TPLV07 - Cubic orthotropic

Abstract:

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

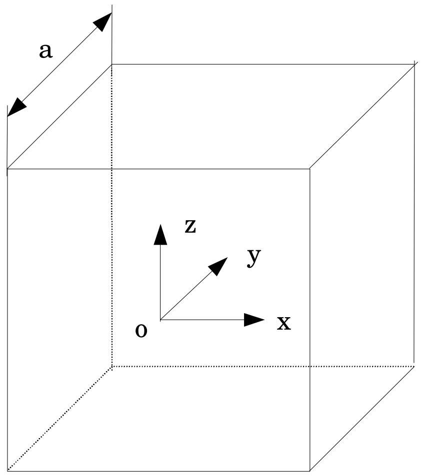
It validates the voluminal thermal elements under imposed flux conditions, of convection but also of variation linear of the outside temperature.

The results are compared with an analytical solution (VPCS).

In this test one also checks the computation of integral on edge of a thermal field.

1 Problem of reference

1.1 Geometry



Cube d'arête a = 0.2 m
Centre du cube = (0.,0.,0.)

1.2 Properties of the thermal

$\lambda_x = 1.0\, W/m.°C$ material Conductivity along the thermal x
$\lambda_y = 0.75\, W/m.°C$ axis Conductivity along the thermal y
$\lambda_z = 0.50\, W/m.°C$ axis Conductivity along the axis z

1.3 Boundary conditions and loadings

- Density flux normal:
  - $\varphi_n = 60\, W/m^2$ face $y = -0.1$ (entering flux),
  - $\varphi_n = -60\, W/m^2$ face $y = 0.1$ (outgoing flux),
  - $\varphi_n = 30\, W/m^2$ face $z = -0.1$ (entering flux),
  - $\varphi_n = -30\, W/m^2$ face $z = 0.1$ (outgoing flux),
- Convection on the sides $x = -0.1$ and $x = 0.1$: $h = 15\, W/m^2 °C$,
- Linear Variation of the outside temperatures,
  - $T_{ext} = 30 - 80y - 60z$ face $x = -0.1$,
  - $T_{ext} = 15 - 80y - 60z$ face $x = 0.1$.

1.4 Initial conditions

Without object.

2 Reference solution

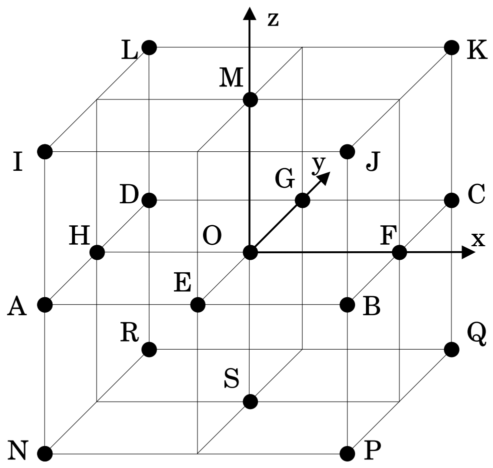
2.1 Method of calculating used for the reference solution

the reference solution is that given in file TPLV07/89 of guide VPCS.

It is about an analytical solution given by the following formula:

$$\begin{aligned} T(x, y, z) &= ax + by + cz + d \\ &= -45x - 80y - 60z + 22.5 \end{aligned}$$

Point	T(°C)
O	22.5
A	35.0
B	26.0
C	10.0
D	19.0
E	30.5
F	18.0
G	14.5
H	27.0
I	29.0
J	20.0
K	4.0
L	13.0
M	16.5
N	41.0
P	32.0
Q	16.0
R	25.0
S	28.5



$\varphi_x = 45\ W/m^2$ = constante
$\varphi_y = 60\ W/m^2$ = constante
$\varphi_z = 30\ W/m^2$ = constante

The density flux normal imposed on the face $y=0.1$ being constant, the resulting normal flux is determined analytically.

2.2 Results of reference

Temperature to the points quoted in the table above.
Value of resulting normal flux on the face located in $y=0.1$.

2.3 Uncertainty on the solution

No (analytical solution).

2.4 Bibliographical references

Guides validation of the software packages of structural analysis. French company of Mechanics, AFNOR 1990 ISBN 2-12-486611-7

3 Modelization A

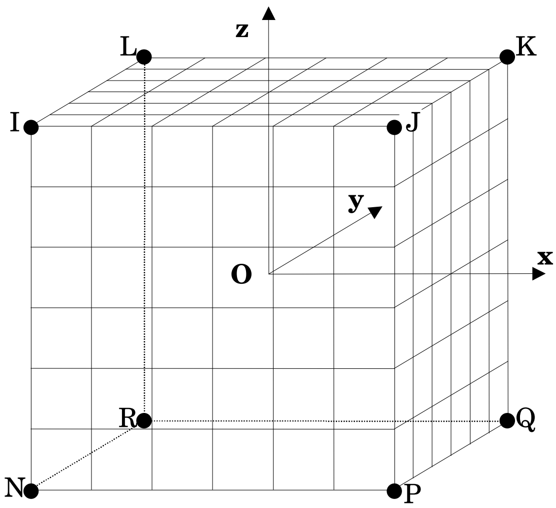
3.1 Characteristic of the modelization

3D (HEXA8)

Conditions limites:

- face NPJI φ_n = 60 W/m²
- face RQKL φ_n = -60 W/m²
- face NPQR φ_n = 30 W/m²
- face IJKL φ_n = -30 W/m²

- face NRLI h = 15 W/m²°C
  T_{ext} = 30-80y-60z
- face PQKJ h = 15 W/m²°C
  T_{ext} = 15-80y-60z



Découpage:

- 6 éléments suivant x
- 6 éléments suivant y
- 6 éléments suivant z

3.2 Characteristic of the mesh

Many nodes: 343
Number of meshes and types: 216 HEXA8 (and 216 QUAD8)

3.3 Remarks

voluminal heat ρC_P do not intervene in this test, but must be declared for *Code_Aster*. One takes $\rho C_P = 1.0\, J/m^3\, °C$.

3.4 Values tested

Identification		Reference
Not	**Node**	$T(°C)$
O	*N169*	22.5
A	*N5*	35.0
B	*N301*	26.0
C	*N337*	10.0
D	*N49*	19.0
E	*N151*	30.5
F	*N316*	18.0
G	*N196*	14.5
H	*N24*	27.0
I	*N1*	29.0
J	*N298*	20.0

K	$N340$	4.0
L	$N44$	13.0
M	$N172$	16.5
N	$N2$	41.0
P	$N297$	32.0
Q	$N338$	16.0
R	$N43$	25.0
S	$N173$	28.5

Point	Nets	Node	$\varphi(W/m^2)$
φ_x K	$M211$	$N340$	45.0
φ_x F	$M201$	$N316$	45.0
φ_x O	$M129$	$N169$	45.0
φ_y K	$M211$	$N340$	60.0
φ_y F	$M201$	$N316$	60.0
φ_y O	$M129$	$N169$	60.0
φ_z K	$M211$	$N340$	30.0
φ_z F	$M201$	$N316$	30.0
φ_z O	$M129$	$N169$	30.0

Face	resulting normal Flux $\int_{face} \varphi.\boldsymbol{n}\, dS$ (W)
$y=0.1$	-60.0

4 Summary of the results

the got results are excellent. The computed values by *Aster* are identical to the values of reference. That one "normally is result expected" since the field solution which is linear belongs to the space of interpolation of the element tested.

This test made it possible to test the following commands:

- DEFI_NAPPE allowing to define a variation in the external temperature according to the X-coordinate x and the Y-coordinate y,
- DEFI_MATERIAU associated with key word THER_ORTH, allowing to define the characteristics of an orthotropic material,
- AFFE_CARA_ELEM associated with key word MASSIF, allowing to define the axes of orthotropy.