TPLV102 - Transport of heat by convection in a parallelepiped

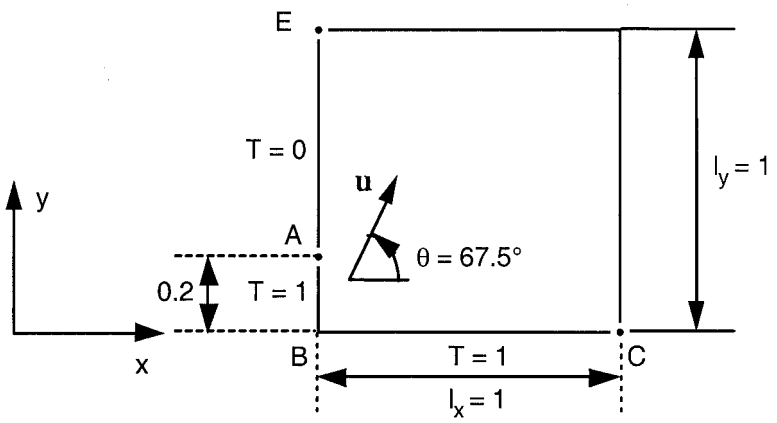
Summary:

This functionality was developed in the code in order to be able to test the nonsymmetrical matrices.

Stationary thermal calculation is carried out on elements of type quadrangle with 4 nodes.

1 Problem of reference

1.1 Geometry



One considers the thermal problem plan of a square cavity (on side equal to 1) where heat is propagated:

- by convection (i.e the particles constituting the medium of the cavity move at a speed u supposed here constant); speed u is supposed to form an angle of $67.5°$ with the axis x ,
- by conduction.

1.2 Material properties

One takes $\rho C_P = 1.$ $\lambda = 10^{-6}$

from where a diffusivity $\alpha = \frac{\lambda}{\rho C_P} = 10^{-6}$

and as one takes $\|u\| = 1$, one has the Peclet number $p_e = \frac{\|u\|.L}{\alpha} = 10^6$ (L is the characteristic length, here $L = 1.$).

1.3 Boundary conditions and loadings

On the segments AB and BC , a temperature is imposed $T = 1.$

On the segment AE , a temperature is imposed $T = 0.$

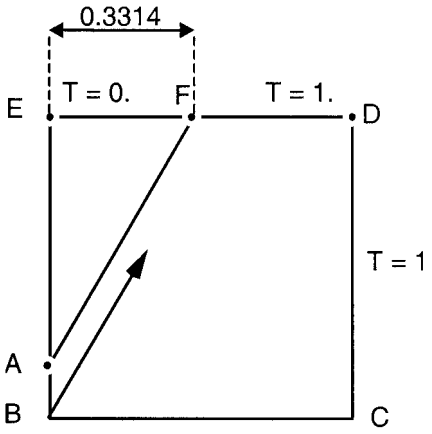
On the 2 other sides, there is the condition by default, namely, one is with null flow.

2 Reference solution

2.1 Method of calculating used for the reference solution

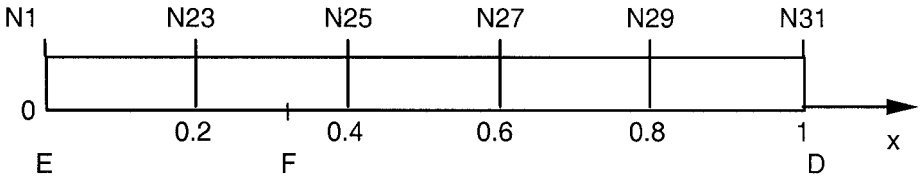
The reference solution is that recommended by Hughes and Brooks in their article referred to bibliographical [bib1].

One can take as exact solution the field of temperature of the border upstream project on the border downstream according to the direction speed.



2.2 Results of reference

One tests the temperatures on the border between the points E and D .



2.3 Uncertainty on the solution

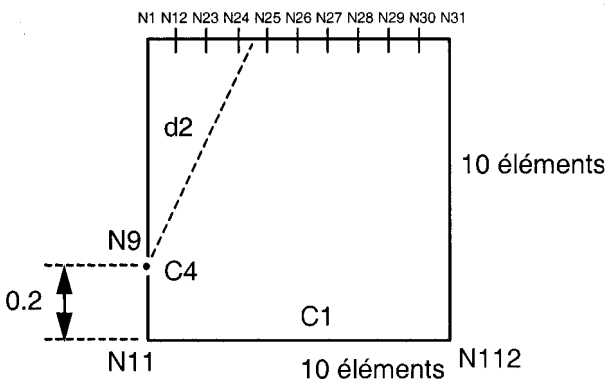
Analytical solution.

2.4 Bibliographical references

- T.J.R. HUGHES, A. BROOKS “with multidimensional design with No crosswind diffusion” - T.J.R. HUGHES ED., Finite Element Methods for convection doninated flows, AMD vol. 34 (ASME, New York (1979)).

3 Modeling A

3.1 Characteristics of modeling



Modeling is plane: the grid consists of 100 elements QUAD4 squares of equal sizes, and 50 elements SEG2 on the borders.

- the temperature of 0.0 is imposed on GROUP_NO $d2$,
- the temperature equalizes to 1.0 is imposed on GROUP_NO $C1$ and $C4$.

3.2 Characteristics of the grid

50 SEG2, 100 QUAD4

3.3 Sizes tested and results

Identification	Type of Reference	Reference	tolerance
T($N31$) $x=1.0$	ANALYTICAL	1.	1.3E-3
T($N29$) $x=0.8$	ANALYTICAL	1.	2.0E-4
T($N27$) $x=0.6$	ANALYTICAL	1.	3.0E-3
T($N25$) $x=0.4$	ANALYTICAL	1.	0.10
T($N23$) $x=0.2$	ANALYTICAL	0.	0,012
T($N1$) $x=0.$	ANALYTICAL	0.	1.0E-10

4 Summary of the results

Good nonsymmetrical matrix installation of for a thermal problem plan.