Scilab Textbook Companion for Manufacturing Processes For Engineering Materials by S. Kalpakjian And S. R. Schmid[1]

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Book Description

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Scilab numbering policy used in this document and the relation to the above book.

Exa Example (Solved example)

Eqn Equation (Particular equation of the above book)

AP Appendix to Example(Scilab Code that is an Appednix to a particular Example of the above book)

For example, Exa 3.51 means solved example 3.51 of this book. Sec 2.3 means a scilab code whose theory is explained in Section 2.3 of the book.

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Chapter 2

Fundamentals of the Mechanical Behavior of Materials

Scilab code Exa 2.1 Calculation of ultimate tensile strength

```
// Calculation of ultimate tensile strength
clc
K = 689655  // in kPa
n = 0.5
A0 = 1 // let
printf("\n Example 2.1")
sigma = K*n^n
A_neck = A0*exp(-n)
P= sigma*A_neck
UTS = P/A0
printf("\n True ultimate tensile strength is %.2fkPa
   ",sigma)
printf("\n Engineering UTS of material is %.2f kPa",
   UTS)
// Answer in book is 295521.79 kPa
```

Scilab code Exa 2.3 Calculation of modulus resilience from hardness

```
// Calculation of modulus resilience from hardness
clc
h = 400 // hardness of specimen in HB
E = 205e3 // Youngs modulus of steel in MPa
g = 9.8 // gravitational acceleration in m/s^2
printf("\n Example 2.3")
Y = h*1e6*g/3 //   As, Hardness = c*Y
m_r = (Y/1e6)^2/(2*E) // modulus of resilience

printf("\n Modulus of resilience of body is %.2f Nm/
   m^3.", m_r)
// while numerical value of answer in book is 4.17
```

Scilab code Exa 2.4 Elimination of stress by tension

```
// Elimination of stress by tension
clc
sigma_t = 140 // in MPa
sigma_c = -140 // in MPa
l = 0.25 // length of specimen in m
Y = 150 // yield stress of material in MPa
E = 70 // Youngs modulus in GPa
printf("\ Example 2.4")
epsilon_tot = (sigma_c*1e6)/(E*1e9)  + Y*1e6/(E*1e9)
     // total strain
l_f = l*exp(epsilon_tot)
```

```

printf("\n Stretched length should be %0.4f m",l_f)
// Numerical value of answer in book is 0.2510
```

Scilab code Exa 2.5 Yielding of a thin walled shell

```
// Yielding of a thin walled shell
clc
r = 254 // radius in mm
t = 2.54 // thickness in mm
sigma_1 = 140 // stress in MPa
sigma_2 = 140 // stress in MPa
sigma_min = 0 // stress in MPa
printf("\ Example 2.5")
Y = sigma_2 - sigma_min
p = 2*(t/1e3)*Y/(r*1e-3)
printf("\n\n According to maximum shear stress
    criterion, Required pressure is %.1f MPa",p)
Y =  sqrt(0.5*(sigma_1^2+sigma_2^2))
p = 2*(t/1e3)*Y/(r*1e-3)
printf("\n\n According to maximum distortion energy
    criterion, Required pressure is %.1f MPa",p)
```

Scilab code Exa 2.8 Temperature rise in simple deformation

```
// Temperature rise in simple deformation
clc
d = 25 // diameter of cylinder in mm
h_i = 25 // Height of cylinder in mm
```

```
cp = 1255 // specific heat capacity in J/kg.K
rho = 2768 // density in kg
del_t = 55 // temperature change in K
K = 104 // in MPa
n = 0.5
printf("\n Example 2.8")
v = %pi/4*(d*1e-3)^2*h_i*1e-3 // volume of cylinder
H = cp*rho*v*del_t // heat in Joule

epsilon = (H/(v*K*1e6/(n+1)))^(1/(n+1))
h_f = h_i/exp(epsilon)

printf("\n Final height of specimen is %.1f mm",h_f)
```

Chapter 4

Surface Tribology Dimensional Characteristics Inspection and Product Quality Assurance

Scilab code Exa 4.1 Determination of coefficient of friction

```
// Determination of coefficient of friction
clc
h = 20 // height in mm
od_i = 40 // initial outer diameter in mm
id_i = 20 // initial inner diameter in mm
od_f = 50 // final outer diameter in mm
del_l = 40// percentage reduction in length
printf("\n Example 4.1")
h_f = h*(1-del_l/100)
v = %pi/4 * (od_i^2-id_i^2)*h
id_f = sqrt(od_f^2-(4/%pi)*v/h_f)
del_id = (id_f - id_i)/id_i *100

printf("\n For a change of %d %% in length and %.1f %% in ID, \n By interpolation from figure, \n\n mu is 0.03 and m is 0.11",del_l,del_id)
```

Scilab code Exa 4.2 `Adhesive wear in sliding`

```
// Adhesive wear in sliding
clc
v = 1 // wear volume in mm^3
k = 1e-2 // from table
W = 100 //load in kg
p = 150 // hardness in HB
printf("\n Example 4.2")
L = 3*v*p/(k*W)
printf("\n Distance traveled is %d mm.",L)
```

Chapter 5

Metal Casting Processes and Equipment Heat Treatment

Scilab code Exa 5.1 Determining the amount of phases in carbon steel

```
// Determining the amount of phases in carbon steel
clc
m = 10 // mass in kg
t1 = 1173 // temperature in kelvin
t2 = 1001 // temperature in kelvin
t3 = 999 // temperature in kelvin
c_gamma1 = 0.77 // from table for t2
c_o = 0.4// from table
c_a = 0.022// from table
c_gamma2 = 6.67// from table for t3
printf("\n Example 5.1")
printf("\n\n Part A:")
printf("\n From figure, Percent gamma is 100 (10 kg)
    and percent alpha is zero")
printf("\n\n Part B:")
per_alpha = 100*((c_gamma1-c_o)/(c_gamma1-c_a))
per_gamma = 100*((c_o-c_a)/(c_gamma1-c_a))
printf("\n %% alpha is : %.1f%% \t %% gamma is : %0
  .1f%%",per_alpha, per_gamma)
```

```
printf("\n Mass of alpha is : %.1f kg \t mass of gamma is : %.1f kg",per_alpha*m/100, per_gamma*m/100)
// while alpha percentage is 50 and gamma percentage is 50
printf("\n\n Part C:")
per_alpha = 100*((c_gamma2-c_o)/(c_gamma2-c_a))
printf("\n %% alpha is : %d%% ",per_alpha)
printf("\n Mass of alpha is : %.1f kg ",per_alpha*m/100 )
```

Scilab code Exa 5.2 Design and analysis of sprue for casting

```
// Design and analysis of sprue for casting
clc
Q = 1.667e-4 // discharge in m^3/sec
d = 20 // diameter of sprue in mm
h = 200 // height of sprue in mm
g = 9.81 // acceleration due to gravity in m/s^2
p = 2700 // density in kg/m^3
neeta = 0.004 // viscosity coefficient

printf("\n Example 5.2")
A1 = %pi/4*(d*1e-3)^2
v1 = Q/A1
v2 = sqrt((h*1e-3)*2*g+v1^2)
A2 = Q/v2^2
D = sqrt(4/%pi * A2)
Re = v2*D*p/neeta

printf("\n Resultant velocity is %.2f m/sec \n Reynolds number is %d",v2,Re)
// answers in book are as velocity: 1.45 m/sec and
```

```
Reynolds number: 11745
```

Scilab code Exa 5.3 Solidification time for various solid shapes

```
// solidification time for various solid shapes
clc
n = 2
v = 1 // let
printf("\n Example 5.3")
A_cube = 6*(v^(1/3))^2// surface area of cube
A_cylinder = 6*%pi*((v/(2*%pi))^(1/3))^2 //surface area of cylinder

A_sphere = 4*%pi*((((3*v)/(4*%pi))^(1/3))^2)
K1 = 1/(A_sphere)^2 // proportional solidification time for sphere
K2 = 1/(A_cube)^2// proportional solidification time for cube
K3 = 1/(A_cylinder)^2// proportional solidification time for cylinder
printf("\n Respective time periods are as:")
printf("\n t_sphere: %.3fC \t t_cube = %.3fC \t t_cylinder = %.3fC",K1,K2,K3 )
```

Chapter 6

Bulk deformation Processes

Scilab code Exa 6.1 Calculation of upsetting force

```
// Calculation of upsetting force
clc
d1 = 200 // diameter in mm
h1 = 125 // height in mm
h2 = 50 // height in mm
K = 760 // in MPa
n = 0.19
mu = 0.2 // coefficient of friction
printf("\n Example 6.1")
epsilon1 = log(h1/h2)
Yf = K*epsilon1^n
v = %pi/4*d1^2*h1
r2 = sqrt(v/(%pi*h2))

P_av= Yf*(1+(2*mu*r2/(3*h2)))
F = P_av*1e6*%pi*(r2*1e-3)^2
printf("\n Required upsetting force is %.2e N",F)
// Answer in book is 8.32e7N
```

Scilab code Exa 6.4 Power required for rolling

```
// Power required for rolling
clc
t1 = 20 // initial thickness in mm
t2 = 12 // final thickness in mm
R = 300 // roll radius
N = 100 // rpm of roll
w = 250 // width in mm
K = 895 // in MPa
n = 0.49 // from table
mu = 0.1 // frictional coefficient
printf("\n Example 6.4")
L = sqrt((R*1e-3)*(t1-t2)*1e-3)
epsilon = log(t1/t2)
Y_bar = K*epsilon^n/(1+n)
Y_bar_1 = Y_bar*(1+(mu*L/((t1+t2)*1e-3)))
F = L*w*Y_bar_1*1e3
p = 2*%pi*F*L*N/60000

printf("\n Power required for rolling is %d kW.",p)
// Answer in book is 3111kW
```

Scilab code Exa 6.6 Force in hot extrusion

```
// Force in hot extrusion
clc
D = 150 // initial diameter in mm
```

```
H = 300 // height in mm
v = 330 // velocity in m/sec
d = 75 // final diameter in mm
mu = 0.1 // frictional coefficient
C = 240 // in MPa
m = 0.06 // constant
a = 0.8 // from table
b = 1.5 // from table
printf("\n Example 6.6")
R = D^2/d^2 // its calculated value in book is 2, while in actual its 4
epsilon = 6*(H*1e-3)*log(R)/(D*1e-3)
sigma = C*epsilon^m
Y_bar = sigma // assumption
p = Y_bar*(a+b*log(R))
F = p*1e6*%pi*(D*1e-3)^2/4
printf("\n Force required for rolling is %.1e N.",F)
// Answer in book is 8.8e6 N. It is because of wrong calculation of value of R
```

Scilab code Exa 6.7 Power required for rolling

```
// Power required for rolling
clc
t1 = 6 // initial thickness in mm
t2 = 3 // final thickness in mm
v = 0.6 // velocity in m/s
x = 0.35 // fractional difference between values
K = 895 // in MPa
n = 0.49 // from table

printf("\n Example 6.7")

```

```
epsilon = log(t1/t2)
Y_bar = K*epsilon^n/(1+n)
Af = %pi/4*(t2*1e-3)^2
F = Y_bar*Af*epsilon
power = F*v // power
printf("\n Part A:")
printf("\n Power required for operation is %d W.",
   power*1e6)
p_act = (1+x)*power
Yf = K*epsilon^n
sigma_d = F*(1+x)/Af
p = Yf - sigma_d

printf("\n\n Part B:")
printf("\n Die pressure at exit of die is %d MPa.",p
   )
```

Chapter 7

Sheet Metal Forming processes

Scilab code Exa 7.1 Calculation of maximum punch force

```
// Calculation of maximum punch force
clc
L = 30 // diameter of punching in mm
t = 3 // thickness of sheet in mm
UTS = 1e3 // Tensile strength in MN
printf("\n Example 7.1")
F = 0.7*UTS*t*1e-3*L*1e-3*%pi
printf("\n Maximum required punching force is %.3f
   MN.",F) // Answer in book is 0.197 MN
```

Scilab code Exa 7.3 Estimating springback

```
// Estimating springback
clc
Ri = 10 // initial radius in mm
Y = 205 // Yield stress in MPa
E = 190 // Youngs modulus  in GPa
```

```
t = 10 // thickness in mm
printf("\n Example 7.3")
K = Ri*Y*1e6/(E*1e9*t)
R_ratio = 4*K^3-3*K+1
printf("\n Estimated Springback is %.4f",R_ratio)
// Answer in book is 0.9967
```

Scilab code Exa 7.4 `Work done in stretch forming`

```
// Work done in stretch forming
clc
L_o = 400 // initial length in mm
L_f = 441.4 // final length in mm
C = 700 // in MPa
n = 0.3
a = 300 // cross sectional area in mm^2
A = 250 // distance between support and force point
B = 150 // distance between support and force point
epsilon = log(L_f/L_o)
printf("\n Example 7.4")
u = C*1e6*epsilon^(1+n)/(1+n)
V  = L_o*1e-3*a*1e-6
work = u*V
printf("\n\n Part A:")
printf("\n Total work done on ignoring end effect and bending is %d Nm.",work)
// Answer in book is 3133 Nm
printf("\n Part B:")
sigma = 0.3
L_max = L_o*exp(sigma)
a = 1/2*((A^2-B^2)/L_max + L_max)
```

```
b = L_max - a
alpha_max = acos(A/a)*180/%pi

printf(" \n Maximum value of alpha before necking
    begins is %.1f degrees.",alpha_max) // Answer in
    book is 35.4 degrees
```

Scilab code Exa 7.5 Peak pressure in explosive forming

```
// Peak pressure in explosive forming
clc
m = 0.1 // mass of TNT in kg
d = 0.5 // standoff distance in m
K = 3.9e7 // constant of explosive
a = 1.15
printf("\n Example 7.5")
p = K*((m^(1/3))/d)^a
printf("\n Pressure of amount %.1f MPa is sufficient
     to form sheet metals.", p/1e6)
```

Scilab code Exa 7.7 Estimating the limiting drawing ratio

```
// Estimating the limiting drawing ratio
clc

del_l = 0.23 // fractional change in length
del_t = -0.1 // fractional change in thickness
printf("\n Example 7.7")
l_ratio = (1+del_l)
```

```
t_ratio = (1+del_t)
w_ratio = 1/(l_ratio*t_ratio)

R = log(1/w_ratio)/log(1/t_ratio)
printf("\n\n For planar isotropy and from figure , R
    = %.3f\n we estimate LDR to be 2.4",R)
```

Scilab code Exa 7.8 Theoretical limiting drawing ratio

```
// Theoretical limiting drawing ratio
clc
epsilon_max = 1
printf("\n Example 7.8")
D0_Dp = exp(epsilon_max)
printf("\n  Theoretical limiting drawing ratio is %0
   .3f",D0_Dp)
```

Scilab code Exa 7.9 Estimating cup diameter and earing

```
// Estimating cup diameter and earing
clc
r_0 = 0.9
r_45 = 1.3
r_90 = 1.9
theta1 = 0 // angle in degree
theta2 = 45 // angle in degree
theta3 = 90 //  angle in degree
printf("\n Example 7.9")
R_avg = (r_0+2*r_45+r_90)/4
```

```
del_r = (r_0-2*r_45+r_90)/4
printf(" \n\n For average R value %.2f LDR of steel can be approximated to be 2.5 (deduced from figure).",R_avg)
if del_r>0 then
    printf("\n\n Ear will form in deep drawing of this material.")
end
```

Scilab code Exa 7.10 Estimating diameter of expansion

```
// Estimating diameter of expansion
clc

D_0 = 300 // original diameter in mm
e = 40 // allowable strain in %
printf("\n Example 7.10")
D_f = (1+e/100)*D_0
printf("\n Maximum diameter to which object can be safely expanded is %d mm.",D_f)
```

Chapter 8

Material Removal Processes Cutting

Scilab code Exa 8.1 Relative energies in cutting

```
// Relative energies in cutting
clc
t_o = 0.01 // depth in mm
V = 125 // velocity in m/min
alpha = 10 // angle i degree
t_c = 0.014 // depth of cut in mm
w = 6 // width of cut in mm
F_c = 55 // force in Kg
F_t = 25 // force in kg
printf("\n Example 8.1")
r = t_o/t_c
R = sqrt(F_c^2+F_t^2)
Beta = acos(F_c/R)*180/%pi + alpha
F = R*(sin(Beta*%pi/180))
percentage = 100*(F*r/F_c)
printf("\n Percentage frictional energy is %.1f%%",
   percentage)
printf("\n Percentage shear energy is %.1f%%",100-
   percentage)
```

Scilab code Exa 8.2 Comparison of forming and machining energy

```
// Comparison of forming and machining energy
clc
d_i = 10 // diameter in mm
l = 125 // length in mm
del_d = 0.5 // reduction in diameter in mm
K = 1275 // constant in MPa
n = 0.45 // constant
Es = 4.1 // Specific energy in machining in W-S/mm^3
printf("\n Example 8.2")
printf("\n\n Part A:")
d_o = d_i - del_d
epsilon = log((d_i/d_o)^2)
u = K*1e6*epsilon^(n+1)/(1+n)
W_tension = u*%pi*l*1e-3*(del_d*1e-2)^2

printf("\n Work done by pulling in tension is %d Nm.
    ",W_tension)
printf("\n\n Part B:")
V = %pi/4*(d_i^2-d_o^2)*l
W_mach = Es*V
ratio = W_mach/W_tension
printf("\n Work done by machining on lathe is %d Nm.
    ",W_mach)
printf("\n Work done on machining is about %d time
    higher than that of tension.",ratio)
```

Scilab code Exa 8.3 Increase in tool life by reducing the cutting speed

```
// increase in tool life by reducing the cutting speed
clc
n = 0.5 // Exponential factor
C = 400 // Constant
v_ratio = 0.5 // velocity
printf("\n Example 8.3")
t_ratio = (1/v_ratio)^(1/n) // From Tylor's equation V*T^n = constant
del_t = t_ratio -1
printf("\n On making velocity to %.1f times of initial , \n Increase in life time is %d%%.",v_ratio,del_t*100)
```

Scilab code Exa 8.4 Material removal rate and cutting force in turning

```
// Material removal rate and cutting force in turning
clc
D_o = 10 // diameter in mm
N = 360 // spindle rpm
D_i = 9 // machined diameter in mm
x = 1.75 // axial speed in mm/min
l = 125 // length in mm
rate = 4 // specific energy in W-s/mm^3
printf("\n Example 8.4")
V_o = %pi*D_o*1e-3*N
V_i =%pi*D_i*1e-3*N
d = (D_o-D_i)/2
f = x*100/N
mrr = %pi*(D_o-d)*d*f*N
```

```
t = l/(d*N)
power = rate*mrr/60
T = power/(2*%pi*N/60) // torque
F_c = T/((D_o-d)/(2*1000))
printf("\n Material removal rate is %.2f mm^3/min.", mrr)
// Answer in book is 2610.08 mm^3/min
printf("\n Cutting force is %d N.", F_c)
// Answer in book is 994N
```

Scilab code Exa 8.6 Calculation of material removal rate power required and cuttin

```
// Calculation of material removal rate, power required and cutting time in face milling
clc
D = 160 // diameter in mm
w = 70 // width in mm
l = 450//length in mm
d = 3 // depth in mm
v = 0.5 // velocity in m/min
N= 120 // rotation in rpm
p_u = 1.1 // unit power for material
printf("\n Example 8.6")
a = w*d
mrr = a*v*1000
l_c = D/2
t = (l+2*l_c)/(v*1000)
f = v*1000/(d*N*10)
power = p_u*mrr/60

printf("\n Material removal rate is %d mm^3/min.", mrr)
printf("\n power required in milling is %.3f kW.",
```

```
power/1000)
printf("\n Required time for milling is %.2f min.",t
)
```

Chapter 9

Material Removal Processes Abrasive Chemical Electrical and High Energy Beams

Scilab code Exa 9.1 Chip dimensions in grinding

```
// chip dimensions in grinding
clc
D = 150 // diameter in mm
d = 0.03 // depth in mm
C = 3 // per mm^2
r = 12 // radius in mm
v = 0.4 // velocity in m/sec
V = 25 // velocity in m/sec
printf("\n Example 9.1")
l = sqrt(D*d)
t = sqrt((4*v/(V*C*r))*sqrt(d/D))
printf("\n Length of chip is %.2f mm. \n Thickness
    of chip is %.3f mm.",l,t)
```

Scilab code Exa 9.2 Forces in surface grinding

```
// Forces in surface grinding
clc
d = 0.04 // depth of cut in mm
D  = 200 // diameter in mm
N = 3600 // Rotation in rpm
w = 20 // width of cut in mm
v = 1200 // velocity in mm/min
u = 41 // specific energy in W-s/mm^3
x = 0.3 // fractional increase
printf("\n Example 9.2")
mrr = d*w*v*10
power = u*mrr/60
T = power/(2*%pi*N/60)
F_c = T/(D*1e-3/2)
F_n = (1+x)*F_c

printf("\n\n Forces in surface grinding are as: \n
   F_c:%d N \t F_n: %d N",F_c, F_n)
```

Scilab code Exa 9.5 Machining time in electrochemical machining vs drilling

```
// Machining time in electrochemical machining vs.
   drilling

clc
d = 12 // hole diameter in mm
```

```
I = 5 // current density in A/mm^2
C = 1.5 // material constant in mm^3/A-min
neeta = 0.92 // efficiency
depth = 15 // depth of hole in mm
N = 325 // rotation in rpm
f1 = 0.15 // feed in mm/rev

printf("\n Example 9.5")
f = C*I*neeta // feed rate
T_e = depth/f // time by electrochemical machining
f_rate = N*f1
T_d = depth/f_rate// time by drilling
t_ratio = T_d/T_e
printf("\n Machining time in electrochemical is %.2f
    min.",T_e)
printf("\n Machining time in drilling is %.2f min.",
    T_d) // answer in boook is 0.030
printf("\n Machining time in drilling is %d %% of
    ECM. ",t_ratio*100)
```

Scilab code Exa 9.6 Machining time in electrical discharge machining vs drilling

```

//Machining time in electrical discharge machining
    vs drilling
clc
d = 12.5 // hole diameter in mm
I = 100 // current density in A/mm^2 for EDM
I1 = 5 // current density in A/mm^2 for ECM
h = 20 // depth in mm
C = 1.5
neeta = 0.92 // efficiency
depth = 15 // depth of hole in mm
```

```
N = 325 // rotation in rpm
f1 = 0.15 // feed in mm/rev
T_m = 1873.15 // melting point of titanium in K
t_m = 1373.15 // melting point of electrode in K
printf("\n Example 9.6")
printf("\n\n Part A:")
T_w = T_m -273.15 // melting point in Celsius
mrr = 4e4*I*T_w^(-1.23)
v = %pi/4*d^2*h
t = v/mrr // time by EDM
f = C*I1*neeta // feed rate
T_e = depth/f // time by electrochemical machining
f_rate = N*f1
T_d = depth/f_rate// time by drilling
t_edm_ecm = t/T_e // Time ratio between EDM and ECM
t_edm_d = t/T_d // Time ratio between EDM and drilling
printf("\n Machining time for EDM is %.1f min.",t)
printf("\n This time is %.2f time of that for ECM. ",t_edm_ecm) // Answer in book is 2.35 time
printf("\n This time is %.2f time of that for drilling. ",t_edm_d) // Answer in book is 11.3 times
printf("\n Part B:")
t_t = t_m - 273.15
W_t = 1.1e4*I*t_t^(-2.38)
printf("\n Wear rate of electrode is %.3f mm^3/min.",W_t)
```

Chapter 10

Properties and Processing of Polymers and Reinforced Plastics Rapid prototyping and Rapid Tooling

Scilab code Exa 10.1 Degree of polymerization in polyvinyl chloride

```

// Degree of polymerization in polyvinyl chloride
clc
w_avg = 62500 // average molecular weight

A_H = 1 // Atomic weight of hydrogen
A_C = 12// Atomic weight of carbon
A_cl= 35.5 // Atomic weight of Chlorine
n_H= 3 // Number of hydrogen atoms in a molecule
n_C = 2// Number of carbon atoms in a molecule
n_cl = 1// Number of chlorine atoms in a molecule
printf("\n Example 10_1")
w  = A_H*n_H+A_C*n_C+A_cl*n_cl // molecular weight
D = w_avg/w

```

```
printf("\n Degree of polymerization in polyvinyl
   chloride is %d",D)
```

Scilab code Exa 10.2 Lowering the viscosity of a polymer

```
// Lowering the viscosity of a polymer
clc
T1 = 453 // First temperature in K
T2  = 423 // Second temperature in K
k = 2.2 // ratio of obtained result to desired
   output
printf("\n Example 10.2")
del_t = T1-T2 // temperature difference in Kelvin
neeta1 = 10^(12-(17.5*del_t/(52+del_t))) // First
   viscosity
neeta2 = neeta1/k // Desired viscocity
del_t = ((12-log10(neeta2))*52/(5.5+log10(neeta2)))
T_n = T2 + del_t
printf("\n Polymer should be processed at %.1f K .",
   T_n)
```

Scilab code Exa 10.3 Stress relaxation in a thermoplastic members under tension

```

// stress relaxation in a thermoplastic members
   under tension

clc
sigma1 = 6 // stress in MPa
```

```
sigma2 = 3 // stress factor after 25 days
sigma3 = 1 // stress factor at one tenth of initial
    value
t1 = 25 // number of days
printf("\n Example 10.3")
lambda = -t1/log(sigma2/sigma1)
t = -lambda*log(sigma3/sigma1)
printf("\n It will take time of %.1f days \n for
    stress level to reach one tenth of its original
    value.",t)
```

Scilab code Exa 10.4 Properties of a graphite epoxy reinforce plastic

```
// properties of a graphite epoxy reinforce plastic
clc
x = 0.15
Ef = 250 // elastic modulus of fiber in GPa
Em = 80 // elastic modulus of resin in GPa
sigma_f = 2000 // strength of fiber in MPa
sigma_m = 100 // strength of resin in MPa
Fc = 1 // let
printf("\n Example 10.4")
Ec = x*Ef+(1-x)*Em
F_ratio = x*Ef/((1-x)*Em)
printf("\n Part A:")
printf("\n Elastic modulus of composite is %.1f GPa.
    ",Ec)
Fm = Fc/(1+F_ratio)
Ff = Fc*(1-(1/(1+F_ratio)))
printf("\n Fraction of load supported by fibers is
    %d%%.",Ff*100)
```

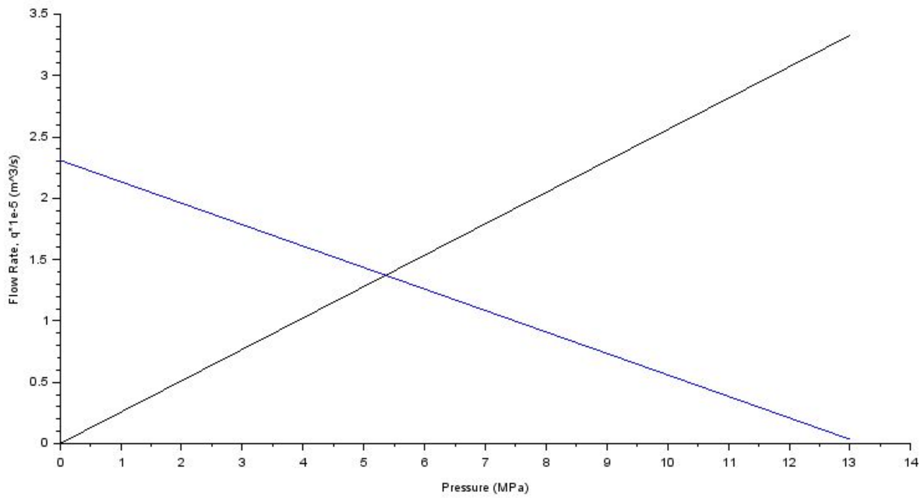

Figure 10.1: Analysis of plastic extruder

Scilab code Exa 10.5 Analysis of plastic extruder

```
// Analysis of plastic extruder
clc
H = 0.007 // channel depth in m
D = 0.05 // diameter barrel in m
N = 0.833 // revolution / sec
theta= 20 // thread angle in degrees
D_d = 0.005 // screw diameter in m
neeta = 300 // temperature in degree Celsius
l_d = 0.02 // land length in m
l = 1 // melt pumping zone in m
A = 1.96e-5 // area
printf("\n Example 10.5")
```

```
K = %pi*D_d^4/(128*neeta*l_d)
a = (%pi)^2*H*D^2*N*sin(theta*%pi/180)*cos(theta*%pi
    /180)/2
b = %pi*D*H^3*(sin(theta*%pi/180))^2/(12*neeta*l)
p=a/(K+b)
Q = K*p
v = Q/A
printf("\n Flow rate is %.2e m^3/sec.",Q)
printf("\n Final velocity is %0.2f m/sec.",v)

p = 0 : 1 : 13;
y = 0.256*p;
z = 2.31 - 0.175e*p
plot2d(p, y);
plot(p, z);
xlabel("Pressure (MPa)");
ylabel("Flow Rate, q*1e-5 (m^3/s)")
```

Scilab code Exa 10.6 Blow film

```
// Blow film
clc
w = 300 // width in mm
printf("\n Example 10.6")
printf("\n\n Part A:")
p = 2*w // perimeter
D = p/%pi // tube diameter
d = D/2.5  // tube expansion consideration
printf("\n Extrusion diameter is to be %d mm.",d)

printf("\n Part B:")
printf("\n It is a theoretical problem.")
```

Scilab code Exa 10.7 Injection molding of gears

```
// Injection molding of gears
clc
D = 110 // diameter in mm
p = 100 // pressure on mould cavity in MPa
C = 980 // capacity of machine in KN
printf("\n Example 10.7")
A = %pi*D^2/4
f = A*1e-6*p*1e6/1e3 // required force in kN
k = floor(C/f)

printf("\n Mould can support the production of %d
    gear per cycle.",k)
```

Chapter 11

Properties and Processing of Metal Powders Ceramics Glasses and Superconductors

Scilab code Exa 11.1 Particle shape factor determination

```
// Particle shape factor determination
clc
D = 1 // let
L = 1 //let
h = 2*D // length to diameter ratio
printf("\n Example 11.1")
printf("\n Part A:")
D_eq = D
A = %pi*D^2
V = %pi*D^3/6
k = A/V*D_eq
printf("\n Shape factor for spherical particle is %d
    ",k)
printf("\n\n Part B:")
A = 6*L^2
V = L^3
D_eq = (6*V/%pi)^(1/3)
```

```
k = A/V*D_eq
printf("\n Shape factor for cubic particle is %.2f",
   k)
printf("\n\n Part C:")
A = 2*%pi*D^2/4+%pi*D*h
V= %pi*D^2/4*h
D_eq = (6*V/%pi)^(1/3)
k = A/V*D_eq
printf("\n Shape factor for cylindrical particle is
   %.2f",k)
```

Scilab code Exa 11.2 Density of metal powder lubricant mix

```
// Density of metal powder lubricant mix
clc
m_fe = 1000 // mass of iron in gram
m_l = 25 // mass  in gram
d_fe = 7.86 // density of iron in gram/cc
d_l = 1.2 // density of lubricant in gram/cc
d_ap = 2.75 // apparent density in gram/cc
m_L = 30 // mass of lubricant in gram
printf("\n Example 11.2")
V = m_fe/d_fe + m_l/d_l // Combined volume in CC
w = m_fe + m_L // combined mass in gram
d_th = w/V // theoretical density in gram/cc
d_m_ap = d_ap/d_fe*d_th // apparent density of mix

printf("\n Apparent density of metal powder
   lubricant mix is %.2f g/cm^3.",d_m_ap) // Answer
   in book is 2.42 g/cm^3
```

Scilab code Exa 11.3 Pressure decay in composition

```
// Pressure decay in composition
clc
k = 0.6 // given constant
mu = 0.4// given constant
d = 10 // diameter in mm
px = 0 // pressure measure in N/mm^2
px_p0 = 0.5 // pressure ratio
printf("\n Example 11.3")
printf("\n\n Part A:")
if px==0 then  // no function deals with the
   calculation for an infinite number so if
   statement is used here
    printf("\n Value of X must approach infinity for
        pressure to decay to zero.")
end

printf("\n Part B:")
X = - log(px_p0)/(4*k*mu/d)
printf("\n Value of X, required to get pressure to
   decay to %.1f is %.2f mm. ",px_p0,X)
```

Scilab code Exa 11.4 Shrinkage in sintering

```
// Shrinkage in sintering
clc
L = 1 // let
```

```
del_l = 5/100*L // linear shrinkage
rho_sint = 90 // sintered density in%
printf("\n Example 11.4")
rho_green = rho_sint*(1-(del_l/L))^3
printf("\n Density of green compact becomes %d%%.",
   rho_green)
```

Scilab code Exa 11.7 `Effect of porosity on properties`

```
// Effect of porosity on properties
clc
UTS0 = 125 // in MPa
E0 = 500 // Youngs modulus in GPa
k0 = 0.6 // thermal conductivity in W/m-K
n = 6 // given
p = 0.15 // given
printf("\n Example 11.7")
UTS = UTS0*exp(-5*p)
E = E0*(1-1.9*p+0.9*p^2)
k = k0*(1-p)
printf("\n Due to %d%% porosity", p*100)
printf("\n Tensile strength becomes %d MPa.",UTS)
printf("\n Modulus of elasticity becomes %d GPa.",E)
printf("\n Thermal conductivity becomes %.2f W/m-K."
   ,k)
```

Scilab code Exa 11.9 `Dimensional changes during shaping of ceramic components`

```
// Dimensional changes during shaping of ceramic
   components
clc
L = 25 // length in mm
s_d = 0.09 // drying shrinkage
s_f = 0.05 // firing shrinkage
p_f = 4 //porosity of fired part
printf("\n Example 11.9")
printf("\n\n Part A:")
L_d = L/(1-s_f)
L_o = (1+s_d)*L_d
printf("\n Initial length of part is %.2f mm.",L_o)
printf("\n Part B:")
Va_Vd = (1-p_f/100)/(1/(1-s_f)^3)
printf("\n Porosity P_d of dried part is %.2f%%."
   ,(1-Va_Vd)*100) // Answer in book is 18%
```

Chapter 12

Joining and Fastening Processes

Scilab code Exa 12.1 Estimation of welding speed for different materials

```
// Estimation of welding speed for different materials
clc
V = 20 // applied voltage in Volt
I = 200 // Current in ampere
A = 30 // cross sectional area in mm^2
e = 0.75 // efficiency
u_al = 2.9 // specific energy of aluminium in J/mm^3
u_c = 12.3 // specific energy of carbon in J/mm^3
u_ti = 14.3// specific energy of titanium in J/mm^3
printf("\n Example 12.1")
v_al = e*V*I/(u_al*A)// velocity for aluminum in mm/s
v_c = e*V*I/(u_c*A) // velocity for carbon in mm/s
v_ti = e*V*I/(u_ti*A) // velocity for titanium in mm/s
printf("\n velocity for aluminum is %.1f mm/sec. ",v_al)
printf("\n velocity for carbon is %.1f mm/sec. ",v_c
```

```
)
printf("\n velocity for titanium is %.1f mm/sec. ",
    v_ti)
```

Scilab code Exa 12.2 Current in shielded metal arc welding

```
// current in shielded metal arc welding
clc
V = 20 // applied voltage in Volt
b = 10 // base in mm
h = 10 // height in mm
e = 0.75 // efficiency
u = 10.3 // specific energy in J/mm^3
v = 10 // weld speed in mm/sec
printf("\n Example 12.2")
A  = 1/2*b*h // Area in mm^2
I = v*u*A/(e*V) // Current in Ampere
printf("\n Amount of current needed for welding is
    %d Ampere.",I)
```

Scilab code Exa 12.5 Heat generation in resistance spot welding

```
// Heat generation in resistance spot welding
clc
I = 5500 // current in ampere
R = 250 // resistance in micro ohm
T = 0.15 // time in sec
d = 6 // diameter in mm
t = 3 // thickness in mm
```

```
rho = 7850 // density in kg/m^3
E = 1400 // energy required per gram mass
printf("\n Example 12.5")
Heat = I^2*R*1e-6*T
V = %pi/4*d^2*t
m = V*rho*1e-6
E_tot = m*E
H_r = Heat - E_tot
H_per = H_r/Heat*100
printf("\n Amount of heat generated is %d J.", Heat)
printf("\n Amount of heat in weld zone is %d J or
   %d%%.", H_r, H_per)
// Answer in book is 196 J
```