ZZZZ166 - Calculation of flow in thermics

Summary:

This test has as an aim the validation of the options of calculation of flow in thermics: FLUX_ELGA and FLUX_ELNO.

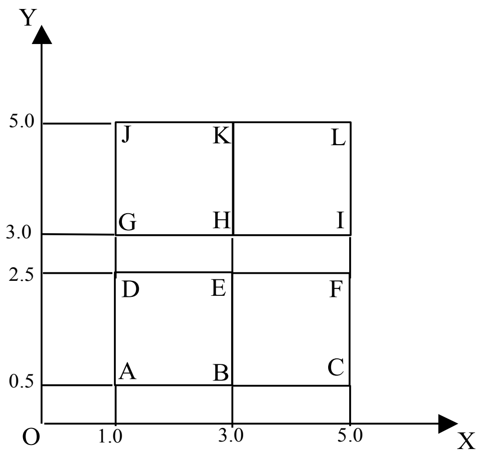
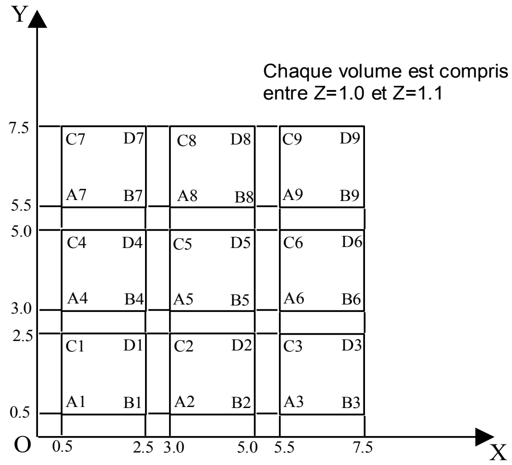
6 modelings tested are:

- With In 2D PLAN : 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.

	
For all modelings 2D. **For modelings 3D.** (**Note:** in `AXIS` and `AXIS_DIAG`, the axis of rotation is OY and X-coordinate X thus corresponds to the ray).	(**Note:** in `3D_DIAG`, only the 4 hexahedrons in bottom on the left are with a grid).

1.2 Material properties

The thermal properties applied to the model are:

- $\lambda = 1.0\, W/m°C$

1.3 Boundary conditions and loadings

Nondefinite.

1.4 Field of temperature

The field of temperature is directly affected with the model starting from a function. For each modeling, the calculation of flow is tested for a linear thermal field and a quadratic thermal field.

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

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

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

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

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

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

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

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 flow obtained for each configuration is thus:

For modelings `2D PLAN` and `PLAN_DIAG` (modelings A and B):

- $T(X,Y)=2.X+3.Y$ that is to say $\Phi_x(X,Y)=-2$ and $\Phi_y(X,Y)=-3$
- $T(X,Y)=2.X^2+3.Y^2$ that is to say $\Phi_x(X,Y)=-4.X$ and $\Phi_y(X,Y)=-6.Y$

For modelings `2D AXIS` and `AXIS_DIAG` (modelings C and D):

- $T(X,Y,Z)=2.R+3.Y$ ($R=X$ in the plan (OXY)) that is to say $\Phi_x(X,Y,Z)=-2$ and $\Phi_y(X,Y,Z)=-3$
- $T(X,Y,Z)=2.R^2+3.Y^2$ ($R=X$ in the plan (OXY)) that is to say $\Phi_x(X,Y,Z)=-4.X$ and $\Phi_y(X,Y,Z)=-6.Y$

For modelings `3D` and `3D_DIAG` (modelings E and F):

- $T(X,Y,Z)=2.X+3.Y+4.Z$ that is to say $\Phi_x(X,Y,Z)=-2$, $\Phi_y(X,Y,Z)=-3$ and $\Phi_z(X,Y,Z)=-4$
- $T(X,Y,Z)=2.X^2+3.Y^2+4Z^2$ that is to say $\Phi_x(X,Y,Z)=-4.X$, $\Phi_y(X,Y,Z)=-6.Y$ and $\Phi_z(X,Y,Z)=-8.Z$

2.2 Results of reference

For modelings 2D (`PLAN`, `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 , following flow X and Y by element with the nodes A , C , J and L and flow at the first point of Gauss of the same elements,
- With the quadratic field of temperature: the temperature with the nodes A , C , J and L , and following flow X and Y by element with the nodes A , C , J and L .

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

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

With $i=1$ with 9 for modeling 3D and $i=1$ with 4 for modeling `3D_DIAG`.

3 Modeling A

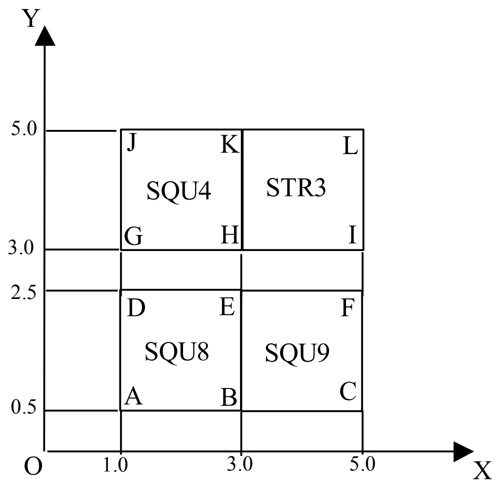
3.1 Characteristics of modeling

Elements 2D modeling `PLAN`

3.2 Characteristics of the grid

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

The grid 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 according to X and following Y.



Name of GROUP_MA	Type of element
SQU8	QUAD8
SQU9	QUAD9
SQU4	QUAD4
STR3	TRIA3

The nodes used for postprocessing are:

Name of the node	Coordinates	Number of the node	Name of a mesh containing this node	Type 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 whole of the grid is affected by a thermal modeling `PLAN`.

3.3 Results and sizes tested

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

Localization		**Size**	**Reference**	***Aster***	**% difference**
Mesh	**Node or PG**				
	Node 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 flow):

Localization		**Size**	**Reference**	***Aster***	**% difference**
Mesh	**Node or PG**				
	Node 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 Modeling B

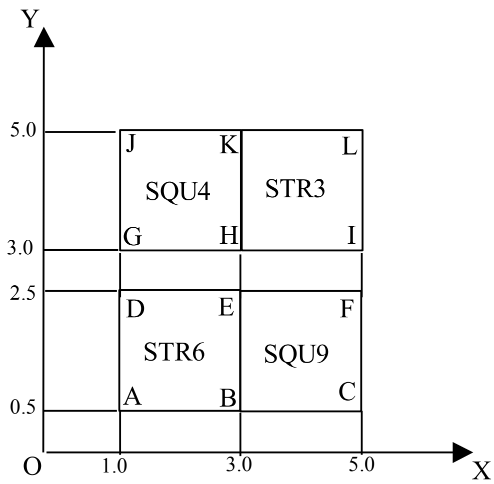
4.1 Characteristics of modeling

Elements 2D modeling `PLAN_DIAG`

4.2 Characteristics of the grid

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

The grid 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 according to X and following Y.



Name of `GROUP_MA`	Type of element
STR6	TRIA6
SQU9	QUAD9
SQU4	QUAD4
STR3	TRIA3

The nodes used for postprocessing are:

Name of the node	Coordinates	Number of the node	Name of a mesh containing this node	Type of the mesh
With	(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 whole of the grid is affected by a thermal modeling `PLAN_DIAG`.

4.3 Results and sizes tested

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

Localization		Size	Reference	*Aster*	% difference
Mesh	Node or PG				
	Node 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 flow):

Localization		**Size**	**Reference**	***Aster***	**% difference**
Mesh	**Node or PG**				
	Node 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 Modeling C

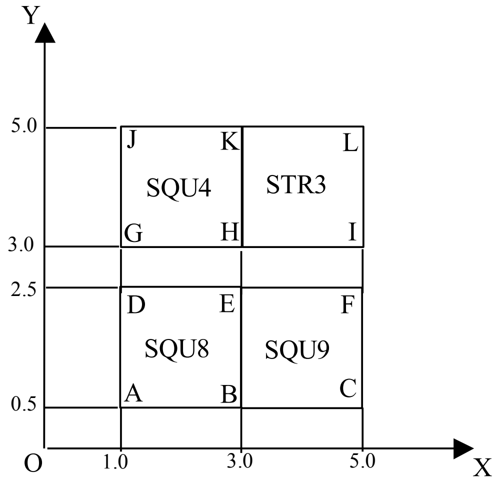
5.1 Characteristics of modeling

Elements 2D modeling AXIS

5.2 Characteristics of the grid

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

The grid 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 according to X and following Y.



Name of GROUP_MA	Type of element
SQU8	QUAD8
SQU9	QUAD9
SQU4	QUAD4
STR3	TRIA3

The nodes used for postprocessing are:

Name of the node	Coordinates	Number of the node	Name of a mesh containing this node	Type of the mesh
With	(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 whole of the grid is affected by a thermal modeling AXIS.

5.3 Results and sizes tested

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

Localization		**Size**	**Reference**	***Aster***	**% difference**
Mesh	**Node or PG**				
	Node 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 flow):

Localization		**Size**	**Reference**	***Aster***	**% difference**
Mesh	**Node or PG**				
	Node 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 Modeling D

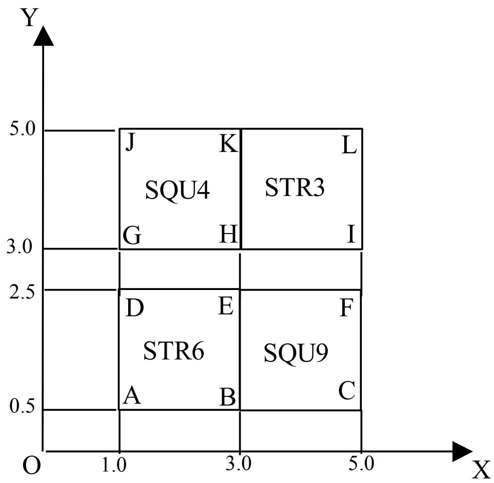
6.1 Characteristics of modeling

Elements 2D modeling `AXIS_DIAG`

6.2 Characteristics of the grid

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

The grid 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 according to X and following Y.



Name of `GROUP_MA`	Type of element
STR6	TRIA6
SQU9	QUAD9
SQU4	QUAD4
STR3	TRIA3

The nodes used for postprocessing are:

Name of the node	Coordinates	Number of the node	Name of a mesh containing this node	Type of the mesh
With	(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 whole of the grid is affected by a thermal modeling `AXIS_DIAG`.

6.3 Results and sizes tested

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

Localization		**Size**	**Reference**	***Aster***	**% difference**
Mesh	**Node or PG**				
	Node 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 flow):

Localization		**Size**	**Reference**	***Aster***	**% difference**
Mesh	**Node or PG**				
	Node 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 Modeling E

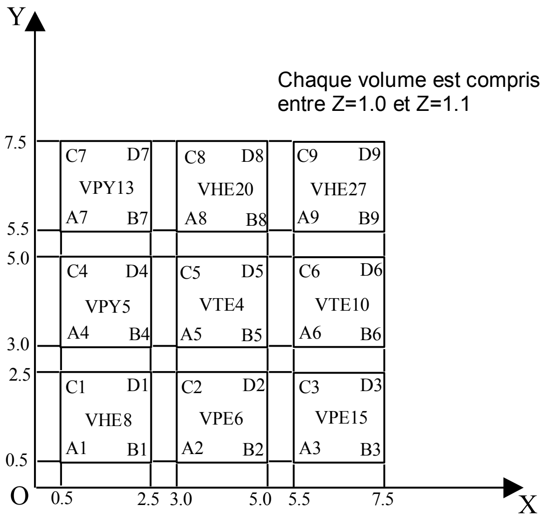
7.1 Characteristics of modeling

Elements 3D modeling `3D`

7.2 Characteristics of the grid

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

The grid 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 of element	Discretization according to: X	Y	Z	tization ding to: Y	Z
VHE8	HEXA8	20	20	1	:0	1
VHE20	HEXA20	20	20	1	:0	1
VHE27	HEXA27	20	20	1	:0	1
VPE6	PENTA6	20	20	1	:0	1
VPE15	PENTA15	20	20	1	:0	1
VPY5	PYRAM5	10	10	1	0	1
VPY13	PYRAM13	10	10	1	0	1
VTE4	TETRA4	10	10	1	0	1
VTE10	TETRA10	10	10	1	0	1

The nodes used for postprocessing are:

Name of the node	Coordinates	Number of the node	Name of a mesh containing this node	Type 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 whole of the grid is affected by a thermal modeling `3D`.

7.3 Results and sizes tested

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

Localization		**Size**	**Reference**	***Aster***	**% difference**
Mesh	**Node or PG**				
	D1 node	T	16.5	16.5	0%
M400 (HEXA8)	D1 node	Φ_X (ELNO)	-2.0	-2.0	0%

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

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

8 Modeling F

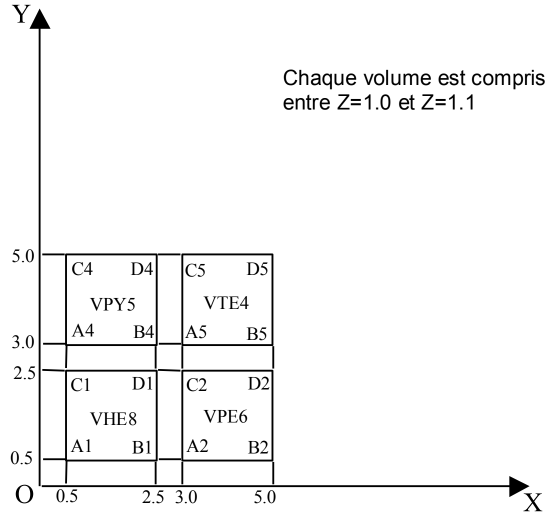
8.1 Characteristics of modeling

Elements 3D modeling 3D_DIAG

8.2 Characteristics of the grid

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

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



Name of the GROUP_MA	Type of element	Discretization according to:		
		X	Y	Z
VHE8	HEXA8	20	20	1
VPE6	PENTA6	20	20	1
VPY5	PYRAM5	10	10	1
VTE4	TETRA4	10	10	1

Name of GROUP_MA	Type of element	Discretization according to:		
		X	Y	Z
VHE8	HEXA8	20	20	1
VPE6	PENTA6	20	20	1
VPY5	PYRAM5	10	10	1
VTE4	TETRA4	10	10	1

The nodes used for postprocessing are:

Name of the node	Coordinates	Number of the node	Name of a mesh containing this node	Type 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 whole of the grid is affected by a thermal modeling `3D_DIAG`.

8.3 Results and sizes tested

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

Localization		**Size**	**Reference**	***Aster***	**% difference**
Mesh	**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 flow):

Localization		**Size**	**Reference**	***Aster***	**% difference**
Mesh	**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 results

Summary of the results

modeling		**Flow with the nodes or with PG with a linear temperature**		**Flow with the nodes with a quadratic temperature**	
Type of element	**Discretization in X and Y**	**Relative error max %**		**Relative error max %**	
Modeling 2D 'PLAN'					
QUAD4	$10 el/m$	0%		5%	
TRIA3	$10 el/m$	0%		1%	
QUAD8	$10 el/m$	0%		0%	
QUAD9	$10 el/m$	0%		0%	
Modeling 2D 'PLAN_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%	
Modeling 2D 'AXIS'					
QUAD4	$10 el/m$	0%		5%	
TRIA3	$10 el/m$	0%		1%	
QUAD8	$10 el/m$	0%		0%	
QUAD9	$10 el/m$	0%		0%	
Modeling 2D '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%	
Modeling '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%	
Modeling '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 flow):

- All modelings give exact results.

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

- The results are exact with elements of order 2 and one modeling not DIAG. These elements having quadratic functions of form can represent the field exactly of temperature imposed. Flows are exact and would be it still with a coarser discretization.
- Elements of order 2 with a modeling DIAG are treated like elements of order 1 for the calculation of flow. For these elements, flows are constant by element. The error is thus directly dependent in keeping with elements