Chapter 26: Multiple Choice Questions
26.5 (c) and (d)
26.7 (e)
26.10 (d)

Problems
26.5 Solution: (a) From Table 26.1, C = 0.000126 in³/A-min.
MRR = f_r x A = (CI/A)(A) = CI
MRR = CI = 0.000126(1500) = 0.189 in³/min at 100% efficiency.
At 90% efficiency MRR = 0.189(0.90) = 0.1701 in³/min = 10.206 in³/hr.
(b) I = EA/gr; Rearranging, g = EA/Ir = 12(2.5)/(1500 x 6.2) = 0.0032 in.

26.11 Solution: From Table 4.1, T_m = 2802°F for iron.
MRR = 5.08 I/28021.23 = 5.08 I/17,393 = 0.000292 I in³/min
Given that MRR = 0.01 in³/min.
0.000292 I = 0.01
I = 0.01/0.000292 = 34.24 A.
From Table 4.1, T_m = 2651°F for iron.
MRR = 5.08(34.24)/26511.23 = 173.93/16,248 = 0.0107 in³/min

26.16 Solution: (a) Neglecting the fact that the initial area would be less than the given dimensions of 9 in. by 6 in., and that the material removal rate (MRR) would therefore increase during the cut as the area increased, area of an ellipse A = πab = π(9.0)(6.0) = 54π = 169.65 in.²
MRR = (0.001 in/min)(169.65 in²) = 0.16965 in³/min = 10.18 in³/hr
(b) Time to machine (etch) = 0.4/0.001 = 400 min. = 6.67 hr.
(c) Given F_c = 2.0, undercut u = d/F_c = 0.4/2.0 = 0.2 mm
Maskant opening a’ = a – u = 9.0 – 0.2 = 8.8 in
Maskant opening b’ = b – u = 6.0 – 0.2 = 5.8 in

Chapter 28: Multiple Choice Questions
28.1(a), (c), (d), and (e).
28.5(a), (b), (c), (d), and (e).
28.6(a)

Chapter 29: Multiple Choice Questions
29.4 either (a) or (b) is acceptable
29.7(e)
29.11(b) and (c).
29.14(a)
Problems

29.3 Solution: From Table 29.1, \( C = 0.92 \times 10^{-4} \text{ in}^3/\text{A-min} \), cathode efficiency \( E = 15\% \).
Volume \( V = ECIt = 0.15(0.92 \times 10^{-4})(15)(10) = 0.00207 \text{ in}^3 \).
Plating thickness \( d = 0.00207/15 = 0.000138 \text{ in.} \)

29.6 Solution: From Table 29.1, \( C = 2.69 \times 10^{-4} \text{ in}^3/\text{A-min} \), cathode efficiency \( E = 98\% \).
Required volume of plate metal = 36(0.001) = 0.036 \text{ in}^3
Plated volume \( V = ECIt = 0.98(2.69 \times 10^{-4} \text{ in}^3/\text{A-min})(15 \text{ A}) t = 0.003954 t \text{ in}^3 \).
0.003954 t = 0.036 t = 0.036/0.003954 = 9.1 \text{ min.} \)

Chapter 30: Multiple Choice Questions

30.6(b)
30.7(b) and (c)

Problems

30.3 Solution: (a) Area \( A = \pi(0.1)^2/4 = 0.00785 \text{ in}^2 \)
150 Btu/min = 2.5 Btu/sec.
Power \( P = 0.50(2.5) = 1.25 \text{ Btu/sec} \)
Power density \( PD = (1.25 \text{ Btu/sec})/0.00785 \text{ in}^2 = 159 \text{ Btu/sec-in}^2 \)
(b) \( A = \pi(0.252 - 0.12)/4 = 0.0412 \text{ in}^2 \)
Power \( P = (0.75 - 0.50)(2.5) = 0.625 \text{ Btu/sec} \)
Power density \( PD = (0.625 \text{ Btu/sec})/0.0412 \text{ in}^2 = 15.16 \text{ Btu/sec-in}^2 \)
(c) Power densities are sufficient certainly in the inner circle and probably in the outer ring for welding.

30.8 Solution: (a) Eq. (30.2) for SI units: \( U_m = 3.33 \times 10^{-6} T_m^2 \)
From Table 30.2, \( T_m \) for austenitic stainless steel = 1670 K
\( U_m = 3.33 \times 10^{-6} (1670)^2 = 9.29 \text{ J/mm}^3 \)
Volume of metal melted \( V = 20(200) = 4000 \text{ mm}^3 \)
\( H_m = 9.29(4000) = 37,148 \text{ J} \) at weld
(b) Given \( f_1 = 0.8 \) and \( f_2 = 0.6 \). \( H = 37,148/(0.8 \times 0.6) = 77,392 \text{ J} \) at source.

30.15 Solution: \( U_m = 1.467 \times 10^{-5} (1800 + 460)^2 = 74.9 \text{ Btu/in}^3 \)
\( v = f_1 f_2 HR/U_mA_w = 0.8(0.5)(125)/(74.9 \times 0.04) = 16.7 \text{ in/min.} \)

Chapter 31: Multiple Choice Questions

31.6(b) The arc is sustained, not by the transfer of molten metal, but by the presence of a thermally ionized column of gas through which the current flows.
31.10(a)
31.17(a) and (b)

Problems

31.3 Solution: (a) \( HR_w = f_1 f_2 EI = (0.85)(0.75)(30)(225) = 4303.1 \text{ W} \)
(b) \( WVR = (4303.1 \text{ W})/(10.2 \text{ J/mm}^3) = 421.9 \text{ mm}^3/\text{sec.} \)
31.10 **Solution:** (a) \( PD = I^2R/A \)

\[ A = \pi D^2/4 = \pi(0.19)^2/4 = 0.02835 \text{ in}^2 \]

\[ I^2R = (9500)^2 \times (100 \times 10^{-6}) = 9025 \text{ W} \]

1 Btu/sec = 1055 W, so 9025 W = 8.554 Btu/sec

\[ PD = 8.554/0.02835 = 302 \text{ Btu/sec-in}^2 \]

(b) \( H = I^2Rt = (9500)^2 \times (100 \times 10^{-6})(0.17) = 1534 \text{ W-sec} = 1.454 \text{ Btu} \)

Weld nugget volume \( V = \pi D^2d/4 = \pi(0.19)^2(0.060)/4 = 0.0017 \text{ in}^3 \)

Heat required for melting \( =UmV = (150 \text{ Btu/in}^3)(0.0017) = 0.255 \text{ Btu} \)

Proportion of heat for welding \( = 0.255/1.454 = 0.175 = 17.5\% \)

31.17 **Solution:** Available heat for welding \( HR_w = f_1f_2EI = UmAwv \)

Travel velocity \( v = f_1f_2EI/UmAw \)

Cross sectional area of weld seam \( A_w = (0.35)(3.0) = 1.05 \text{ mm}^2 \)

\[ v = 0.85(0.75)(25 \times 10^3)(30 \times 10^{-3})/(5.0 \times 1.05) = 91.05 \text{ mm/s} \]

Chapter 32: Multiple Choice Questions
32.2(b)
32.4(b)
32.9(a), (c), (d), and (e)
32.13(c) and (d)

Chapter 33: Multiple Choice Questions
33.4(b), (c), and (d)
33.9(a) and (e)

Problems
33.5 **Solution:** \( F = T/CD = 125/(0.2 \times 0.75) = 833.3 \text{ lb.} \)

\[ A_s = 0.25\pi(0.75 - 0.9743/10)^2 = 0.334 \text{ in}^2 \]

\[ \sigma = 833.3/0.334 = 2495 \text{ lb/in}^2 \]

Chapter 34: Multiple Choice Questions
34.4(a), (e), and (f)
34.8(b), (c), and (d)

Problems
34.1 **Solution:** Layer area \( A_i \) same for all layers.

\[ A_i = 100^2 - 90^2 = 1900 \text{ mm}^2 \]

Time to complete one layer \( T_i \) same for all layers.

\[ T_i = (1900 \text{ mm}^2)/(0.25 \text{ mm})(500 \text{ mm/s}) + 10 \text{ s} = 15.2 + 10 = 25.2 \text{ s} \]

Number of layers \( n = (80 \text{ mm})/(0.10 \text{ mm/layer}) = 800 \text{ layers} \)

\[ T_c = 800(25.2) = 20,160 \text{ s} = 336.0 \text{ min} = 5.6 \text{ hr} \]

Chapter 35: Multiple Choice Questions
35.3(d)
Problems

35.1 Solution: (a) Total volume \( V = V_1 \text{ (tang)} + V_2 \text{ (cylinder)} + V_3 \text{ (seed)} \)
\[
V_1 = V_3 = \pi R^2 h/3 = 0.333 \pi (55)^2 (125) = 395,972 \text{ mm}^3.
\]
\[
V_2 = \pi R^2 L = \pi (55)^2 (950) = 9,028,152 \text{ mm}^3.
\]
Total \( V = 2(395,972) + 9,028,152 = \textbf{9,820,095 mm}^3 \)

(b) Number of wafers = \( 950/(0.50 + 0.33) = 1144.6 \) \( \rightarrow \) \textbf{1144 wafers}

(c) Area of one wafer \( A_w = A_c - A_s \), where \( A_c \) = area of the circle of radius \( R = 50 \text{ mm} \), and \( A_s \) = the area of the segment \( A_s \) created by the flat ground on the cylindrical surface.
\[
A_c = \pi R^2 = \pi (50)^2 = 7854.0 \text{ mm}^2.
\]
The area of a segment of the circle created by the 30 mm chord \( A_s = \pi R^2/360 - 0.5R^2 \sin \theta \), where \( \theta \) is the angle formed by two radii of the circle and the chord. \( \theta = \sin^{-1}(15/50) = 17.46^\circ \).
\[
A_s = \pi (50)^2(34.92)/360 - 0.5(50)^2 \sin 34.92 = 761.8 - 715.5 = 46.3 \text{ mm}^2.
\]
\[
A_w = A_c - A_s = 7854.0 - 46.3 = 7807.7 \text{ mm}^2.
\]

Volume of one wafer \( V_w = A_w t = 7807.7(0.5) = 3903.8 \text{ mm}^3 \)

Volume of 1144 wafers = 1144(3903.8) = 4,465,994 mm³
Volume wasted = 9,820,095 - 4,465,994 = 5,354,101 mm³
Proportion wasted = 5,354,101/9,820,095 = 54.52%.

35.14 Solution: (a) Rent’s rule: \( n_{io} = 6.0 n_c \)
\[
o.12 = 6.0 \times (64 \times 64) .0.12 = 6.0(4096) .0.12 = 16.3 \rightarrow \textbf{16 pins}
\]
(b) Eq. (35.11): \( n_{io} = 1.4427 \ln (64 \times 64) = 1.4427 \ln 4096 = \textbf{12 pins}.

Chapter 36: Multiple Choice Questions

36.2(c)
36.6(a)
36.10(a)