ZZZZ166 - Computation of flux in thermal

Summarized:

This test has as an aim the validation of the flux computation options in thermal: FLUX_ELGA and FLUX_ELNO.

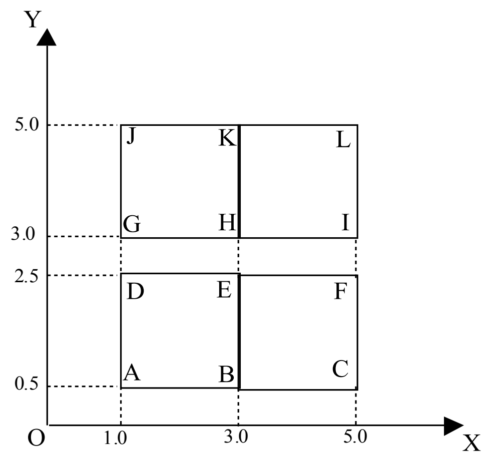
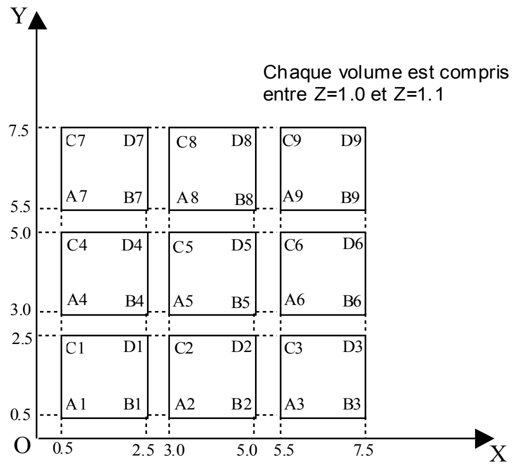
The 6 modelizations tested are:

- A In 2D PLANE : triangles of degree 1, quadrangles of degree 1 and 2 and quadrangles with 9 nodes,
- B In 2D PLAN_DIAG : triangles of degree 1 and 2, quadrangles of degree 1 and quadrangles with 9 nodes,
- C In 2D AXIS : triangles of degree 1, quadrangles of degree 1 and 2 and quadrangles with 9 nodes,
- D In 2D AXIS_DIAG : triangles of degree 1 and 2, quadrangles of degree 1 and quadrangles with 9 nodes,
- E In 3D : hexahedrons, pentahedrons, pyramids and tetrahedrons of degree 1 and 2, hexahedrons with 27 nodes,
- F In 3D_DIAG : hexahedrons, pentahedrons, pyramids and tetrahedrons of degree 1.

1 Problem of reference

1.1 Geometry

Each square is with a grid with a kind of distinct element.

<table>
<tr>
<td>
</td>
<td>
</td>
</tr>
<tr>
<td>For all the modelizations 2D.Pour modelizations 3D.
(Note:: in <code>AXIS</code> and <code>AXIS_DIAG</code>, the rotational axis is OY and the X-coordinate X thus corresponds to the radius).</td>
<td>(Note:: in <code>3D_DIAG</code>, only the 4 hexahedrons in bottom on the left are with a grid).</td>
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</table>

1.2 Material properties

the thermal properties applied to the model are:

- $\lambda=1.0\,W/m°C$

1.3 Nondefinite boundary conditions

and loadings.

1.4 Field of temperature

the field of temperature is directly affected with the model from a function. For each modelization, the computation of flux is tested for a linear thermal field and a quadratic thermal field.

For the modelizations 2D `PLANE` and `PLAN_DIAG` (modelizations A and B), the two successively affected fields are:

- $T(X,Y)=2.\mathrm{X}+3.\mathrm{Y}$
- $T(X,Y)=2.\mathrm{X}^2+3.\mathrm{Y}^2$

For the modelizations 2D `AXIS` and `AXIS_DIAG` (modelizations C and D), the two successively affected fields are:

- $T(X,Y,Z)=2.\mathrm{R}+3.\mathrm{Y}$ (with $R=\sqrt{X^2+Z^2}=X$ in the plane of the mesh (OXY))
- $T(X,Y,Z)=2.\mathrm{R}^2+3.\mathrm{Y}^2$

For the modelizations `3D` and `3D_DIAG` (modelizations E and F), the two successively affected fields are:

- $T(X,Y,Z)=2.\mathrm{X}+3.\mathrm{Y}+4.\mathrm{Z}$

- $T(X, Y, Z) = 2.X^2 + 3.Y^2 + 4Z^2$

2 Reference solution

2.1 Method of calculating used for the reference solution

the reference solution is analytical:

$$\begin{cases} \Phi_x = -\lambda.\dfrac{\partial T}{\partial X} \\ \Phi_y = -\lambda.\dfrac{\partial T}{\partial Y} \\ \Phi_z = -\lambda.\dfrac{\partial T}{\partial Z} \quad (\text{en 3D uniquement}) \end{cases}$$

Taking into account the value λ (1), the flux obtained for each configuration is thus:

For the modelizations 2D PLANE and PLAN_DIAG (modelizations A and B):

- $T(X,Y)=2.X+3.Y$ either $\Phi_x(X,Y)=-2$ and $\Phi_y(X,Y)=-3$
- $T(X,Y)=2.X^2+3.Y^2$ or $\Phi_x(X,Y)=-4.X$ and $\Phi_y(X,Y)=-6.Y$

For the modelizations 2D AXIS and AXIS_DIAG (modelizations C and D):

- $T(X,Y,Z)=2.R+3.Y$ ($R=X$ in the plane (OXY)) either $\Phi_x(X,Y,Z)=-2$ and $\Phi_y(X,Y,Z)=-3$
- $T(X,Y,Z)=2.R^2+3.Y^2$ ($R=X$ in the plane (OXY)) or $\Phi_x(X,Y,Z)=-4.X$ and $\Phi_y(X,Y,Z)=-6.Y$

For the modelizations 3D and 3D_DIAG (modelizations E and F):

- $T(X,Y,Z)=2.X+3.Y+4.Z$ either $\Phi_x(X,Y,Z)=-2$, $\Phi_y(X,Y,Z)=-3$ and $\Phi_z(X,Y,Z)=-4$
- $T(X,Y,Z)=2.X^2+3.Y^2+4Z^2$ or $\Phi_x(X,Y,Z)=-4.X$, $\Phi_y(X,Y,Z)=-6.Y$ and $\Phi_z(X,Y,Z)=-8.Z$

2.2 Results of reference

For the modelizations 2D (PLANE, PLAN_DIAG, AXIS and AXIS_DIAG), the values tested are:

- With the linear field of temperature: the temperature with the nodes A , C , J and L , the following flux X and Y by element with the nodes A C , J and L the flux at the first Gauss point of the same elements,
- With the quadratic field of temperature: the temperature with the nodes A , C , J and L , and the following flux X and Y by element with the nodes A , C , J and L .

For the modelizations 3D (3D and 3D_DIAG), the values tested are:

- With the linear field of temperature: the temperature with the nodes D_i , following flux X and Y by element with the nodes D_i and flux at the first Gauss point of the same elements,
- With the quadratic field of temperature: the temperature with the nodes D_i , and following flux X and Y by element with the nodes D_i .

With $i=1$ 9 for the modelization 3D and $i=1$ with 4 modelization 3D_DIAG.

3 Modelization A

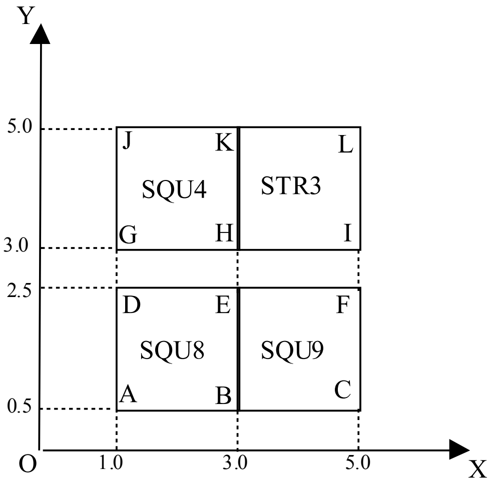
3.1 Characteristic of the modelization

Elements 2D modelization `Characteristics`

3.2 PLANE of the mesh

Many nodes: 3382
Number of meshes and types: 2000 meshes including 400 QUAD8, 400 QUAD9, 400 QUAD4 and 800 TRIA3.

The mesh understands 4 squares SQU8, SQU9, SQU4 and STR3 with a grid respectively with elements QUAD8, QUAD9, QUAD4 and TRIA3. Each square is discretized with 20 elements following X and following Y.



Nom of the Standard	GROUP_MA of élémentSQU8QUAD8 SQU9QUAD9SQU4QUAD4STR3TRIA3

the nodes used for postprocessing are:

Name of the node	Coordinated	Number of the node	Name of a mesh containing this Standard	node of the mesh
A	$(1.0;0.5)$	$N1$	$M1$	`QUAD8`
C	$(5.0;0.5)$	$N1620$	$M420$	`QUAD9`
J	$(1.0;5.0)$	$N3001$	$M1181$	`QUAD4`
L	$(5.0;5.0)$	$N3440$	$M2000$	`TRIA3`

the group of the mesh is affected by a thermal modelization `PLANE`.

3.3 Results and quantities tested

- With a linear field of temperature (constant flux):

Localization		**Quantity**	**Reference**	***Aster***	**% difference**
Nets	**Node or PG**				
	Nœud A	T	3.5.3.5		0%
M1 (QUAD8)	Node A	Φ_x (ELNO)	-2.0	-2.0	0%

M1 (QUAD8)	Node A	Φ_{there} (ELNO)	-3.0	-3.0	0%
M1 (QUAD8)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M1 (QUAD8)	Point 1	Φ_{there} (ELGA)	-3.0	-3.0	0%
	Node C	T	11.5	11.5	0%
M420 (QUAD9)	Node C	Φ_x (ELNO)	-2.0	-2.0	0%
M420 (QUAD9)	Node C	Φ_{there} (ELNO)	-3.0	-3.0	0%
M420 (QUAD9)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M420 (QUAD9)	Point 1	Φ_{there} (ELGA)	-3.0	-3.0	0%
	Node J	T	17.0	17.0	0%
M1181 (QUAD4)	Node J	Φ_x (ELNO)	-2.0	-2.0	0%
M1181 (QUAD4)	Node J	Φ_{there} (ELNO)	-3.0	-3.0	0%
M1181 (QUAD4)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M1181 (QUAD4)	Point 1	Φ_{there} (ELGA)	-3.0	-3.0	0%
	Node L	T	25.0	25.0	0%
M2000 (TRIA3)	Node L	Φ_x (ELNO)	-2.0	-2.0	0%
M2000 (TRIA3)	Node L	Φ_{there} (ELNO)	-3.0	-3.0	0%
M2000 (TRIA3)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M2000 (TRIA3)	Point 1	Φ_{there} (ELGA)	-3.0	-3.0	0%

- With a quadratic field of temperature (linear flux):

Localization		**Quantity**	**Reference**	***Aster***	**% difference**
Nets	**Node or PG**				
	Nœud A	T	2.75	2.75	0%
M1 (QUAD8)	Node A	Φ_x (ELNO)	-4.0	-4.0	0%
M1 (QUAD8)	Node A	Φ_{there} (ELNO)	-3.0	-3.0	0%
	Node C	T	50.75	50.75	0%
M420 (QUAD9)	Node C	Φ_x (ELNO)	-20.0	-20.0	0%
M420 (QUAD9)	Node C	Φ_{there} (ELNO)	-3.0	-3.0	0%
	Node J	T	77.0	77.0	0%
M1181 (QUAD4)	Node J	Φ_x (ELNO)	-4.0	-4.2	5%
M1181 (QUAD4)	Node J	Φ_{there} (ELNO)	-30.0	-29.7	-1%
	Node L	T	125.0	125.0	0%
M2000 (TRIA3)	Node L	Φ_x (ELNO)	-20.0	-19.8	-1%
M2000 (TRIA3)	Node L	Φ_{there} (ELNO)	-30.0	-29.7	-1%

4 Modelization B

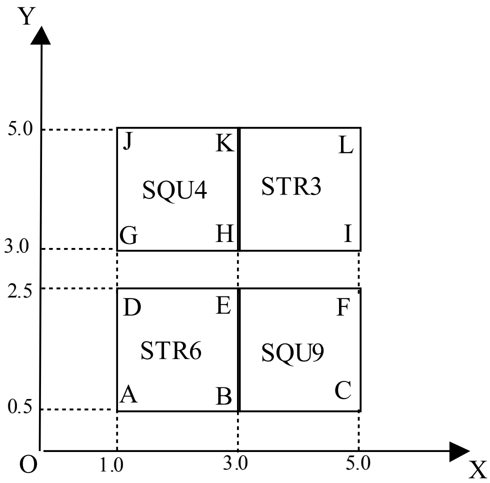
4.1 Characteristic of the modelization

Elements 2D modelization `PLAN_DIAG`

4.2 Characteristics of the mesh

Many nodes: 3782.
Number of meshes and types: 2400 meshes including 800 TRIA6, 400 QUAD9, 400 QUAD4 and 800 TRIA3.

The mesh understands 4 squares STR6, SQU9, SQU4 and STR3 with a grid respectively with elements TRIA6, QUAD9, QUAD4 and TRIA3. Each square is discretized with 20 elements following X and following Y.



Nom of the Standard	GROUP_MA of élémentSTR6TRIA6SQU9QUAD9SQU4QUAD4STR3TRIA3

the nodes used for postprocessing are:

Name of the node	Coordinated	Number of the node	Name of a mesh containing this Standard	node of the mesh
A	(1.0; 0.5)	N1	M1	TRIA6
C	(5.0; 0.5)	N2481	M820	QUAD9
J	(1.0; 5.0)	N3401	M1581	QUAD4
L	(5.0; 5.0)	N3840	M2400	TRIA3

the group of the mesh is affected by a thermal modelization `PLAN_DIAG`.

4.3 Results and quantities tested

- With a linear field of temperature (constant flux):

Localization		**Quantity**	**Reference**	***Aster***	**% difference**
Nets	**Node or PG**				
	Nœud A	T	3.5.3.5		0%
M1 (TRIA6)	Node A	Φ_x (ELNO)	-2.0	-2.0	0%

M1 (TRIA6)	Node A	Φ there (ELNO)	-3.0	-3.0	0%
M1 (TRIA6)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M1 (TRIA6)	Point 1	Φ there (ELGA)	-3.0	-3.0	0%
	Node C	T	11.5	11.5	0%
M420 (QUAD9)	Node C	Φ_x (ELNO)	-2.0	-2.0	0%
M420 (QUAD9)	Node C	Φ there (ELNO)	-3.0	-3.0	0%
M420 (QUAD9)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M420 (QUAD9)	Point 1	Φ there (ELGA)	-3.0	-3.0	0%
	Node J	T	17.0	17.0	0%
M1181 (QUAD4)	Node J	Φ_x (ELNO)	-2.0	-2.0	0%
M1181 (QUAD4)	Node J	Φ there (ELNO)	-3.0	-3.0	0%
M1181 (QUAD4)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M1181 (QUAD4)	Point 1	Φ there (ELGA)	-3.0	-3.0	0%
	Node L	T	25.0	25.0	0%
M2000 (TRIA3)	Node L	Φ_x (ELNO)	-2.0	-2.0	0%
M2000 (TRIA3)	Node L	Φ there (ELNO)	-3.0	-3.0	0%
M2000 (TRIA3)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M2000 (TRIA3)	Point 1	Φ there (ELGA)	-3.0	-3.0	0%

- With a quadratic field of temperature (linear flux):

Localization		**Quantity**	**Reference**	***Aster***	**% difference**
Nets	**Node or PG**				
	Nœud A	T	2.75	2.75	0%
M1 (QUAD8)	Node A	Φ_x (ELNO)	-4.0	-4.2	5%
M1 (QUAD8)	Node A	Φ there (ELNO)	-3.0	-3.3	10%
	Node C	T	50.75	50.75	0%
M420 (QUAD9)	Node C	Φ_x (ELNO)	-20.0	-19.8	-1%
M420 (QUAD9)	Node C	Φ there (ELNO)	-3.0	-3.3	10%
	Node J	T	77.0	77.0	0%
M1181 (QUAD4)	Node J	Φ_x (ELNO)	-4.0	-4.2	5%
M1181 (QUAD4)	Node J	Φ there (ELNO)	-30.0	-29.7	-1%
	Node L	T	125.0	125.0	0%
M2000 (TRIA3)	Node L	Φ_x (ELNO)	-20.0	-19.8	-1%
M2000 (TRIA3)	Node L	Φ there (ELNO)	-30.0	-29.7	-1%

5 Modelization C

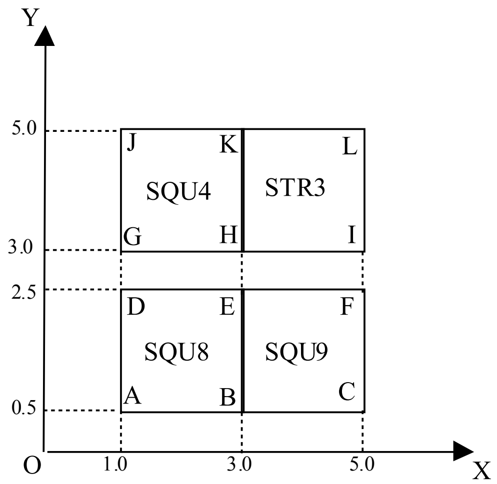
5.1 Characteristic of the modelization

Elements 2D modelization `AXIS`

5.2 Characteristics of the mesh

Many nodes: 3382.
Number of meshes and types: 2000 meshes including 400 QUAD8, 400 QUAD9, 400 QUAD4 and 800 TRIA3.

The mesh understands 4 squares SQU8, SQU9, SQU4 and STR3 with a grid respectively with elements QUAD8, QUAD9, QUAD4 and TRIA3. Each square is discretized with 20 elements following X and following Y.



Nom of `the Standard`	GROUP_MA of élémentSQU8QUAD8 SQU9QUAD9SQU4QUAD4STR3TRIA3

the nodes used for postprocessing are:

Name of the node	Coordinated	Number of the node	Name of a mesh containing this Standard	node of the mesh
A	(1.0; 0.5)	N1	M1	QUAD8
C	(5.0; 0.5)	N1620	M420	QUAD9
J	(1.0; 5.0)	N3001	M1181	QUAD4
L	(5.0; 5.0)	N3440	M2000	TRIA3

the group of the mesh is affected by a thermal modelization `AXIS`.

5.3 Results and quantities tested

- With a linear field of temperature (constant flux):

Localization		**Quantity**	**Reference**	***Aster***	**% difference**
Nets	**Node or PG**				
	Nœud A	T	3.5.3.5		0%
M1 (QUAD8)	Node A	Φ_x (ELNO)	-2.0	-2.0	0%

M1 (QUAD8)	Node A	Φ_{there} (ELNO)	-3.0	-3.0	0%
M1 (QUAD8)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M1 (QUAD8)	Point 1	Φ_{there} (ELGA)	-3.0	-3.0	0%
	Node C	T	11.5	11.5	0%
M420 (QUAD9)	Node C	Φ_x (ELNO)	-2.0	-2.0	0%
M420 (QUAD9)	Node C	Φ_{there} (ELNO)	-3.0	-3.0	0%
M420 (QUAD9)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M420 (QUAD9)	Point 1	Φ_{there} (ELGA)	-3.0	-3.0	0%
	Node J	T	17.0	17.0	0%
M1181 (QUAD4)	Node J	Φ_x (ELNO)	-2.0	-2.0	0%
M1181 (QUAD4)	Node J	Φ_{there} (ELNO)	-3.0	-3.0	0%
M1181 (QUAD4)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M1181 (QUAD4)	Point 1	Φ_{there} (ELGA)	-3.0	-3.0	0%
	Node L	T	25.0	25.0	0%
M2000 (TRIA3)	Node L	Φ_x (ELNO)	-2.0	-2.0	0%
M2000 (TRIA3)	Node L	Φ_{there} (ELNO)	-3.0	-3.0	0%
M2000 (TRIA3)	Point 1	Φ_x (ELGA)	-2.0	-2.0	0%
M2000 (TRIA3)	Point 1	Φ_{there} (ELGA)	-3.0	-3.0	0%

- With a quadratic field of temperature (linear flux):

Localization		**Quantity**	**Reference**	***Aster***	**% difference**
Nets	**Node or PG**				
	Nœud A	T	2.75	2.75	0%
M1 (QUAD8)	Node A	Φ_x (ELNO)	-4.0	-4.0	0%
M1 (QUAD8)	Node A	Φ_{there} (ELNO)	-3.0	-3.0	0%
	Node C	T	50.75	50.75	0%
M420 (QUAD9)	Node C	Φ_x (ELNO)	-20.0	-20.0	0%
M420 (QUAD9)	Node C	Φ_{there} (ELNO)	-3.0	-3.0	0%
	Node J	T	77.0	77.0	0%
M1181 (QUAD4)	Node J	Φ_x (ELNO)	-4.0	-4.2	5%
M1181 (QUAD4)	Node J	Φ_{there} (ELNO)	-30.0	-29.7	-1%
	Node L	T	125.0	125.0	0%
M2000 (TRIA3)	Node L	Φ_x (ELNO)	-20.0	-19.8	-1%
M2000 (TRIA3)	Node L	Φ_{there} (ELNO)	-30.0	-29.7	-1%

6 Modelization D

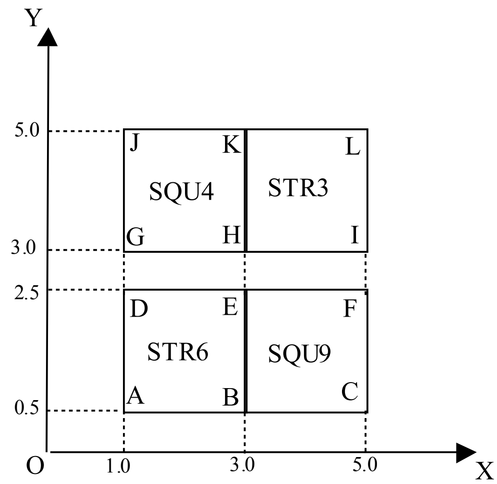
6.1 Characteristic of the modelization

Elements 2D modelization AXIS_DIAG

6.2 Characteristics of the mesh

Many nodes: 3782
Number of meshes and types: 2400 meshes including 800 TRIA6, 400 QUAD9, 400 QUAD4 and 800 TRIA3.

The mesh understands 4 squares STR6, SQU9, SQU4 and STR3 with a grid respectively with elements TRIA6, QUAD9, QUAD4 and TRIA3. Each square is discretized with 20 elements following X and following Y.



Nom of the Standard	GROUP_MA of élémentSTR6TRIA6SQU9QUAD9SQU4QUAD4STR3TRIA3

the nodes used for postprocessing are:

Name of the node	Coordinated	Number of the node	Name of a mesh containing this Standard	node of the mesh
A	(1.0; 0.5)	N1	M1	TRIA6
C	(5.0; 0.5)	N2481	M820	QUAD9
J	(1.0; 5.0)	N3401	M1581	QUAD4
L	(5.0; 5.0)	N3840	M2400	TRIA3

the group of the mesh is affected by a thermal modelization AXIS_DIAG.

6.3 Results and quantities tested

- With a linear field of temperature (constant flux):

Localization		**Quantity**	**Reference**	***Aster***	**% difference**
Nets	**Node or PG**				
	Nœud A	T	3.5.3.5		0%
M1 (TRIA6)	Node A	Φ_x (ELNO)	-2.0	-2.0	0%

M1 (TRIA6)	Node A	Φ there (ELNO)	-3.0	-3.0	0%
M1 (TRIA6)	Point 1	Φ x (ELGA)	-2.0	-2.0	0%
M1 (TRIA6)	Point 1	Φ there (ELGA)	-3.0	-3.0	0%
	Node C	T	11.5	11.5	0%
M420 (QUAD9)	Node C	Φ x (ELNO)	-2.0	-2.0	0%
M420 (QUAD9)	Node C	Φ there (ELNO)	-3.0	-3.0	0%
M420 (QUAD9)	Point 1	Φ x (ELGA)	-2.0	-2.0	0%
M420 (QUAD9)	Point 1	Φ there (ELGA)	-3.0	-3.0	0%
	Node J	T	17.0	17.0	0%
M1181 (QUAD4)	Node J	Φ x (ELNO)	-2.0	-2.0	0%
M1181 (QUAD4)	Node J	Φ there (ELNO)	-3.0	-3.0	0%
M1181 (QUAD4)	Point 1	Φ x (ELGA)	-2.0	-2.0	0%
M1181 (QUAD4)	Point 1	Φ there (ELGA)	-3.0	-3.0	0%
	Node L	T	25.0	25.0	0%
M2000 (TRIA3)	Node L	Φ x (ELNO)	-2.0	-2.0	0%
M2000 (TRIA3)	Node L	Φ there (ELNO)	-3.0	-3.0	0%
M2000 (TRIA3)	Point 1	Φ x (ELGA)	-2.0	-2.0	0%
M2000 (TRIA3)	Point 1	Φ there (ELGA)	-3.0	-3.0	0%

- With a quadratic field of temperature (linear flux):

Localization		**Quantity**	**Reference**	***Aster***	**% difference**
Nets	**Node or PG**				
	Nœud A	T	2.75	2.75	0%
M1 (QUAD8)	Node A	Φ x (ELNO)	-4.0	-4.2	5%
M1 (QUAD8)	Node A	Φ there (ELNO)	-3.0	-3.3	10%
	Node C	T	50.75	50.75	0%
M420 (QUAD9)	Node C	Φ x (ELNO)	-20.0	-19.8	-1%
M420 (QUAD9)	Node C	Φ there (ELNO)	-3.0	-3.3	10%
	Node J	T	77.0	77.0	0%
M1181 (QUAD4)	Node J	Φ x (ELNO)	-4.0	-4.2	5%
M1181 (QUAD4)	Node J	Φ there (ELNO)	-30.0	-29.7	-1%
	Node L	T	125.0	125.0	0%
M2000 (TRIA3)	Node L	Φ x (ELNO)	-20.0	-19.8	-1%
M2000 (TRIA3)	Node L	Φ there (ELNO)	-30.0	-29.7	-1%

7 Modelization E

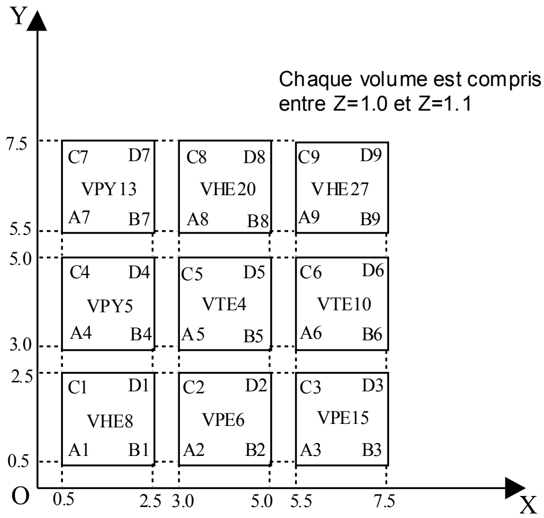
7.1 Characteristic of the modelization

Elements 3D modelization `3D`

7.2 Characteristic of the mesh

Many nodes: 17281.
Number of meshes and types: 5268 meshes including 400 HEXA8, 400 HEXA20, 400 HEXA27, 800 PENTA6, 800 PENTA15, 600 PYRAM5, 600 PYRAM13, 634 TETRA4 and 634 TETRA10.

mesh understands 9 hexahedrons VHE8, VHE20, VHE27, VPE6, VPE15, VPY5, VPY13, VTE4 and VTE10 with a grid respectively with elements HEXA8, HEXA20, HEXA27, PENTA6, PENTA15, PYRAM5, PYRAM13, TETRA4 and TETRA10.



Name of GROUP_MA Type | Name of GROUP_MA | of element Discretisation | Element Discretisation | according to: X Y | according to: X Y

VHE8 HEXA8 20 1 VHE20 HEXA20 20 1 VHE27 HEXA27 20 1 VPE6 PENTA6 20 1 VPE15 PENTA15 20 1 VPY5 PYRAM5 10 1 VPY13 PYRAM13 10 1 VTE4 TETRA4 10 1 VTE10 TETRA10

the nodes used for postprocessing are:

Name of the node	Coordinated	Number of the node	Name of a mesh containing this Standard	node of the mesh
D1	(2.5; 2.5; 1.0)	N440	M400	HEXA8
D2	(5.0; 2.5; 1.0)	N1322	M1200	PENTA6
D3	(7.5; 2.5; 1.0)	N11453	M4034	PENTA15
D4	(2.5; 5.0; 1.0)	N1995	M1795	PYRAM5
D5	(5.0; 5.0; 1.0)	N2323	M1838	TETRA4
D6	(7.5; 5.0; 1.0)	N16603	M4672	TETRA10
D7	(2.5; 7.5; 1.0)	N14756	M4629	PYRAM13
D8	(5.0; 7.5; 1.0)	N3596	M2834	HEXA20
D9	(7.5; 7.5; 1.0)	N6599	M3234	HEXA27

the group of the mesh is affected by a thermal modelization `3D`.

7.3 Results and quantities tested

- With a linear field of temperature (constant flux):

Localization		Quantity	Reference	*Aster*	% difference
Nets	Node or PG				
	Nœud D1	T	16.5	16.5	0%
M400 (HEXA8)	Node D1	Φ_X (ELNO)	-2.0	-2.0	0%

M400 (HEXA8)	Node D1	Φ there (ELNO)	-3.0	-3.0	0%
M400 (HEXA8)	Node D1	Φ_Z (ELNO)	-4.0	-4.0	0%
M400 (HEXA8)	Point 1	Φ_X (ELGA)	-2.0	-2.0	0%
	Node D2	T	21.5	21.5	0%
M1200 (PENTA6)	Node D2	Φ_X (ELNO)	-2.0	-2.0	0%
M1200 (PENTA6)	Node D2	Φ there (ELNO)	-3.0	-3.0	0%
M1200 (PENTA6)	Node D2	Φ_Z (ELNO)	-4.0	-4.0	0%
M1200 (PENTA6)	Point 1	Φ_X (ELGA)	-2.0	-2.0	0%
	Node D3	T	26.5	26.5	0%
M4034 (PENTA15)	Node D3	Φ_X (ELNO)	-2.0	-2.0	0%
M4034 (PENTA15)	Node D3	Φ there (ELNO)	-3.0	-3.0	0%
M4034 (PENTA15)	Node D3	Φ_Z (ELNO)	-4.0	-4.0	0%
M4034 (PENTA15)	Point 1	Φ_X (ELGA)	-2.0	-2.0	0%
	Node D4	T	24.0	24.0	0%
M1795 (PYRAM5)	Node D4	Φ_X (ELNO)	-2.0	-2.0	0%
M1795 (PYRAM5)	Node D4	Φ there (ELNO)	-3.0	-3.0	0%
M1795 (PYRAM5)	Node D4	Φ_Z (ELNO)	-4.0	-4.0	0%
M1795 (PYRAM5)	Point 1	Φ_X (ELGA)	-2.0	-2.0	0%
	Node D5	T	29.0	29.0	0%
M1838 (TETRA4)	Node D5	Φ_X (ELNO)	-2.0	-2.0	0%
M1838 (TETRA4)	Node D5	Φ there (ELNO)	-3.0	-3.0	0%
M1838 (TETRA4)	Node D5	Φ_Z (ELNO)	-4.0	-4.0	0%
M1838 (TETRA4)	Point 1	Φ_X (ELGA)	-2.0	-2.0	0%
	Node D6	T	34.0	34.0	0%
M4672 (TETRA10)	Node D6	Φ_X (ELNO)	-2.0	-2.0	0%
M4672 (TETRA10)	Node D6	Φ there (ELNO)	-3.0	-3.0	0%
M4672 (TETRA10)	D6 Node	Φ_Z (ELNO)	-4.0	-4.0	0%
M4672 (TETRA10)	Point 1	Φ_X (ELGA)	-2.0	-2.0	0%
	Node D7	T	31.5	31.5	0%
M4629 (PYRAM13)	Node D7	Φ_X (ELNO)	-2.0	-2.0	0%
M4629 (PYRAM13)	Node D7	Φ there (ELNO)	-3.0	-3.0	0%
M4629 (PYRAM13)	Node D7	Φ_Z (ELNO)	-4.0	-4.0	0%
M4629 (PYRAM13)	Point 1	Φ_X (ELGA)	-2.0	-2.0	0%
	Node D8	T	36.5	36.5	0%
M2834 (HEXA20)	Node D8	Φ_X (ELNO)	-2.0	-2.0	0%
M2834 (HEXA20)	Node D8	Φ there (ELNO)	-3.0	-3.0	0%
M2834 (HEXA20)	Node D8	Φ_Z (ELNO)	-4.0	-4.0	0%
M2834 (HEXA20)	Point 1	Φ_X (ELGA)	-2.0	-2.0	0%
	Node D9	T	41.5	41.5	0%
M3234 (HEXA27)	Node D9	Φ_X (ELNO)	-2.0	-2.0	0%
M3234 (HEXA27)	Node D9	Φ there (ELNO)	-3.0	-3.0	0%
M3234 (HEXA27)	Node D9	Φ_Z (ELNO)	-4.0	-4.0	0%
M3234 (HEXA27)	Point 1	Φ_X (ELGA)	-2.0	-2.0	0%

- With a quadratic field of temperature (linear flux):

Localization		Quantity	Reference	*Aster*	% difference
Nets	**Node or PG**				
	Nœud D1	T	35.25	35.25	0%
M400 (HEXA8)	Node D1	Φ_x (ELNO)	-10.0	-9.8	-2%
M400 (HEXA8)	Node D1	Φ there (ELNO)	-15.0	-14.7	-2%
M400 (HEXA8)	Node D1	Φ_z (ELNO)	-8.0	-8.4	5%
	Node D2	T	72.75	72.75	0%
M1200 (PENTA6)	Node D2	Φ_x (ELNO)	-20.0	-19.8	-1%
M1200 (PENTA6)	Node D2	Φ there (ELNO)	-15.0	-14.7	-2%
M1200 (PENTA6)	Node D2	Φ_z (ELNO)	-8.0	-8.4	5%
	Node D3	T	135.25	135.25	0%
M4034 (PENTA15)	Node D3	Φ_x (ELNO)	-30.0	-30.0	0%
M4034 (PENTA15)	Node D3	Φ there (ELNO)	-15.0	-15.0	0%
M4034 (PENTA15)	Node D3	Φ_z (ELNO)	-8.0	-8.0	0%
	Node D4	T	91.50	91.50	0%
M1795 (PYRAM5)	Node D4	Φ_x (ELNO)	-10.0	-9.6	-4%
M1795 (PYRAM5)	Node D4	Φ there (ELNO)	-30.0	-29.4	-2%
M1795 (PYRAM5)	Node D4	Φ_z (ELNO)	-8.0	-7.2	-10%
	Node D5	T	129.00	129.00	0%
M1838 (TETRA4)	Node D5	Φ_x (ELNO)	-20.0	-19.6	-2%
M1838 (TETRA4)	Node D5	Φ there (ELNO)	-30.0	-29.4	-2%
M1838 (TETRA4)	Node D5	Φ_z (ELNO)	-8.0	-8.4	5%
	Node D6	T	191.5	191.5	0%
M4672 (TETRA10)	Node D6	Φ_x (ELNO)	-30.0	-30.0	0%
M4672 (TETRA10)	Node D6	Φ there (ELNO)	-30.0	-30.0	0%
M4672 (TETRA10)	Node D6	Φ_z (ELNO)	-8.0	-8.0	0%
	Node D7	T	185.25	185.25	0%
M4629 (PYRAM13)	Node D7	Φ_x (ELNO)	-10.0	-10.0	0%
M4629 (PYRAM13)	Node D7	Φ there (ELNO)	-45.0	-45.0	0%
M4629 (PYRAM13)	Node D7	Φ_z (ELNO)	-8.0	-8.0	0%
	Node D8	T	222.75	222.75	0%
M2834 (HEXA20)	Node D8	Φ_x (ELNO)	-20.0	-20.0	0%
M2834 (HEXA20)	Node D8	Φ there (ELNO)	-45.0	-45.0	0%
M2834 (HEXA20)	Node D8	Φ_z (ELNO)	-8.0	-8.0	0%
	Node D9	T	285.25	285.25	0%
M3234 (HEXA27)	Node D9	Φ_x (ELNO)	-30.0	-30.0	0%
M3234 (HEXA27)	Node D9	Φ there (ELNO)	-45.0	-45.0	0%
M3234 (HEXA27)	Node D9	Φ_z (ELNO)	-8.0	-8.0	0%

8 Modelization F

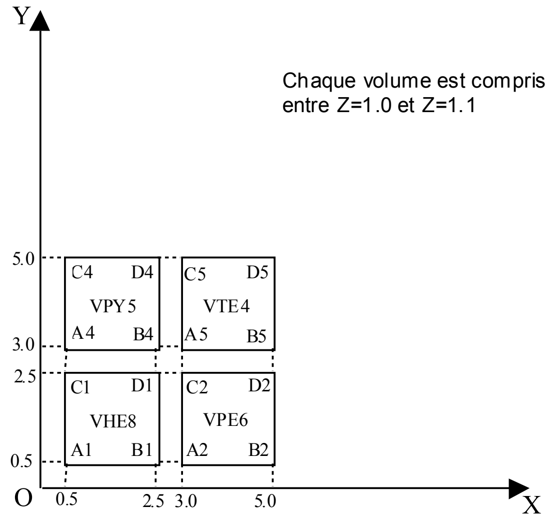
8.1 Characteristic of the modelization

Elements 3D modelization `3D_DIAG`

8.2 Characteristics of the mesh

Many nodes: 2356.
Number of meshes and types: 2434 meshes including 400 HEXA8, 800 PENTA6, 600 PYRAM5 and 634 TETRA4.

The mesh understands 4 hexahedrons VHE8, VPE6, VPY5 and VTE4 with a grid respectively with elements HEXA8, PENTA6, PYRAM5 and TETRA4.



Name of GROUP_MA Type	of elementDiscretisation	according to: X Y ZVHE8HEXA820201VPE6PENTA620201VPY5PYRAM510101VTE4TETRA410101

Name of `the Standard`	GROUP_MA of elementDiscretisation	according to: X Y ZVHE8HEXA820201VPE6PENTA620201VPY5PYRAM510101VTE4TETRA410101

the nodes used for postprocessing are:

Name of the node	Coordinated	Number of the node	Name of a mesh containing this Standard	node of the mesh
D1	$(2.5 ; 2.5 ; 1.0)$	*N440*	*M400*	HEXA8

$D2$	$(5.0;2.5;1.0)$	$N1322$	$M1200$	PENTA6
$D3$	$(7.5;2.5;1.0)$	$N11453$	$M4034$	PENTA15
$D4$	$(2.5;5.0;1.0)$	$N1995$	$M1795$	PYRAM5

the group of the mesh is affected by a thermal modelization `3D_DIAG`.

8.3 Results and quantities tested

- With a linear field of temperature (constant flux):

Localization		Quantity	Reference	*Aster*	% difference
Nets	**Node or** PG				
	Node $D1$	T	16.5	16.5	0%
$M400$ (HEXA8)	Node $D1$	Φ_x ($ELNO$)	-2.0	-2.0	0%
$M400$ (HEXA8)	Node $D1$	Φ_y ($ELNO$)	-3.0	-3.0	0%
$M400$ (HEXA8)	Node $D1$	Φ_z ($ELNO$)	-4.0	-4.0	0%
$M400$ (HEXA8)	Point 1	Φ_x ($ELGA$)	-2.0	-2.0	0%
	Node $D2$	T	21.5	21.5	0%
$M1200$ (PENTA6)	Node $D2$	Φ_x ($ELNO$)	-2.0	-2.0	0%
$M1200$ (PENTA6)	Node $D2$	Φ_y ($ELNO$)	-3.0	-3.0	0%
$M1200$ (PENTA6)	Node $D2$	Φ_z ($ELNO$)	-4.0	-4.0	0%
$M1200$ (PENTA6)	Point 1	Φ_x ($ELGA$)	-2.0	-2.0	0%
	Node $D3$	T	24.0	24.0	0%
$M1795$ (PYRAM5)	Node $D3$	Φ_x ($ELNO$)	-2.0	-2.0	0%
$M1795$ (PYRAM5)	Node $D3$	Φ_y ($ELNO$)	-3.0	-3.0	0%
$M1795$ (PYRAM5)	Node $D3$	Φ_z ($ELNO$)	-4.0	-4.0	0%
$M1795$ (PYRAM5)	Point 1	Φ_x ($ELGA$)	-2.0	-2.0	0%
	Node $D4$	T	29.0	29.0	0%
$M1838$ (TETRA4)	Node $D4$	Φ_x ($ELNO$)	-2.0	-2.0	0%
$M1838$ (TETRA4)	Node $D4$	Φ_y ($ELNO$)	-3.0	-3.0	0%
$M1838$ (TETRA4)	Node $D4$	Φ_z ($ELNO$)	-4.0	-4.0	0%
$M1838$ (TETRA4)	Point 1	Φ_x ($ELGA$)	-2.0	-2.0	0%

- With a quadratic field of temperature (linear flux):

Localization		Quantity	Reference	*Aster*	% difference
Nets	**Node or** PG				
	Node $D1$	T	35.25	35.25	0%
$M400$ (HEXA8)	Node $D1$	Φ_x ($ELNO$)	-10.0	-9.8	-2%
$M400$ (HEXA8)	Node $D1$	Φ_y ($ELNO$)	-15.0	-14.7	-2%
$M400$ (HEXA8)	Node $D1$	Φ_z ($ELNO$)	-8.0	-8.4	5%
	Node $D2$	T	72.75	72.75	0%
$M1200$ (PENTA6)	Node $D2$	Φ_x ($ELNO$)	-20.0	-19.8	-1%
$M1200$ (PENTA6)	Node $D2$	Φ_y ($ELNO$)	-15.0	-14.7	-2%
$M1200$ (PENTA6)	Node $D2$	Φ_z ($ELNO$)	-8.0	-8.4	5%
	Node $D3$	T	91.50	91.50	0%
$M1795$ (PYRAM5)	Node $D3$	Φ_x ($ELNO$)	-10.0	-9.6	-4%
$M1795$ (PYRAM5)	Node $D3$	Φ_y ($ELNO$)	-30.0	-29.4	-2%
$M1795$ (PYRAM5)	Node $D3$	Φ_z ($ELNO$)	-8.0	-7.2	-10%
	Node $D4$	T	129.00	129.00	0%
$M1838$ (TETRA4)	Node $D4$	Φ_x ($ELNO$)	-20.0	-19.6	-2%
$M1838$ (TETRA4)	Node $D4$	Φ_y ($ELNO$)	-30.0	-29.4	-2%

$M1838$ (TETRA4)	Node $D4$	Φ_z ($ELNO$)	-8.0	-8.4	5%

9 Summary of the Summary

results of the results

modelization		Flux to the nodes or with PG a linear temperature		Flux with the nodes with a Standard quadratic	
temperature of element	Discretization in X and Y	relative Error max %		relative Error max %	
Modelization 2D "PLANE"					
QUAD4	$10\,el/m$	0%		5%	
TRIA3	$10\,el/m$	0%		1%	
QUAD8	$10\,el/m$	0%		0%	
QUAD9	$10\,el/m$	2D		0%	
0% Modelization "PLAN_DIAG"					
QUAD4	$10\,el/m$	0%.10%			
TRIA3	$10\,el/m$	0%.10%			
TRIA6	$10\,el/m$	0%		5%	
QUAD9	$10\,el/m$	2D		0%	
1% Modelization "AXIS"					
QUAD4	$10\,el/m$	0%		5%	
TRIA3	$10\,el/m$	0%		1%	
QUAD8	$10\,el/m$	0%		0%	
QUAD9	$10\,el/m$	2D		0%	
0% Modelization "AXIS_DIAG"					
QUAD4	$10\,el/m$	0%.10%			
TRIA3	$10\,el/m$	0%.10%			
TRIA6	$10\,el/m$	0%		5%	
QUAD9	$10\,el/m$	0%		1%	
Modelization "3D"					
HEXA8	$10\,el/m$	0%		5%	
PENTA6	$10\,el/m$	0%		5%	
PYRAM5	$5\,el/m$	0%.10%			
TETRA4	$5\,el/m$	0%		5%	
HEXA20	$10\,el/m$	0%		0%	
HEXA27	$10\,el/m$	0%		0%	
PENTA15	$10\,el/m$	0%		0%	
PYRAM13	$5\,el/m$	0%		0%	
TETRA10	$5\,el/m$	0%		0%	
Modelization "3D_DIAG"					
HEXA8	$10\,el/m$	0%		5%	
PENTA6	$10\,el/m$	0%		5%	
PYRAM5	$5\,el/m$	0%.10%			
TETRA4	$5\,el/m$	0%		5%	

With a linear field of temperature (and a constant flux):

- All the modelizations give exact results.

With a quadratic field of temperature (and a linear flux):

- The results are exact with elements of order 2 and one modelization not DIAG. These elements having quadratic shape functions can represent the imposed field of temperature exactly. The flux are exact and would be it still with a coarser discretization.
- The elements of order 2 with a modelization DIAG are treated like elements of order 1 for the computation of flux. For these elements, the flux are constant by element. The error is thus directly dependant in keeping with elements