

TPLS302 - Distribution of temperature in one thin section

Summary:

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

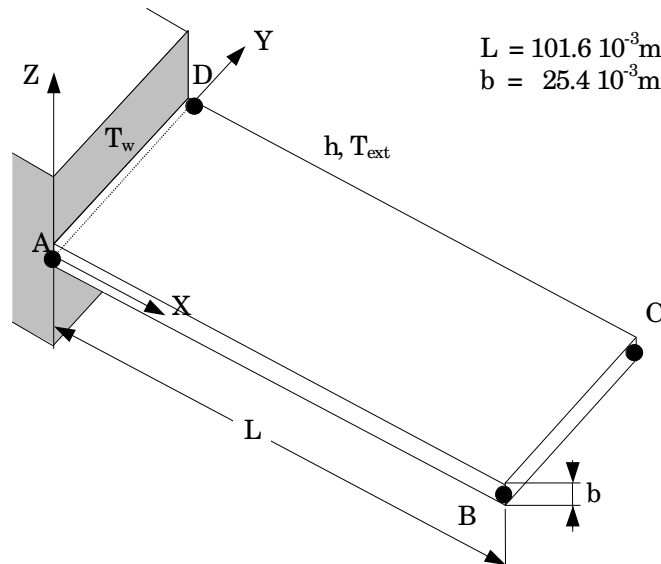
The goal of this test is to validate the thermal element of hull in conduction in the plan and convection [R3.11.01] and [U1.01.01]. It also makes it possible to validate the elements of edge in convection.

Because of the boundary conditions and 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 thermics.

1 Problem of reference

1.1 Geometry



1.2 Material properties

$$\rho C_p = 1. \text{ J/m}^3 \cdot \text{ }^\circ\text{C}$$

$$\lambda = 25.961 \text{ W/m} \cdot \text{ }^\circ\text{C}$$

1.3 Boundary conditions and loadings

Convection on the lower, higher face:

$$h = 85.169 \text{ W/m}^2 \cdot \text{ }^\circ\text{C}$$

$$T_{ext} = 37.778 \text{ }^\circ\text{C}$$

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

$$h' = 2.163 \text{ W/m} \cdot \text{ }^\circ\text{C} \text{ correspondent with } h \times b \text{ for this test}$$

Temperature imposed on with dimensions one AD : $T_w = 593.333 \text{ }^\circ\text{C}$

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 at the points of coordinates $x/L=0, 0.1, 0.2, \dots, 0.8, 0.9, 1$.

2.3 Bibliographical references

- Kreith, F., "Principles of heat transfer", International Textbook Co., Scranton, Pennsylvania, 2nd Printing, 1959.
- ANSYS: "Checking manual", 1st edition, June 1.1976

3 Modeling A

3.1 Characteristics of modeling

Because of symmetry of the boundary conditions and loadings, modeling is independent of the width of with dimensions ones AD and BC (the distribution of temperature is uniform in the direction of the width).

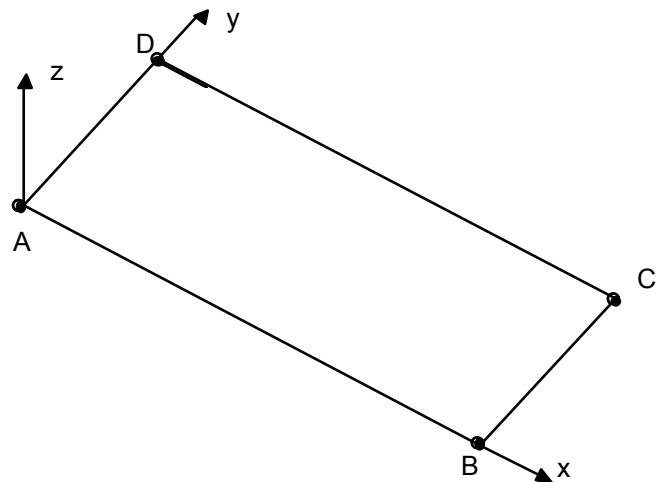
Modeling: HULL (QUAD8 + SEG3)

Conditions limites :

- coté AD $T_w = 593.33^\circ\text{C}$
- face supérieure, inférieure et bord BC
 $h = 85.169 \text{ Wm}^2\text{C}$
 $T_{\text{ext}} = 37.78^\circ\text{C}$

Découpage

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



3.2 Characteristics of the grid

There are 28 nodes on the whole

- 5 meshes QUAD8 on the average surface of hull
- 1 mesh SEG3 on with dimensions one BC

3.3 Values tested

| Identification | Reference |
|----------------|-----------------------|
| Localization | $T(^{\circ}\text{C})$ |
| $x/L=0.0$ | 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.

Code_Aster

Version
default

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4 Modeling B

4.1 Characteristics of modeling

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

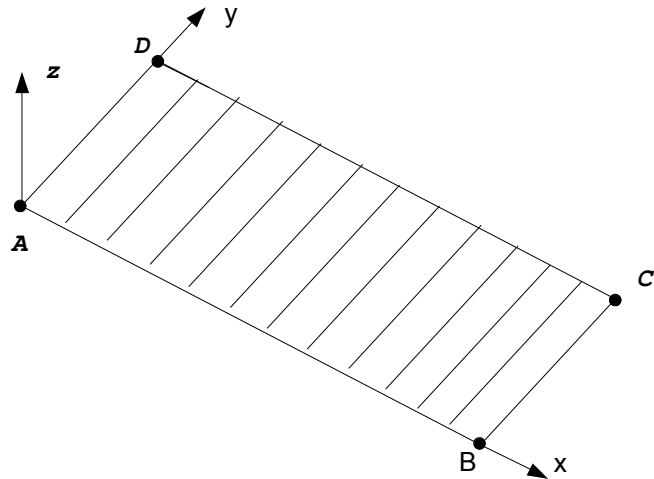
Modeling: HULL (QUAD4 + SEG2)

Conditions limites:

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

Découpage

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



4.2 Characteristics of the grid

There are 22 nodes on the whole
10 meshes QUAD4 on the average surface of hull
1 mesh SEG2 on with dimensions one BC

4.3 Values tested

| Identification | Reference |
|----------------|---------------------|
| Localization | $T(^\circ\text{C})$ |
| $x/L=0.0$ | 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 Modeling C

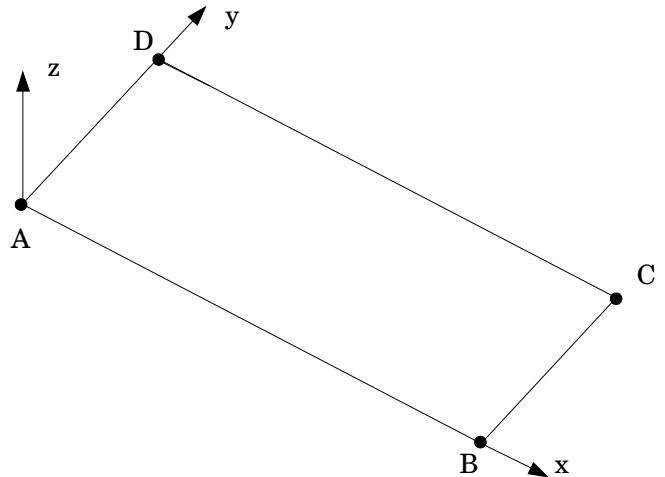
Modeling: HULL (QUAD9 + SEG3)

Conditions limites:

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

Découpage

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



5.1 Characteristics of modeling

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

5.2 Characteristics of the grid

There are 33 nodes on the whole
5 meshes QUAD9 on the average surface of hull
1 meshes SEG3 on with dimensions BC

5.3 Values tested

| Identification | Reference | Aster | % difference | tolerance |
|----------------|---------------------|---------|--------------|-----------|
| Localization | $T(^\circ\text{C})$ | | | |
| $x/L=0.0$ | 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 Modeling D

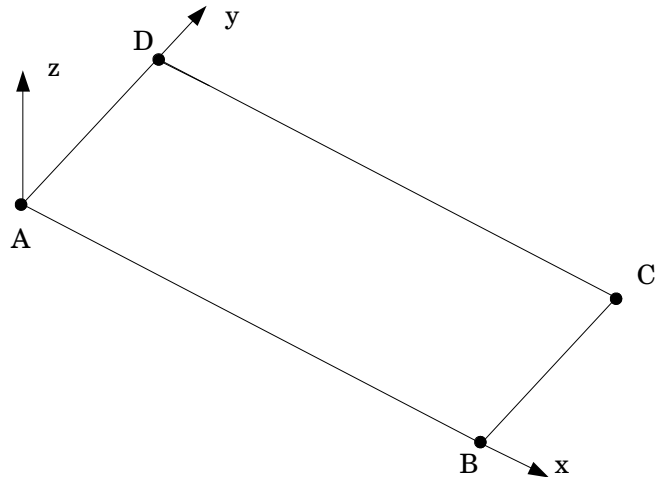
Modeling: HULL (TRIA7 + SEG3)

Conditions limites:

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

Découpage

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



6.1 Characteristics of modeling

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

6.2 Characteristics of the grid

There are 43 nodes on the whole
10 meshes TRIA7 on the average surface of hull
1 meshes SEG3 on with dimensions one BC

6.3 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 two modelings (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%.