

Ma, Xiaoli (2004) Investigation of novel thermoelectric refrigeration systems. PhD thesis, University of Nottingham.

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program main
real le,lc,la,lp,leff,mf,keff,kl,mfl,mv,qc

write(*,*)'1-parameter input'
data gama,rn/1.33,2.54e-7/

write(*,*)'please input working temperature t'
read(*,*)t

write(*,*)'please input code number of working liquid'
read(*,*)cl
if(cl.eq.1) then
write(*,*)'water as the working liquid'
rrv=462
else if(cl.eq.2) then
write(*,*)'n-pentane as the working liquid'
rrv=115.2
goto 1
else if(cl.eq.3) then
write(*,*)'HFE-7100 as the working fluid'
rrv=31.5
goto 2
end if

if(t.gt.300) stop
if(t.ge.60.and.t.le.80) then
hfg=2509e3-2.5e3*T
rol=1016-0.55*T
rov=0.008*T-0.35
keff=0.008*t-0.35
rmu=0.8e-3-0.0055e-3*t
rmuv=0.004e-5*t+0.87e-5
pv=0.0135e5*t-0.61e5
cpl=0.0008*t+4.131
cpv=0.002*t+1.79
delt=-0.018e-2*t+7.7e-2

else if(t.gt.80.and.t.le.100) then
hfg=2513e3-2.55e3*T
rol=1028-0.7*T
rov=0.0155*T-0.95
keff=0.0009*T+0.592
rmu=0.8e-3-0.0055e-3*t
rmuv=0.0035e-5*t+0.91e-5
pv=0.027e5*t-1.69e5
cpl=0.0008*t+4.131
cpv=0.003*t+1.71
delt=-0.0185e-2*t+7.74e-2

else if(t.gt.100.and.T.le.120) then
hfg=2548e3-2.9e3*T
rol=1023-0.65*T
rov=0.026*T-2
keff=0.0001*T+0.67

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rmu=0.53e-3-0.0025e-3*t
rmuv=0.0035e-5*t+0.92e-5
pv=0.0505e5*t-4.04e5
cpl=0.0008*t+4.131
cpv=0.004*t+1.61
delt=-0.0195e-2*t+7.84e-2

else if(t.gt.120.and.T.le.140) then
hfg=2566e3-3.05e3*T
rol=1047-0.85*T
rov=0.0435*T-4.1
keff=0.0001*T+0.67
rmu=0.41e-3-0.0015e-3*t
rmuv=0.0035e-5*t+0.92e-5
pv=0.094e5*t-9.26e5
cpl=0.0008*t+4.131
cpv=0.006*t+1.37
delt=-0.022e-2*t+8.14e-2

else if(t.gt.140.and.T.le.160) then
hfg=2566e3-3.05e3*T
rol=1061-0.95*T
rov=0.064*T-6.97
keff=-0.0002*T+0.711
rmu=0.41e-3-0.0015e-3*t
rmuv=0.0035e-5*t+0.92e-5
pv=0.127e5*t-13.88e5
cpl=0.0008*t+4.131
cpv=0.0085*t+1.02
delt=-0.02e-2*t+7.86e-2

else if(t.gt.160.and.T.le.180) then
hfg=2642e3-3.55e3*T
rol=1077-1.05*T
rov=0.0945*T-11.85
keff=-0.0005*T+0.759
rmu=0.33e-3-0.001e-3*t
rmuv=0.004e-5*t+0.85e-5
pv=0.18e5*t-22.36e5
cpl=0.0008*t+4.131
cpv=0.012*t+0.46
delt=-0.0185e-2*t+7.86e-2

else if(t.gt.180.and.t.le.300) then
hfg=2327e3-1.8e3*T
rol=1095-1.15*T
rov=0.1355*T-19.23
keff=-0.0005*T+0.759
rmu=0.24e-3-0.0005e-3*t
rmuv=(17.073+0.0373*(t-240))*1e-6
pv=0.3075e5*t-45.31e5
cpl=0.0008*t+4.131
cpv=0.0145*t+0.01
delt=-0.02e-2*t+7.89e-2

else
end if
goto 3

```

1

```
if(t.gt.300) stop
if(t.ge.-20.and.t.le.-10) then
hfg=1000*(398.5+(390.7-398.5)*(t+20)/10)
rol=659.476+(649.970-659.476)*(t+20)/10
rov=0.313+(0.511-0.313)*(t+20)/10
keff=0.0009*t+0.592
kl=0.143-0.0003*t
rmu=0.283e-3-0.00305e-3*t
rmuv=0.001e-5*t+0.53e-5
pv=10000*(0.907+(1.533-0.907)*(t+20)/10)
delt=-0.011e-2*t+1.79e-2
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```
else if(t.gt.-10.and.t.le.0) then
hfg=1000*(390.7+(380.7-390.7)*(t+10)/10)
rol=649.970+(640.541-649.970)*(t+10)/10
rov=0.511+(0.798-0.511)*(t+10)/10
keff=0.0009*t+0.592
kl=0.143-0.0003*t
rmu=0.283e-3-0.00305e-3*t
rmuv=0.001e-5*t+0.53e-5
pv=10000*(1.533+(2.471-1.533)*(t+10)/10)
delt=-0.011e-2*t+1.79e-2
```

```
else if (t.gt.0.and.t.le.10)then
hfg=1000*(380.7+(374.7-380.7)*t/10)
rol=640.541+(631.144-640.541)*t/10
rov=0.798+(1.198-0.798)*t/10
keff=0.0009*t+0.592
kl=0.143-0.00025*t
rmu=0.283e-3-0.00205e-3*t
rmuv=0.0025e-5*t+0.53e-5
pv=10000*(2.471+(3.824-2.471)*t/10)
delt=-0.0105e-2*t+1.79e-2
```

```
else if (t.gt.10.and.t.le.20)then
hfg=1000*(374.7+(368.5-374.7)*(t-10)/10)
rol=631.144+(621.7-631.144)*(t-10)/10
rov=1.198+(1.741-1.198)*(t-10)/10
keff=0.0009*t+0.592
kl=0.143-0.00025*t
rmu=0.283e-3-0.00205e-3*t
rmuv=0.0025e-5*t+0.53e-5
pv=10000*(3.824+(5.708-3.824)*(t-10)/10)
delt=-0.0105e-2*t+1.79e-2
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else if(t.gt.20.and.t.le.30) then
hfg=1000*(368.5-.82*(t-20))
rol=621.7+(612.286-621.7)*(t-20)/10
rov=1.741+(2.45789-1.741)*(t-20)/10
keff=0.0009*t+0.592
kl=-0.00025*t+0.143
rmu=0.284e-3-0.0021e-3*t
rmuv=0.0025e-5*t+0.53e-5
pv=10000*(5.708+(8.259-5.708)*(t-20)/10)
cpl=2.36565+(2.37762-2.36565)*(t-20)/10
cpv=1.67377+(1.72415-1.67377)*(t-20)/10
delt=-0.0105e-2*t+1.79e-2
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else if(t.gt.30.and.t.le.40) then
hfg=1000*(360.3+(352-360.3)*(t-30)/10)
rol=612.266+(602.69-612.266)*(t-30)/10
rov=2.45789+(2.89318-2.45789)*(t-30)/10
keff=0.0001*T+0.67
kl=-0.00025*t+0.143
rmu=0.284e-3-0.0021e-3*t
rmuv=0.0025e-5*t+0.53e-5
pv=10000*(8.259+(11.6-8.259)*(t-30)/10)
cpl=2.37762+(2.397-2.37762)*(t-30)/10
cpv=1.72415+(1.77749-1.72415)*(t-30)/10
delt=-0.0105e-2*t+1.79e-2

else if(t.gt.40.and.T.le.50) then
hfg=1000*(352+(343.7-352)*(t-40)/10)
rol=602.69+(592.957-602.69)*(t-40)/10
rov=3.38605+(4.56589-3.38605)*(t-40)/10
keff=0.0001*T+0.67
kl=-0.00025*t+0.143
rmu=0.252e-3-0.0021e-3*t
rmuv=0.003e-5*t+0.51e-5
pv=10000*(11.6+(15.97-11.6)*(t-40)/10)
cpl=2.397+(2.42456-2.397)*(t-40)/10
cpv=1.77749+(1.83381-1.77749)*(t-40)/10
delt=-0.01e-2*t+1.77e-2

else if(t.gt.50.and.T.le.60) then
hfg=1000*(343.7+(335.1-343.7)*(t-50)/10)
rol=592.957+(583.009-592.957)*(t-50)/10
rov=4.56589+(6.04367-4.56589)*(t-50)/10
keff=-0.0002*T+0.711
kl=-0.00025*t+0.143
rmu=0.252e-3-0.0021e-3*t
rmuv=0.003e-5*t+0.51e-5
pv=10000*(15.97+(21.475-15.97)*(t-50)/10)
cpl=2.42456+(2.45864-2.42456)*(t-50)/10
cpv=1.83381+(1.89318-1.83381)*(t-50)/10
delt=-0.01e-2*t+1.77e-2

else if(t.gt.60.and.T.le.70) then
hfg=1000*(335.1+(326.3-335.1)*(t-60)/10)
rol=583.009+(572.783-583.009)*(t-60)/10
rov=6.04367+(7.8725-6.04367)*(t-60)/10
keff=-0.0005*T+0.759
kl=-0.00005*t+0.131
rmu=0.255e-3-0.00135e-3*t
rmuv=0.0025e-5*t+0.54e-5
pv=10000*(21.475+(28.325-21.475)*(t-60)/10)
cpl=2.45864+(2.49957-2.45864)*(t-60)/10
cpv=1.89318+(1.95581-1.89318)*(t-60)/10
delt=-0.01e-2*t+1.77e-2

else if(t.gt.70.and.T.le.80) then
hfg=1000*(326.3+(317.1-326.3)*(t-70)/10)
rol=572.783+(562.21-572.783)*(t-70)/10
rov=7.8725+(10.1143-7.8725)*(t-70)/10
keff=-0.0005*T+0.759

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```

kl=-0.00005*t+0.131
rmu=0.255e-3-0.00135e-3*t
rmuv=0.0025e-5*t+0.54e-5
pv=10000*(28.325+(36.7-28.325)*(t-70)/10)
cpl=2.49957+(2.54754-2.49957)*(t-70)/10
cpv=1.95581+(2.02206-1.95581)*(t-80)/10
delt=-0.01e-2*t+1.77e-2

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```

else if(t.gt.80.and.t.le.90) then
hfg=1000*(317.1+(307.3-317.1)*(t-80)/10)
rol=562.21+(551.191-562.29)*(t-80)/10
rov=10.1143+(12.8425-10.1143)*(t-80)/10
keff=-0.0005*T+0.759
kl=-0.00015*t+0.139
rmu=0.223e-3-0.00095e-3*t
rmuv=0.0035e-5*t+0.46e-5
pv=10000*(36.7+(46.9-36.7)*(t-80)/10)
cpl=2.54754+(2.60308-2.54754)*(t-80)/10
cpv=2.02206+(2.09252-2.02206)*(t-80)/10
delt=-0.007e-2*t+1.53e-2

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```

else if(t.gt.90.and.t.le.100) then
hfg=1000*(307.3+(297-307.3)*(t-90)/10)
rol=551.191+(539.628-551.191)*(t-90)/10
rov=12.8425+(16.1469-12.8425)*(t-90)/10
keff=-0.0005*T+0.759
kl=-0.00015*t+0.139
rmu=0.223e-3-0.00095e-3*t
rmuv=0.0035e-5*t+0.46e-5
pv=10000*(46.9+(59.06-46.9)*(t-90)/10)
cpl=2.60308+(2.667-2.60308)*(t-90)/10
cpv=2.09252+(2.168-2.09252)*(t-90)/10
delt=-0.007e-2*t+1.53e-2

```

```

else if(t.gt.100.and.t.le.110) then
hfg=1000*(297+(285.9-297)*(t-100)/10)
rol=539.628+(527.379-539.628)*(t-100)/10
rov=16.1469+(20.1394-16.1469)*(t-100)/10
keff=-0.0005*T+0.759
kl=-0.0001*t+0.134
rmu=0.168e-3-0.0004e-3*t
rmuv=0.0045e-5*t+0.36e-5
pv=10000*(59.06+(73.475-59.06)*(t-100)/10)
cpl=2.667+(2.74199-2.667)*(t-100)/10
cpv=2.168+(2.25049-2.168)*(t-100)/10
delt=-0.0075e-2*t+1.58e-2

```

```

else
end if
goto 3

```

```

2 if(t.gt.300) stop
if(t.ge.-20.and.t.le.-10) then
hfg=-260*t+131700
rol=-2.45*t+1539.3
rov=0.024*t+0.79
keff=0.0009*t+0.592
kl=-0.00019548*t+0.073714

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rmu=-0.01973e-3*t+0.791037e-3
rmuv=rmu/rov
pv=1.0e5*(0.00225*t+0.071)
delt=0.19e-4*(789.7+(774-789.7)*(t+20)/10)

else if(t.gt.-10.and.t.le.0) then
hfg=-220*t+132100
rol=-2.74*t+1536.4
rov=0.0385*t+0.935
keff=0.0009*t+0.592
kl=-0.00019548*t+0.073714
rmu=-0.01526e-3*t+0.83573e-3
rmuv=rmu/rov
pv=1.0e5*(0.0036*t+0.0845)
delt=0.19e-4*(774+(758.3-774)*(t+10)/10)

else if(t.gt.0.and.t.le.10) then
hfg=-430*t+132100
rol=-2.65*t+1536.4
rov=0.0575*t+0.935
keff=0.0009*t+0.592
kl=-0.00019548*t+0.073714
rmu=-0.01202e-3*t+0.83573e-3
rmuv=rmu/rov
pv=1.0e5*(0.0056*t+0.0845)
delt=0.19e-4*(758.3+(742.6-758.3)*t/10)

else if(t.gt.10.and.t.le.20) then
hfg=-300*t+130800
rol=-2.76*t+1537.5
rov=0.0815*t+0.695
keff=0.0009*t+0.592
kl=-0.00019548*t+0.073714
rmu=-0.0096e-3*t+0.811548e-3
rmuv=rmu/rov
pv=1.0e5*(0.00825*t+0.058)
delt=0.19e-4*(742.6+(726.9-742.6)*(t-10)/10)

else if(t.gt.20.and.t.le.30) then
hfg=-300*t+130800
rol=-2.77*t+1537.7
rov=0.112*t+0.085
keff=0.0009*t+0.592
kl=-0.00019548*t+0.073714
rmu=-0.00776e-3*t+0.774746e-3
rmuv=rmu/rov
pv=1.0e5*(0.01175*t-0.012)
cpl=2*t+1133
cpv=0.7*cpl
delt=0.19e-4*(726.9+(712.2-726.9)*(t-20)/10)

else if(t.gt.30.and.t.le.40) then
hfg=-370*t+132900
rol=-2.63*t+1533.5
rov=0.153*t-1.145
keff=0.0001*t+0.63
kl=-0.00019548*t+0.073714
rmu=-0.00634e-3*t+0.732059e-3

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rmuv=rmu/rov
pv=1.0e5*(0.01615*t-0.144)
cpl=2*t+1133
cpv=0.7*cpl
delt=0.19e-4*(712.2+(696.5-712.2)*(t-30)/10)

else if(t.gt.40.and.T.le.50) then
hfg=-290*t+129700
rol=-2.79*t+1539.9
rov=0.201*t-3.065
keff=0.0001*T+0.65
kl=-0.00019548*t+0.073714
rmu=-0.00522e-3*t+0.687495e-3
rmuv=rmu/rov
pv=1.0e5*(0.0217*t-0.4)
cpl=2*t+1133
cpv=0.7*cpl
delt=0.19e-4*(696.5+(678.9-696.5)*(t-40)/10)

else if(t.gt.50.and.T.le.60) then
hfg=-350*t+132700
rol=-2.66*t+1533.4
rov=0.2595*t-5.99
keff=-0.0002*T+0.69
kl=-0.00019548*t+0.073714
rmu=-0.00434e-3*t+0.643415e-3
rmuv=rmu/rov
pv=1.0e5*(0.02845*t-0.7835)
cpl=2*t+1133
cpv=0.7*cpl
delt=0.19e-4*(676.9+(662.2-676.9)*(t-50)/10)

else if(t.gt.60.and.T.le.110) then
hfg=-340*t+132100
rol=-3.1*t+1559.8
rov=0.3315*t-10.31
keff=-0.0005*T+0.759
kl=-0.00019548*t+0.073714
rmu=-0.00364e-3*t+0.601193e-3
rmuv=rmu/rov
pv=1.0e5*(0.0336*t-1.1925)
cpl=2*t+1133
cpv=0.7*cpl
delt=0.19e-4*(662.2+(643.5-662.2)*(t-60)/10)

else
end if

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3 write(*,*)'please input inclination fei'
read(*,*)fei
write(*,*)'please input liquid level in the length of panel h'
read(*,*)h
write(*,*)'please input length of evaporation section le'
read(*,*)le
write(*,*)'please input length of adiabatic section la'

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read(*,*)la
write(*,*)'please input length of condensation section lc'
read(*,*)lc
pi=3.1415926
g=9.8

write(*,*)'please input the type of heat pipe geometry'
read(*,*)hpg
if(hpg.eq.1) then
  write(*,*)'circular heat pipe'
  ceg=1
  write(*,*)'please input the inner diameter of the heat pipe'
  read(*,*)di

else if(hpg.eq.2) then
  write(*,*)'parallelepiped heat pipe'
  write(*,*)'please input the length and the height of the geo'
  read(*,*)a,b
  ceg=0.656
  di=sqrt(2*a*b/pi)

else if(hpg.eq.3) then
  write(*,*)'rectangular heat pipe'
  ceg=0.883
  write(*,*)'please input the length and the height of the geo'
  read(*,*)a1,b1
  di=sqrt(4*a1*b1/pi)
else
end if

atot=pi*di**2/4

write(*,*)'please input code of the wick structure'
read(*,*)struc
if(struc.eq.1) then

  write(*,*)'3 layers net mesh structure'
  write(*,*)'please input thickness of the wick, thmass, m'
  read(*,*) thmass
  write(*,*)'please input number of holes, rnn'
  read(*,*) rnn
  write(*,*)'please input diameter of the mesh, dmass'
  read(*,*) dmass
  else if(struc.eq.2) then
  write(*,*)'gravitational pipe'
  else
  end if

mf=h*atot*rol

write(*,*)'calculation of dry out limit qdm'
qdm=(0.8*lc+la+0.8*le)**(-3)*hfg*g*mf**3/(3*rmu*rol*pi**2*di**2)

qc=0
do 5 m=1,5000
qmax=qdm
qc=qc+1

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mf1=(0.8*lc+la+0.8*(le-h))*((3*rmu*rol*pi**2*di**2*qc*(le-
h))/(hfg*g)**(1./3)
hrr=le+lc+la-h
if(struc.eq.1) then
av=pi*(di-2*thmass)**2/4
al=atot-av
else if(struc.eq.2) then
al=(mf1/hrr-rov*atot)/(rol-rov)
av=atot-al
else
end if

if(al.ge.atot) goto 10

rv=sqrt(av/pi)
ri=di/2
leff=0.5*(le-h)+0.5*la+0.5*lc

write(*,*)'calculation of sonic transmission limit qsm'
qsm=av*rov*hfg*(gama*rrv*(t+273)/(2*(gama+1)))**0.5
qsm=qsm*ceg
if((qmax-qsm).gt.0) qmax=qsm

write(*,*)'calculation of entrainment limit qem'
if(struc.eq.1) then
rhs=1/(2*rnn)-dmass/2
qem=av*hfg*(rov*delt/(2*rhs))**0.5
else if(struc.eq.2) then
cofei=(fe/180+sqrt(sin(2*fe/pi/180)))**0.65

qem1=0.725**2*pi*di**2.5/4*(hfg*sqrt(g*rov*(rol-
rov)))/((1+(rov/rol)**0.25)**2)
qem=cofei*qem1
else
end if
qem=qem*ceg
if((qmax-qem).gt.0) qmax=qem

write(*,*)'calculation of boiling limit qbm'
x=log(ri/rv)
if(x.le.0) then
x=1.e-30
else
end if

if(struc.eq.1) then
rce=1/(2*rnn)
dpcm=2*delt/rce
qbm=(2*pi*leff*keff*(t+273))/(hfg*rov*x)*(2*delt/rn-dpcm)
else if(struc.eq.2) then
qbm=(2*pi*leff*k1*(t+273))/(hfg*rov*x)*(2*delt/rn)
else
end if
qbm=qbm*ceg
if((qmax-qbm).gt.0) qmax=qbm

write(*,*)'calculation of viscous limit qvm'
qvm=rv**2*hfg*rov*pv*av/(16*rmuv*leff)

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qvm=qvm*ceg
if((qmax-qvm).gt.0) qmax=qvm

write(*,*)'3-capillary limit calculation'
if(struc.eq.1) then
dpc=2*delt/rce
else if(struc.eq.2) then
dpc=0
else
end if

write(*,*)'4-radial gravity difference calculation'
Dv=2*rv
dpgr=-rol*g*dv*cos(fei*pi/180)
write(*,*)'dpgr=',dpgr

write(*,*)'5-axial gravity difference calculation'
if(struc.eq.1) then
lp=lc+la*sin(30*pi/180)
else if(struc.eq.2) then
lp=le-h+lc+la*sin(30*pi/180)
else
end if
dpga=-rol*g*lp*sin(fei*pi/180)
write(*,*)'dpga=',dpga

dpc=dpc-dpgr-dpga

write(*,*)'6-liquid phase pressure difference calculation'
if(struc.eq.1) then
s=1.05
eps11=1-pi*s*rnn*dmass/4
rk=dmass**2*eps11**3/(122*(1-eps11)**2)
dpl=(rmu/(rk*al*hfg*rol))*0.5*(le-h)*qc
else if(struc.eq.2) then
dpl=(rmu/(al*hfg*rol))*leff*qc
else
end if
write(*,*)'dpl=',dpl

write(*,*)'7-vapour phase pressure difference calculation'
if(hpg.eq.1) then
rhv=rv
else if(hpg.eq.2) then
rhv=2*a*b/(4*sqrt(a**2+b**2))
else if(hpg.eq.3) then
rhv=a1*b1/(a1+b1)
else
end if

Rev=2*rhv*qc/(av*rmuv*hfg)
write(*,*)'rev=',rev
mv=qc/(av*rov*hfg*(rrv*(t+273)*gama)**0.5)
write(*,*)'mv=',mv
c10=(1+((gama-1)/2)*mv**2)**0.5
c20=(2*rhv*qc/(av*hfg*rmuv))**0.75
if(rev.le.2300.and.mv.le.0.2) then
frv=16

```

```

c=1.0
else if (rev.le.2300.and.mv.gt.0.2) then
frv=16
c1=(1+((gama-1)/2)*mv**2)**0.5
c=c1
else if (rev.gt.2300.and.mv.le.0.2) then
frv=0.038
c2=(2*gama*qc/(av*hfg*rmuv))**0.75
c=c2
else if (rev.gt.2300.and.mv.gt.0.2) then
frv=0.038
c=c1*c2
else
end if
write(*,*) 'c=',c, 'frv=',frv, 'rmuv=',rmuv
write(*,*) 'leff=',leff, 'qc=',qc, 'rov=',rov, 'hfg=',hfg

dpv=c*frv*rmuv*leff*qc/(2*rhv**2*av*rov*hfg)

write(*,*) 'dpv=',dpv

dpr=dpv+dpl
write(*,*) 'dpv=',dpv, 'dpl=',dpl, 'dpga=',dpga, 'dpgr=',dpgr
write(*,*) 'dpc=',dpc, 'dpr=',dpr
if((dpc-dpr).le.0) then
  qcapi=qc
  qlim=qc
  if((qmax-qlim).gt.0) qmax=qlim
  ncir=m
  qx=qmax
  qdmx=qdm
  qsmx=qsm
  qemx=qem
  qbm x=qbm
  qvmx=qvm
  qcap=qc

goto 10
else if((dpc-dpr).gt.0) then
  ncir=m
  qx=qmax
  qdmx=qdm
  qsmx=qsm
  qemx=qem
  qbm x=qbm
  qvmx=qvm
  qcap=qc
  else
  end if
  if((qc-qmax).ge.0) then
    qmax=qc
    goto 10
  else
  end if
5 continue

10 if(hpg.eq.1) then
write(*,11)di

```

```

11  format(1x,'pipe diameter di=',e11.5)
    else if(hpg.eq.2) then
        write(*,12)a,b
12  format(1x,'parallelpiped a=',e11.5,'b=',e11.5)
    else if(hpg.eq.3) then
        write(*,14)a1,b1
14  format(1x,'rectacular pipe a1=',e11.5,'b1=',e11.5)
    else
        end if

    if(struc.eq.1) then
        write(*,*)'wicked structure'
    else if(struc.eq.2) then
        write(*,*)'wickless structure'
    else
        end if
        write(*,*)'ncir=',ncir,'dpc=',dpc,'dpr=',dpr
        write(*,*)'maximum dry out limit qdm=',qdmx
        write(*,*)'sonic limit qsm=',qsmx
        write(*,*)'entrainment limit qem=',qemx
        write(*,*)'boiling limit qbm=',qbm
        write(*,*)'viscous limit qvm=',qvmx
        write(*,*)'capillary limit qcapi=',qcap
        write(*,*)'maximum heat transfer limit qmin=',qmax
        write(*,*)'renolds number rev=',rev
        write(*,*)'dpv=',dpv,'dpl=',dpl,'dpga=',dpga,'dpgr=',dpgr
        write(*,*)'dpc=',dpc,'dpr=',dpr
        write(*,*)'dpl=',dpl
        write(*,*)'dpv=',dpv

70  write(*,75)t
75  format(5x,'working temperat.=',11x,f11.2,1x,'oC')
    write(*,76)le
76  format(5x,'length of evap section=',5x,f11.5,2x,'m')
    write(*,77)lc
77  format(5x,'length of cond section=',5x,f11.5,2x,'m')
    write(*,78)h
78  format(5x,'liquid fill level=',11x,f11.2,1x,'m')
    write(*,79)fei
79  format(5x,'inclination angle=',11x,f11.2,1x,'deg')
    write(*,80)di
80  format(5x,'mini pipe diameter di=',16x,e11.5,2x,'m')
    write(*,82)qmax
82  format(5x,'max heat trans cap. qmin=',4x,f11.5,3x,'w')

    stop
    end

```