Drilling formulas

The material removal rate (MRR) in drilling is the volume of material removed by the drill per unit time. For a drill with a diameter $D$, the cross-sectional area of the drilled hole is $\pi D^2 / 4$. The velocity of the drill perpendicular to the workpiece $f$ is the product of the feed $f_r$ and the rotational speed $N$ where $N = V / \pi D$.

Thus,

$$MRR = \left( \frac{\pi D^2}{4} \right) (f) \text{ mm}^3 / \text{min}$$

Conversion of feedrate $f_r$ (mm/rev) to feedrate $f$ (mm/min)

$$f = N f_r \text{ (mm/min)}$$
1. Drilling Problem:

A drilling operation is to be performed with a 12.7 mm diameter twist drill in a block of magnesium alloy (figure 1). The hole is a blind hole at a depth of 60 mm. The cutting speed $V$ is 25 m/min and the feed $f_r$ is 0.30 mm/rev. Determine:

(a) the cutting time to complete the drilling operation,
(b) metal removal rate $MRR$ during the operation, after the drill bit reaches full diameter.
(c) the power required if the average unit power for magnesium alloys is 0.5 W.s/mm$^3$.

Solution:

(a) Cutting Time $T_m = L / f$

$$f = N f_r$$

$$N = \frac{V}{\pi D} = \frac{25 \times 10^3}{\pi \times 12.7} = 626.6 \text{ rev/min}$$

$$f = N f_r = 626.6 \times 0.30 = 188 \text{ mm/min}$$

$$T_m = L / f = 60 / 188 = 0.319 \text{ min}$$

(b) The material removal rate is

$$MRR = \frac{\pi D^2}{4} f = 0.25 \pi (12.7)^2 (188) = 23800 \text{ mm}^3/\text{min} = 397 \text{ mm}^3/\text{s}$$

(c) The power required is:

$$\text{Power} = MRR \times \text{unit power} = (397) (0.5) = 198.5 \text{ W}$$
2. Shaping Problem:

A shaper is used to reduce the thickness of a 50 mm part to 45 mm. The part is made of cast iron and has a tensile strength of 270 MPa and a Brinell hardness of 165 HB. The starting dimensions of the part are 750 mm x 450 mm x 50 mm. The cutting speed is 0.125 m/sec and the feed is 0.40 mm/pass. The shaper ram is hydraulically driven and has a return stroke time that is 50% of the cutting stroke time. An extra 150 mm must be added before and after the part for acceleration and deceleration to take place. Assuming the ram moves parallel to the long dimension of the part, how long will it take to machine?

Solution:
Time per forward stroke = (150 + 750 + 150)/(0.125 x 1000) = 8.4 sec

Time per reverse stroke = 0.50(8.4) = 4.2 sec

Total time per pass = 8.4 + 4.2 = 12.6 sec = 0.21 min

Number of passes = 450/0.40 = 1125 passes

Total time $T_m = 1125(0.21) = \boxed{236 \text{ min}}$