SSNP155 – Benchmark NAFEMS of validation of the contact 3: *sheet metal forming*

Summarized:

This problem constitutes the third benchmark of a benchmark NAFEMS of validation of contact-friction. The references of the benchmark are obtained with the codes Abaqus and MARC.
This test models a stamping of a sheet by a punch in a matrix. The problem is three times over nonlinear: nonlinear isotropic hardening, large displacements and contact-friction.

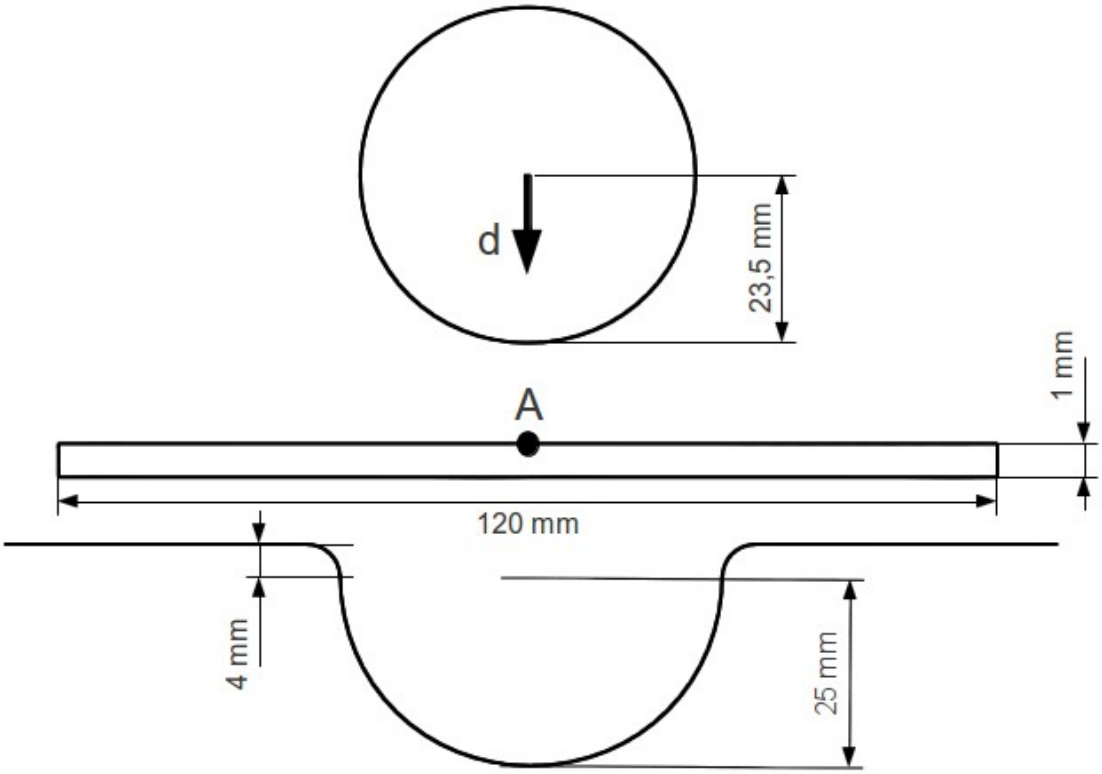
This test comprises only one modelization with:

- under-integrated quadratic elements
- formulation of processing of the contact without friction "DISCRETE".

1 Problem of reference

1.1 Geometry

the structure is modelled in plane strains. One takes account of symmetry to represent only one half.



One notes A the point medium of the plate located on higher edge.

1.2 Properties of the materials

Punch and matrix:

Rigid

Plate:

Poisson's ratio: $0,342$

Young modulus: $70500\ N.mm^{-2}$

Yield stress: $\sigma_0 = 194\ N.mm^{-2}$

Isotropic hardening of Hollomon type: $\sigma = K\ \bar{\epsilon}^{n}$

- $K = 550,4\ N.mm^{-2}$
- $n = 0,223$

In computation, this hardening is represented by a nonlinear hardening with curve of tension:

ϵ	σ (Mpa)
2.75177E-03	1.94000E+02

2.32630E-02	2.30043E+02
4.38085E-02	2.68496E+02
6.41689E-02	2.93904E+02
8.44451E-02	3.13378E+02
1.04672E-01	3.29365E+02
2.05453E-01	3.84423E+02
3.05969E-01	4.20802E+02
4.06364E-01	4.48681E+02
5.06689E-01	4.71573E+02
6.06967E-01	4.91140E+02
7.07210E-01	5.08317E+02
8.07428E-01	5.23682E+02
9.07626E-01	5.37619E+02
1.00781E+00	5.50399E+02
1.10797E+00	5.62224E+02
1.20813E+00	5.73239E+02
1.30828E+00	5.83564E+02
1.40842E+00	5.93287E+02

and the coefficient of kinetic friction between the plate rigid tools is worth $\mu=0,1342$.

1.3 Boundary conditions and loadings

the structure symmetric and being subjected to a loading respecting symmetry, only a half is represented. One thus applies $DX=0$ as regards symmetry.

The matrix is clamped:

- $DX=0$
- $DY=0$

The punch is subjected to a vertical displacement:

- $DY=d=-28,5\,mm$

In the second time one withdraws the punch (discharge).

2 Reference solution

2.1 Method of calculating

the reference solution comes of results obtained with the codes Abaqus and MARC in a benchmark NAFEMS from validation of contact-friction [bib1].
Experimental results are available for the case where friction is taken into account.

2.2 Quantities and results of reference

vertical Displacement of the point A (according to y) after complete descent of the punch then, discharge.

2.3 Uncertainties on the Important

solution (average of codes).

2.4 Bibliographical reference

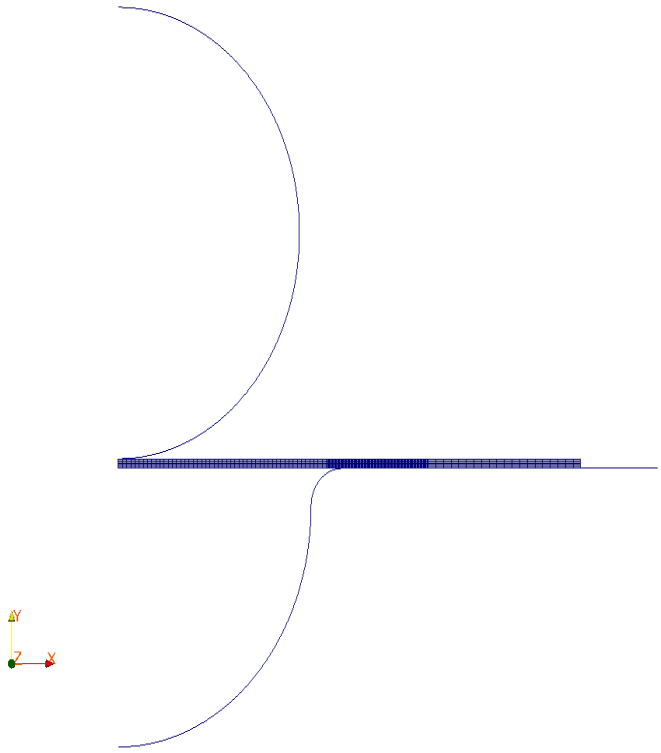
[1] A. KONTER. *"Advanced Finite Element Benchmarks Contact"*. NAFEMS, 2006.

3 Modelization A

3.1 Characteristic of the modelization

The modelization is D_PLAN_SI, the formulation of the contact is DISCRETE, friction is disabled.

3.2 Characteristics of the mesh



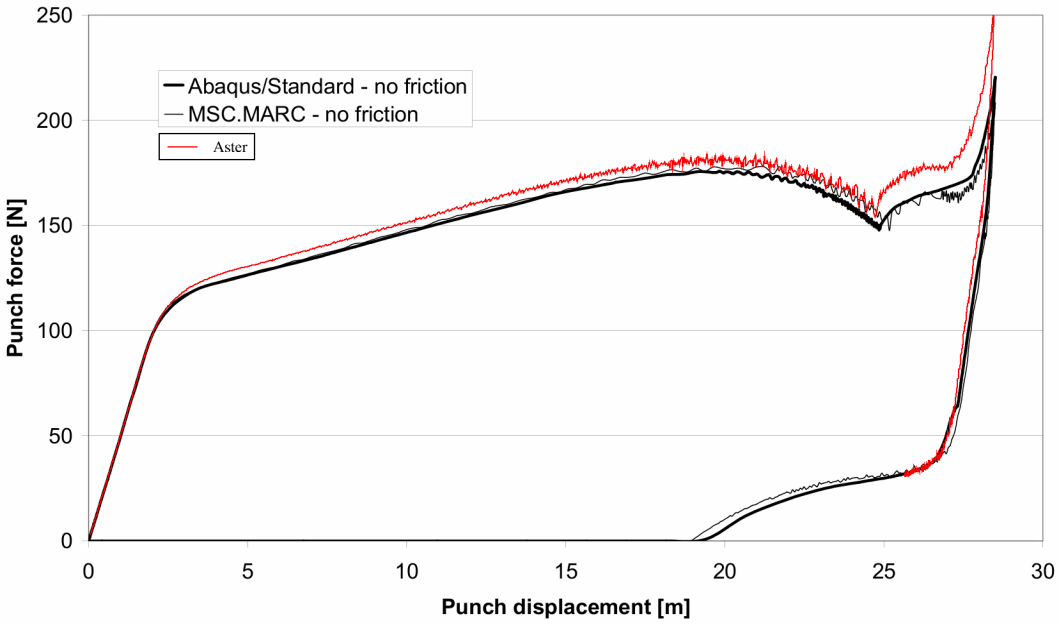
Many nodes: 3436
Number of meshes and types: 850 QUAD8 and 533 SEG2.

3.3 Quantities tested and Computation

results with “LAGRANGIAN” contact algorithm

Standard	Identification of reference	Value of reference	Tolerance
DY to the point A after load	"SOURCE_EXTERNE"	-28,5	0,1%
DY to the point A after discharge	"SOURCE_EXTERNE"	-25,65	0,1%

3.4 Remarks



the results got into quadratic under-integrated without friction with the discrete formulation are in concord with the reference solution.
One will note a light deviation compared to the commercial codes which can be explained by the processing in slow dynamics of the problem. Indeed the very unstable response force-displacement obliged to carry out computation thus in order to profit from the stabilization of a mass matrix.
The discharge was not continued until the end in order to minimize the computing time of the test.

It will be noted that in this test and contrary with the recommendations of the note of use of the contact ([U2.04.04]), a “TANGENT″ prediction was used. It is because the “ELASTIC″ prediction cannot pass the final phase of the load, one sees it on the response force-displacement: the slope at this place is stiffer than the elastic slope.

4 Summary of the results

This test makes it possible to validate the contact coupled to all other non-linearities compared to references given by commercial computer codes (Abaqus and MARC).
One observes a good agreement between the results of reference and those obtained by *Code_Aster*.

It will be noted that in this *benchmark* particularly difficult:
-computation in continuous formulation was not possible
-stabilization (by a dynamic computation in long time) is essential to the unrolled good of the test

The computation with friction was carried out successfully in continuous formulation but requires a too long computing time to make a modelization of this test of it. For information one gives nevertheless the response force-displacement of such a computation.