Scilab Textbook Companion for Manufacturing Technology - Volume 1 : Foundry, Forming And Welding
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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.

Contents

List of Scilab Codes

Chapter 1

Introduction

Scilab code Exa 1.1 Find the economical manufacturing method

```
//Example 1.1
clc
FDCB=33500//forging die cost for blocker type
FSCB=2500//forging die setup cost for blocker type
FPCB=160//forging piece cost for blocker type
MTCB=86240//machining tooling cost for blocker type
MSCB=7120//machining setup cost for blocker type
MRCB=1600//machining running cost for blocker type
FDCCT=65000//forging die cost for close tolerance
FSCCT=3600//forging die setup cost for close
    tolerance
FPCCT=220//forging piece cost for close tolerance
MTCCT=10000//machining tooling cost for close
    tolerance
MSCCT=1080//machining setup cost for close tolerance
MRCCT=200//machining running cost for close
    tolerance
N=1000//number of production quantities
FCB=FDCB+FSCB+MTCB+MSCB//fixed cost for blocker type
VCB=FPCB+MRCB//variable cost for close tolerance
FCCT=FDCCT+FSCCT+MTCCT+MSCCT//fixed cost for close
```

```
tolerance
VCCT=FPCCT+MRCCT//variable cost for close tolerance
if (FCB>FCCT&&VCB>VCCT)
    disp("close tolerance type is economical")
elseif (FCB<FCCT&&VCB<VCCT)
    disp("blocker type is economical")
else
    disp("economical method is neither blocker type nor close tolerance type")
end
```

Scilab code Exa 1.2 Prepare the break even analysis

```
//Example 1.2
clc
FPC1=35820//forging piece cost for open die
MTC1=93000//machining tooling cost for open die
MRC1=53625///machining running cost for open die
FDC2=93900//forging die cost for blocker
FSC2=3375//forging setup cost for blocker
FPC2=18150//forging piece cost for blocker
MTC2=93000//machining tooling cost for blocker
MRC2=33450//machining running cost for blocker
FC1=MTC1//fixed cost for open die
VC1=FPC1+MRC1//variable cost for open die
FC2=FDC2+FSC2+MTC2//fixed cost for blocker
VC2=FPC2+MRC2//variable cost for blocker
BEQ=(FC2-FC1)/(VC1-VC2)//break even quantity
printf("Break-even quantity is %f pieces",BEQ)
```

Chapter 3

Metal Casting Processes

Scilab code Exa 3.1 Calculate the dimensions of the pattern if the casting is to b

```
//Example 3.1
clc
SA=21.0//shrinkage allowance for steel in mm/m
D1=200//dimension 1 in mm
D2=150//dimension 2 in mm
D3=100//dimension 3 in mm
D4=80//dimension 4 in mm
A200=D1*SA/1000//allowance for dimension 1 in mm
A150=D2*SA/1000//allowance for dimension 2 in mm
A100=D3*SA/1000//allowance for dimension 3 in mm
A80=D4*SA/1000//allowance for dimension 4 in mm
d1=D1+A200//dimension of the pattern with respect to dimension 1 in mm
d2=D2+A150//dimension of the pattern with respect to dimension 2 in mm
d3=D3+A100//dimension of the pattern with respect to dimension 3 in mm
d4=D4+A80//dimension of the pattern with respect to dimension 4 in mm
printf('Allowances of the pattern are %.2f mm,%.2f mm,%.2f mm,%.2f mm \n',A200,A150,A100,A80)
```

```
printf('Dimensions of the pattern are %.2f mm,%.2f
   mm,%.2f mm,%.2f mm \n',d1,d2,d3,d4)
```

Scilab code Exa 3.2 Calculate the dimensions of the wooden pattern if the master p

```
//Example 3.2
clc
SAal=13.0//shrinkage allowance for aluminium in mm/m
SAs=21.0//shrinkage allowance for steel in mm/m
TS=SAal+SAs//total shrinkage
D1=200//dimension 1 in mm
D2=150//dimension 2 in mm
D3=100//dimension 3 in mm
D4=80//dimension 4 in mm
A200=D1*TS/1000//allowance for dimension 1 in mm
A150=D2*TS/1000//allowance for dimension 2 in mm
A100=D3*TS/1000//allowance for dimension 3 in mm
A80=D4*TS/1000//allowance for dimension 4 in mm
d1=D1+A200//dimension of the pattern with respect to
    dimension 1 in mm
d2=D2+A150//dimension of the pattern with respect to
    dimension 2 in mm
d3=D3+A100//dimension of the pattern with respect to
    dimension 3 in mm
d4=D4+A80//dimension of the pattern with respect to
   dimension 4 in mm
printf('Allowances of the wooden pattern are %f mm,
   %f mm,%f mm,%f mm \n',A200,A150,A100,A80)
printf('Dimensions of the wooden pattern are %f mm,
   %f mm,%f mm,%f mm \n',d1,d2,d3,d4)
```

Scilab code Exa 3.3 Calculate the dimensions of the pattern if all the surfaces of

```
//Example 3.3
clc
MAB=3//machining allowance for bore in mm
MAS=3//machining allowance for all surfaces in mm
MAC=6//machining allowance for cope side in mm
D1=200//dimension 1 in mm
D2=150//dimension 2 in mm
D3=100//dimension 3 in mm
D4=80//dimension 4 in mm
FD1=D1+(5.5+5.5)//final dimension for dimension 1 in
    mm
FD2=D2+(MAS+MAS)//final dimension for dimension 2 in
    mm
FD3=D3+(MAS+MAC)//final dimension for dimension 3 in
    mm
FD4=D4+(2*MAB)//final dimension for dimension 4 in
    mm
printf('Final dimensions of the pattern after
    providing machining allowance are %f mm,%f mm,%f
    mm,%f mm \n',FD1,FD2,FD3,FD4)
```

Scilab code Exa 3.4 Provide draft allowance to the pattern

```
//Example 3.4
clc
DAE=0.75*%pi/180//draft angle for external surface
    in degrees
DAI=1*%pi/180//draft angle for internal surface in
    degrees
H=109//height of the surface in mm
D=74//bore diameter before providing draft allowance
    in mm
L=211//length of the surface in mm
TE=H*tan(DAE)//taper required for external surface
    in mm
```

```
TI=H*tan(DAI)//taper required for internal surface in mm
BD=D-(2*TI)//the bore dimension in mm
ED=L+(2*TE)//external dimension in mm
printf('After providing draft allowance the bore dimension is %f mm and the external dimension is %f mm',BD,ED)
```

Scilab code Exa 3.5 Calculate the permeability number

```
//Example 3.5
clc
p=5.0//air pressure in g/cm^2
T=1+(25/60)//required time in min
P=501.28/(p*T)//standard permeability number
printf('Permeability number of sand is %f \n',P)
```

Scilab code Exa 3.6 Find the weights that need to be kept to compensate for the fo

```
//Example 3.6
clc
od=12.5//outer diameter in cm
id=10//inner diameter in cm
l=180//length in cm
h=20//metal head in cm
Vs=200*25*20//volume of the sand in the cope in cm^3
d=0.0165//density of the core sand in N/cm^3
p=0.0771//liquid metal density in N/cm^3
Vc=%pi*(id^2)*l/4//volume of the core in cm^3
Fb=Vc*(p-d)//buoyancy force in N
Ac=l*od//projected area of the casting in cm^2
Fm=Ac*p*h//upward metallostatic force in N
Fu=Fb+Fm//total upward force in N
```

```
W=Vs*d//weight of the cope in N
Fn=Fu-W//net upward force in N
printf('Net upward force is %f N\n',Fn)
printf('Approximately the foundry has to keep a
    total weight of about 3000 N to compensate for
    this upward thrust exerted by the core and the
    metallostatic forces')
```

Chapter 4

Gating Systems for Casting

Scilab code Exa 4.1 Calculate the optimum pouring time for a casting

```
//Example 4.1
clc
W=20//mass in kg
T=15//thickness in mm
k=28//fluidity of iron in inches
K=k/40//fluidity of iron in mm
t1=K*(1.41+(T/14.59))*(W^(1/2))//pouring time of
    grey cast iron in s
printf('Pouring time of grey cast iron is %f s \n',
    t1)
t2=(2.4335-(0.3953*(log10(W))))*(W^(1/2))//pouring
    time of steel in s
printf('Pouring time of steel is %f s',t2)
```

Scilab code Exa 4.2 Calculate the optimum pouring time for a casting

```
//Example 4.2
clc
```

```
W=100//mass in kg
T=25//thickness in mm
k=32//fluidity of iron in inches
K=k/40//fluidity of iron in mm
t1=K*(1.41+(T/14.59))*(W^(1/2))//pouring time of grey cast iron in s
printf('Pouring time of grey cast iron is %f s \n',t1)
t2=(2.4335-(0.3953*(log10(W))))*(W^(1/2))//pouring time of steel in s
printf('Pouring time of steel is %f s',t2)
```

Scilab code Exa 4.3 Calculate the choke area

```
//Example 4.3
clc
L=500//length in mm
B=250//breadh in mm
T=50//thickness in mm
V=L*B*T//volume of the casting in mm^3
d=7.86*(10^(-6))//density of casting particles in kg/mm^3
W=d*V//weight in kg
k=22//fluidity in inches
K=k/40//fluidity in mm
t=K*(1.41+(T/14.59))*(W^(1/2))//pouring time of cast iron in s
printf('Pouring time of cast iron is %f s \n',t)
H=100//sprue height in mm
C=0.73//efficiency factor
D=6.90*(10^(-6))//density of the liquid metal in kg/mm^3
g=9800//gravity in mm/s^2
A=W/(D*t*C*((2*g*H)^(1/2)))//choke area in mm^2
printf('Actual choke area of the gate system is %f
```

```
mm^2 \n',A)
Ac=360//approximately choke area of gate system in mm^2
printf('Approximately choke area of the gate system is %f mm^2 \n',Ac)
printf('Each of choke area is %f mm^2 \n',Ac/4)
printf('Assuming the rectangular gate dimension is 15*6 mm')
//the answer may slightly vary due to rounding off values
```

Scilab code Exa 4.4 Calculate the gating requirements for the casting

```
//Example 4.4
clc
roh=68//outer radius of hemisphere in mm
rih=60//inner radius of hemisphere in mm
doc=58//outer diameter of top cylinder in mm
dic=30//inner diameter of top cylinder in mm
lc=42//length of the top cylinder in mm
dof=200//outer diameter of flange in mm
dif=120//inner diameter of flange in mm
tf=10//thickness of flange in mm
d=7.86*(10^(-6))//density of the casting particles in kg/mm^3
yc=0.60//casting yield factor
Vh=(4/3)*(%pi/2)*((roh^3)-(rih^3))//volume of hemisphere in mm^3
Vc=(%pi/4)*((doc^2)-(dic^2))*lc//volume of the top cylinder in mm^3
Vf=(%pi/4)*((dof^2)-(dif^2))*tf//volume of the flange in mm^3
V=Vh+Vc+Vf//total volume in mm^3
m=V*d//mass of the casting in kg
w=2*m//total weight of the casting in the mould in
```

```
kg. because, there are two ccastings in the mould .
W=2*m/yc//weight of metal poured in kg
t=(2.4335-(0.3953*(log10(W))))*(W^(1/2))//pouring time of C30 steel in s
r=W/t//pouring rate in kg/s
C=0.73//efficiency factor
D=7.7*(10^(-6))//density of the liquid metal in kg/mm^3
g=9800//gravity in mm/s^2
H=150//sprue height in mm
Ac=W/(D*t*C*((2*g*H)^(1/2)))//choke area in mm^2
dc=(4*Ac/%pi)^(1/2)//choke diameter in mm
Ar=2*(%pi/4)*(dc^2)//runner area in mm^2
printf('Assuming a rectangular cross section, the runner dimensions would be approximately 16*25 mm \n')
Ag=0.5*Ar//each gate area in mm^2
printf('Each gate area is %f mm^2 \n',Ag)
printf('The size of the gate is approximately 7*28 mm')
//the answer may slightly vary due to rounding off values
```

Scilab code Exa 4.5 Calculate the size of a cylindrical riser necessary to feed a

```
//Example 4.5
clc
L=25//length in cm
B=25//breadh in cm
T=5//thickness in cm
V=L*B*T//volume of the casting in cm^3
As=(2*L*B)+(2*B*T)+(2*L*T)//surface area of the casting in cm^2
//Vr=%pi*(D^3)/4//volume of the riser in cm^3
```

```
//Asr=(%pi*(D^2))+((%pi*(D^2))/4)//surface area of
    the riser in cm^2
//X=(As/V)/(Asr/Vr)//freezing ratio
//Y=Vr/V
a=0.10//constant value for steel
b=0.03//constant value for steel
c=1.0//constant value for steel
//X=(a/(Y-b))+c//caine's equation for steel
//(D^4)-(8.9286*(D^3))-(119.52*D)=2490
//Using bisection method to solve this equation
deff('y=f(D)','y=(D^4)-(8.9286*(D^3))-(119.52*D)
    -2490')
D1=0//interval. because of zero, we are avoiding the
     negative values
D2=100//interval
Tol=10^(-3)//tolerance
i=0//iteration
while abs(D1-D2)>Tol
    m=(D1+D2)/2
    if f(m)*f(D1)>0
        D1=m
    else
        D2=m
    end
    i=i+1
end
printf('Riser diameter is %f cm \n',m)
```

Scilab code Exa 4.6 Calculate the riser size using the modulus method

```
//Example 4.6
clc
L=25//length of the slab in cm
B=25//breadh of the slab in cm
T=5//thickness of the slab in cm
```

```
a=25//breadh of the long bar in cm
H=5//width of the long bar in cm
c=0
Mc=a*H/(2*(a+H-c))//modulus in cm
D=6*Mc//riser diameter in cm
printf('Riser diameter is %f cm',D)
```

Scilab code Exa 4.7 Recalculate the riser dimensions

```
//Example 4.7
clc
L=25//length of the slab in cm
B=25//breadh of the slab in cm
T=5//thickness of the slab in cm
Vc=L*B*T//volume of the casting in cm^3
sf=(L+B)/T//shape factor
Vr=0.47*Vc//riser volume in cm^3 from the riser volume selection chart based on shape factor
//Vr=0.25*%pi*(D^3)//riser volume in cm^3 for cylindrical riser of equal diameter and height
D=(Vr/(0.25*%pi))^(1/3)
printf('Riser diameter is %f cm',D)
```

Scilab code Exa 4.8 Calculate the riser requirement for the casting

```
//Example 4.8
clc
L=25//length of the main plate in cm
B=12.5//breadh the main plate in cm
T=5//thickness the main plate in cm
sf=(L+B)/T//shape factor for main plate
Vc=L*B*T//volume of the main plate casting in cm^3
Vr1=0.575*Vc//volume of the riser in cm^3
```

```
l=10//length of the branch in cm
b=2.5//breadh the branch in cm
t=2.5//thickness the branch in cm
Vb=l*b*t//volume of the branch in cm^3
Vp=0.3//It says the parasitic volume as 30%
Vr=(Vp*Vb)+Vr1//final riser volume in cm^3
D=(4*Vr/%pi)^(1/3)//riser diameter in cm
printf('Riser diameter is %f cm',D)
```

Scilab code Exa 4.9 Calculate the riser diameter for an annular cylinder

```
//Example 4.9
clc
od=30//outside diameter in cm
id=10//inside diameter in cm
T=10//plate thickness in cm
k=1.14//correction factor
L=20*%pi//length in cm
W=30//height in cm
sf=(L+W)/(k*T)//shape factor
Vc=(%pi/4)*((od^2)-(id^2))*W//casting volume in cm^3
Vr=0.48*Vc//riser volume in cm^3
D=(4*Vr/%pi)^(1/3)//riser diameter in cm
printf('Riser diameter is %f cm',D)
```

Chapter 5

Melting and Casting Quality

Scilab code Exa 5.1 Estimate the final composition of the cast iron produced

```
//Example 5.1
clc

W=1000//total weight in kg

Cp1=3.50//carbon content in pig iron 1
Cp2=3.20//carbon content in pig iron 2
Cg=3.20//carbon content in grey iron scrap

Sip1=2.50//silicon content in pig iron 1
Sip2=1.50//silicon content in pig iron 2
Sig=2.50//silicon content in grey iron scrap

Map1=0.40//manganese content in pig iron 1
Map2=1.00//manganese content in pig iron 2
Mag=0.50//manganese content in grey iron scrap

Sup1=0.01//sulphur content in pig iron 1
Sup2=0.02//sulphur content in pig iron 2
Sug=0.10//sulphur content in grey iron scrap

```

```
cp1=40//% in the charge of pig iron 1
cp2=35//% in the charge of pig iron 2
cg=25//% in the charge of grey iron scrap

Wp1=cp1*W/100//weight of pig iron 1 in kg
Wp2=cp2*W/100//weight of pig iron 2 in kg
Wg=cg*W/100//weight of grey iron scrap in kg

Ccp1=Cp1*cp1/100//% of carbon in charge of pig iron
    1
Ccp2=Cp2*cp2/100//% of carbon in charge of pig iron
    2
Ccg=Cg*cg/100//% of carbon in charge of grey iron
    scrap

Sicp1=Sip1*cp1/100//% of silicon in charge of pig
    iron 1
Sicp2=Sip2*cp2/100//% of silicon in charge of pig
    iron 2
Sicg=Sig*cg/100//% of silicon in charge of grey iron
     scrap

Macp1=Map1*cp1/100//% of manganese in charge of pig
    iron 1
Macp2=Map2*cp2/100//% of manganese in charge of pig
    iron 2
Macg=Mag*cg/100//% of manganese in charge of grey
    iron scrap

Sucp1=Sup1*cp1/100//% of sulphur in charge of pig
    iron 1
Sucp2=Sup2*cp2/100//% of sulphur in charge of pig
    iron 2
Sucg=Sug*cg/100//% of sulphur in charge of grey iron
     scrap

Ctc=Ccp1+Ccp2+Ccg//% of total in charge of carbon
Sitc=Sicp1+Sicp2+Sicg//% of total in charge of
```

```
silicon
Matc=Macp1+Macp2+Macg//% of total in charge of manganese
Sutc=Sucp1+Sucp2+Sucg//% of total in charge of sulphur

Cc=0.15//change in cupola in carbon
Suc=0.05//change in cupola in sulphur
Sil=10//% of loss in silicon
Mal=20//% of loss in manganese
Sic=-Sil*Sitc/100//change in cupola in silicon
Mac=-Mal*Matc/100//change in cupola in manganese
CC=Ctc+Cc//% of estimated composition of carbon

printf('Estimated composition of Carbon is %f %% \n',CC)
SiC=Sitc+Sic//% of estimated composition of silicon
printf('Estimated composition of Silicon is %f %% \n',SiC)
MaC=Matc+Mac//% of estimated composition of manganese
printf('Estimated composition of Manganese is %f %% \n',MaC)
SuC=Sutc+Suc//% of estimated composition of sulphur
printf('Estimated composition of Sulphur is %f %% \n',SuC)
```

Scilab code Exa 5.2 Estimate the best charge proportions

```
//Example 5.2
clc

W=1000//total weight in kg

Cp1=3.50//carbon content in pig iron 1
```

```
Cp2=3.20//carbon content in pig iron 2
Cp3=3.50//carbon content in pig iron 3
Cs1=3.50//carbon content in scrap 1
Cs2=3.20//carbon content in scrap 2

Sip1=3.00//silicon content in pig iron 1
Sip2=1.50//silicon content in pig iron 2
Sip3=2.50//silicon content in pig iron 3
Sis1=1.80//silicon content in scrap 1
Sis2=1.20//silicon content in scrap 2
FSi=50.00//silicon content in ferrosilicon

Map1=1.00//manganese content in pig iron 1
Map2=0.50//manganese content in pig iron 2
Map3=0.80//manganese content in pig iron 3
Mas1=0.60//manganese content in scrap 1
Mas2=0.60//manganese content in scrap 2

Sup1=0.02//sulphur content in pig iron 1
Sup2=0.01//sulphur content in pig iron 2
Sup3=0.02//sulphur content in pig iron 3
Sus1=0.08//sulphur content in scrap 1
Sus2=0.10//sulphur content in scrap 2

//pig iron 2 and scrap 2 has got very low silicon
   and therefore it should not be used.

cp1=30//% in the charge of pig iron 1
cp3=30//% in the charge of pig iron 3
cs1=40//% in the charge of scrap 1

Wp1=cp1*W/100//weight of pig iron 1 in kg
Wp3=cp3*W/100//weight of pig iron 2 in kg
Ws1=cs1*W/100//weight of grey iron scrap in kg

Ccp1=Cp1*cp1/100//% of carbon in charge of pig iron
   1
Ccp3=Cp3*cp3/100//% of carbon in charge of pig iron
```

```
3
Ccs1=Cs1*cs1/100//% of carbon in charge of scrap 1

Sicp1=Sip1*cp1/100//% of silicon in charge of pig iron 1
Sicp3=Sip3*cp3/100//% of silicon in charge of pig iron 3
Sics1=Sis1*cs1/100//% of silicon in charge of scrap 1

Macp1=Map1*cp1/100//% of manganese in charge of pig iron 1
Macp3=Map3*cp3/100//% of manganese in charge of pig iron 3
Macs1=Mas1*cs1/100//% of manganese in charge of scrap 1

Sucp1=Sup1*cp1/100//% of sulphur in charge of pig iron 1
Sucp3=Sup3*cp3/100//% of sulphur in charge of pig iron 3
Sucs1=Sus1*cs1/100//% of sulphur in charge of scrap 1

Ctc=Ccp1+Ccp3+Ccs1//% of total in charge of carbon
Sitc=Sicp1+Sicp3+Sics1//% of total in charge of silicon
Matc=Macp1+Macp3+Macs1//% of total in charge of manganese
Sutc=Sucp1+Sucp3+Sucs1//% of total in charge of sulphur

Cc=0.15//change in cupola in carbon
Suc=0.05//change in cupola in sulphur
Sil=10//% of loss in silicon
Mal=20//% of loss in manganese
Sic=-Sil*Sitc/100//change in cupola in silicon
Mac=-Mal*Matc/100//change in cupola in manganese
```

```

CC=Ctc+Cc//% of estimated composition of carbon
printf('Estimated composition of Carbon is %f %% \n',CC)
//required composition of carbon is 3.2 to 3.6 %
Cl=3.2//% of lowest required composition of carbon
Ch=3.6//% of highest required composition of carbon
SiC=Sitc+Sic//% of estimated composition of silicon
printf('Estimated composition of Silicon is %f %% \n',SiC)
//required composition of Silicon is 2.3 to 2.6 %
MaC=Matc+Mac//% of estimated composition of manganese
printf('Estimated composition of Manganese is %f %% \n',MaC)
//required composition of manganese is 0.6 to 0.8 %
SuC=Sutc+Suc//% of estimated composition of sulphur
printf('Estimated composition of Sulphur is %f %% \n\n',SuC)
//required composition of sulphur is 0.08 % max
Sur=0.08//% of maximum required composition of sulphur

SuR=(Sus1-Sup2)/100//reduction in sulphur in kg --> addition of 1 kg of pig iron 2 for scrap 1
CR=(Cs1-Cp2)/100//reduction in carbon in kg --> addition of 1 kg of pig iron 2 for scrap 1
SuE=W*(SuC-Sur)/100//excess sulphur present in 1000 kg in kg
CE=W*(CC-Ch)/100//excess carbon present in 1000 kg in kg
Surd=SuE/SuR//reduce the sulphur to the desirable limit in kg
Crd=CE/CR//reduce the carbon to the desirable limit in kg

//substitution of Surd of pig iron would be sufficient to give the desired analysis.
```

```
Wsn1=W-Wp1-Wp3-Surd//weight of the new scrap 1 in kg
cp2=Surd*100/W//% in the charge of pig iron 2
csn1=Wsn1*100/W//% in the charge of new scrap 1

Ccp2=Cp2*cp2/100//% of carbon in charge of pig iron 2
Ccsn1=Cs1*csn1/100//% of carbon in charge of new scrap 1

Sicp2=Sip2*cp2/100//% of silicon in charge of pig iron 2
Sicsn1=Sis1*csn1/100//% of silicon in charge of new scrap 1

Macp2=Map2*cp2/100//% of manganese in charge of pig iron 2
Macsn1=Mas1*csn1/100//% of manganese in charge of new scrap 1

Sucp2=Sup2*cp2/100//% of sulphur in charge of pig iron 2
Sucsn1=Sus1*csn1/100//% of sulphur in charge of new scrap 1

Cntc=Ccp1+Ccp2+Ccp3+Ccsn1//% of new total in charge of carbon
Sintc=Sicp1+Sicp2+Sicp3+Sicsn1//% of new total in charge of silicon
Mantc=Macp1+Macp2+Macp3+Macsn1//% of new total in charge of manganese
Suntc=Sucp1+Sucp2+Sucp3+Sucsn1//% of new total in charge of sulphur

Sinc=-Sil*Sintc/100//new change in cupola in silicon
Manc=-Mal*Mantc/100//new change in cupola in manganese

```

```
CnC=Cntc+Cc//% of new estimated composition of carbon
printf('New estimated composition of Carbon is %f %% \n',CnC)
SinC=Sintc+Sinc//% of new estimated composition of silicon
printf('New estimated composition of Silicon is %f %% \n',SinC)
ManC=Mantc+Manc//% of new estimated composition of manganese
printf('New estimated composition of Manganese is %f %% \n',ManC)
SunC=Suntc+Suc//% of new estimated composition of sulphur
printf('New estimated composition of Sulphur is %f %% \n\n',SunC)

Sia=W*(Sintc-SinC)/100//amount of silicon to be added for 1000 kg in kg
FSia=Sia*100/(FSi-Sis1)//amount of ferro silicon required in kg by adding silicon in place of scrap 1
FSia1p=FSia*100/W//% of ferro silicon content
Ws1c=Wsn1-FSia//weight of scrap 1 content in kg
S1cp=(Wsn1-FSia)*100/W//% of scrap 1 content

printf('Final mix of the charge is \n Pig iron 1 = %f kg (%f %%) \n Pig iron 2 = %f kg (%f %%) \n Pig iron 3 = %f kg (%f %%) \n Scrap 1 = %f kg (%f %%) \n Ferro silicon = %f kg (%f %%) ',Wp1,cp1,Surd,cp2,Wp3,cp3,Ws1c,S1cp,FSia,FSia1p)
//the answer may slightly vary due to rounding off values
```

Chapter 7

Metal Forming Processes

Scilab code Exa 7.1 Determine the stock size required for the air radius arm

```
//Example 7.1
clc
Aaa=1440//maximum area of cross section occurs at
    section AA in mm^2
ds=((4/%pi)*Aaa)^(1/2)//stock diameter in mm
wf=5.3//flash width in mm
tf=1.0//flash thickness in mm
Asf=Aaa+(2*wf*tf)//area of stock with flash in mm^2
dsf=((4/%pi)*Asf)^(1/2)//stock diameter with flash
    in mm
Vf=73000///volume of the forging in mm^3
//actual volume of the forging is 72870 mm^3.
//but, we are taking the approximate volume of the
    forging of 73000 mm^3
Pf=(%pi*30/2)+33+34+24+78+(%pi*30/2)+78+33+34//
    perimeter of forging in mm
Vfl=wf*tf*Pf//flash volume in mm^3
//This being too small
//So consider the flash to be 10% of forging volume
Vfn=10*Vf/100//new flash volume in mm^3
Vs=Vf+Vfn//total stock volume in mm^3
```

```
As=(%pi/4)*dsf^2//cross sectional area of stock in mm^2
Ls=Vs/As//length of stock in mm
printf('Length of stock is %f mm',Ls)
//the answer may slightly vary due to rounding off values
```

Scilab code Exa 7.2 Design the upsetting die required for the C24 shaft

```
//Example 7.2
clc
ds=35//diameter of stock in mm
du1=135//diameter of upset 1 in mm
du2=70//diameter of upset 2 in mm
lu1=15//length of upset 1 in mm
lu2=50//length of upset 2 in mm
As=(%pi/4)*(ds^2)//area of stock cross section in mm^2
Vu=(%pi/4)*(((du1^2)*lu1)+((du2^2)*lu2))//volume of upset portion in mm^3
Ls=Vu/As//stock length in mm
rld=Ls/ds//ratio between the length of stock to be upset to diameter of stock
r=int(rld)//approximated ratio
Vs=(%pi/4)*(ds^2)*Ls//stock volume in mm^3
dp1=45//first pass maximum diameter in mm
Lc=r*Vs/(%pi*((ds^2)+(ds*dp1)+(dp1^2)))//length of conical portion in mm
ds2=(ds+dp1)/2//average stock diameter after pass 1 in mm
rld2=Lc/ds2//ratio between the length of stock to be upset to diameter of stock after pass 1
dp2=60//second pass maximum diameter in mm
Lc2=r*Vs/(%pi*((ds2^2)+(ds2*dp2)+(dp2^2)))//length of conical portion in second pass in mm
```

```
ds3=(ds2+dp2)/2//average stock diameter after pass 2
    in mm
rld3=Lc2/ds3//ratio between the length of stock to
   be upset to diameter of stock after pass 2
c=du1*ds/ds3//cavity in mm
dp3=70//third pass maximum diameter in mm
Lc3=r*Vs/(%pi*((ds3^2)+(ds3*dp3)+(dp3^2)))//length
   of conical portion in third pass in mm
ds4=(ds3+dp3)/2//average stock diameter after pass 3
    in mm
rld4=Lc3/ds4//ratio between the length of stock to
   be upset to diameter of stock after pass 3
//ratio is less than 3. So, it is suitable
printf('Length of the conical portion is %f mm',Lc3)
//the answer may slightly vary due to rounding off
   values
```

Scilab code Exa 7.3 Design the upsetting tools required for the finished component

```
//Example 7.3
clc
od=60//outer diameter of smallest cross section in
   mm
id=35//inner diameter of smallest cross section in
   mm
Asm=(%pi/4)*((od^2)-(id^2))//smallest cross
   sectional area in mm^2
ds=sqrt((4/%pi)*Asm)//stock size in mm
As=(%pi/4)*(ds^2)//stock area of cross section in mm
   ^2
da=65//diameter of section A in mm
la=20//length of section A in mm
db=100//diameter of section B in mm
lb=45//length of section B in mm
dc=61.5//diameter of section C in mm
```

```
lc=25//length of section C in mm
dd=35//diameter of section D in mm
ld1=52.5//length of section D in mm
ld2=17.5//length of traingular of section D in mm
Va=(%pi/4)*(da^2)*la//volume of A in mm^3
Vb=(%pi/4)*(db^2)*lb//volume of B in mm^3
Vc=(%pi/4)*(dc^2)*lc//volume of C in mm^3
Vd=((%pi/4)*(dd^2)*ld1)+((%pi/3)*(dd^2)*ld2)//volume of D in mm^3
V=Va+Vb+Vc-Vd//total volume in mm^3
Ls=V/As//stock length in mm
Vs=As*Ls//total stock volume in mm^3
r=Ls/ds//length to diameter ratio
dh=35//diameter of the traingular hole in mm
lh=25//length of the traingular hole in mm
Vh=(%pi/3)*(dh^2)*lh//volume of the traingular hole in mm^3
dp2=30//first pass maximum diameter in mm
ds2=(id+dp2)/2//average stock diameter after pass 1 in mm
Ls2=(Vs+Vh)/((%pi/3)*((ds2^2)+(ds2*dp2)+(dp2^2)))//length of stock after pass 1 in mm
ds3=(ds2+dp2)/2//average stock diameter after pass 2 in mm
r2=Ls2/ds2//length to diameter ratio
//now the length to diameter ratio is under 3
printf('Length of stock is %f mm',Ls2)
//as befor the length is 66.21 mm
//the answer may slightly vary due to rounding off values
```

Chapter 8

Sheet Metal Operations

Scilab code Exa 8.1 Determine the die and punch sizes for blanking

```
//Example 8.1
clc
d=20//diameter of circular disc in mm
t=1.5//thickness of disc in mm
ss=294//shear strength of annealed C20 steel in Mpa
C=0.0032*t*sqrt(ss)//clearance in mm
//for blanking operation
dsb=d//die size is equal to blank size in mm
printf('Die size for blanking is %f mm \n',dsb)
psb=d-(2*C)//punch size for blanking in mm
printf('Punch size for blanking is %f mm \n',psb)
//for piercing operation
psp=d//punch size is equal to blank size in mm
printf('Punch size for piercing is %f mm \n',psp)
dsp=d+(2*C)//die size for piercing in mm
printf('Die size for piercing is %f mm \n',dsp)
L=%pi*d//perimeter in mm
Fp=L*t*ss/1000//punching force in kN
printf('Punching force is %f kN \n',Fp)
Fs=0.024*L*t//stripping force in kN
printf('Stripping force is %f kN',Fs)
```

```
//the answer may slightly vary due to rounding off
   values
```

Scilab code Exa 8.2 Give the suitable diameters for the punch and die and shear an

```
//Example 8.2
clc
t=6//plate thickness in mm
d=100//hole diameter in mm
r=d/2//radius of the hole in mm
dp=d//punch diameter in mm
printf('Punch diameter is %f mm \n',dp)
ss=550//maximum shear strength for C40 steel in MPa
C=0.0032*t*sqrt(ss)//clearance per side in mm
dd=dp+(2*C)//die diameter in mm
printf('Die diameter is %f mm \n',dd)
L=%pi*dp//perimeter in mm
Fp=L*t*ss/1000//maximum punching load in kN
pp=40//% of penetration of punch
Wp=Fp*t*pp/100//total workdone in punching in J
Fap=200//available punch load in kN
p=(Wp-(Fap*t*pp/100))/Fap//penetration in mm
r=dp/2//radius of the hole in mm
As=atand(p/r)
printf('Shear angle is %f degree',As)
```

Scilab code Exa 8.3 Make the necessary design calculations for preparing the die f

```
//Example 8.3
clc
d=40//diameter of cup in mm
h=60//height of cup in mm
r=2//corner radius of cup in mm
```

```
t=0.6//thickness of C20 steel in mm
ss=550//shear strength for C20 steel in MPa
ratio=r/d//corner radius to shell diameter ratio
//d=20r is proved by the way of ratio
db=sqrt((d^2)+(4*d*h))//blank diameter in mm
at=6//trim allowance in mm
D=db+at//final blank diameter in mm
printf('Final blank diameter is %f mm \n',D)
//for first draw
pr=100*(1-(d/D))//percent reduction
//this is more than 45
//two draws with the first one at 40% and the second one at 25%
d1=D*(1-(40/100))//cup diameter after first draw in mm
rcp=6*t//corner radius on punch in mm
rdd1=0.8*%pi*(D-d1)*t//draw radius on die in mm
rdd=int(rdd1)//approximate draw radius on die in mm
Cd=1.09*t//die clearance in mm
//for second draw
rcp22=4*t//corner radius on punch in mm
rcp2=int(rcp22)//approximate corner radius on punch in mm
rdd2=6//draw radius on die in mm
Cd2=1.11*t//die clearance in mm
C=0.6//constant to cover friction and bending
P=%pi*d*t*ss*((D/d)-t)/1000//drawing force in kN
printf('Drawing force is %f kN',P)
//the answer may slightly vary due to rounding off values
```

Scilab code Exa 8.4 Calculate the length of the sheet required for making the comp

```
//Example 8.4
clc
```

```
t=3//sheet thickness in mm
h=50//height of the component in mm
l=100//length of the component in mm
R1=5//inside radius of bend in mm
R2=10//inside radius of bend in mm
a1=90//bend angle in degree
a=a1*(2*%pi)/360//bend angle in radian
//R1<2t ---> K1=0.33
K1=0.33//location of neutral axis from bottom surface
B1=a*(R1+(K1*t))//bend allowance in mm
//R2>2t ---> K2=0.50
K2=0.50//location of neutral axis from bottom surface
B2=a*(R2+(K2*t))//bend allowance in mm
L=h-(R1+t)+B1+l-(R2+t)+B2+h-(R1+t)-(R2+t)//total length of the sheet in mm
printf('Required sheet length is %f mm',L)
```

Scilab code Exa 8.5 Estimate the force required for a 90 degree bending of St 50 s

```
//Example 8.5
clc
t=2//steel thickness in mm
l=1//length of the bend part in m
L=l*1000//length of the bend part in mm
su=500//ultimate tensile strength of the St 50 steel in MPa
W=8*t//die opening in mm
//K=1.33 for die opening of 8t
K=1.33
Fb1=K*L*su*(t^2)/W//bending force in N
Fb=Fb1/1000//bending force in kN
printf('Bending force is %f kN',Fb)
```

Scilab code Exa 8.6 Calculate the bending force required for a C50 steel

```
//Example 8.6
clc
t=1.5//sheet thickness in mm
l=1//width of the sheet in m
L=l*1000//width of the sheet in mm
r=3//die radius in mm
su=800//ultimate tensile strength of the C50 steel
   in MPa
//K=0.33 for a wiping die
K=0.33
W=t+r+r//die opening in mm
Fb1=K*L*su*(t^2)/W//bending force in N
Fb=Fb1/1000//bending force in kN
printf('Bending force is %f kN',Fb)
```

Scilab code Exa 8.7 Design a die block for blanking

```
//Example 8.7
clc
d=80//diameter of circle in mm
t=1//thickness of C20 steel in mm
ss=390//shear strength of C20 steel in Mpa
Fs1=ss*%pi*d*t//shearing load in N
Fs=Fs1/1000//shearing load in kN
//case (1)
td1=22//die thickness in mm
dp1=1.25*td1//die opening to edge in mm
//hence die block is to be 140*140*22 mm
//case (2)
p=%pi*d//perimeter of cut in mm
```

```
td2=30//die thickness in mm
dp2=td2//die opening to edge in mm
//hence die block is to be 140*140*30 mm
//case (3)
td3=0.18*ss//die thickness in mm
Fe=1.75//expansion factor
td44=Fe*td3//die thickness in mm
td4=td44+2.15//die thickness in mm
//it to be properly supported in die shoe
td5=65//die thickness in mm
//after adding grinding allowance, die thickness is
    70 mm
td=70//die thickness in mm
dcd=30//die cavity to edge distance in mm
pi=Fs1/(dcd*td)//impact pressure in Mpa
//pi < 770 Mpa
//hence the die is too safe
//therefore die thickness can be reduced to 25 mm
t1d=25//die thickness in mm
pi2=Fs1/(dcd*t1d)//impact pressure in Mpa
//pi < 770 Mpa
//hence the die is too safe
//die block size is therefore 140*140*25 mm
printf('Die block size is 140*140*25 mm')
//the answer may slightly vary due to rounding off
    values
```

Scilab code Exa 8.8 Prepare the scrap strip layout for the component

```
//Example 8.8
clc
t=1.6//sheet thickness in mm
l1=25//length of the half portion of component in mm
or=16.5//outside radius of component in mm
dm=l1+or//maximum dimension of the component in mm
```

```
ws=1.25*t//scrap web in mm
le=2//lead end in mm
//for 1st layout
sw=(2*or)+le+le//strip width in mm
da=dm+le//advance distance in mm
A=(l1*or)+(0.75*%pi*(or^2))//area of the cross section of one component in mm^2
up1=A*100/(da*sw)//percentage utilization of stock in %
printf('%% of utilization of 1st layout is %f %% \n',up1)
//for 2nd layout
sw2=(2*or)+le+le+le//strip width in mm
da2=(2*or)+le+dm+le//advance distance in mm
up2=2*A*100/(da2*sw2)//percentage utilization of stock in %
printf('%% of utilization of 2nd layout is %f %% \n',up2)
//for 3rd layout
sw3=dm+le+le//strip width in mm
da3=(2*or)+le//advance distance in mm
up3=A*100/(da3*sw3)//percentage utilization of stock in %
printf('%% of utilization of 3rd layout is %f %% \n',up3)
printf('3rd layout gives the highest utilization with %f %% utilization',up3)
//the answer may slightly vary due to rounding off values
```

Scilab code Exa 8.9 Find out the centre of pressure for the die layout

```
//Example 8.9
clc
l1=15.70//length of element 1 in mm
```

```
l2=20.00//length of element 2 in mm
l3=31.4//length of element 3 in mm
l4=10.00//length of element 4 in mm
l5=20.00//length of element 5 in mm
l6=5.00//length of element 6 in mm
l7=5.00//length of element 7 in mm
l8=30.00//length of element 8 in mm
l9=15.70//length of element 9 in mm
l10=15.70//length of element 10 in mm
l11=15.70//length of element 11 in mm
l12=10.00//length of element 12 in mm
l13=10.00//length of element 13 in mm
l14=10.00//length of element 14 in mm
x1=3.69//x axis distance for element 1 in mm
x2=0//x axis distance for element 2 in mm
x3=10.00//x axis distance for element 3 in mm
x4=20.00//x axis distance for element 4 in mm
x5=30.00//x axis distance for element 5 in mm
x6=40.00//x axis distance for element 6 in mm
x7=40.00//x axis distance for element 7 in mm
x8=25.00//x axis distance for element 8 in mm
x9=65.00//x axis distance for element 9 in mm
x10=65.00//x axis distance for element 10 in mm
x11=81.82//x axis distance for element 11 in mm
x12=90.00//x axis distance for element 12 in mm
x13=95.00//x axis distance for element 13 in mm
x14=90.00//x axis distance for element 14 in mm
y1=3.69//y axis distance for element 1 in mm
y2=20.00//y axis distance for element 2 in mm
y3=36.37//y axis distance for element 3 in mm
y4=25.00//y axis distance for element 4 in mm
y5=20.00//y axis distance for element 5 in mm
y6=17.50//y axis distance for element 6 in mm
y7=2.50//y axis distance for element 7 in mm
y8=0//y axis distance for element 8 in mm
y9=10.00//y axis distance for element 9 in mm
y10=30.00//y axis distance for element 10 in mm
y11=10.00//y axis distance for element 11 in mm
```

```
y12=15.00//y axis distance for element 12 in mm
y13=10.00//y axis distance for element 13 in mm
y14=5.00//y axis distance for element 14 in mm
l1x1=l1*x1
l2x2=l2*x2
l3x3=l3*x3
l4x4=l4*x4
l5x5=l5*x5
l6x6=l6*x6
l7x7=l7*x7
l8x8=l8*x8
l9x9=l9*x9
l10x10=l10*x10
l11x11=l11*x11
l12x12=l12*x12
l13x13=l13*x13
l14x14=l14*x14
l1y1=l1*y1
l2y2=l2*y2
l3y3=l3*y3
l4y4=l4*y4
l5y5=l5*y5
l6y6=l6*y6
l7y7=l7*y7
l8y8=l8*y8
l9y9=l9*y9
l10y10=l10*y10
l11y11=l11*y11
l12y12=l12*y12
l13y13=l13*y13
l14y14=l14*y14
L=l1+l2+l3+l4+l5+l6+l7+l8+l9+l10+l11+l12+l13+l14//
    sum of all elements length in mm
LX=l1x1+l2x2+l3x3+l4x4+l5x5+l6x6+l7x7+l8x8+l9x9+
    l10x10+l11x11+l12x12+l13x13+l14x14
LY=l1y1+l2y2+l3y3+l4y4+l5y5+l6y6+l7y7+l8y8+l9y9+
    l10y10+l11y11+l12y12+l13y13+l14y14
X=LX/L//centre of pressure of x axis in mm
```

```
Y=LY/L//centre of pressure of y axis in mm
printf('Centre of pressure is (%f , %f) mm',X,Y)
```

Chapter 9

Welding Processes

Scilab code Exa 9.1 Calculate the melting efficiency in the case of arc welding of

```
//Example 9.1
clc
V=20//potential in V
I=200//current in A
v=5//travel speed in mm/s
A=20//cross sectional area of the joint in mm^2
Q=10//heat required to melt steel in J/mm^3
e=0.85//heat transfer efficiency
Qn=e*V*I//net heat supplied in W
V=A*v//volume of the base metal melted in mm^3/s
Qr=V*Q//heat required for melting in J/s
em=Qr/Qn//melting efficiency
printf('Melting efficiency as %f',em)
```

Scilab code Exa 9.2 Calculate the heat lost to surroundings

```
//Example 9.2
clc
```

```
I=10000//current in A
t=0.1//time in sec for which the current is flowing through the joint
R1=100//effective resistance of the joint in micro ohms
R=R1*(10^(-6))//effective resistance of the joint in ohms
d=5//diameter of the joint in mm
l=1.5//height of the joint in mm
p=0.00786//density of steel in g/mm^3
Q=10//heat required for melting steel in J/mm^3
H=(I^2)*R*t//heat supplied in J
V=(%pi/4)*(d^2)*l//volume of the joint in mm^3
Qr=V*Q//heat required for melting in J
Ql=H-Qr//heat lost to surroundings in J
printf('Heat lost to surroundings is %f J \n',Ql)
Qlp=Ql*100/H//% of heat lost to surroundings
printf('Heat lost to surroundings is %f %%',Qlp)
//the answer may slightly vary due to rounding off values
```

Scilab code Exa 9.3 Calculate the heat lost to surroundings

```
//Example 9.3
clc
I=30000//current in A
t=0.005//time in sec for which the current is flowing through the joint
T=1.0//thickness of steel sheet in mm
R1=100//effective resistance of the joint in micro ohms
R=R1*(10^(-6))//effective resistance of the joint in ohms
d=5//diameter of the joint in mm
l=1.5//height of the joint in mm
```

```
p=0.00786//density of steel in g/mm^3
Q=10//heat required for melting steel in J/mm^3
H=(I^2)*R*t//heat supplied in J
V=(%pi/4)*(d^2)*l//volume of the joint in mm^3
Qr=V*Q//heat required for melting in J
Ql=H-Qr//heat lost to surroundings in J
printf('Heat lost to surroundings is %f J \n',Ql)
Qlp=Ql*100/H//% of heat lost to surroundings
printf('Heat lost to surroundings is %f %%',Qlp)
//higher efficiency achieved
//because of the short time the current is flowing
//heat losses are minimized
//the answer may slightly vary due to rounding off values
```

Scilab code Exa 9.4 Find the best welding speed used for the welding

```
//Example 9.4
clc
T0=30//ambient temperature in  C
k=0.028//thermal conductivity in J/mm.s. C
R=6//limiting cooling rate in  C /s
Tc=550//temperature at which cooling rate in  C
V=25//voltage in V
I=300//current in A
h=6//thickness of the base metal in mm
f1=0.9//efficiency
pc=0.0044//p as density of base metal in g/mm^3 and c as specific heat of the base metal in J/g. C
v=9//travel speed in mm/s
//v = 6 to 9 mm/s //possible travel speeds in mm/s
Hnet=f1*V*I/v//heat input in J/mm
tow=h*sqrt(pc*(Tc-T0)/Hnet)//relative plate thickness factor
//tow < 0.6
```

```
//it is a thin plate
R=2*%pi*k*pc*((h/Hnet)^2)*((Tc-T0)^3)//cooling rate
   in  C /s
printf('Cooling rate is %f  C /s \nThis cooling rate
    being a little higher. \nSo, we may reduce the
   travel speed to 8 mm/s and recalculate. \n\n',R)
v2=8//travel speed in mm/s
Hnet2=f1*V*I/v2//heat input in J/mm
tow=h*sqrt(pc*(Tc-T0)/Hnet2)//relative plate
   thickness factor
//tow < 0.6
//it is a thin plate
R2=2*%pi*k*pc*((h/Hnet2)^2)*((Tc-T0)^3)//cooling
   rate in  C /s
printf('Satisfactory cooling rate is %f  C /s \nThe
   welding speed can be finalised at %f mm/s',R2,v2)
```

Scilab code Exa 9.5 `Calculate the heat affected zone`

```
//Example 9.5
clc
T0=30//ambient temperature in  C
k=0.028//thermal conductivity in J/mm.s. C
R=6//limiting cooling rate in  C /s
Tc=550//temperature at which cooling rate in  C
V=25//voltage in V
I=300//current in A
h=6//thickness of the base metal in mm
f1=0.9//efficiency
pc=0.0044//p as density of base metal in g/mm^3 and
   c as specific heat of the base metal in J/g. C
v=7//welding speed in mm/s
Tm=1510//melting temperature in  C
y=1//interval of fusion zone in mm
Hnet=f1*V*I/v//heat input in J/mm
```

```
e=2.71821828//base of natural logarithm
Tp=(1/(((sqrt(2*%pi*e))*pc*h*y/Hnet)+(1/(Tm-T0))))+T0//peak temperature in  C
y2=2//interval of fusion zone in mm
Tp2=(1/(((sqrt(2*%pi*e))*pc*h*y2/Hnet)+(1/(Tm-T0))))+T0//peak temperature in  C
y3=3//interval of fusion zone in mm
Tp3=(1/(((sqrt(2*%pi*e))*pc*h*y3/Hnet)+(1/(Tm-T0))))+T0//peak temperature in  C
y4=4//interval of fusion zone in mm
Tp4=(1/(((sqrt(2*%pi*e))*pc*h*y4/Hnet)+(1/(Tm-T0))))+T0//peak temperature in  C
y5=6//interval of fusion zone in mm
Tp5=(1/(((sqrt(2*%pi*e))*pc*h*y5/Hnet)+(1/(Tm-T0))))+T0//peak temperature in  C
y6=8//interval of fusion zone in mm
Tp6=(1/(((sqrt(2*%pi*e))*pc*h*y6/Hnet)+(1/(Tm-T0))))+T0//peak temperature in  C
y7=10//interval of fusion zone in mm
Tp7=(1/(((sqrt(2*%pi*e))*pc*h*y7/Hnet)+(1/(Tm-T0))))+T0//peak temperature in  C
y8=12//interval of fusion zone in mm
Tp8=(1/(((sqrt(2*%pi*e))*pc*h*y8/Hnet)+(1/(Tm-T0))))+T0//peak temperature in  C
y9=14//interval of fusion zone in mm
Tp9=(1/(((sqrt(2*%pi*e))*pc*h*y9/Hnet)+(1/(Tm-T0))))+T0//peak temperature in  C
y10=16//interval of fusion zone in mm
Tp10=(1/(((sqrt(2*%pi*e))*pc*h*y10/Hnet)+(1/(Tm-T0))))+T0//peak temperature in  C
v2=8//welding speed in mm/s
Hnet2=f1*V*I/v2//heat input in J/mm
Tp11=(1/(((sqrt(2*%pi*e))*pc*h*y/Hnet2)+(1/(Tm-T0))))+T0//peak temperature in  C
Tp12=(1/(((sqrt(2*%pi*e))*pc*h*y2/Hnet2)+(1/(Tm-T0))))+T0//peak temperature in  C
Tp13=(1/(((sqrt(2*%pi*e))*pc*h*y3/Hnet2)+(1/(Tm-T0))))+T0//peak temperature in  C
```

```
Tp14=(1/((((sqrt(2*%pi*e))*pc*h*y4/Hnet2)+(1/(Tm-T0))))+T0//peak temperature in  C
Tp15=(1/((((sqrt(2*%pi*e))*pc*h*y5/Hnet2)+(1/(Tm-T0))))+T0//peak temperature in  C
Tp16=(1/((((sqrt(2*%pi*e))*pc*h*y6/Hnet2)+(1/(Tm-T0))))+T0//peak temperature in  C
Tp17=(1/((((sqrt(2*%pi*e))*pc*h*y7/Hnet2)+(1/(Tm-T0))))+T0//peak temperature in  C
Tp18=(1/((((sqrt(2*%pi*e))*pc*h*y8/Hnet2)+(1/(Tm-T0))))+T0//peak temperature in  C
Tp19=(1/((((sqrt(2*%pi*e))*pc*h*y9/Hnet2)+(1/(Tm-T0))))+T0//peak temperature in  C
Tp20=(1/((((sqrt(2*%pi*e))*pc*h*y10/Hnet2)+(1/(Tm-T0))))+T0//peak temperature in  C
Y1=[y y2 y3 y4 y5 y6 y7 y8 y9 y10]
Y2=[y y2 y3 y4 y5 y6 y7 y8 y9]
TP1=[Tp Tp2 Tp3 Tp4 Tp5 Tp6 Tp7 Tp8 Tp9 Tp10]
TP2=[Tp11 Tp12 Tp13 Tp14 Tp15 Tp16 Tp17 Tp18 Tp19]
plot(Y1,TP1,'r')
plot(Y2,TP2,'g')
y0=0
Y0=[y0 y2 y3 y4 y5 y6 y7 y8 y9 y10]
TP3=[768.3 768.3 768.3 768.3 768.3 768.3 768.3 768.3 768.3 768.3]
//above TP3 ---> transformation zone
TP4=[432 432 432 432 432 432 432 432 432 432]
//TP3 to TP4 ---> over-tempered zone
plot(Y0,TP3,'k--')
plot(Y0,TP4,'k--')
xlabel('Distance from fusion boundary, mm')
ylabel('Peak temperature,  C ')
title('Peak temperatures reached in the base metal as varied by the welding speed')
legend("7 mm/s","8 mm/s")
```

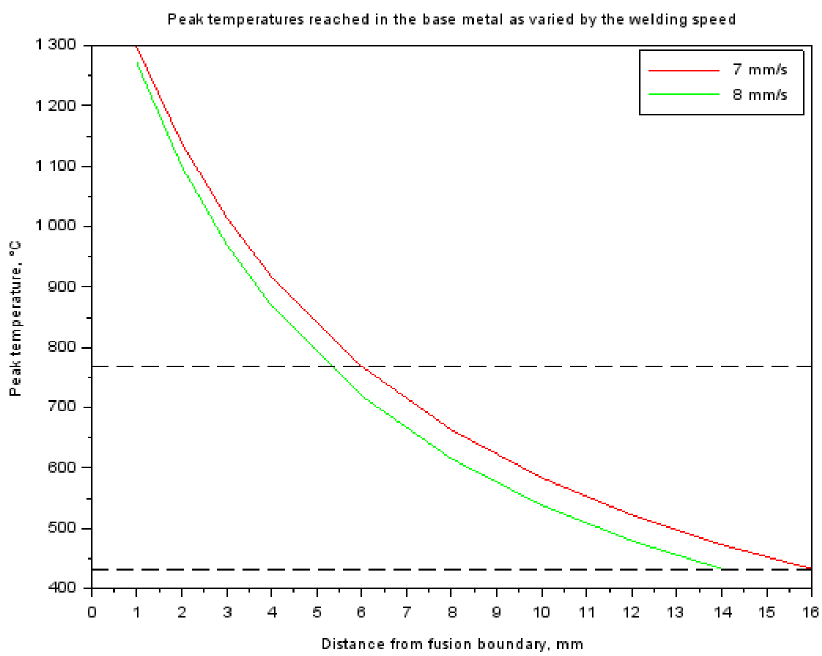

Figure 9.1: Calculate the heat affected zone