TPLV105 - Stationary nonlinear thermics in pointer: simulation of the Varestrain test

Summary:

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

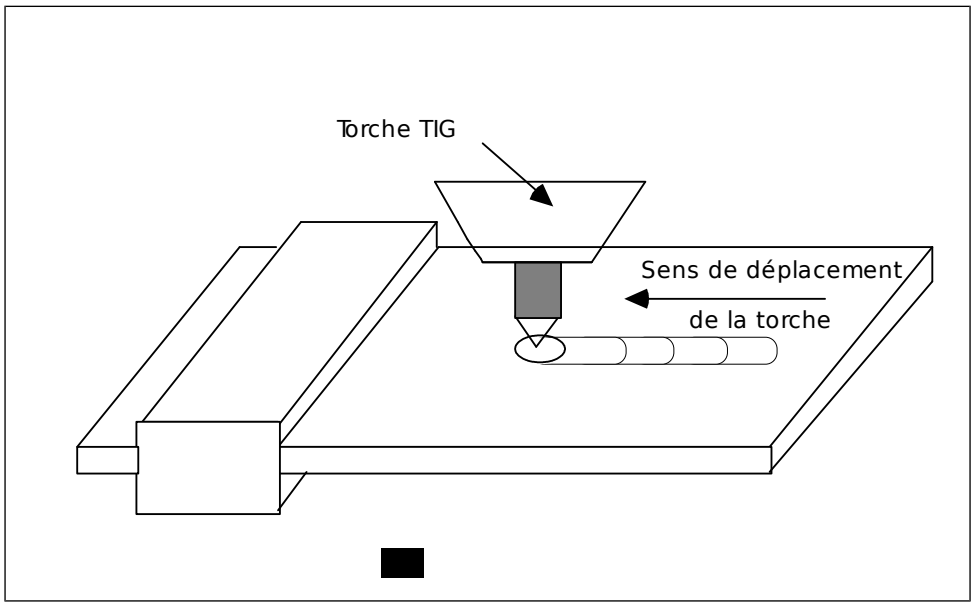
This test makes it possible to test a nonlinear thermal problem formulated in a pointer under condition of stationnarity.

In this test only one modeling is carried out, it acts of a thermal modeling PLAN associated with the operator THER_NON_LINE_MO allowing to calculate the nonlinear stationary answer 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.



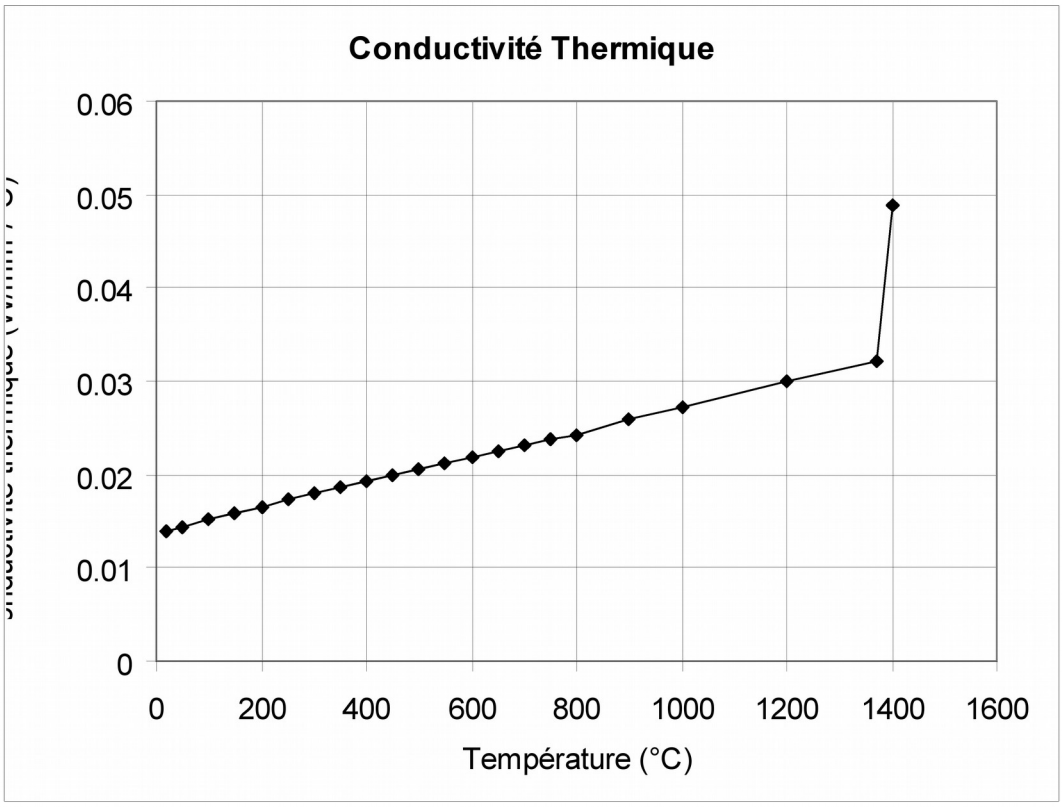
Thickness test-tube	Width of the test-tube	Length of the test-tube
$7\,mm$	$60\,mm$	$200\,mm$

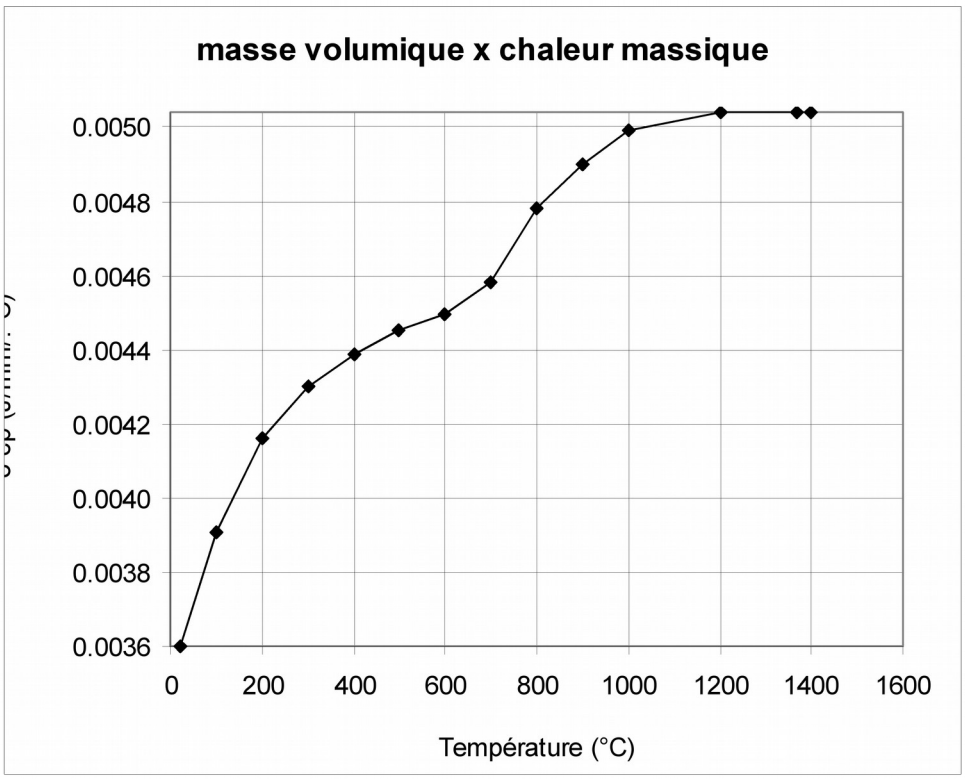
1.2 Properties of material

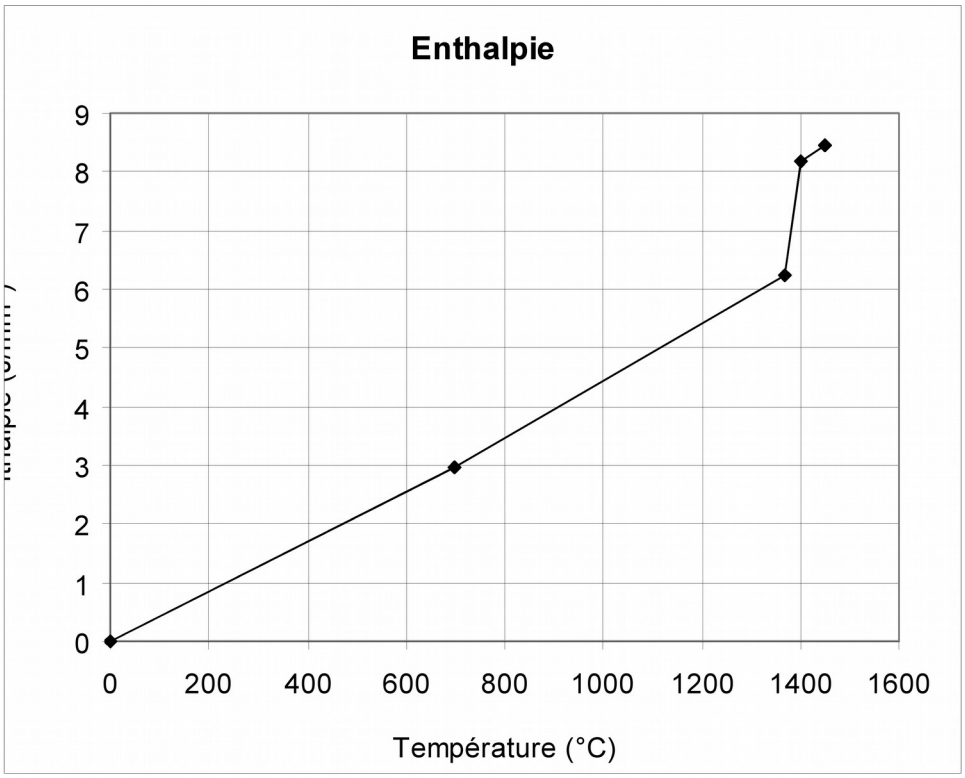
The material considered is a forged austenitic stainless steel of 316L type (Z2CND17-12).

For nonlinear thermal modeling thermal conductivity and the product density heat-storage capacity ρc vary according to the temperature. Their values are given in the table below:

T Temperature ($°C$)	λ Thermal conductivity ($W/(mm°C)$)	ρ c ($J/mm^3°C$)	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, with $15\,mm$ edge, and parallel to moves its length at constant speed ($14\mathrm{cm}/min$) until $85.5\mathrm{mm}$ 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, boundary conditions imposed, as well as the test results are presented in [bib1].

2.2 Sizes and results of reference

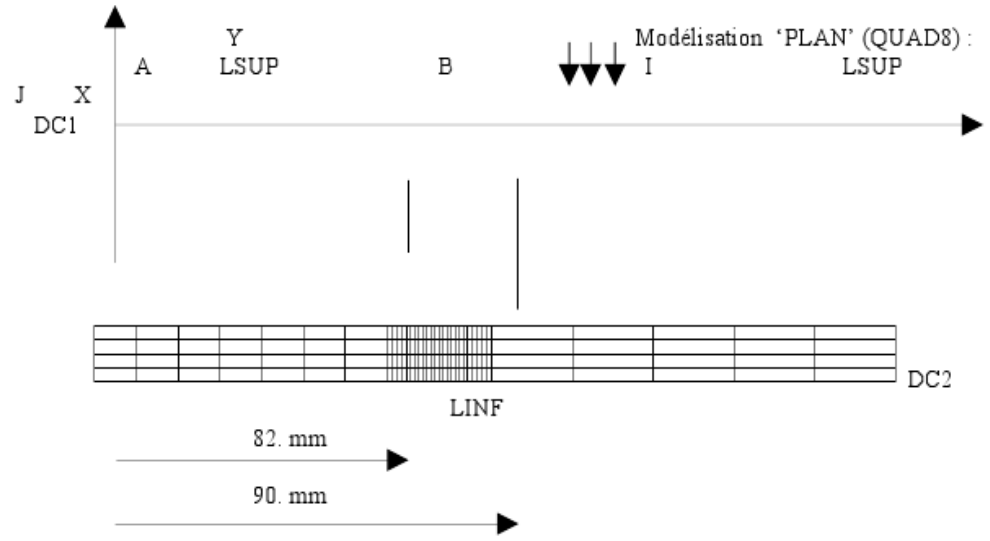
Temperatures on the higher and lower face of the plate close to the torch

2.3 Bibliographical references

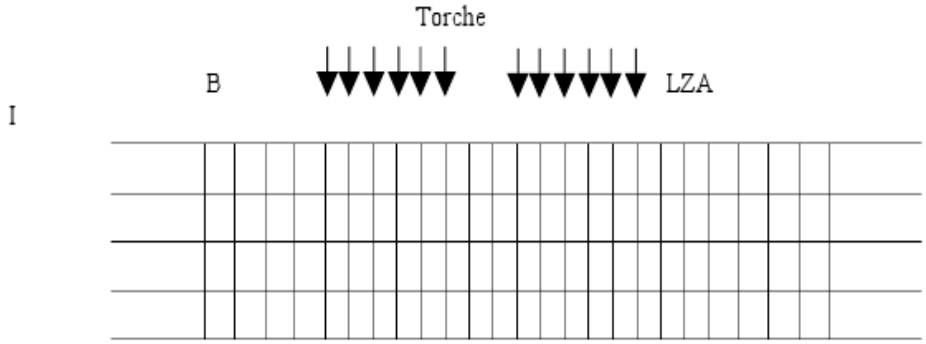
- D. BUI: “Thermal simulations by finite elements of the Varestraint test”, HI74/97/09 Notes

3 Modeling A

3.1 Characteristics of modeling



Central zone of the grid



The center of the torch is placed at $x=86.mm$ left edge.

Boundary conditions:

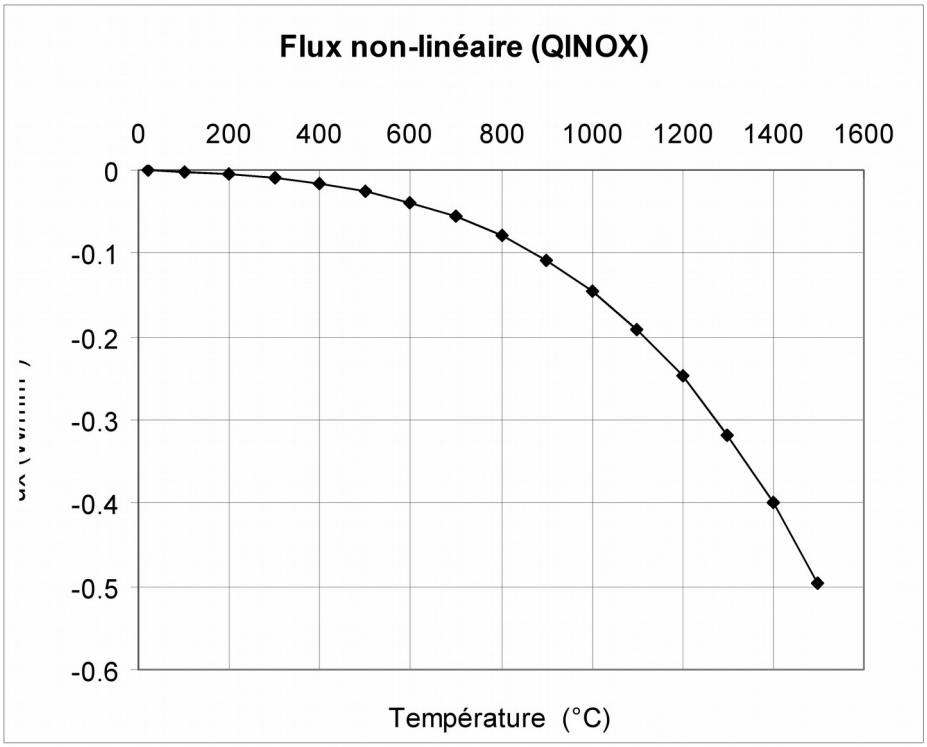
- Side $DC1$: adiabatic condition ($flux=0$)
- Side $DC2$: imposed temperature 20°C
- Upper surface LSUP : this part is made up on the sides AB and IJ
  Imposed nonlinear flow $QINOX$ (see table and figure below)
  Convectif exchange: $h=15.10^{-6}W/(mm^{2.}{}^{\circ}C)$, $T_{ext}=20{}^{\circ}C$.
- Lower surface: LINF
  Imposed nonlinear flow $QINOX$ (see table and figure below)
  Convectif 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 one LZA ($B\rightarrow I$)

Temperature (°C)	$QINOX$ Nonlinear flow (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)	$QINOX$ Nonlinear flow 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 Characteristics of the grid

Many meshs: 144 (QUAD8)
Many nodes: 565

3.3 Sizes tested and results

Identification	Size	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 mark (xy) 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)
$N1: x=-4\,mm\,,y=0$	$N173: x=-39.0\,mm\,,y=0$	$N478: x=-86.0\,mm$
$N2: x=-3\,mm\,,y=0$	$N174: x=-28.6\,mm\,,y=0$	$N522: x=-81.0\,mm$
$N3: x=-2\,mm\,,y=0$	$N175: x=-18.2\,mm\,,y=0$	$N559: x=-18.2\,mm$
$N7: x=2\,mm\,,y=0$		
$N8: x=3\,mm\,,y=0$		