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

Summary:

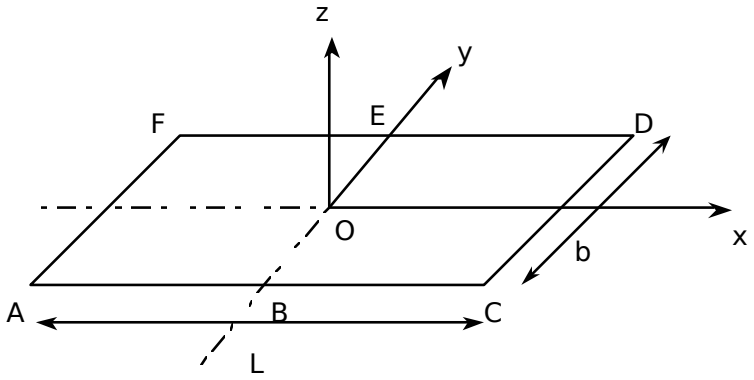
The purpose of this test is to test the model of thermal hull linear with three fields per comparison with the analytical solution, for an infinite plate subjected to a couple of conditions of heat exchange with outside, symmetrical compared to the average layer. The equation of heat is solved in hover, 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 $\lambda=1000\,W/mm/°\,C$

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: $h=10\,W/mm^2/°\,C$

  outside temperature: $Text=50°\,C$
- On the faces higher $(BCDE)^+$ and lower $(BCDE)^-$:

  coefficient of exchange: $h=10\,W/mm^2/°\,C$

  outside temperature: $T_{ext}=-50°\,C$

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

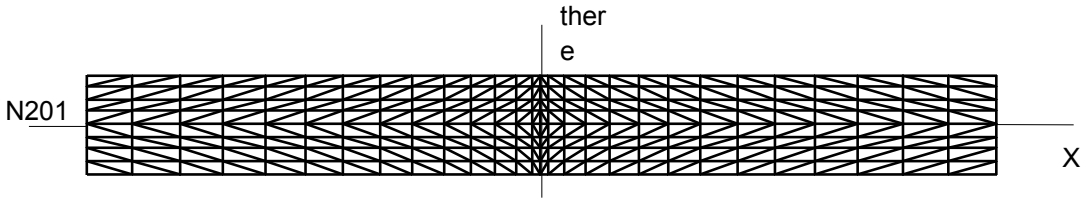
Analytical solution.

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 meshs and types: 448 meshs TRIA6

3.3 Values tested

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

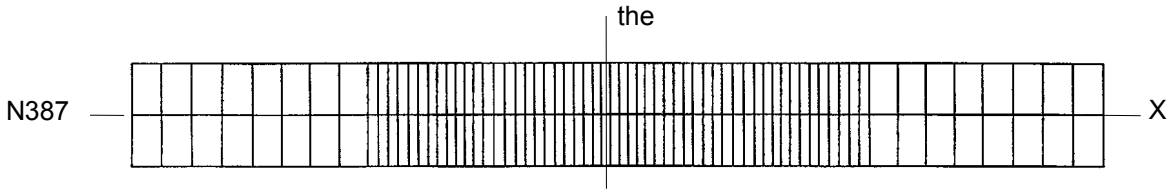
$(-2.8,0.)$	Temp_mil	49.0542
	Temp_inf	49.0542
N156 node	Temp_sup	47,556
$(-2.13,0.)$	Temp_mil	47,556
	Temp_inf	47,556
Node $N141$	Temp_sup	26,700
$(-0.54,0.)$	Temp_mil	26,700
	Temp_inf	26,700
Node $N136$	Temp_sup	11,830
$(-0.19,0.)$	Temp_mil	11,830
	Temp_inf	11,830
Node $N11$	Temp_sup	– 26,700
$(0.54,0.)$	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 meshs and types: 136 meshs QUAD4

4.3 Values tested

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

	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 meshs and types: 60 meshs 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

	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 meshs and types: 60 meshs QUAD9

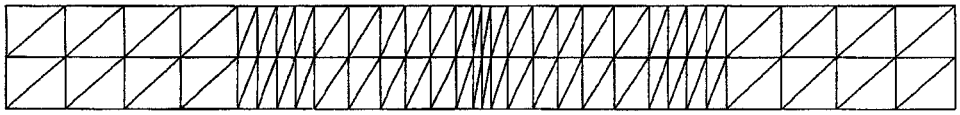
6.3 Values tested

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 $N238$	Temp_sup	49.0542
$(-2.8,0.)$	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 meshs and types: 120 meshs 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

	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%).

Meshs QUAD8 and QUAD9 give the same results.