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 $\theta = 67.5^\circ$ 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.

![Diagram](image)

2.2 Results of reference

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

![Diagram](image)

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 dominated 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
### Sizes tested and results

<table>
<thead>
<tr>
<th>Identification</th>
<th>Type of Reference</th>
<th>Reference</th>
<th>Tolerance</th>
</tr>
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4 Summary of the results

Good nonsymmetrical matrix installation of for a thermal problem plan.