8.3 Machining

Name: _____ Class: _____ Date: _____ **Total: 15 marks**

KEY WORDS cutting speed • feed • depth of cut • material removal rate • Taylor's tool-life equation

Objective

Set spindle speed, removal rate, power and time for a turning pass, predict surface roughness, and trade cutting speed against tool life.

1 Key knowledge and worked examples

■ **The turning toolkit**

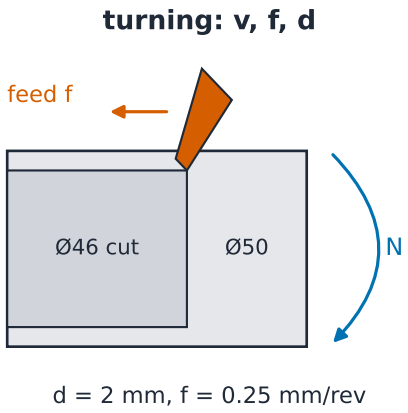
- Spindle speed from **cutting speed** : $N = 1000v/(\pi D)$ (rpm, v in m/min, D in mm).
- **Material removal rate** : MRR $= vfd$, with **feed** f and **depth of cut** d.
- Power $P = u \times$ MRR; time $t = L/(fN)$.
- Roughness $R_a \approx f^2/(32r)$; **Taylor's tool-life equation** $vT^n = C$.

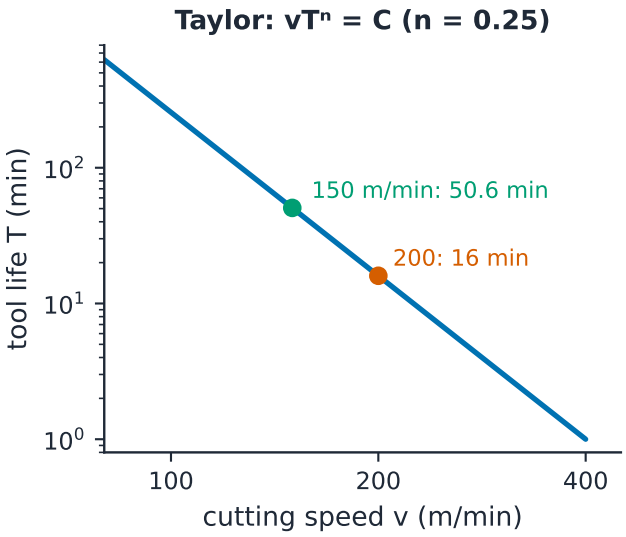
■ **Worked example. One pass on the shaft**

50 mm bar, $v = 150$ m/min, $f = 0.25$ mm/rev, $d = 2$ mm, $L = 200$ mm, $u = 2.8$ J/mm^3.

- $N = 1000v/(\pi D) = 1000 \times 150/(\pi \times 50) = 955$ rpm.
- MRR $= vfd = 150\,000 \times 0.25 \times 2 = 1250$ mm^3/s, so $P = 2.8 \times 1250 = \mathbf{3.5}$ kW.
- $t = L/(fN) = 200/(0.25 \times 955) = \mathbf{0.84}$ min.

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2 Practice

Steel bar, $u = 2.8$ J/mm^3, nose radius $r = 0.8$ mm, Taylor $n = 0.25$, $C = 400$.

2.1 An 80 mm bar is turned at $v = 120$ m/min. Find the spindle speed (nearest rpm). [2]

2.2 With $f = 0.3$ mm/rev and $d = 3$ mm over $L = 300$ mm, find the removal rate (mm^3/s), the power (two decimals, kW) and the cutting time (two decimals, min). [5]

2.3 Estimate the surface roughness R_a of that pass (two decimals, µm). [2]

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3 Exam-style questions

3.1 Find the tool life at 120 and at 180 m/min (one decimal, min), and how many 300 mm passes each edge lasts at each speed (whole passes). Explain what decides which speed is cheaper. [6]

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Solutions

2.1

- $N = 1000v/(\pi D) = 1000 \times 120/(\pi \times 80) = \mathbf{477}$ rpm.

2.2

- $\text{MRR} = vfd = 120\,000 \times 0.3 \times 3 = 108\,000$ mm^3/min $= \mathbf{1800}$ mm^3/s.
- $P = u \times \text{MRR} = 2.8 \times 1800 = \mathbf{5.04}$ kW.
- $t = L/(fN) = 300/(0.3 \times 477) = \mathbf{2.09}$ min.

2.3

- $R_a \approx f^2/(32r) = 0.3^2/(32 \times 0.8) = 0.00352$ mm $= \mathbf{3.52}$ µm.

3.1

- Taylor: $T = (C/v)^{1/n}$. At 120: $T = (400/120)^4 = \mathbf{123.5}$ min; at 180: $T = (400/180)^4 = \mathbf{24.4}$ min.
- At 180 m/min $N = 716$ rpm and a pass takes $300/(0.3 \times 716) = 1.40$ min. Passes per edge: $123.5/2.09 = \mathbf{59}$ at 120; $24.4/1.40 = \mathbf{17}$ at 180.
- The faster speed saves a third of the machine time but changes edges three times as often: it wins only when machine time costs more than edges and tool changes.

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