ME477
Fall 2005
Solution for Homework #5

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 in^3/A-min.
MRR = f_r x A = (CI/A)(A) = CI
MRR = CI = 0.000126(1500) = 0.189 in^3/min at 100% efficiency.
At 90% efficiency MRR = 0.189(0.90) = 0.1701 in^3/min = **10.206 in^3/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/$2802^{1.23}$ = 5.08 I/17,393 = 0.000292 I in^3/min
Given that MRR = 0.01 in^3/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)/$2651^{1.23}$ = 173.93/16,248 = **0.0107 in^3/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 in^2) = 0.16965 in^3/min = **10.18 in^3/hr**
(b) Time to machine (etch) = 0.4/0.001 = **400 min. = 6.67 hr**.
(c) Given F_e = 2.0, undercut u = d/F_e = 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 ()
29.4either (a) or (b) is acceptable
29.7(e)
29.11(b) and (c).
29.14(a)

Problems

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

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

Chapter 30: Multiple Choice Questions

30.6(b)

30.7(b) and (c)

Problems

30.3**Solution**: (a) Area $A = \pi(0.1)^2/4 = 0.00785$ in^2
150 Btu/min = 2.5 Btu/sec.
Power P = 0.50(2.5) = 1.25 Btu/sec
Power density PD = (1.25 Btu/sec)/0.00785 in^2 = **159 Btu/sec-in^2**
(b) $A = \pi(0.25^2 - 0.1^2)/4 = 0.0412$ in^2
Power P = (0.75 - 0.50)(2.5) = 0.625 Btu/sec
Power density PD = (0.625 Btu/sec)/0.0412 in^2 = **15.16 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
$U_m = 3.33 \times 10^{-6} (1670)^2 = 9.29$ J/mm^3
Volume of metal melted V = 20(200) = 4000 mm^3
H_m = 9.29(4000) = **37,148 J** at weld
(b) Given $f_1 = 0.8$ and $f_2 = 0.6$. H = 37,148/(0.8 x 0.6) = **77,392 J** at source.

30.15**Solution**: $U_m = 1.467 \times 10^{-5} (1800 + 460)^2 = 74.9$ Btu/in^3
$v = f_1 f_2 HR/U_m A_w$ = 0.8(0.5)(125)/(74.9 x 0.04) = **16.7 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 W**
(b) WVR = (4303.1 W)/(10.2 J/mm^3) = **421.9 mm^3/sec.**

31.10**Solution**: (a) $PD = I^2R/A$
$A = \pi D^2/4 = \pi(0.19)^2/4 = 0.02835$ in^2
$I^2R = (9500)^2 (100 \times 10^{-6}) = 9025$ W
1 Btu/sec = 1055 W, so 9025 W = 8.554 Btu/sec
PD = 8.554/0.02835 = **302 Btu/sec-in^2**
(b) $H = I^2Rt = (9500)^2 (100 \times 10^{-6})(0.17) = 1534$ W-sec = 1.454 Btu
Weld nugget volume $V = \pi D^2 d/4 = \pi(0.19)^2(0.060)/4 = 0.0017$ in^3
Heat required for melting = U_mV = (150 Btu/in^3)(0.0017) = 0.255 Btu
Proportion of heat for welding = 0.255/1.454 = **0.175 = 17.5%**

31.17**Solution**: Available heat for welding $HR_w = f_1f_2EI = U_mA_wv$
Travel velocity $v = f_1f_2EI/U_mA_w$
Cross sectional area of weld seam A_w = (0.35)(3.0) = 1.05 mm^2
$v = 0.85(0.75)(25 \times 10^3)(30 \times 10^{-3})/(5.0 \times 1.05)$ = **91.05 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 x 0.75) = 833.3 lb.
$A_s = 0.25\pi(0.75 - 0.9743/10)^2 = 0.334$ in^2
σ = 833.3/0.334 = **2495 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.
$A_i = 100^2 – 90^2 = 1900$ mm^2
Time to complete one layer T_i same for all layers.
T_i = (1900 mm^2)/(0.25 mm)(500 mm/s)+ 10 s = 15.2 + 10 = 25.2 s
Number of layers n_l = (80 mm)/(0.10 mm/layer) = 800 layers
T_c = 800(25.2) = **20,160 s = 336.0 min = 5.6 hr**

Chapter 35: Multiple Choice Questions
35.3(d)

35.5(b)
35.8(c)
35.10(a)
Problems
35.1**Solution**: (a) Total volume V = V_1 (tang) + V_2 (cylinder) + V_3 (seed)
$V_1 = V_3$ = (cone in which h = 0.5(1200-950) = 125, D = 110, R = 55) = $\pi R^2 h/3$
= $0.333\pi(55)^2(125)$ = 395,972 mm^3.
$V_2 = \pi R^2 L = \pi(55)^2(950)$ = 9,028,152 mm^3
Total V = 2(395,972) + 9,028,152 = **9,820,095 mm^3**
(b) Number of wafers = 950/(0.50 + 0.33) = 1144.6 $\rightarrow$ **1144 wafers**
(c) Area of one wafer $A_w = A_c - A_s$, where A_c = area of the circle of radius R = 50 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 mm^2
The area of a segment of the circle created by the 30 mm chord $A_s = \pi R^2\theta/360 - 0.5R^2 \sin\theta$, where θ is the angle formed by two radii of the circle and the chord. . $0.5\theta = \sin^{-1}(15/50)$ =17.46°.
θ = 34.92°.
$A_s = \pi(50)^2(34.92)/360 - 0.5(50)^2 \sin 34.92$ = 761.8 - 715.5 = 46.3 mm^2
$A_w = A_c - A_s$ = 7854.0 - 46.3 = 7807.7 mm^2
Volume of one wafer $V_w = A_w t$ = 7807.7(0.5) = 3903.8 mm^3
Volume of 1144 wafers = 1144(3903.8) = 4,465,994 mm^3
Volume wasted = 9,820,095 - 4,465,994 = 5,354,101 mm^3
Proportion wasted = 5,354,101/9,820,095 = **54.52%.**

35.14**Solution**: (a) Rent's rule: $n_{io} = 6.0\ n_c^{0.12} = 6.0\ (64 \times 64)^{0.12} = 6.0(4096)^{0.12}$ = 16.3 $\rightarrow$ **16 pins**
(b) Eq. (35.11): n_{io} = 1.4427 ln (64 x 64) = 1.4427 ln 4096 = **12 pins.**

Chapter 36: Multiple Choice Questions
36.2(c)
36.6(a)
36.10(a)