{275.9\ N}$

E

6. **Find the required *source power* given a mechanical efficiency of 65%.**

A. 369 kW

B. 4.0 kW

C. 240 kW

D. 2.6 kW

E. $6.15\ kW$

$$Power_{source} = \frac{Power_c}{\eta_{mech}}$$

$$Power_c = F_c V = 600\ (N) * 400 \left(\frac{m}{min}\right) = 240{,}000 \left(\frac{N \cdot m}{min}\right)$$

$$= 240 \left(\frac{kJ}{\cancel{min}}\right) * \left(\frac{1\ \cancel{min}}{60\ s}\right) = 4.0\ kW$$

$$\Rightarrow \boldsymbol{Power_{source}} = \frac{4.0}{0.65} = \boldsymbol{6.15\ kW}$$

7. **What is the effect on *increase in mean temperature* of doubling the cutting speed?**

C

A. increase in T by 74%

B. decrease in T by 74%

C. increase in T by 26%.

D. decrease in T by 26%

E. increase in T by 41%

Using the equation for mean temperature in orthogonal cutting (as given in the problem statement),

$$T = \frac{0.000665 Y_f}{\rho c} \sqrt[3]{\frac{V t_0}{K}}$$

$$\frac{\boldsymbol{T_2 - T_1}}{\boldsymbol{T_1}} = \frac{\sqrt[3]{V_2} - \sqrt[3]{V_1}}{\sqrt[3]{V_1}} = \frac{\sqrt[3]{2V_1} - \sqrt[3]{V_1}}{\sqrt[3]{V_1}} = \frac{\sqrt[3]{2V_1}}{\sqrt[3]{V_1}} - 1 = \sqrt[3]{\frac{2\cancel{V_1}}{\cancel{V_1}}} - 1$$

$$= \sqrt[3]{2} - 1 = 1.26 - 1 = \mathbf{0.26}$$

i.e. doubling the cutting speed resulted in a 26% increase in temperature, assuming all other parameters have not changed.

B

8. **What is the effect on *tool life* of doubling the cutting speed?**

A. reduction in tool life by 37.1%

B. reduction in tool life by 62.9%

C. reduction in tool life by 61.6%

D. reduction in tool life by 38.4%

E. reduction in tool life by 50.0%

$$V_1 T_1^n = V_2 T_2^n \Rightarrow \left(\frac{T_2}{T_1}\right)^n = \frac{V_1}{V_2} \Rightarrow \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{1/n} = 0.5^{\left(1/0.7\right)} = 0.371$$

$$\Rightarrow \frac{T_1 - T_2}{T_1} = 1 - 0.371 = 0.629$$

i.e. doubling the cutting speed has resulted in a 62.9% reduction in tool life