

TPLS101 - Infinite plate subjected to an exchange symmetrical thermics with outside

Summary:

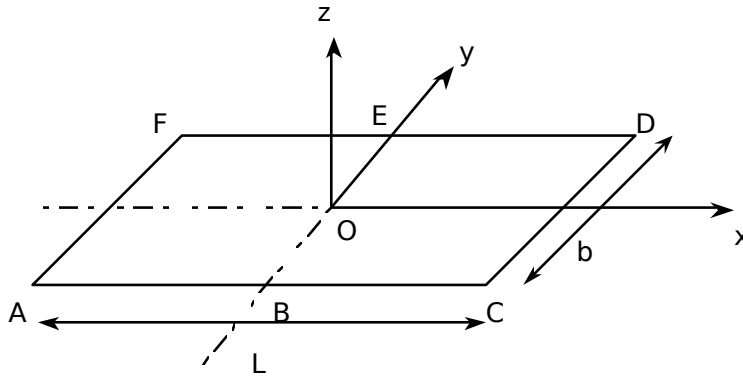
The purpose of this test is to test the model of thermal hull linear with three fields per comparison with the analytical solution, for an infinite plate subjected to a couple of conditions of heat exchange with outside, symmetrical compared to the average layer. The equation of heat is solved in hover, with a linear, isotropic, homogeneous conduction.

The results are presented for the finite elements available of thermal surface hull triangles and quadrangles.

Compared to test TPLS100 [V4.03.100], this one makes it possible to check the contribution of the coefficients of exchange to thermal rigidity, like various methods of assignment of the boundary conditions. Moreover, the solution is such as the temperature is uniform in the thickness.

1 Problem of reference

1.1 Geometry



Length: $L = 20\text{mm}$

Width: $b = 2\text{mm}$

Thickness: $h = 4\text{mm}$

1.2 Material properties

Conductivity $\lambda = 1000 \text{ W/mm/}^\circ\text{C}$

1.3 Boundary conditions and loadings

- Worthless temperature at the point O , on all the thickness.
- On the higher faces $(ABEF)^+$ and lower $(ABEF)^-$:
coefficient of exchange: $h = 10 \text{ W/mm}^2/\text{ }^\circ\text{C}$
outside temperature: $T_{ext} = 50^\circ\text{C}$
- On the faces higher $(BCDE)^+$ and lower $(BCDE)^-$:
coefficient of exchange: $h = 10 \text{ W/mm}^2/\text{ }^\circ\text{C}$
outside temperature: $T_{ext} = -50^\circ\text{C}$

2 Reference solution

2.1 Method of calculating used for the reference solution

Analytical

For more details to refer to the document [R3.11.01] and the note [bib1].

2.2 Results of reference

Temperature in higher, lower skin and average layer.

2.3 Uncertainty on the solution

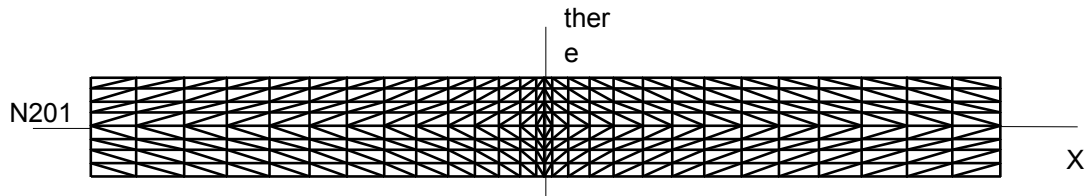
Analytical solution.

2.4 Bibliographical references

- S. ANDRIEUX, F. VOLDOIRE HI-71/7131 - Formulation of a model of thermics for the thin hulls (12/7/90).

3 Modeling A

3.1 Characteristics of modeling



Cutting: 28 elements in length,
8 elements in width.

Boundary conditions - loading (three calculations for three choices):

- calculation a: scalar loadings and dualisation of the condition of Dirichlet:

```
TEMP_IMPO (NOEUD= 'N1', TEMP_SUP= 0. , TEMP_MIL= 0. , TEMP_INF= 0.)
EXCHANGE (GROUP_MA = ' GRSD1', COEF_H_SUP: 10. , COEF_H_INF = 10. ,
          TEMP_EXT_SUP = -50. , TEMP_EXT_INF = -50.)
          (GROUP_MA = ' GRSD2', COEF_H_SUP = 10. , COEF_H_INF = 10. ,
          TEMP_EXT_SUP = 50. , TEMP_EXT_INF = 50.)
```

- calculation b: loadings constant functions and dualisation of the condition of Dirichlet:
as above, but with constant functions having same values.
- calculation C: scalar loadings and "kinematic" loading:

```
THER_IMPO (NOEUD= 'N1', TEMP_SUP= 0. , TEMP_MIL= 0. , TEMP_INF= 0.)
```

3.2 Characteristics of the grid

Many nodes: 969

Many meshes and types: 448 meshes TRIA6

3.3 Values tested

| Identification | | Reference |
|--------------------------------|----------|-----------|
| Node <i>N201</i> (-10.,0.) | Temp_sup | 49,999 |
| | Temp_mil | 49,999 |
| | Temp_inf | 49,999 |
| Node <i>N176</i> (-5.15,0.) | Temp_sup | 49.9658 |
| | Temp_mil | 49.9658 |
| | Temp_inf | 49.9658 |
| Node <i>N171</i> (-4.32,0.) | Temp_sup | 49.8888 |
| | Temp_mil | 49.8888 |
| | Temp_inf | 49.8888 |
| Node <i>N166</i> (-3.53,0.) | Temp_sup | 49.6631 |
| | Temp_mil | 49.6631 |
| | Temp_inf | 49.6631 |
| Node <i>N161</i> | Temp_sup | 49.0542 |

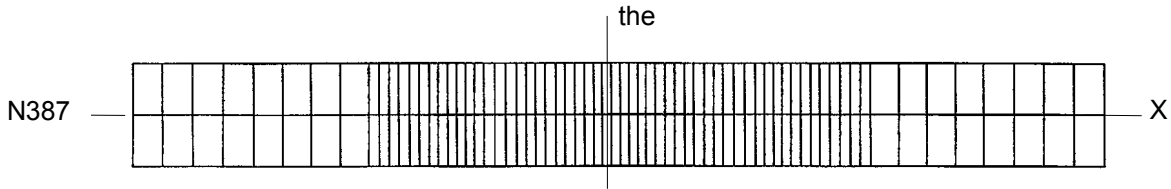
| | | |
|------------|----------|----------|
| (-2.8,0.) | Temp_mil | 49.0542 |
| | Temp_inf | 49.0542 |
| N156 node | Temp_sup | 47,556 |
| (-2.13,0.) | Temp_mil | 47,556 |
| | Temp_inf | 47,556 |
| Node N141 | Temp_sup | 26,700 |
| (-0.54,0.) | Temp_mil | 26,700 |
| | Temp_inf | 26,700 |
| Node N136 | Temp_sup | 11,830 |
| (-0.19,0.) | Temp_mil | 11,830 |
| | Temp_inf | 11,830 |
| Node N11 | Temp_sup | - 26,700 |
| (0.54,0.) | Temp_mil | - 26,700 |
| | Temp_inf | - 26,700 |
| Node N26 | Temp_sup | - 47,556 |
| (2.13,0.) | Temp_mil | - 47,556 |
| | Temp_inf | - 47,556 |

Contents of the file results

- Temperatures with the nodes of calculation has,
- heat flow on the average layer (calculation a),
- values tested deferred above (calculations has, B, c).

4 Modeling B

4.1 Characteristics of modeling



Cutting: 68 elements in length,
2 elements in width.

Boundary conditions - loading (three calculations for three choices):

- scalar loadings and dualisation of the condition of Dirichlet:

```
TEMP_IMPO (NODE: N1, TEMP_SUP: 0. , TEMP_MIL: 0. , TEMP_INF: 0.)
EXCHANGE: (GROUP_MA: GRSD1, COEF_H_SUP: 10. , COEF_H_INF: 10. ,
            TEMP_EXT_SUP: -50. , TEMP_EXT_INF: -50.)
            (GROUP_MA: GRSD2, COEF_H_SUP: 10. , COEF_H_INF: 10. ,
            TEMP_EXT_SUP: 50. , TEMP_EXT_INF: 50.)
```
- loadings constant functions and dualisation of the condition of Dirichlet:
as above, but with constant functions having same values.
- scalar loadings and "kinematic" loading:

```
THER_IMPO: (NODE: N1, TEMP_SUP: 0. , TEMP_MIL: 0. , TEMP_INF: 0.)
```

4.2 Characteristics of the grid

Many nodes: 456

Many meshes and types: 136 meshes QUAD4

4.3 Values tested

| Identification | | Reference |
|--------------------------------|----------|-----------|
| Node <i>N387</i> (-10.,0.) | Temp_sup | 49,999 |
| | Temp_mil | 49,999 |
| | Temp_inf | 49,999 |
| Node <i>N397</i> (-5.15,0.) | Temp_sup | 49.9658 |
| | Temp_mil | 49.9658 |
| | Temp_inf | 49.9658 |
| Node <i>N401</i> (-4.32,0.) | Temp_sup | 49.8888 |
| | Temp_mil | 49.8888 |
| | Temp_inf | 49.8888 |
| Node <i>N405</i> (-3.53,0.) | Temp_sup | 49.6631 |
| | Temp_mil | 49.6631 |
| | Temp_inf | 49.6631 |
| Node <i>N409</i> (-2.8,0.) | Temp_sup | 49.0542 |
| | Temp_mil | 49.0542 |

Code Aster

Version
default

Titre : TPLS101 - Plaque infinie soumise à un échange ther[...]
Responsable : HAELEWYN Jessica

Date : 17/04/2013 Page : 7/14
Clé : V4.03.101 Révision :
42cb353bf9bc

| | | |
|------------------|----------|---------|
| | Temp_inf | 49,0542 |
| Node N412 | Temp_sup | 47,556 |
| (-2.13,0.) | Temp_mil | 47,556 |
| | Temp_inf | 47,556 |
| Node N420 | Temp_sup | 26,700 |
| (-0.54,0.) | Temp_mil | 26,700 |
| | Temp_inf | 26,700 |
| Node N422 | Temp_sup | 11,830 |
| (-0.19,0.) | Temp_mil | 11,830 |
| | Temp_inf | 11,830 |
| Node N426 | Temp_sup | -26,700 |
| (0.54,0.) | Temp_mil | -26,700 |
| | Temp_inf | -26,700 |
| Node N434 | Temp_sup | -47,556 |
| (2.13,0.) | Temp_mil | -47,556 |
| | Temp_inf | -47,556 |

5 Modeling C

5.1 Characteristics of modeling



Cutting: 30 elements in length,
2 elements in width.

Boundary conditions - loading (three calculations for three choices):

- scalar loadings and dualisation of the condition of Dirichlet:

```
TEMP_IMPO (NODE: N1, TEMP_SUP: 0. , TEMP_MIL: 0. , TEMP_INF: 0.)
EXCHANGE: (GROUP_MA: GRSD1, COEF_H_SUP: 10. , COEF_H_INF: 10. ,
           TEMP_EXT_SUP: -50. , TEMP_EXT_INF: -50.)
           (GROUP_MA: GRSD2, COEF_H_SUP: 10. , COEF_H_INF: 10. ,
           TEMP_EXT_SUP: 50. , TEMP_EXT_INF: 50.)
```
- loadings constant functions and dualisation of the condition of Dirichlet:
as above, but with constant functions having same values.
- scalar loadings and "kinematic" loading:

```
THER_IMPO: (NODE: N1, TEMP_SUP: 0. , TEMP_MIL: 0. , TEMP_INF: 0.)
```

5.2 Characteristics of the grid

Many nodes: 410

Many meshes and types: 60 meshes QUAD8

5.3 Values tested

| Identification | | Reference |
|-------------------------|----------|-----------|
| Node N227 (-10.,0.) | Temp_sup | 49,999 |
| | Temp_mil | 49,999 |
| | Temp_inf | 49,999 |
| Node N233 (-5.15,0.) | Temp_sup | 49.9658 |
| | Temp_mil | 49.9658 |
| | Temp_inf | 49.9658 |
| Node N235 (-4.32,0.) | Temp_sup | 49.8888 |
| | Temp_mil | 49.8888 |
| | Temp_inf | 49.8888 |
| Node N237 (-3.53,0.) | Temp_sup | 49.6631 |
| | Temp_mil | 49.6631 |
| | Temp_inf | 49.6631 |
| Node N238 (-2.8,0.) | Temp_sup | 49.0542 |
| | Temp_mil | 49.0542 |

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| | | |
|------------------|----------|---------|
| | Temp_inf | 49.0542 |
| Node N239 | Temp_sup | 47,556 |
| (-2.13,0.) | Temp_mil | 47,556 |
| | Temp_inf | 47,556 |
| Node N242 | Temp_sup | 26,700 |
| (-0.54,0.) | Temp_mil | 26,700 |
| | Temp_inf | 26,700 |
| Node N243 | Temp_sup | 11,830 |
| (-0.19,0.) | Temp_mil | 11,830 |
| | Temp_inf | 11,830 |
| Node N246 | Temp_sup | -26,700 |
| (0.54,0.) | Temp_mil | -26,700 |
| | Temp_inf | -26,700 |
| Node N249 | Temp_sup | -47,556 |
| (2.13,0.) | Temp_mil | -47,556 |
| | Temp_inf | -47,556 |

6 Modeling D

6.1 Characteristics of modeling



Cutting: 30 elements in length,
2 elements in width.

Boundary conditions - loading (three calculations for three choices):

- scalar loadings and dualisation of the condition of Dirichlet:

```
TEMP_IMPO (NODE: N1, TEMP_SUP: 0. , TEMP_MIL: 0. , TEMP_INF: 0.)
EXCHANGE: (GROUP_MA: GRSD1, COEF_H_SUP: 10. , COEF_H_INF: 10. ,
            TEMP_EXT_SUP: -50. , TEMP_EXT_INF: -50.)
            (GROUP_MA: GRSD2, COEF_H_SUP: 10. , COEF_H_INF: 10. ,
            TEMP_EXT_SUP: 50. , TEMP_EXT_INF: 50.)
```
- loadings constant functions and dualisation of the condition of Dirichlet:
as above, but with constant functions having same values.
- scalar loadings and "kinematic" loading:

```
THER_IMPO: (NODE: N1, TEMP_SUP: 0. , TEMP_MIL: 0. , TEMP_INF: 0.)
```

6.2 Characteristics of the grid

Many nodes: 470

Many meshes and types: 60 meshes QUAD9

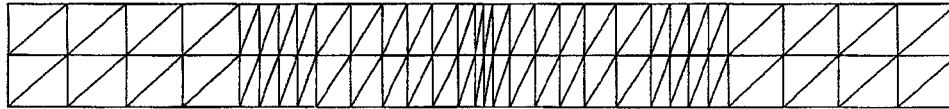
6.3 Values tested

| Identification | | Reference |
|--------------------------|----------|-----------|
| Node N227 (- 10., 0.) | Temp_sup | 49,999 |
| | Temp_mil | 49,999 |
| | Temp_inf | 49,999 |
| Node N233 (-5.15, 0.) | Temp_sup | 49.9658 |
| | Temp_mil | 49.9658 |
| | Temp_inf | 49.9658 |
| Node N235 (-4.32, 0.) | Temp_sup | 49.8888 |
| | Temp_mil | 49.8888 |
| | Temp_inf | 49.8888 |
| Node N237 (-3.53, 0.) | Temp_sup | 49.6631 |
| | Temp_mil | 49.6631 |
| | Temp_inf | 49.6631 |
| Node N238 (-2.8, 0.) | Temp_sup | 49.0542 |
| | Temp_mil | 49.0542 |

| | | |
|------------|----------|---------|
| | Temp_inf | 49,0542 |
| Node N239 | Temp_sup | 47,556 |
| (-2.13,0.) | Temp_mil | 47,556 |
| | Temp_inf | 47,556 |
| Node N242 | Temp_sup | 26,700 |
| (-0.54,0.) | Temp_mil | 26,700 |
| | Temp_inf | 26,700 |
| Node N243 | Temp_sup | 11,830 |
| (-0.19,0.) | Temp_mil | 11,830 |
| | Temp_inf | 11,830 |
| Node N246 | Temp_sup | -26,700 |
| (0.54,0.) | Temp_mil | -26,700 |
| | Temp_inf | -26,700 |
| Node N249 | Temp_sup | -47,556 |
| (2.13,0.) | Temp_mil | -47,556 |
| | Temp_inf | -47,556 |

7 Modeling E

7.1 Characteristics of modeling



Cutting: 30 elements in length,
2 elements in width.

Boundary conditions - loading (three calculations for three choices):

- scalar loadings and dualisation of the condition of Dirichlet:

```
TEMP_IMPO (NODE = N1, TEMP_SUP = 0. , TEMP_MIL = 0. , TEMP_INF = 0.)
EXCHANGE (GROUP_MA =GRSD1, COEF_H_SUP = 10. , COEF_H_INF = 10. ,
          TEMP_EXT_SUP = -50. , TEMP_EXT_INF = -50.)
          (GROUP_MA =GRSD2, COEF_H_SUP = 10. , COEF_H_INF = 10. ,
          TEMP_EXT_SUP = 50. , TEMP_EXT_INF = 50.)
```
- loadings constant functions and dualisation of the condition of Dirichlet:
as above, but with constant functions having same values.
- scalar loadings and "kinematic" loading:

```
THER_IMPO: (NODE: N1, TEMP_SUP: 0. , TEMP_MIL: 0. , TEMP_INF: 0.)
```

7.2 Characteristics of the grid

Many nodes: 590

Many meshes and types: 120 meshes TRIA7

7.3 Values tested

| Identification | | Reference |
|-------------------------|----------|-----------|
| Node N227 (-10.,0.) | Temp_sup | 49,999 |
| | Temp_mil | 49,999 |
| | Temp_inf | 49,999 |
| Node N233 (-5.15,0.) | Temp_sup | 49.9658 |
| | Temp_mil | 49.9658 |
| | Temp_inf | 49.9658 |
| Node N235 (-4.32,0.) | Temp_sup | 49.8888 |
| | Temp_mil | 49.8888 |
| | Temp_inf | 49.8888 |
| Node N237 (-3.53,0.) | Temp_sup | 49.6631 |
| | Temp_mil | 49.6631 |
| | Temp_inf | 49.6631 |
| Node N238 (-2.8,0.) | Temp_sup | 49.0542 |
| | Temp_mil | 49.0542 |

Code Aster

Version
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| | | |
|------------------|----------|---------|
| | Temp_inf | 49,0542 |
| Node N239 | Temp_sup | 47,556 |
| (-2.13,0.) | Temp_mil | 47,556 |
| | Temp_inf | 47,556 |
| Node N242 | Temp_sup | 26,700 |
| (-0.54,0.) | Temp_mil | 26,700 |
| | Temp_inf | 26,700 |
| Node N243 | Temp_sup | 11,830 |
| (-0.19,0.) | Temp_mil | 11,830 |
| | Temp_inf | 11,830 |
| Node N246 | Temp_sup | -26,700 |
| (0.54,0.) | Temp_mil | -26,700 |
| | Temp_inf | -26,700 |
| Node N249 | Temp_sup | -47,556 |
| (2.13,0.) | Temp_mil | -47,556 |
| | Temp_inf | -47,556 |

8 Summary of the results

It is noted that the variations on the temperature are weak compared to the reference solution (lower than 0.41%).

Meshes QUAD8 and QUAD9 give the same results.