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7

Apêndice

Nesse capítulo o algoritmo utilizado no processo de otimização é apresentado.

1) Shoulder fillet with quarter-circle arc fillet subject to uniaxial tension loading (figura 3.15):

```

k,N+3,L,d/2
k,N+4,L,0

/psmacro
finish
/clear,start

/filn,teste

/psprep7

! Geometry input
multipro,'start',7
*cset,1,3,H,'Shoulder Major Height',80
*cset,4,6,d,'Shoulder Minor Height',60
*cset,7,9,L,'Shoulder Length',110
*cset,10,12,T,'Shoulder Thickness',2
*cset,13,15,L1,'Shoulder Length',50
*cset,16,18,Rad,'Fillet radius',10
*cset,19,21,N,'Number of control point',30
*cset,61,63,'Enter with the',' parameters shown below'
multipro,'end'

! FEM input
multipro,'start',6
*cset,1,3,etype,'Element Type',82
*cset,4,6,e_size,'Element Size',2
*cset,7,9,E,'Elasticity Modulus',200e3
*cset,10,12,nu,'Poissons Ratio',0.3
*cset,13,15,Level,'Enter refinement level (1-5)',3
*cset,16,18,Depth,'Enter depth mesh refinement',1
*cset,61,63,'Enter with the',' parameters shown below'
multipro,'end'

! Defining spline control points position
pi=3.14159265359
teta=0
pitch=(90*pi/180)/(N-1)

*do,fall,1,N
x1=Rad*cos(teta)
y2=Rad*sin(teta)
k,fall,(L1+Rad)-x1,((d/2)+Rad)-y2
teta=teta+pitch
*enddo

! DRAWING B-SPLINE
FLST,3,N,3
*DO,FIT,1,N
FITEM,3,FIT
*ENDDO
BSPLIN,,P51X

! Defining keypoints
k,N+1,0,0
k,N+2,0,H/2

! Creating lines
L,N,N+3
L,N+3,N+4
L,N+4,N+1
L,N+1,N+2
L,N+2,1

! Creating areas from boundary lines
AL,ALL

! Element properties
ET,1,ETYPE
KEYOPT,1,3,3
R,1,T
MP,EX,1,E
MP,NUXY,1,NU

! Meshing
SMRTSIZE,4
ESIZE,E_SIZE
MSHAPE,1,2D
MSHKEY,0
AMESH,ALL

! Fillet refinement
LRFINE,1,2,,Level,Depth,smooth,off
FINISH

multipro,'start',1
*cset,1,3,S,'Applied stress',1
*cset,61,63,'Enter with the',' value of the parameters
shown below'
multipro,'end'

! Solving model
/SOL
ANTYPE,0
DL,5,,UX
DL,4,,SYMM
!D,Origen,ALL
SFL,3,PRES,-S
SOLVE
FINISH

/POST1
/dscale,1,off
PLNSOL,S,EQV
FINISH

*ask,Factor,'Enter with scaling factor',0.2
*ask,Question,'Tolerance (1) / Iterations (2)',2

*if,Question,EQ,1,then

```

```

*ask,Tolerance,'Enter with tolerance',0,5
*else
*ask,Iteracoes,'Entre com o numero de iteracoes',10
*endif

initial=2
final=N-1

Stopper=1

/prep7
Contador=0
Contador2=0
*DIM,TABELA, TABLE, 1000,3
*dowhile,Stopper
*do,lok,initial,final
LocationX=KX(LOK)
LocationY=KY(LOK)
nse1,s,s,eqv
Location=NODE(LocationX,LocationY,0)
*if,lok,eq,final,then
xx1=KX(lok)
xx2=KX(N)
yy1=KY(lok)
yy2=KY(N)
*else
xx1=KX(lok)
xx2=KX(lok+1)
yy1=KY(lok)
yy2=KY(lok+1)
*endif
Positionx=KX(N)
Positiony=KY(N)
Position=NODE(Positionx,Positiony,0)
*get,vonmises,NODE,Location,S,EQV
*get,Ref,NODE,Position,S,EQV
dist=((vonmises-Ref)/Ref)*Factor
nse1,s,node,,all

/prep7
*if,xx1,eq,xx2,then
KMODIF,lok,xx1,yy1
*else
deltax=xx2-xx1
deltay=yy1-yy2
alfa=atan(deltay/deltax)
beta=(pi/2)-alfa

xxx=dist*cos(beta)
yyy=dist*sin(beta)

KMODIF,lok,xx1+xxx,yy1+yyy
finish
*endif
*enddo

/PREP7

*do,Moving,initial,(final-1)
Movex=KX(Moving)
Movey=KY(Moving)
*if,Movex,LT,L1,then
KMODIF,Moving,L1,KY(Moving)
*endif
*if,Movey,LT,((H-d)/2),then
KMODIF,Moving,KX(Moving),((H-d)/2)
*endif
*enddo

DDELE,ALL,ALL
SFLDELE,LINE,ALL
ACLEAR,ALL,ALL
ADELE,ALL
LDELE,1

! DRAWING B-SPLINE
FLST,3,N,3
*DO,FIT,1,N
FITEM,3,FIT
*ENDDO
BSPLIN,,P51X

! Creating areas from boundary lines
AL,ALL
AMESH,ALL

! Fillet refinement
LREFINE,1,2,,Level,Depth,smooth,off
FINISH

/SOL
ANTYPE,0
DL,5,,UX
DL,4,,SYMM
SFL,3,PRES,-S
SOLVE
FINISH

/POST1
PLNSOL,S,EQV
lse1,s,line,,1
nsl,s,1
Point1=(rad+11)
Point2=L1*1.001
nse1,r,loc,x,Point1,Point2
nsort,s,eqv
*get,maximo,sort,0,max
*get,minimo,sort,0,min

RE=abs((maximo-minimo)/(maximo+minimo))
nse1,s,node,,all
lse1,s,line,,all

Contador=Contador+1

*if,Question,EQ,1,then
*if,RE,LE,Tolerance,then
Stopper=-1
*else
Stopper=1
*endif
*else
*if,Contador,EQ,Iteracoes,then
Stopper=-1
*else
Stopper=1
*endif
*endif

PLNSOL,S,EQV
nsort,s,eqv
*get,free,sort,0,max
*get,mute,sort,0,imax
Contador2=Contador2+1
TABELA(Contador2,1)=Contador
TABELA(Contador2,2)=free
TABELA(Contador2,3)=RE
finish

*enddo

/POST1
/dscale,1,off
PLNSOL,S,EQV

```



```
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!                                     !!!!
!!!! IMPROVING GEOMETRY !!!!!
!!!!                                     !!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
```

```
/prep7
DDELE,ALL,ALL
SFLDELE,LINE,ALL
ACLEAR,ALL,ALL
ADELE,ALL
LDELE,all
```

```
ksel,s,kp,,1,N
ksel,r,loc,x,0,L1
*get,need,kp,all,count
Universe=N-need+1
initial=need
ksel,s,kp,,all
```

```
! DRAWING B-SPLINE
FLST,3,Universe,3
*DO,FIT,need,N
FITEM,3,FIT
*ENDDO
BSPLIN,,P51X
```

```
! Creating lines
L,1,need
L,N,N+3
L,N+3,N+4
L,N+4,N+1
L,N+1,N+2
L,N+2,1
```

```
! Creating areas from boundary lines
AL,ALL
AMESH,ALL
```

```
! Fillet refinement
LREFINE,1,3,,Level,Depth,smooth,off
FINISH
```

```
/SOL
ANTYPE,0
DL,6,,UX
DL,5,,SYMM
SFL,4,PRES,-S
SOLVE
FINISH
/POST1
PLESOL,S,EQV
```

```
!!!!!! THE END !!!!!!!
```

2) Shoulder fillet with a 45° chamfer fillet subject to uniaxial tension loading (figura 3.22):

```
/pmacro
finish
/clear,start
```

```
/filn,teste
```

```
/prep7
! Geometry input
multipro,'start',7
*cset,1,3,H,'Shoulder Major Height',80
*cset,4,6,d,'Shoulder Minor Height',60
*cset,7,9,L,'Shoulder Length',110
*cset,10,12,T,'Shoulder Thickness',2
*cset,13,15,L1,'Shoulder Length',50
*cset,16,18,Rad,'Fillet radius',10
```

```
*cset,19,21,N,'Number of control point',30
*cset,61,63,'Enter with the',' parameters shown below'
multipro,'end'
```

```
! FEM input
multipro,'start',6
*cset,1,3,etype,'Element Type',82
*cset,4,6,e_size,'Element Size',2
*cset,7,9,E,'Elasticity Modulus',200e3
*cset,10,12,nu,'Poissons Ratio',0.3
*cset,13,15,Level,'Enter refinement level (1-5)',3
*cset,16,18,Depth,'Enter depth mesh refinement',1
*cset,61,63,'Enter with the',' parameters shown below'
multipro,'end'
```

```
! Defining spline control points position
teta=0
pi=3.14159265359
delta=0
```

```
Length=sqrt(2*(Rad*Rad))
Pitch=Length/N
```

```
*do,fall,1,N
x1=L1+delta
y2=((d/2)+Rad)-delta
k,fall,x1,y2
teta=teta+pitch
delta=cos(pi/4)*teta
*enddo
```

```
! DRAWING B-SPLINE
FLST,3,N,3
*DO,FIT,1,N
FITEM,3,FIT
*ENDDO
BSPLIN,,P51X
```

```
! Defining keypoints
k,N+1,0,0
k,N+2,0,H/2
k,N+3,L,d/2
k,N+4,L,0
```

```
! Creating lines
L,N,N+3
L,N+3,N+4
L,N+4,N+1
L,N+1,N+2
L,N+2,1
```

```
! Creating areas from boundary lines
AL,ALL
```

```
! Element properies
ET,1,ETYPE
KEYOPT,1,3,3
R,1,T
MP,EX,1,E
MP,NUXY,1,NU
```

```
! Meshing
SMRTSIZE,4
ESIZE,E_SIZE
MSHAPE,1,2D
MSHKEY,0
AMESH,ALL
```

```
! Fillet refinement
LREFINE,1,2,,Level,Depth,smooth,off
```

```
multipro,'start',1
*cset,1,3,S,'Applied tension',1
*cset,61,63,'Enter with the',' value of the parameters
shown below'
```

```

multipro,'end'
FINISH

! Solving model
/SOL
ANTYPE,0
DL,5,,UX
DL,4,,SYMM
SFL,3,PRES,-S
SOLVE
FINISH

! Viewing results
/POST1
/dscale,1,off
PLNSOL,S,EQV

*ask,Factor,'Enter with scaling factor',0.2
*ask,Question,'Tolerance (1) / Iterations (2)',2

*if,Question,EQ,1,then
*ask,Tolerance,'Enter with tolerance',0.5
*else
*ask,Iteracoes,'Entre com o numero de iteracoes',10
*endif

initial=2
final=N-1

Stopper=1

Contador=0
/prep7

Contador2=0

*DIM,Tabela,TABLE,Iteracoes,3
*dowhile,Stopper
*do,lok,initial,final
LocationX=KX(LOK)
LocationY=KY(LOK)
nse1,s,s,eqv
Location=NODE(LocationX,LocationY,0)
*if,lok,eq,final,then
xx1=KX(lok)
xx2=KX(N)
yy1=KY(lok)
yy2=KY(N)
*else
xx1=KX(lok)
xx2=KX(lok+1)
yy1=KY(lok)
yy2=KY(lok+1)
*endif

Positionx=KX(N)
Positiony=KY(N)
Position=NODE(Positionx,Positiony,0)
*get,vonmises,NODE,Location,S,EQV
*get,Ref,NODE,Position,S,EQV
dist=((vonmises-Ref)/Ref)*Factor
nse1,s,node,,all

/prep7
*if,xx1,eq,xx2,then
KMODIF,lok,xx1,yy1
*else
deltax=xx2-xx1
deltay=yy1-yy2
alfa=atan(deltay/deltax)
beta=(pi/2)-alfa

xxx=dist*cos(beta)
yyy=dist*sin(beta)

KMODIF,lok,xx1+xxx,yy1+yyy

finish
*endif
*enddo

/PREP7
*do,Moving,initial,(final-1)
MoveX=KX(Moving)
MoveY=KY(Moving)
*if,MoveX,LT,L1,then
KMODIF,Moving,L1,KY(Moving)
*endif
*if,MoveY,LT,((H-d)/2),then
KMODIF,Moving,KX(Moving),((H-d)/2)
*endif
*enddo

DDELE,ALL,ALL
SFLDELE,LINE,ALL
ACLEAR,ALL,ALL
ADELE,ALL
LDELE,1

! DRAWING B-SPLINE
FLST,3,N,3
*DO,FIT,1,N
FITEM,3,FIT
*ENDDO
BSPLIN,,P51X

! Creating areas from boundary lines
AL,ALL
AMESH,ALL

! Fillet refinement
LREFINE,1,2,,Level,Depth,smooth,off
FINISH

! Solving model
/SOL
ANTYPE,0
DL,5,,UX
DL,4,,SYMM
SFL,3,PRES,-S
SOLVE
FINISH

/POST1
PLNSOL,S,EQV
lse1,s,line,,1
nsl1,s,1
Point1=(rad+11)
Point2=L1*1.001
nse1,r,loc,x,Point1,Point2
nsort,s,eqv
*get,maximo,sort,0,max
*get,minimo,sort,0,min

RE=abs((maximo-minimo)/(maximo+minimo))
nse1,s,node,,all
lse1,s,line,,all

Contador=Contador+1

*if,Question,EQ,1,then
*if,RE,LE,Tolerance,then
Stopper=-1
*else
Stopper=1
*endif
*else
*if,Contador,EQ,Iteracoes,then
Stopper=-1
*else
Stopper=1
*endif
*endif

```

```

PLNSOL,S,EQV
nsort,s,eqv
*get,free,sort,0,max
*get,mute,sort,0,imax
Contador2=Contador2+1
Tabela(Contador2,1)=Contador
Tabela(Contador2,2)=free
Tabela(Contador2,3)=RE

*enddo

/POST1
/dscale,1,off
PLNSOL,S,EQV

!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
!!!!                                     !!!!
!!!! IMPROVING GEOMETRY !!!!
!!!!                                     !!!!
!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

/prep7
DDELE,ALL,ALL
SFLDELE,LINE,ALL
ACLEAR,ALL,ALL
ADELE,ALL
LDELE,all

ksel,s,kp,,1,N
ksel,r,loc,x,0,L1*1.001
*get,need,kp,all,count
Universe=N-need+1
initial=need
ksel,s,kp,,all

! DRAWING B-SPLINE
FLST,3,Universe,3
*DO,FIT,need,N
FITEM,3,FIT
*ENDDO
BSPLIN,,P51X

! Creating lines
L,1,need
L,N,N+3
L,N+3,N+4
L,N+4,N+1
L,N+1,N+2
L,N+2,1

! Creating areas from boundary lines
AL,ALL
AMESH,ALL

! Fillet refinement
LREFINE,1,2,,Level,Depth,smooth,off
FINISH

/SOL
ANTYPE,0
DL,6,,UX
DL,5,,SYMM
SFL,4,PRES,-S
SOLVE
FINISH

/POST1
PLESOL,S,EQV

!!!! THE END !!!!

```

3) Shoulder fillet with a Grodzinski fillet subject to uniaxial tension loading (figura 3.29):

```

/pmacro
finish
/clear,start

/filn,teste

/prep7

! Data input by user
multipro,'start',9
*cset,1,3,H,'Shoulder Major Height',80
*cset,4,6,d,'Shoulder Minor Height',60
*cset,7,9,L,'Shoulder Length',110
*cset,10,12,T,'Shoulder Thickness',2
*cset,13,15,L1,'Shoulder Length',50
*cset,16,18,etype,'Element Type',82
*cset,19,21,e_size,'Element Size',2
*cset,22,24,E,'Elasticity Modulus',200e3
*cset,25,27,nu,'Poissons Ratio',0.3
*cset,61,63,'Enter with the',' value of the parameters
shown below'
multipro,'end'

multipro,'start',3
*cset,1,3,R,'Vertical size',10
*cset,4,6,W,'Horizontal size',17.7
*cset,7,9,N,'Number of divisions',100
*cset,61,63,'Enter with the',' geometric parameters'
multipro,'end'

multipro,'start',2
*cset,1,3,Level,'Enter refinement level (1-5)',3
*cset,4,6,Depth,'Enter depth mesh refinement',1
*cset,61,63,'Define refinement','at radius fillet'
multipro,'end'

*set,vertical,(H-D)/2
*set,Pitch_R,R/N
*set,Pitch_W,W/N

! Horizontal
x1=-Pitch_W
y1=0
Count=0
*do,I,1,N+1
x1=x1+Pitch_W
k,I,x1,y1
Count=Count+1
*enddo

! Vertical
x2=0
y2=0
J=count
*do,J,Count+1,Count+N
y2=y2+Pitch_R
k,J,x2,y2
*enddo

xkp=1
ykp=(2*N)+2
*do,v,1,N
xkp=v+1
ykp=ykp-1
L,xkp,ykp
*enddo

*do,int,1,N-1
LSBL,int,int+1,,KEEP,KEEP
*enddo

```

```

LDELE,all

*DO,AA,1,N
KDELE,AA
*ENDDO

*DO,BB,N+2,2*N
KDELE,BB
*ENDDO

numcmp,kp

/PNUM,KP,1
GPLOT

! DRAWING B-SPLINE
FLST,3,N+1,3
FITEM,3,2
*DO,FIT,3,N+1
FITEM,3,FIT
*ENDDO
FITEM,3,1
BSPLIN,,P51X

*get,Counter,kp,0,count

LGEN,1,1,,L1,(d/2),0,0,1,1
KGEN,1,3,Counter,1,L1,(d/2),0,0,1,1

K,Counter+1,0,0
K,Counter+2,0,h/2
K,Counter+3,L,0
K,Counter+4,L,d/2

L,1,Counter+4
L,Counter+4,Counter+3
L,Counter+3,Counter+1
L,Counter+1,Counter+2
L,Counter+2,2
gplot

! Creating areas from boundary lines
AL,ALL

! Element properties
ET,1,ETYPE
KEYOPT,1,3,3
R,1,T
MP,EX,1,E
MP,NUXY,1,NU

! Meshing
SMRTSIZE,4
ESIZE,E_SIZE
MSHAPE,1,2D
MSHKEY,0
AMESH,ALL

! Fillet refinement
LREFINE,1,2,,Level,Depth,smooth,off
FINISH

multipro,'start',1
*cset,1,3,S,'Applied stress',1
*cset,61,63,'Enter with the',' value of the parameters
shown below'
multipro,'end'

/SOL
ANTYPE,0
DL,5,,UX
DL,4,,SYMM
SFL,3,PRES,-S
SOLVE
FINISH

/POST1
/dscale,1,off
PLESOL,S,EQV
FINISH

*ask,Factor,'Enter with scaling factor',0.2
*ask,Iteracoes,'Enter with the number of iterations',10

pi=3.14159265359
initial=3
final=N+1

Stopper=1

Contador=0
Contador2=0

/prep7

*DIM,Tabela,TABLE,Iteracoes,3
*dowhile,Stopper
*do,lok,initial,final
LocationX=KX(LOK)
LocationY=KY(LOK)
nsel,s,s,eqv
Location=NODE(LocationX,LocationY,0)
*if,lok,eq,final,then
xx1=KX(lok)
xx2=KX(1)
yy1=KY(lok)
yy2=KY(1)
*else
xx1=KX(lok)
xx2=KX(lok+1)
yy1=KY(lok)
yy2=KY(lok+1)
*endif
*get,vonmises,NODE,Location,S,EQV
*get,Ref,NODE,2,S,EQV
dist=((vonmises-Ref)/Ref)*Factor
nsel,s,node,,all
/prep7
*if,xx1,eq,xx2,then
KMODIF,lok,xx1,yy1
*else
deltax=xx2-xx1
deltay=yy1-yy2
alfa=atan(deltay/deltax)
beta=(pi/2)-alfa
xxx=dist*cos(beta)
yyy=dist*sin(beta)
KMODIF,lok,xx1+xxx,yy1+yyy
finish
*endif
*enddo

/PREP7

Glue=KX(3)
*if,Glue,LT,L1,then
KMODIF,3,L1,(KY(2)+KY(3)+KY(4))/3
*else
KMODIF,3,(KX(2)+KX(3)+KX(4))/3,(KY(2)+KY(3)+
KY(4))/3
*endif

KMODIF,FINAL,(KX(FINAL-
1)+KX(FINAL)+KX(1))/3,(KY(FINAL-
1)+KY(FINAL)+KY(1))/3

*do,Contador3,initial+1,final-1
Coordx=KX(Contador3)
Coordy=KY(Contador3)
KMODIF,Contador3,(KX(Contador3-
1)+KX(Contador3)+KX(Contador3+1))/3,(KY(Contado
r3-1)+KY(Contador3)+KY(Contador3+1))/3

```

```

PlocLu=KX(Contador3)
*if,PlocLu,LT,L1,then
KMODIF,Contador3,L1,(KY(Contador3-
1)+KY(Contador3)+KY(Contador3+1))/3
*endif
*enddo

! Smooth Last kpt
Smooth1=KY(N+1)
Smooth2=KY(1)
Smooth3=Smooth1-Smooth2

KMODIF,N+1,KX(N+1),(KY(1)+0.7*Smooth3)

DDELE,ALL,ALL
SFLDELE,LINE,ALL
ACLEAR,ALL,ALL
ADELE,ALL
LDELE,1

! DRAWING B-SPLINE
FLST,3,N+1,3
FITEM,3,2
*DO,FIT,3,N+1
FITEM,3,FIT
*ENDDO
FITEM,3,1
BSPLIN,,P51X

! Creating areas from boundary lines
AL,ALL
AMESH,ALL

! Fillet refinement
LREFINE,1,2,,Level,Depth,smooth,off
FINISH

/SOLU
ANTYPE,0
DL,5,,UX
DL,4,,SYMM
SFL,3,PRES,-S
SOLVE
FINISH

/POST1
lsel,s,line,,1
nsl,s,1
nsl,r,loc,x,(L1*1.001),(L1+W)
nsl,r,s,eqv
nsort,s,eqv
*get,maximo,sort,0,max
*get,minimo,sort,0,min
*get,curitiba,sort,0,imax
*get,fortaleza,sort,0,imin

RE=abs((maximo-minimo)/(maximo+minimo))
nsl,s,node,,all
lsel,s,line,,all

Contador=Contador+1

*if,Contador,EQ,Iteracoes,then
Stopper=-1
*else
Stopper=1
*endif

PLNSOL,S,EQV
nsort,s,eqv
*get,free,sort,0,max
*get,mute,sort,0,imax
Contador2=Contador+1
Tabela(Contador2,1)=Contador
Tabela(Contador2,2)=free

```

```

Tabela(Contador2,3)=RE
finish

*enddo

/POST1
/dscale,1,off
PLNSOL,S,EQV

```

4) Plate with a hole in a biaxial stress field – Geometry I (figure 3.xx):

```

/pmacro
finish
/clear,start

/filn,teste

/prep7

! Data input by user
multipro,'start',5
*cset,1,3,H,'Plate height',300
*cset,4,6,W,'Plate width',300
*cset,7,9,R,'Hole radius',40
*cset,10,12,t,'Plate Thickness',2
*cset,13,15,N,'Number of keypoints',30
*cset,61,63,'Enter with the',' parameters shown below'
multipro,'end'

multipro,'start',6
*cset,1,3,etype,'Element Type',82
*cset,4,6,e_size,'Element Size',4
*cset,7,9,E,'Elasticity Modulus',200e3
*cset,10,12,nu,'Poissons Ratio',0.3
*cset,13,15,Level,'Enter refinement level (1-5)',3
*cset,16,18,Depth,'Enter depth mesh refinement',1
*cset,61,63,'Enter with the',' parameters shown below'
multipro,'end'

pi=3.14159265
teta=0
pitch=(90*pi/180)/N

*do,fall,1,N+1
x1=r*cos(teta)
y2=r*sin(teta)
k,fall,((W/2)-x1),((H/2)-y2)
teta=teta+pitch
*enddo

! DRAWING B-SPLINE
FLST,3,N+1,3
*DO,FIT,1,N+1
FITEM,3,FIT
*ENDDO
BSPLIN,,P51X

L1=(W/2)-R

k,N+2,0,0
k,N+3,0,H/2
k,N+4,W/2,0

L,N+2,N+3
L,N+3,1
L,N+1,N+4
L,N+2,N+4

!! Creating areas from boundary lines
AL,ALL

! Element properties
ET,1,ETYP

```

```

KEYOPT,1,3,3
R,1,T
MP,EX,1,E
MP,NUXY,1,NU

! Meshing
SMRTSIZE,4
ESIZE,E_SIZE
MSHAPE,1,2D
MSHKEY,0
AMESH,ALL

! Fillet refinement
LREFINE,1,,,Level,Depth,smooth,off
FINISH

multipro,'start',2
*cset,1,3,Sx,'Applied pressure in the x direction',45
*cset,4,6,Sy,'Applied pressure in the y direction',22.5
*cset,61,63,'Enter with the,' value of the parameters
shown below'
multipro,'end'

/SOL
ANTYPE,0
DL,4,,UX
DL,4,,ROTY
DL,4,,ROTZ
DL,3,,UY
DL,3,,ROTX
DL,3,,ROTZ
SFL,2,PRES,-Sx
SFL,5,PRES,-Sy
SOLVE
FINISH

/POST1
/dscale,1,off
PLNSOL,S,EQV

*ask,Factor,'entre com o fator',0.2
*ask,Iteracoes,'Entre com o numero de iteracoes',10

initial=2
final=N
Stopper=1
Contador=0

/prep7

Contador2=0
*DIM,Tabela,TABLE,Iteracoes,3
*dowhile,Stopper
*do,lok,initial,final
LocationX=KX(LOK)
LocationY=KY(LOK)
nse1,s,s,eqv
Location=NODE(LocationX,LocationY,0)
*if,lok,eq,final,then
xx1=KX(lok)
xx2=KX(N+1)
yy1=KY(lok)
yy2=KY(N+1)
*else
xx1=KX(lok)
xx2=KX(lok+1)
yy1=KY(lok)
yy2=KY(lok+1)
*endif

/post1
Colax=KX(N+1)
Colay=KY(N+1)
Cola=NODE(Colax,Colay,0)
*get,vonmises,NODE,Location,S,EQV
*get,Ref,NODE,Cola,S,EQV

dist=((vonmises-Ref)/Ref)*Factor
nse1,s,node,,all

/prep7
*if,xx1,eq,xx2,then
KMODIF,lok,xx1,yy1
*else
deltax=xx2-xx1
deltay=yy1-yy2
alfa=atan(deltay/deltax)
beta=(pi/2)-alfa
xxx=dist*cos(beta)
yyy=dist*sin(beta)

KMODIF,lok,xx1+xxx,yy1+yyy
finish
*endif
*enddo

/PREP7

*do,Contador3,initial,final
PositionX=KX(Contador3)
PositionY=KY(Contador3)
*if,PositionX,LT,L1,then
KMODIF,Contador3,L1,(KY(Contador3-
1)+KY(Contador3)+KY(Contador3+1))/3
*endif
*if,PositionY,LT,((H/2)-R),then
KMODIF,Contador3,(KX(Contador3-
1)+KX(Contador3)+KX(Contador3+1))/3,((H/2)-R)
*endif
*enddo

DDELE,ALL,ALL
SFLDELE,LINE,ALL
ACLEAR,ALL,ALL
ADELE,ALL
LDELE,1

! DRAWING B-SPLINE
FLST,3,N+1,3
*DO,FIT,1,N+1
FITEM,3,FIT
*ENDDO
BSPLIN,,P51X

! Creating areas from boundary lines
AL,ALL
AMESH,ALL

! Fillet refinement
LREFINE,1,,,Level,Depth,smooth,off
FINISH

/SOL
ANTYPE,0
DL,4,,UX
DL,4,,ROTY
DL,4,,ROTZ
DL,3,,UY
DL,3,,ROTX
DL,3,,ROTZ
SFL,2,PRES,-Sx
SFL,5,PRES,-Sy
SOLVE
FINISH

/POST1
PLNSOL,S,EQV
lse1,s,line,,1
nsl1,s,1
nse1,r,loc,x,((W/2)-R)*1.001,(w/2)
nsort,s,eqv
*get,maximo,sort,0,max
*get,minimo,sort,0,min

```

```

*get,curitiba,sort,0,imax
*get,fortaleza,sort,0,imin

RE=abs((maximo-minimo)/(maximo+minimo))
nset,s,node,,all
lset,s,line,,all

Contador=Contador+1

*if,Contador,EQ,Iteracoes,then
Stopper=-1
*else
Stopper=1
*endif

PLNSOL,S,EQV
nsort,s,eqv
*get,free,sort,0,max
*get,mute,sort,0,imax
Contador2=Contador2+1
Tabela(Contador2,1)=Contador
Tabela(Contador2,2)=free/38.971
Tabela(Contador2,3)=RE
finish

*enddo

/POST1
/dscale,1,off
PLNSOL,S,EQV

5) Plate with a hole in a biaxial stress field – Geometry II (figure 3.xx)

/pmacro
finish
/clear,start

/filn,teste

/prep7

! Data input by user
multipro,'start',9
*cset,1,3,H,'Plate height',300
*cset,4,6,d,'Plate width',300
*cset,7,9,L,'Shoulder Length',100
*cset,10,12,t,'Plate Thickness',2
*cset,13,15,L1,'Shoulder Length',40
*cset,16,18,etype,'Element Type',82
*cset,19,21,e_size,'Element Size',5
*cset,22,24,E,'Elasticity Modulus',200e3
*cset,25,27,nu,'Poissons Ratio',0.3
*cset,61,63,'Enter with the',' value of the parameters
shown below'
multipro,'end'

multipro,'start',3
*cset,1,3,r,'Radius',40
*cset,4,6,W,'Horizontal size',17.7
*cset,7,9,N,'Number of divisions',30
*cset,61,63,'Enter with the',' geometric parameters'
multipro,'end'

multipro,'start',2
*cset,1,3,Level,'Enter refinement level (1-5)',3
*cset,4,6,Depth,'Enter depth mesh refinement',1
*cset,61,63,'Define refinement','at radius fillet'
multipro,'end'

pi=3.14159265
teta=0
pitch=(90*pi/180)/N

*do,fall,1,N+1
x1=r*cos(teta)
y2=r*sin(teta)
k,fall,((d/2)-x1),((H/2)-y2)
teta=teta+pitch
*enddo

! DRAWING B-SPLINE
FLST,3,N+1,3
*DO,FIT,1,N+1
FITEM,3,FIT
*ENDDO
BSPLIN,,P51X

L1=(d/2)-R

k,N+2,0,0
k,N+3,0,H/2
k,N+4,d/2,0

l,N+2,N+3
l,N+3,1
l,N+1,N+4
l,N+2,N+4

! Creating areas from boundary lines
AL,ALL

! Element properties
ET,1,ETYPE
KEYOPT,1,3,3
R,1,T
MP,EX,1,E
MP,NUXY,1,NU

! Meshing
SMRTSIZE,4
ESIZE,E_SIZE
MSHAPE,1,2D
MSHKEY,0
AMESH,ALL

! Fillet refinement
LREFINE,1,,,Level,Depth,smooth,off
FINISH

multipro,'start',2
*cset,1,3,Sx,'Applied pressure in the x direction',45
*cset,4,6,Sy,'Applied pressure in the y direction',22.5
*cset,61,63,'Enter with the',' value of the parameters
shown below'
multipro,'end'

/SOL
ANTYPE,0
DL,4,,UX
DL,4,,ROTY
DL,4,,ROTZ
DL,3,,UY
DL,3,,ROTX
DL,3,,ROTZ
SFL,2,PRES,-Sx
SFL,5,PRES,-Sy
SOLVE
FINISH

/POST1
/dscale,1,off
PLNSOL,S,EQV

*ask,Factor,'entre com o fator',0.2
*ask,Iteracoes,'Entre com o numero de iteracoes',10

```

```

initial=2
final=N

Stopper=1

Contador=0
/pret7
Reinara=0

*DIM,Tabela,TABLE,Iteracoes,3
*dowhile,Stopper
*do,lok,initial,final
LocationX=KX(LOK)
LocationY=KY(LOK)
nset,s,s,eqv
Location=NODE(LocationX,LocationY,0)
*if,lok,eq,final,then
xx1=KX(lok)
xx2=KX(N+1)
yy1=KY(lok)
yy2=KY(N+1)
*else
xx1=KX(lok)
xx2=KX(lok+1)
yy1=KY(lok)
yy2=KY(lok+1)
*endif

/post1

Colax=KX(1)
Colay=KY(1)
Cola=NODE(Colax,Colay,0)
*get,vonmises,NODE,Location,S,EQV
*get,Ref,NODE,Cola,S,EQV
dist=((vonmises-Ref)/Ref)*Factor
nset,s,node,,all

/pret7
*if,xx1,eq,xx2,then
KMODIF,lok,xx1,yy1

*else
deltax=xx2-xx1
deltay=yy1-yy2
alfa=atan(deltay/deltax)
beta=(pi/2)-alfa
xxx=dist*cos(beta)
yyy=dist*sin(beta)

KMODIF,lok,xx1+xxx,yy1+yyy
finish
*endif

*enddo
/pret7
LocationX=KX(N+1)
LocationY=KY(N+1)
nset,s,s,eqv
Location=NODE(LocationX,LocationY,0)
Colax=KX(1)
Colay=KY(1)
Cola=NODE(Colax,Colay,0)
*get,vonmises,NODE,Location,S,EQV
*get,Ref,NODE,Cola,S,EQV
dist=((vonmises-Ref)/Ref)*Factor
Notes=KY(N+1)
KMODIF,N+1,LocationX,LocationY+dist
nset,s,node,,all

*do,Contador3,initial,final
CoordX=KX(Contador3)
CoordY=KY(Contador3)
*if,CoordX,LT,L1,then
KMODIF,Contador3,L1,(KY(Contador3-
1)+KY(Contador3)+KY(Contador3+1))/3

*endif
*if,CoordY,LT,((H/2)-R),then
KMODIF,Contador3,(KX(Contador3-
1)+KX(Contador3)+KX(Contador3+1))/3,((H/2)-R)
*endif

*enddo

DDELE,ALL,ALL
SFLDELE,LINE,ALL
ACLEAR,ALL,ALL
ADELE,ALL
LDELE,1

! DRAWING B-SPLINE
FLST,3,N+1,3
*DO,FIT,1,N+1
FITEM,3,FIT
*ENDDO
BSPLIN,,P51X

! Creating areas from boundary lines
AL,ALL
AMESH,ALL

! Fillet refinement
LREFINE,1,,Level,Depth,smooth,off
FINISH

/SOL
ANTYPE,0
DL,4,,UX
DL,4,,ROTY
DL,4,,ROTZ
DL,3,,UY
DL,3,,ROTX
DL,3,,ROTZ
SFL,2,PRES,-Sx
SFL,5,PRES,-Sy
SOLVE
FINISH

/POST1
PLNSOL,S,EQV
lset,s,line,,1
nset,s,1
nsort,s,eqv
*get,maximo,sort,0,max
*get,minimo,sort,0,min

RE=abs((maximo-minimo)/(maximo+minimo))
nset,s,node,,all
lset,s,line,,all
Contador=Contador+1

*if,Contador,EQ,Iteracoes,then
Stopper=-1
*else
Stopper=1
*endif

PLNSOL,S,EQV
nsort,s,eqv
*get,free,sort,0,max
*get,mute,sort,0,imax
Reinara=Reinara+1
Tabela(Reinara,1)=Contador
Tabela(Reinara,2)=free/38.971
Tabela(Reinara,3)=RE
finish

*enddo

/POST1
/dscale,1,off
PLNSOL,S,EQV

```