TPLV105 - Steady nonlinear thermal out of mobile coordinate system: simulation of Summarized the Varestrain

test:

This test presents thermal simulation by finite elements of the Varestraint test. This test of weldability is employed to characterize strength with the hot cracking of the materials.

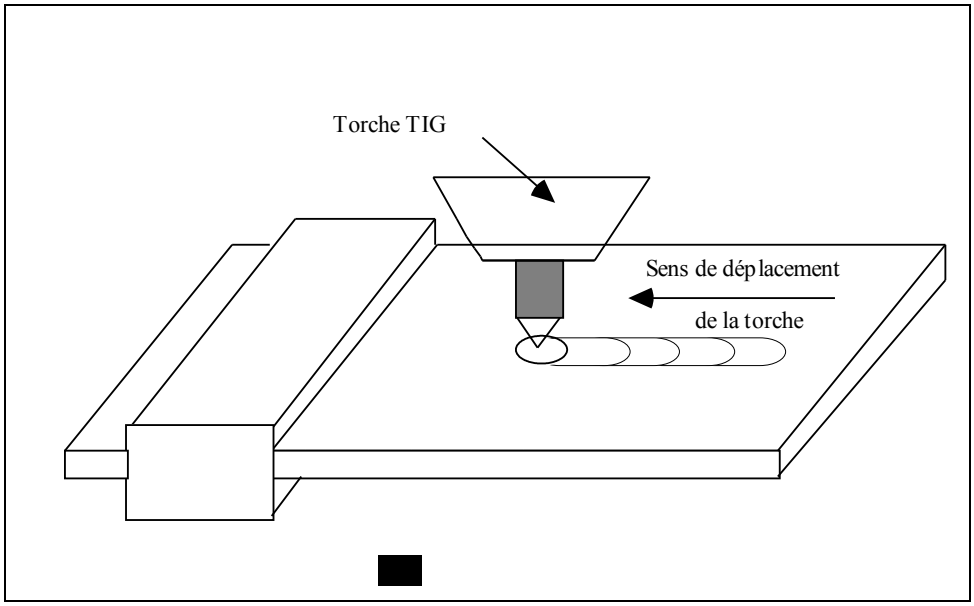
This test makes it possible to test a nonlinear thermal problem formulated in a mobile coordinate system under condition of stationarity.

In this test only one modelization is carried out, it acts of a thermal modelization PLANE associated with operator THER_NON_LINE_MO making it possible to calculate the nonlinear steady response with a mobile loading.

1 Problem of reference

1.1 Geometry

the studied geometry is a 200 mm length parallelepipedic plate, of 60 mm width and 7 mm thickness.



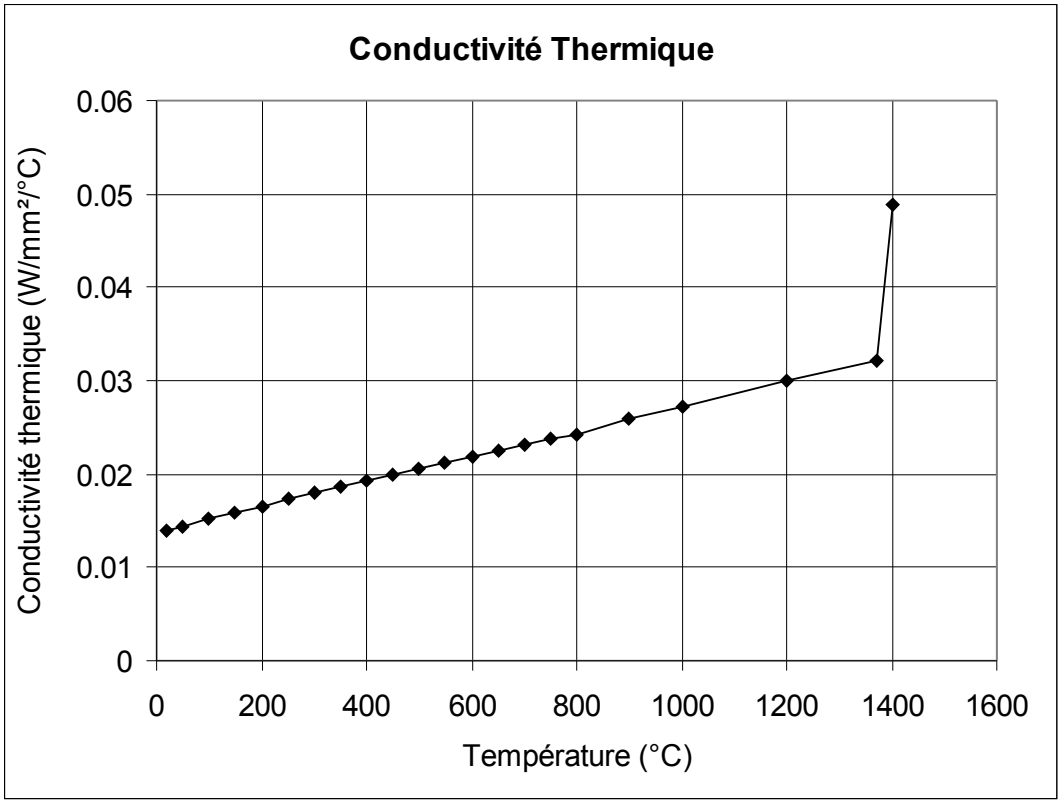
Thickness test-tube	Width of the test-tube	Length of the test-tube
$7\,mm$	$60\,mm$	$200\,mm$

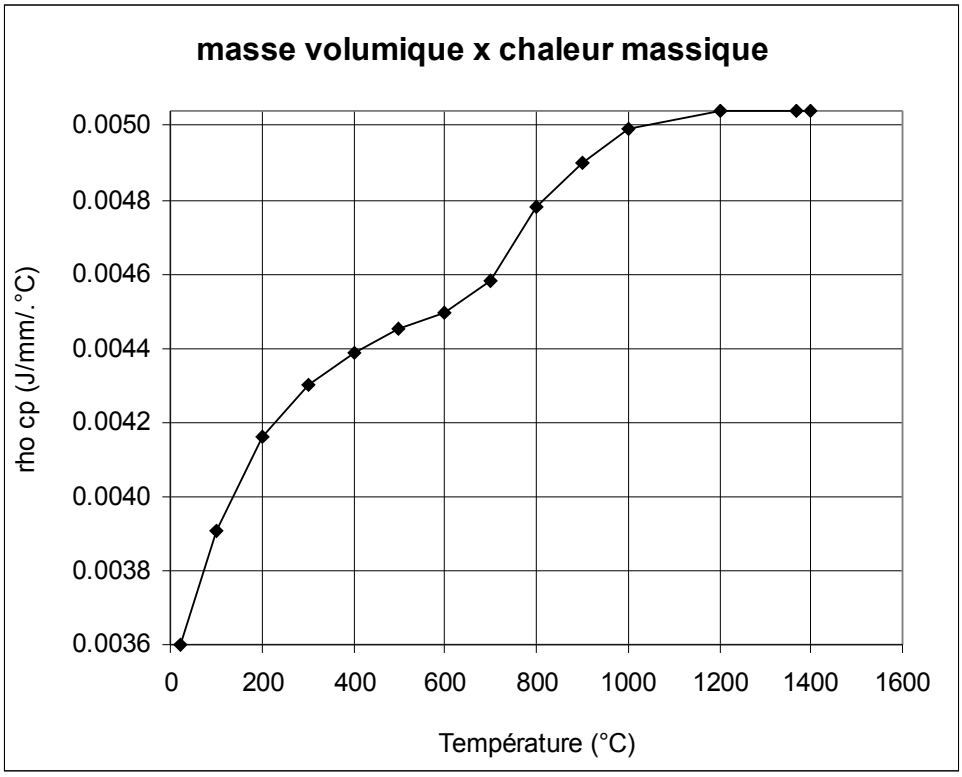
1.2 Properties of the material

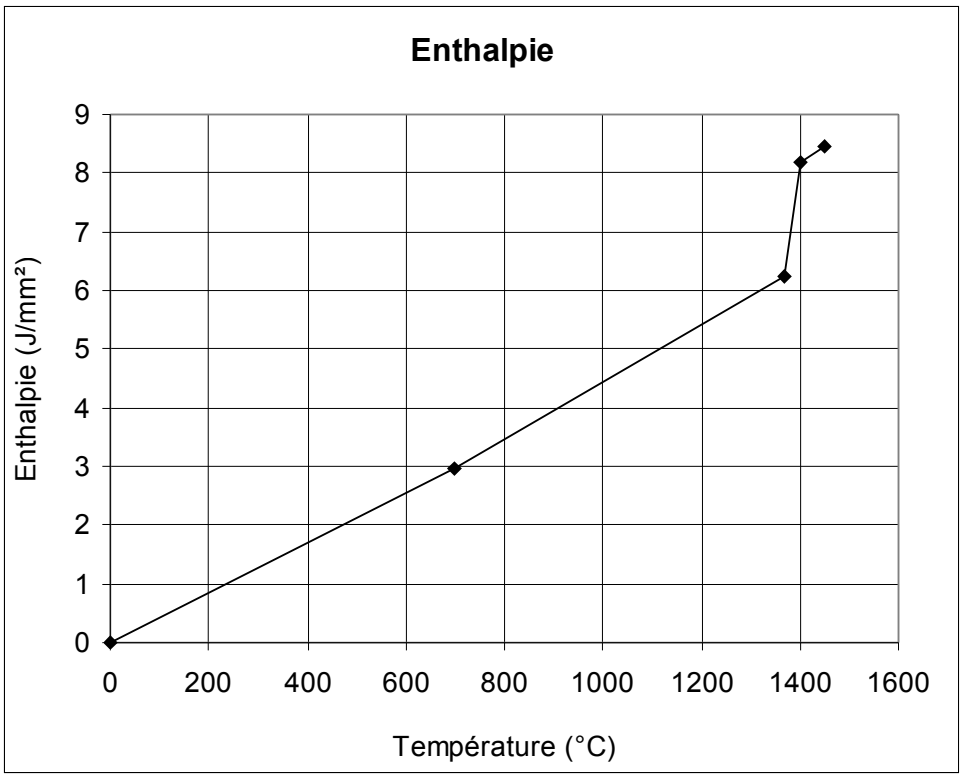
the material considered is a forged austenitic stainless steel of 316L type (Z2CND17-12).

For the nonlinear thermal modelization thermal conductivity and the product density capacity calorifiquevarient ρc according to the temperature. Their values are given in the table below:

T Temperature ($°C$)	λ thermal Conductivity ($W/(mm°C)$)	ρc ($J/mm^3°C$)	β Enthalpy (J/mm^3)
20	14.0 E-3	36.00 E-4	0.0
50	14.4 E-3		
100	15.2 E-3	39.05 E-4	
150	15.8 E-3		
200	16.6 E-3	41.63 E-4	
250	17.3 E-3		
300	17.9 E-3	43.00 E-4	
350	18.6 E-3		
400	19.2 E-3	43.90 E-4	
450	19.9 E-3		
500	20.6 E-3	44.50 E-4	
550	21.2 E-3		
600	21.8 E-3	44.95 E-4	
650	22.4 E-3		
700	23.1 E-3	45.80 E-4	2.979
750	23.7 E-3		
800	24.3 E-3	47.80 E-4	
900	26.0 E-3	49.00 E-4	
1000	27.3 E-3	49.90 E-4	
1200	29.9 E-3	50.40 E-4	
1370	32.2 E-3	50.40 E-4	6.232
1400	48.9 E-3	50.40 E-4	8.184
1450			8.444







1.3 Boundary conditions

the parameters of welding are presented in the table below:

I (Intensity)	U (Voltage)	V (Tape speed of the part)	Diameter of electrode
200A	13V	$14\,cm/min$	$3\,mm$

the upper surface of the plate is subjected to the action of a torch. This torch is placed in the center of the plate, $15\,mm$ board, and parallel to moves its length at constant velocity ($14\mathrm{cm}/min$) to $85.5\mathrm{mm}$ edge corresponding to the position of extinction of the torch.

1.4 Initial conditions

None.

2 Reference solution

2.1 Method of calculating

method of calculating of the density flux constant to impose, imposed boundary conditions, as well as the test results are presented in [bib1].

2.2 Quantities and results of reference

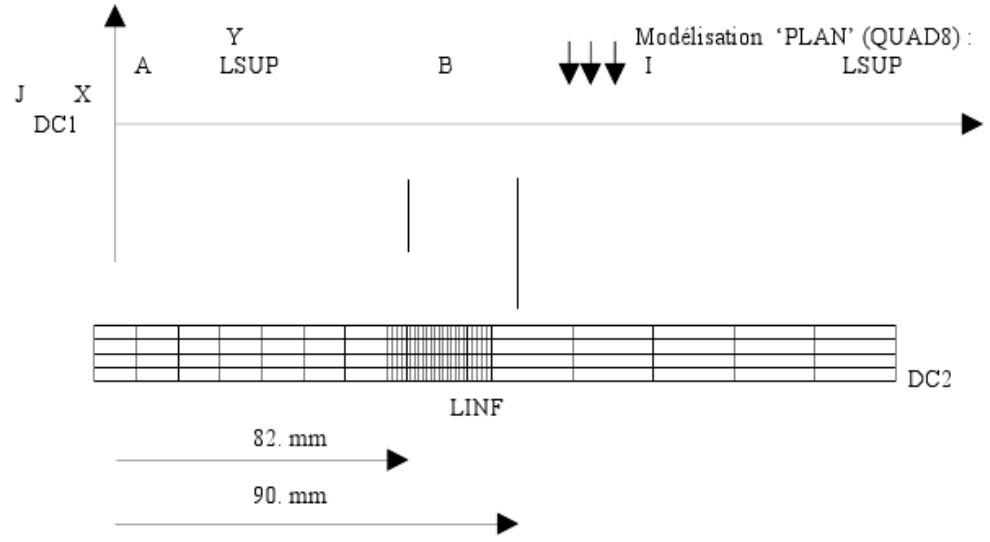
Temperatures on the upper face and lower of the plate close to the torch

2.3 bibliographical References

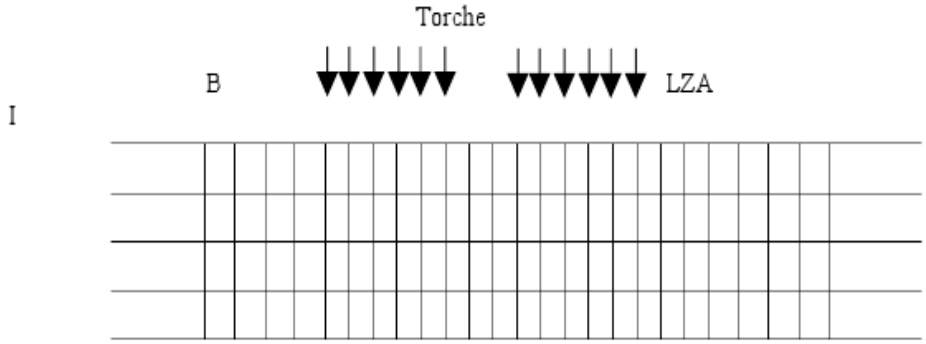
- D. BUI: “Thermal Simulations by finite elements of the Varestraint test”, Notes HI74/97/09

3 Modelization A

3.1 Characteristic of the modelization



Zones central mesh



the center of the torch is placed on $x=86.mm$ left board.

Boundary conditions:

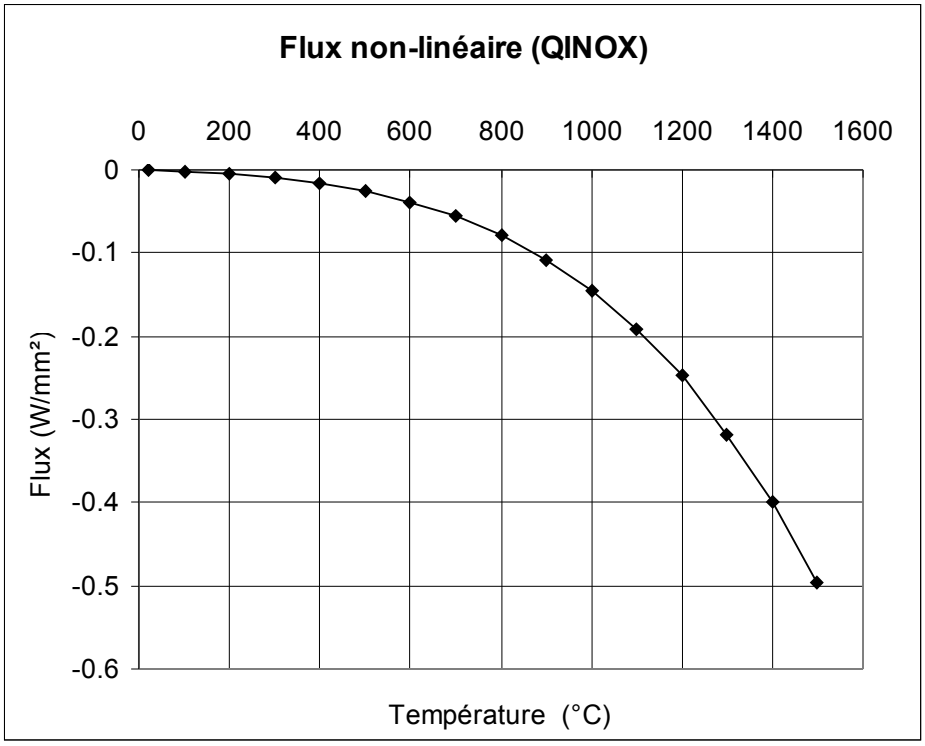
- Side $DC1$: adiabatic condition ($flux=0$)
- Side $DC2$: imposed temperature 20°C
- upper Surface LSUP : this part is made up on the sides AB and nonlinear
  IJ Flux imposed $QINOX$ (see table and figure below)
  Convective exchange: $h=15.10^{-6}W/(mm^{2.}{}^{\circ}C)$ $T_{ext}=20{}^{\circ}C$.
- Lower surface: LINF
  Nonlinear flux imposed $QINOX$ (see table and figure below)
  Convective exchange: $h=15.10^{-6}W/(mm^{2.}{}^{\circ}C)$ $T_{ext}=20{}^{\circ}C$.
- Tape speed of the part $V=-2.33\,mm/s$

Loading: Density flux brought by the torch:

- Density flux imposed $Q=19.62\,W/mm^2$ on with dimensions LZA ($B\rightarrow I$)

the Temperature (°C)	$QINOX$ Flux nonlinear (W/mm^2)
20	0.00E+00
100	-1.76E-03
200	-5.04E-03
300	-9.80E-03
400	-1.63E-02
500	-2.59E-02
600	-3.89E-02
700	-5.64E-02

Temperature (°C)	$QINOX$ Flux nonlinear W/mm^2 ( )
800	-7.96E-02
900	-1.08E-01
1000	-1.46E-01
1100	-1.92E-01
1200	-2.48E-01
1300	-3.17E-01
1400	-3.99E-01
1500	-4.97E-01



3.2 Characteristic of the mesh

Number of meshes: 144 (QUAD8)
Many nodes: 565

3.3 Quantities tested and results

Identification	Quantity	Reference $(°C)$	Aster $(°C)$	% Difference
$N1(X=82,Y=0)$	$TEMP$	1755.0	1756.11	0.063
$N2(X=83,Y=0)$	$TEMP$	1920.0	1919.29	0.037
$N3(X=84,Y=0)$	$TEMP$	1910.0	1908.63	0.072
$N7(X=88,Y=0)$	$TEMP$	1494.0	1493.46	0.036
$N8(X=89,Y=0)$	$TEMP$	1300.0	1297.51	0.191
$N173(X=46.93,Y=0)$	$TEMP$	1160.0	1155.76	0.365

$N174\,(X=57.36\,,Y=0)$	$TEMP$	1215.0	1213.32	0.139
$N175\,(X=67.79\,,Y=0)$	$TEMP$	1295.0	1291.86	0.243
$N478\,(X=10.43\,,Y=-7)$	$TEMP$	1007.0	1001.09	0.587
$N522\,(X=52.14\,,Y=-7)$	$TEMP$	989.0	982.39	0.668
$N559\,(X=0,Y=-7)$	$TEMP$	980.0	973.92	0.621

3.4 Remarks

In the table below we present the position of the nodes in the reference (xy) of the torch.

Nodes located under the torch (Zone 1)	Nodes located on the left of the torch (Zone 2)	Nodes located on the left of the torch and below the plate (Zone 3)
$N1: x=-4\,mm\,,y=0$	$N173: x=-39.0\,mm\,,y=0$	$N478: x=-86.0\,mm$
$N2: x=-3\,mm\,,y=0$	$N174: x=-28.6\,mm\,,y=0$	$N522: x=-81.0\,mm$
$N3: x=-2\,mm\,,y=0$	$N175: x=-18.2\,mm\,,y=0$	$N559: x=-18.2\,mm$
$N7: x=2\,mm\,,y=0$		
$N8: x=3\,mm\,,y=0$		