TPLS302 - Distribution of temperature in a thin plate

Summarized:

One considers a plate subjected to convection applied to the sides lower and higher and an edge of the plate (width). The temperature is imposed on opposite edge of the plate.

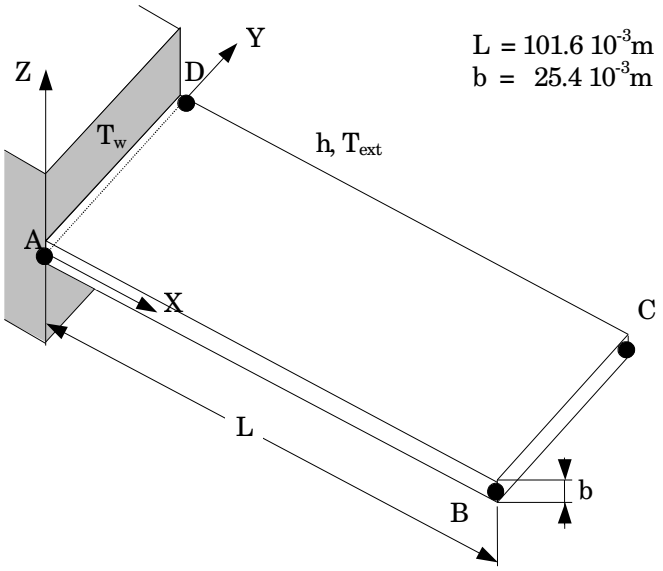
The goal of this test is to validate the thermal shell element in conduction in the plane and convection [R3.11.01] and [U1.01.01]. It also makes it possible to validate the edge elements in convection.

Because as of boundary conditions and of the loadings considered, the distribution of temperature is uniform along the width. The results are compared with a solution based on a graphic estimate. The two types of approach give equivalent results.

This test is resulting from the validation independent of version 3 in thermal.

1 Problem of reference

1.1 Geometry



1.2 Material properties

$\rho C_P = 1.J/m^3 °C$
$\lambda = 25.961 W/m °C$

1.3 Boundary conditions and loadings

Convection on the lower, higher face:

$h = 85.169 W/m^2 °C$
$T_{ext} = 37.778 °C$

and on the end $(x = L, BC)$ of the plate:

$h' = 2.163 W/m °C$ corresponding with $h \times b$ for this test

Temperature imposed on with dimensions one AD : $T_w = 593.333 °C$

2 Reference solution

2.1 Method of calculating used for the reference solution

the original reference solution given in the book [bib1] is based on a graphic estimate. Uncertainty on the solution is unknown.

This reference is quoted in the handbook of checking of ANSYS [bib2].

2.2 Results of reference

Temperature to the points of bibliographical $x/L = 0, 0.1, 0.2, \ldots 0.8, 0.9, 1.$

2.3 coordinates References

- Kreith, F., “Principles of heat transfer”, International Textbook Co., Scranton, Pennsylvania, 2nd Printing, 1959.
- ANSYS: “Checking manual”, 1st edition, June 1,1976

3 Modelization A

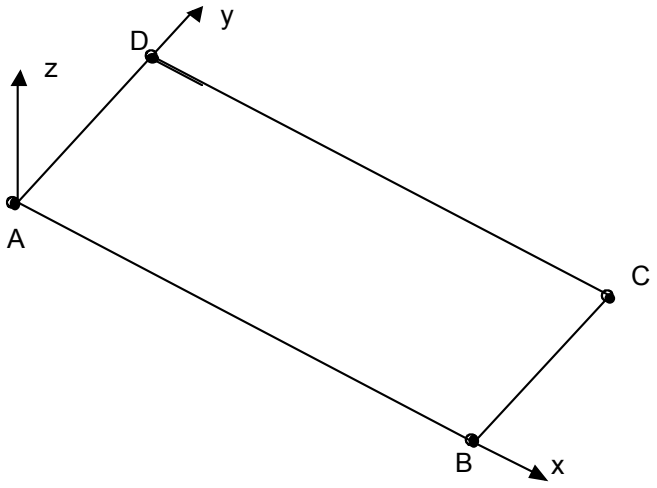
3.1 Characteristic of the modelization

Because of symmetry of the boundary conditions and the loadings, the modelization independent of the width of is dimensioned AD and BC (the distribution of temperature is uniform in the meaning of the width).

Modelization: COQUE (QUAD8 + SEG3)

Conditions limites :

- coté AD T_w = 593.33°C
- face supérieure, inférieure et bord BC
  h = 85.169 W/ m^2°C
  T_{ext} = 37.78 °C



Découpage

- Cotés AB, CD : 5 éléments
- Cotés AD, BC : 1 élément

3.2 Characteristic of the mesh

One have 28 nodes in all

5 meshes QUAD8 on the mean surface of shell
1 nets SEG3 on with dimensions BC

3.3 the Values tested

Identification	Reference
Localization	$T(°C)$
$x/L=0.0$	593.333
$x/L=0.1$	512.778
$x/L=0.2$	446.111
$x/L=0.3$	393.333
$x/L=0.4$	348.889
$x/L=0.5$	312.778
$x/L=0.6$	279.444
$x/L=0.7$	254.444
$x/L=0.8$	237.778
$x/L=0.9$	221.111
$x/L=1.0$	213.333

3.4 Remarks

As envisaged, the distribution of temperature is uniform according to the width. All the got results are in the interval of allowed tolerance which corresponds to the uncertainty supposed on the results of the graphic estimate.

4 Modelization B

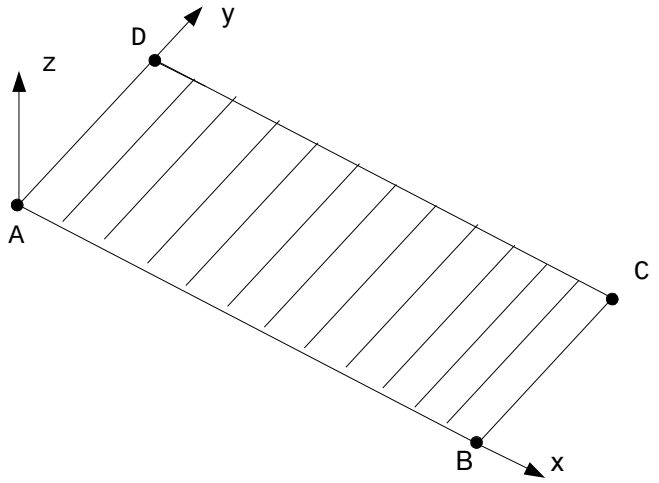
4.1 Characteristic of the modelization

Because of the boundary conditions and the loadings, the modelization independent of the width of is dimensioned AD and BC (the distribution of temperature is uniform along the width).

Modelization: COQUE (QUAD4 + SEG2)

Conditions limites:

• coté AD T_w=593.33°C
• face supérieure, inférieure et bord BC
h = 85.169 W/m²°C
T_{ext}= 37.78 °C



Découpage

• Cotés AB, CD: 10 éléments
• Cotés AD, BC: 1 élément

4.2 Characteristic of the mesh

One have 22 nodes in all
10 meshes QUAD4 on the mean surface of shell
1 nets SEG2 on with dimensions BC

4.3 the Values tested

Identification	Reference
Localization	$T(°C)$
$x/L=0.0$	593.333
$x/L=0.1$	512.778
$x/L=0.2$	446.111
$x/L=0.3$	393.333
$x/L=0.4$	348.889
$x/L=0.5$	312.778
$x/L=0.6$	279.444
$x/L=0.7$	254.444
$x/L=0.8$	237.778
$x/L=0.9$	221.111
$x/L=1.0$	213.333

4.4 Remarks

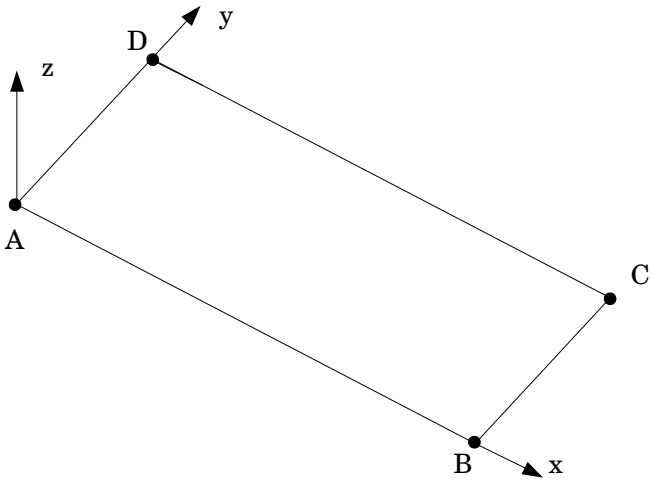
As envisaged, the distribution of temperature is uniform according to the width. All the got results are in the interval of allowed tolerance which corresponds to the uncertainty supposed on the results of the graphic estimate.

5 Modelization C

Modelization: COQUE (QUAD9 + SEG3)

Conditions limites:

- coté AD T_w=593.33°C
- face supérieure, inférieure et bord BC
  h = 85.169 W/m²°C
  T_{ext}= 37.78 °C



Découpage

- Cotés AB, CD: 5 éléments
- Cotés AD, BC: 1 élément

5.1 Characteristic of the modelization

Because of the boundary conditions and loadings, the modelization independent of the width of are dimensioned AD and BC (the distribution of temperature is uniform along the largeu).

5.2 Characteristics of the mesh

There are 33 nodes in all
5 meshes QUAD9 on the mean surface of shell
1 meshes SEG3 on with dimensions BC

5.3 the Values tested

Identification	Reference	*Aster*	% difference	tolerance
Localization	$T(°C)$			
$x/L=0.0$	593.333	593.333	0.000	5%
$x/L=0.1$	512.778	517.947	1.008	5%
$x/L=0.2$	446.111	451.207	1.142	5%
$x/L=0.3$	393.333	395.841	0.638	5%
$x/L=0.4$	348.889	349.658	0.220	5%
$x/L=0.5$	312.778	311.722	-0.338	5%
$x/L=0.6$	279.444	280.993	0.554	5%
$x/L=0.7$	254.444	256.673	0.876	5%
$x/L=0.8$	237.778	238.125	0.146	5%
$x/L=0.9$	221.111	224.854	1.693	5%
$x/L=1.0$	213.333	216.516	1.492	5%

5.4 Remarks

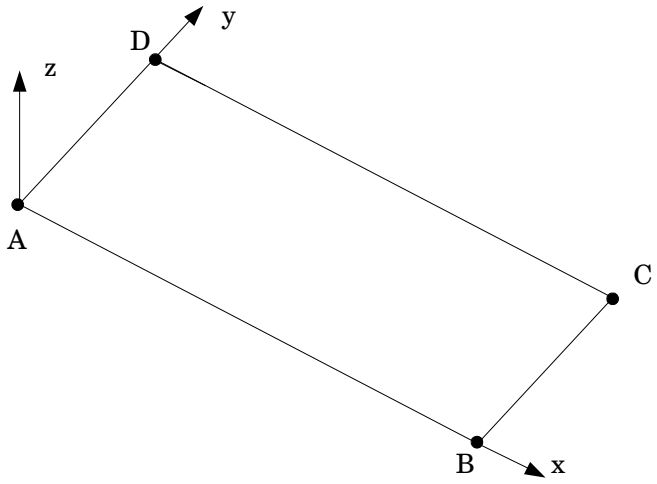
As envisaged, the distribution of temperature is uniform according to the width. All the got results are clearly in the interval of allowed tolerance.

6 Modelization D

Modelization: COQUE (TRIA7 + SEG3)

Conditions limites:

- coté AD T_w=593.33°C
- face supérieure, inférieure et bord BC
  h = 85.169 W/m²°C
  T_{ext}= 37.78 °C



Découpage

- Cotés AB, CD: 10 éléments
- Cotés AD, BC: 1 élément

6.1 Characteristic of the modelization

Because of the boundary conditions and loadings, the modelization are independent of the width of with dimensions AD and BC (the distribution of temperature is uniform along the largeu).

6.2 Characteristics of the mesh

There are 43 nodes in all
10 meshes TRIA7 on the mean surface of shell
1 meshes SEG3 on with dimensions BC

6.3 the Values tested

Identification	Reference	*Aster*	% difference	tolerance
Localization	T (°C)			
x/L = 0.0	593.333	593.333	0.000	5%
x/L = 0.1	512.778	517.863	0.992	5%
x/L = 0.2	446.111	451.193	1.139	5%
x/L = 0.3	393.333	395.862	0.643	5%
x/L = 0.4	348.889	349.635	0.214	5%
x/L = 0.5	312.778	311.737	-0.333	5%
x/L = 0.6	279.444	280.981	0.550	5%
x/L = 0.7	254.444	256.683	0.880	5%
x/L = 0.8	237.778	238.122	0.145	5%
x/L = 0.9	221.111	224.857	1.694	5%
x/L = 1.0	213.333	216.526	1.497	5%

6.4 Remarks

As envisaged, the distribution of temperature is uniform according to the width. All the got results are clearly in the interval of allowed tolerance.

7 Summary of the results

results got for the two modelizations (QUAD8 + SEG3 or QUAD + SEG2) in the interval of allowed tolerance (< 2% for a tolerance of 5%) which corresponds to uncertainty on the results of the graphic estimate of reference.

The data of the test could retain a tolerance of 2%.