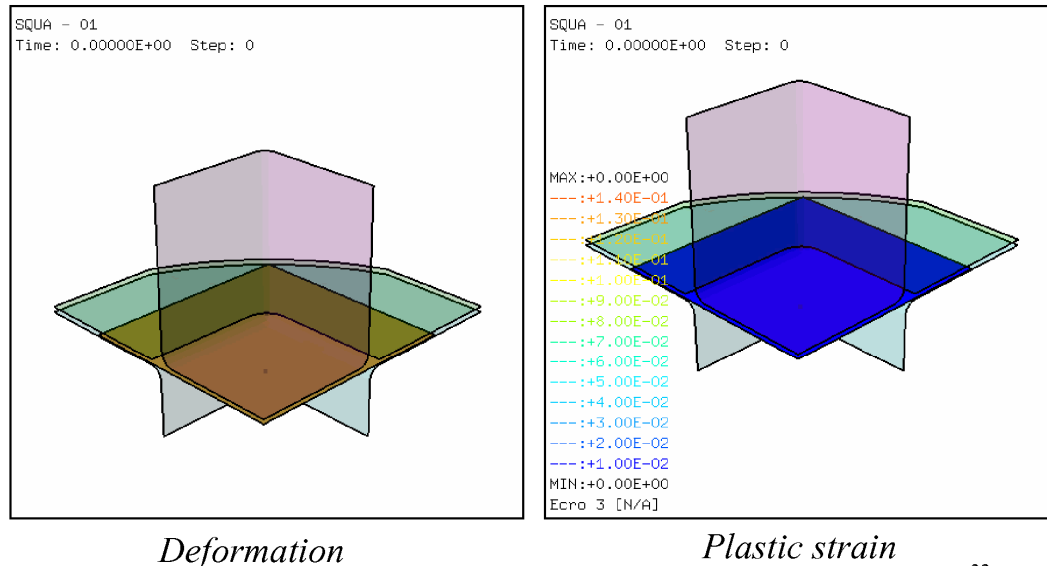


Example 6b – Deep drawing B



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Problem description:

This example is the deep drawing of a thin elasto-plastic square box starting from a thin square metal sheet which is pressed between a punch, a die and a holder.

The simulation assumes a rigid, fixed die and a rigid punch which is moving at constant velocity.

The model assumes friction between the contacting parts (but not between the piece and the holder).

Thanks to symmetries, only $\frac{1}{4}$ of the real geometry is modelled in the calculation.

Numerical Solutions

SQUA01

This model uses 6977 elements of the Q4GS type and 33 elements of the DST3 type to represent the piece, the punch, the die and the holder. Contact is prescribed by the GLIS directive between the piece and the punch (with friction), between the piece and the die (with friction) and between the piece and the holder (without friction).

The input file is:

```
SQUA - 01
*
ECHO
!CONV WIN
*-----Type of problem
TRID NONL
AMOR
*-----Sizing
DIME
FT3L 3 PT6L 7341
ZONE 3
PMAT 3
DST1 33
Q4GS 6977
ECRO 1540391
BLOQ 35382
GLIS 3 10000
DLI 5280 FCOR 5280
DEPL 5280 FORC 6
TABL 3 12 FNOM 3 FTAB 12
WFO 2 WTEL 1
TERM
*-----Geometry (Mesh)
GECM '(3E22.15)' '(7110)' POIN 7344
PMAT 3
DST1 33
Q4GS 6977
TERM
*-----Modal Coordinates
0.000000000000000E+00 1.900000000000000E-01 1.000000000000000E-03
. . . (omissis)
5317 7341 7341 5317 5314 5346
*-----Additional geometrical data
COMP
GROU 6 'massees' LECT 1 PAS 1 3 TERM
'piece' LECT 37 PAS 1 1480 TERM
'die' LECT 23 PAS 1 36 4769 PAS 1 7013 TERM
'punch' LECT 22 3082 PAS 1 4768 TERM
'holder' LECT 4 PAS 1 21 1481 PAS 1 3081 TERM
'e_alit' LECT 1 TERM
COUL jaun LECT masses TERM
roug LECT piece TERM
turq LECT die TERM
rose LECT punch TERM
vert LECT holder TERM
NGRO 15 'n_massees' LECT masses TERM
'n_piece' LECT piece TERM
'n_die' LECT die TERM
'n_punch' LECT punch TERM
'n_holder' LECT holder TERM
'n_ext1' LECT 7342 TERM
'n_ext2' LECT 7343 TERM
'n_ext3' LECT 7344 TERM
'n_pibloq' LECT 39 TERM
'n_bl156' LECT 1 PAS 1 38 TERM
'n_bl246' LECT 78 116 PAS 1 152 TERM
'n_forcz' LECT 2673 TERM
'n_al11' LECT 1522 TERM
'n_al12' LECT 3439 TERM
'n_alit' LECT n_al11 n_al12 TERM
EPAI 0.8E-03 LECT piece TERM
EPAI 1.0E-03 LECT die punch holder TERM
FROT 1 MU0 0.25 MU1 0.25 GAMMA 1
FROT 2 MU0 0.125 MU1 0.125 GAMMA 1
*-----Materials
MATE
VMIS ISOT RO 2.767E+03 YOUN 7.0E+10 NU 3.E-01 ELAS 2.93E+08
TRAC 12 2.93000E+08 4.18571E-03
3.09400E+08 6.10600E-03
3.16350E+08 7.12122E-03
3.24380E+08 8.46700E-03
3.33800E+08 1.03196E-02
3.45120E+08 1.29853E-02
3.59060E+08 1.70604E-02
3.76870E+08 2.38049E-02
4.00710E+08 3.62904E-02
4.34740E+08 6.35266E-02
4.87940E+08 1.40321E-01
1.09500E+09 1.01564E+00
LECT piece TERM
LINE RO 7.8E+03 YOUN 2.E+11 NU 3.E-01
LECT die punch holder TERM
MASS 0.1E-02
LECT masses TERM
*-----Couplings
LIAI
BLOQ 123456 LECT die TERM
156 LECT n_bl156 TERM
12456 LECT n_pibloq n_punch n_holder TERM
246 LECT n_bl246 TERM
DEPL 3 0.1E+01 FONC 1 LECT punch TERM
GLIS 3
CMAI LECT piece TERM EXTE LECT n_ext1 TERM
CSCS LECT punch TERM
CMAI LECT piece TERM EXTE LECT n_ext2 TERM
CSCS LECT die TERM
CMAI LECT piece TERM EXTE LECT n_ext3 TERM
CSCS LECT holder TERM
FONC 1 TABL 2
0.000E+00 0.000E+00
0.101E-01 -0.500E-01
*-----Factorized loads
CHAR 1 FACT 2
FORC 3 0.1E+01 LECT n_forcz TERM
TABU 3
0.000E+00 0.000E+00
0.100E-02 -0.200E+05
0.100E-00 -0.200E+05
*-----Initial conditions
INIT VITE 3 -4.95050 LECT punch TERM
*-----Storage
ECRI
DEPL VITE TFRE 1.0E-3 POIN LECT n_alit TERM
FICH ALIC TFRE 1.0E-04
FICH ALIC TEMP TFRE 1.0E-05
POIN LECT n_alit TERM
ELEM LECT e_alit TERM
*-----Options
OPTI LOG 1
*-----Time Steps
CALC TINI 0.E+00 TFIN 10.E-03
=====
SUIT
Post-treatment (time curves from alice temps file)
ECHO
*
RESU ALIC TEMP GARD PSCR
*
SORT GRAP
*
AXTE 1000.0 'Time [ms]'
*
COUR 1 'dz_1' DEPL COMP 3 NOU LECT n_al11 TERM
COUR 2 'dz_2' DEPL COMP 3 NOU LECT n_al12 TERM
COUR 3 'vz_1' VITE COMP 3 NOU LECT n_al11 TERM
COUR 4 'vz_2' VITE COMP 3 NOU LECT n_al12 TERM
*
trac 1 2 axes 1.0 'DISPL. [M]'
trac 3 4 axes 1.0 'VELOC. [M/S]'
*
QUAL DEPL COMP 3 LECT n_al12 TERM REFE -4.95050E-2 TOLE 5.E-3
=====
FIN
```

The final deformed mesh and plastic strains are:

