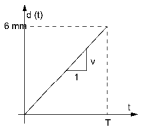
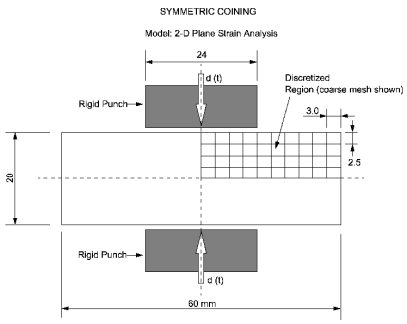
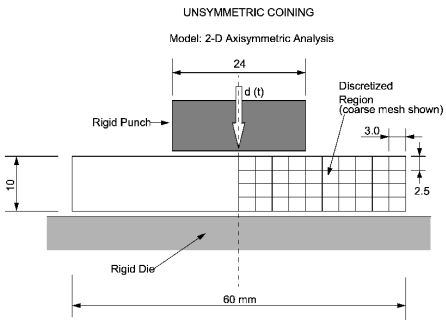
Example 3 – Coining

Material Data	
Density	8930
Young's Modulus	$2.\times10^{11}$
Yield Stress	2.5×10^{8}
Plastic Modulus	$1.\times10^{9}$
Poisson's Ratio	0.3



Punching Time T [ms]	Punching Velocity v [m/s]
40.00	0.15
2.00	3.00
0.10	60.00
0.02	300.00





Bilateral,
Plane strain

Unilateral,
Axisymmetric

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<u>Geometric data and materials:</u>
See slide.

<u>Numerical Solutions</u>

COIN05 (plane bilateral coining).

The mesh generation file is:

```
*%siz 100
opti echo 0;
opti donn 'D:\Users\Folco\Plexis3c\Proc\pxpdroit.proc';
opti donn 'D:\Users\Folco\Plexis3c\Proc\ordpoin.proc';
opti echo 1;
*
opti titr 'COIN - 05';
opti dime 2 elem qua4;
*
p0=0 0;
p1=3.0E-2 0;
p2=3.0E-2 1.0E-2;
p3=0 1.0E-2;
*
tol=0.001E-02;
*
x y=coor p1;
dx=0 -(x / 20.0);
p4=p1 plus (dx 0);
p5=p2 plus (dx 0);
*
p6=1.2E-2 0;
p7=1.2E-2 1.0E-2;
*
c1=p0 d 20 p1;
c2=p1 d 8 p2;
c3=p2 d 20 p3;
c4=p3 d 8 p0;
```

```
stru=(daller c1 c2 c3 c4 'PLAN') coul rose;
*
elim tol (stru et p4 et p5 et p6 et p7);
*
lag=p0 et (stru poin droi p1 p2 tol);
lag=lag et (stru poin droi p4 p5 tol);
*
blocy=stru poin droi p0 p1 tol;
blocx=stru poin droi p0 p3 tol;
*
cha=pxpdroit stru p3 p7 tol;
*
sl=pxpdroit stru p5 p7 tol;
sli=folco sl p5;
*
eul=pxpdroit stru p3 p7 tol;
blocx=blocx et eul;
*
mesh=stru et lag et blocx et blocy et cha et sli et eul;
*
tass mesh;
*
opti sauv form 'coin05.msh';
sauv form mesh;
*
opti trac psc;
trac qual mesh;
fin;
```

The input file is:

```
COIN - 05
*------------------------------------------------------------------------
 ECHO
 CONV win
CAST MESH
*-------------------------------------------------------------Problem type
DPLA NONL ALE
*-------------------------------------------------------------Dimensioning
DIME
  PTGL 189 Q42G 160 NALE 1 NBLE 159
  BLOQ 110
  TABL 1 5
  DEPL 9
  SLPC 1 SLPN 20
  ECRO 7040
  mtpo 4 mtel 2
TERM
```

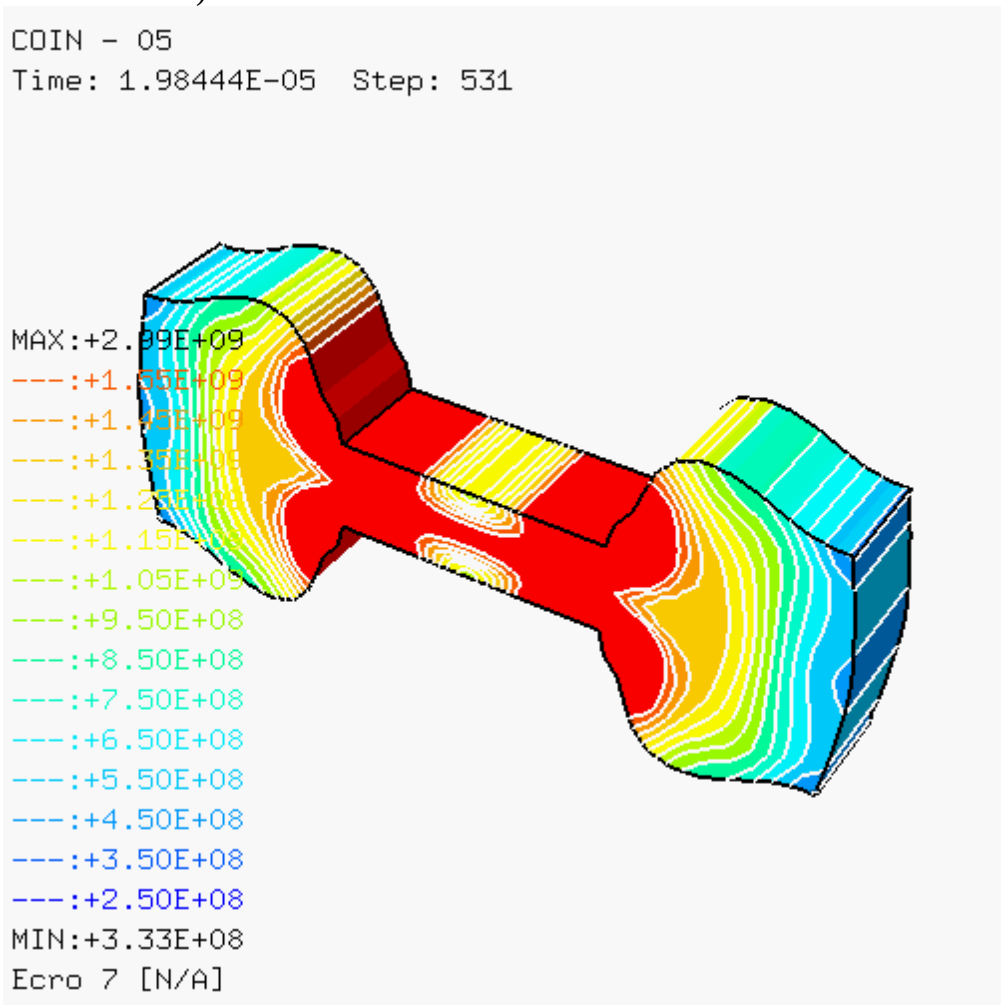
```
*-------------------------------------------------------------Geometry
GEOM Q42G STRU TERM
*-----------------------------------------------------Geometric Complements
COMP EPAI 1.0 TOUS
*-------------------------------------------------------------Grid motion
GRIL LAGR LECT LAG  TERM
     EULE LECT EUL  TERM
     ALE  LECT STRU TERM
     SLIP EQUI LECT SLI  TERM
     AUTO AUTR
*-------------------------------------------------------Material data
MATE VM23 RO 8930. YOUN 2.D11  NU 0.3D0 ELAS 2.5D8
          TRAC 2 2.5D8 1.25D-3 1.00025D12 1000.00125
          LECT STRU TERM
*-----------------------------------------------------Boundary conditions
LIAI RENU FREQ 1
     BLOQ 1 LECT BLOCX TERM
```

```
          2 LECT BLOCY TERM
*-------------------------------------------------------------Applied "loads"
CHAR 1 FACT 2 DEPL 2 -6.D-3 LECT CHA TERM
     TABL 3 0 0 20.D-6 1 1 1
*-------------------------------------------------------------------Outputs
ECRI COOR DEPL VITE CONT ECRO TFRE 20.D-6
     FICH K200 TFRE 4.D-6
               POIN TOUS CHAMELEM
     FICH TPLO FREQ 1 DESC 'COIN05'
               POIN LECT P1 P3 P7 P2 TERM
               ELEM LECT 1 141 TERM
     fich alic temp FREQ 1
                    poin lect P1 P2 term
                    elem lect 1 term
*-------------------------------------------------------------------Options
OPTI NOTE
     cstab 0.5
*-----------------------------------------------------Transient calculation
CALC TINI 0. TEND 20.D-6
*=================================================================ANIMATION
PLAY
CAME   1 EYE   7.32216E-02  1.05557E-01  1.32735E-01
!        Q     9.17872E-01 -2.89889E-01  2.51837E-01  1.00267E-01
         VIEW -4.04175E-01 -5.82665E-01 -7.05085E-01
         RIGH  8.53050E-01  3.80552E-02 -5.20440E-01
         UP   -3.30074E-01  8.11821E-01 -4.81661E-01
         FOV   2.48819E+01
SCEN GEOM NAVI FREE
          LINE HEOU SSHA
     ISO  FILI FIEL ECRO 7 SCAL USER PROG 2.5D8 PAS 1.0D8 1.55D9 TERM
     TEXT ISCA
     colo pape
     LIMA ON
titl titl 'EUROPLEXUS (C) Animation'
```

```
     tit2 'Symmetric Plane Coining'
     tit3 'Author: F. Casadei'
sler cam1 1        nfra 20
trac offs fich avi                  nocl nfto 75  fps 10 kfre 10 comp -1
                                         SYMX SYMY EXTZ 5 1.E-2 REND

sler cam1 1        nfra  1
TRAC OFFS FICH AVI CONT NOCL           SYMX SYMY EXTZ 5 1.E-2 REND
FREQ 10
GOTR LOOP 53  OFFS FICH AVI CONT NOCL SYMX SYMY EXTZ 5 1.E-2 REND
FREQ 9
GOTR          OFFS FICH AVI CONT      SYMX SYMY EXTZ 5 1.E-2 REND
ENDPLAY
*=========================================================POST-TREATMENT
SUIT
Post-treatment
ECHO
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1000.0 'Time [ms]'
*-----------------------------------------------------Curve definitions
COUR 1 'dx_P1'  DEPL COMP 1  LECT  P1 TERM
COUR 2 'dy_P1'  DEPL COMP 2  LECT  P1 TERM
COUR 3 'dx_P2'  DEPL COMP 1  LECT  P2 TERM
COUR 4 'dy_P2'  DEPL COMP 2  LECT  P2 TERM
*-------------------------------------------------------------------------Plots
trac 1 2 3 4 axes 1.0 'DISPL. [M]'
*-----------------------------------------Results qualification
QUAL DEPL COMP 1 lect  P1 term REFE  2.78556E-3 TOLE 5.E-3
     DEPL COMP 2 lect  P1 term REFE  0.00000E+0 TOLE 5.E-3
     DEPL COMP 1 lect  P2 term REFE  1.47361E-3 TOLE 5.E-3
     DEPL COMP 2 lect  P2 term REFE  1.34045E-3 TOLE 5.E-3
*=========================================================================
FIN
```

The resulting final deformed mesh with superposed current yield stress (a measure of plastic deformation) is:



COIN25 (axisymmetric unilateral coining).

The mesh generation file is:

```
*%siz 100
*
opti echo 0;
opti donn 'D:\Users\Folco\Plexis3c\Proc\pxpdroit.proc';
opti donn 'D:\Users\Folco\Plexis3c\Proc\ordpoin.proc';
opti echo 1;
*
opti titr 'COIN - 25';
opti dime 2 elem qua4;
*
p0=0 0;
p1=3.0E-2 0;
p2=3.0E-2 1.0E-2;
p3=0 1.0E-2;
*
tol=0.001E-02;
*
x y=coor p1;
dx=0 -(x / 20.0);
p4=p1 plus (dx 0);
p5=p2 plus (dx 0);
*
p6=1.2E-2 0;
p7=1.2E-2 1.0E-2;
*
c1=p0 d 20 p1;
c2=p1 d 8 p2;
c3=p2 d 20 p3;
c4=p3 d 8 p0;
stru=(daller c1 c2 c3 c4 'PLAN') coul rose;
*
elim tol (stru et p4 et p5 et p6 et p7);
p0m = 0 0;
pm = MANU 'POI1' p0m;
*
lag=p0 et p3 et (stru poin droi p1 p2 tol);
lag=lag et (stru poin droi p4 p5 tol);
*
blocy=pxpdroit stru p0 p6 tol;
blocx=pxpdroit stru p0 p6 tol;
blocx=blocx et (pxpdroit stru p0 p3 tol);
blocx=blocx et (pxpdroit stru p3 p7 tol);
*
uni1=pxpdroit stru p6 p1 tol;
pp6=uni1 elem 'CONTENENT' p6;
uni=diff uni1 pp6;
*
cha=pxpdroit stru p3 p7 tol;
*
sl1=pxpdroit stru p6 p4 tol;
slip1=folco sl1 p6;
*
sl2=pxpdroit stru p5 p7 tol;
slip2=folco sl2 p5;
*
au1=chan 'POI1' stru;
au2=diff au1 lag;
bad1=pxpdroit au2 p6 p1 tol;
au3=diff au2 bad1;
bad2=au3 poin droi p3 p2 tol;
au4=diff au3 bad2;
*
auto=au4 et (au1 elem 'CONTENENT' p6);
*
mesh=stru et pm et lag et blocx et blocy et uni
          et cha et slip1 et slip2 et auto;
*
tass mesh;
*
opti sauv form 'coin25.msh';
sauv form mesh;
*
opti trac psc ftra 'coin25_mesh.ps';
trac qual mesh;
fin;
```

The input file is:

```
COIN - 25 impa
*------------------------------------------------------------------------
 ECHO
 CONV win
CAST MESH
*-------------------------------------------------------------Problem type
AXIS NONL ALE lagc
*-------------------------------------------------------------Dimensioning
DIME
  PT2L 190 Q42G 160 pmat 1 zone 2
  NALE 1 NBLE 142
  BLOQ 110
  TABL 1 5
  DEPL 9
  impa 1 psim 12
  SLPC 2 SLPN 20
  mtpo 2
TERM
*------------------------------------------------------------------Geometry
GEOM Q42G STRU pmat pm TERM
*-----------------------------------------------Geometric Complements
COMP EPAI 1.0 lect stru term
*-------------------------------------------------------------Grid motion
GRIL LAGR LECT LAG pm TERM
     ALE  LECT STRU TERM
     SLIP EQUI LECT SLIP1 TERM
          EQUI LECT SLIP2 TERM
     AUTO NOEU LECT AUTO TERM
*---------------------------------------------------------Material data
MATE VM23 RO 8930. YOUN 2.D11  NU 0.3D0 ELAS 2.5D8
          TRAC 2 2.5D8 1.25D-3 1.00025D12 1000.00125
          LECT STRU TERM
     mass 1.0 lect pm term
*-----------------------------------------------------Boundary conditions
LIAI RENU FREQ 1
     BLOQ 1 LECT BLOCX TERM
          2 LECT BLOCY TERM
          12 lect pm term
     impa ddl 2 cote 1
          proj lect pm term
          cibl lect UNI term
*-------------------------------------------------------Applied "loads"
CHAR 1 FACT 2 DEPL 2 -6.D-3 LECT CHA TERM
     TABL 3 0 0 20.D-6 1 1 1
*-------------------------------------------------------------------Outputs
ECRI COOR DEPL VITE CONT ECRO TFRE 20.D-6
     FICH K200 TFRE 4.D-6
               POIN TOUS CHAMELEM
     FICH TPLO FREQ 1 DESC 'COIN25'
               POIN LECT P1  P2 TERM
               ELEM LECT 1 TERM
     fich alic temp FREQ 1
                    poin lect P1  P2 term
                    elem lect 1 term
*-----------------------------------------------------------------Options
OPTI NOTE
     cstab 0.5
*-----------------------------------------------------Transient calculation
CALC TINI 0. TEND 20.D-6
*=============================================================ANIMATION
PLAY
CAME   1 EYE   7.32216E-02  1.05557E-01  1.32735E-01
!        Q     9.17872E-01 -2.89889E-01  2.51837E-01  1.00267E-01
         VIEW -4.04175E-01 -5.82665E-01 -7.05085E-01
         RIGH  8.53050E-01  3.80552E-02 -5.20440E-01
         UP   -3.30074E-01  8.11821E-01 -4.81661E-01
         POV   2.48819E+01
SCEN GEOM NAVI FREE
          LINE HEOU SSHA
     ISO  FILI FIEL ECRO 7 SCAL USER PROG 2.5D8 PAS 1.0D8 1.55D9 TERM
     TEXT ISCA
     colo pape
          LIMA ON
titl titl 'EUROPLEXUS (C) Animation'
     tit2 'Unilateral Axisymmetric Coining'
     tit3 'Author: F. Casadei'
sler cam1 1        nfra 20
trac offs fich avi               nocl nfto 73  fps 10 kfre 10 comp -1
                                      AXIS 27 270 REND
sler cam1 1        nfra  1
TRAC OFFS FICH AVI CONT NOCL          AXIS 27 270 REND
FREQ 10
GOTR LOOP 51  OFFS FICH AVI CONT NOCL AXIS 27 270 REND
FREQ 5
GOTR          OFFS FICH AVI CONT      AXIS 27 270 REND
ENDPLAY
*=========================================================POST-TREATMENT
SUIT
Post-treatment
ECHO
RESU ALIC TEMP GARD PSCR
SORT GRAP
AXTE 1000.0 'Time [ms]'
*-----------------------------------------------------------Curve definitions
COUR 1 'dx_P1'  DEPL COMP 1 NOEU LECT  P1 TERM
COUR 2 'dy_P1'  DEPL COMP 2 NOEU LECT  P1 TERM
COUR 3 'dx_P2'  DEPL COMP 1 NOEU LECT  P2 TERM
COUR 4 'dy_P2'  DEPL COMP 2 NOEU LECT  P2 TERM
*-------------------------------------------------------------------------Plots
trac 1 2 3 4 axes 1.0 'DISPL. [M]'
*-----------------------------------------------Results qualification
QUAL DEPL COMP 1 lect  P1 term REFE  1.03725E-3 TOLE 5.E-3
     DEPL COMP 2 lect  P1 term REFE  4.76203E-4 TOLE 5.E-3
     DEPL COMP 1 lect  P2 term REFE  7.19865E-4 TOLE 5.E-3
     DEPL COMP 2 lect  P2 term REFE  5.53042E-4 TOLE 5.E-3
*=========================================================================
FIN
```

The resulting final deformed mesh with superposed current yield stress (a measure of plastic deformation) is: