ZZZZ355 - Validation of the order `MACR_ECREVISSE` on the options of transfer of heat

Summary:

This CAS-test makes it possible to validate the cha by means of computerîstroke of Code_Aster with Crayfish, realized via the macro-order `MACR_ECREVISSE`, to estimate the flows of fluid (air/water/vapor) which can cross a crack. This case test aims to validate for a kind of friction given (`FRICTION` = 2), all types of transfer of heat available, and three types of fluids. In this test, the coefficients materials are such as the coupling is cancelled: as the got results must be the same ones as those produced by the software Crayfish alone. It is thus a test without physical relevance concerning the coupling.

8 modelings are proposed to combine all the types of fluid (air, air saturated vapour and air overheated vapor) and all the options of acceptable heat transfer. It is checked that the got results are well those provided by Crayfish.

1 Problem of reference

This test models two plates separated by a crack. The material describes in the following section is infinitely rigid and of worthless thermal conductivity so as to cancel the coupling. Only the choice of the fluid differentiates three modelings.

1.1 Geometry and material

The total geometry is presented onImage 1.1-1. The characteristics of the crack are given then.

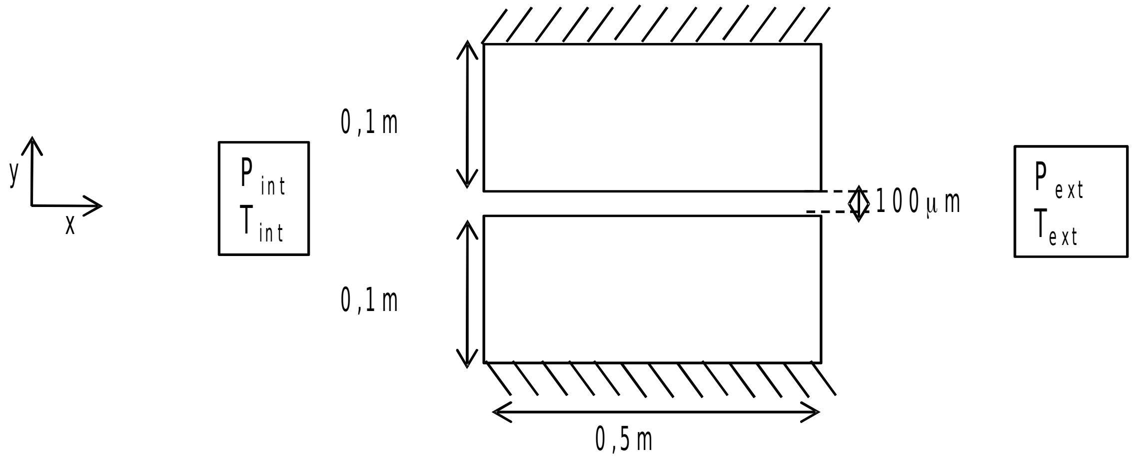

Image 1.1-1: geometry of the CAS-test

Details of the crack :
- section: RECTANGLE
- direction of the flow: X, in the positive direction
- absolute roughness of the wall: $0{,}5 . 10^{-6} m$
- loss ratio of singular load at the entry: none (ZETA = 0)
- dimension of the crack in the normal direction with the plan (z): $1 m$
- remanent opening fixed at $10 \mu m$

Boundary conditions of the flow :
- pressure of stagnation at the entry: $10.10^5 Pa$
- pressure of stagnation at the exit: $10^5 Pa$
- temperature at the entry: $180 °C$ (for the type of fluid 4 and 6, for 5 it is not necessary)
- The type of fluid will depend on modeling (see low: fluids 4,5,6 tested)

Crayfish model:

- Friction of the type Colebrook and White for a Reynolds higher than 5000 (laminar if not) and viscosity given by a formula of Cicchiti): FRICTION = 2.
- All the types of transfer of heat available are tested here: ICHAL = [- 12, - 11, - 2, - 1,0,1,2,11,12]. If ICHAL is negative, it is necessary to inform the coefficients XMINCH and XMAXCH. These coefficients correspond to hight delimiters and lower of the mass fraction of liquid making it possible to calculate the transfer of heat J according to a phase or of another (see U7.01.41). Here XMINCH = 0.7 and XMAXCH = 0.73.

1.2 Properties of material

The selected values are representative of a material of infinite rigidity and worthless conductivity so as to cancel the coupling.

$E=1.10^{25}\,Pa$

$\nu=0.25$

$\alpha=0\,°K^{-1}$

$\lambda=0\,W/m/°K$

$\rho C_p=2\cdot10^{14}\,J/m^3/°K$

1.3 Boundary conditions and loading

The parts higher and lower are embedded.
It is supposed that the crack cannot be entirely closed. Thus, the remanent opening is fixed at $10\,\mu m$ to leave a minimum fluid flow not no one.
With the suction face, the temperature is always worth $T_{ext}=20\,°C$ and pressure $P_{ext}=1\,atm$.
On the faces internal and external, one supposes that the exchanges with the ambient conditions are such as the coefficients of exchange are worthless.
One injects hot air under pressure is $T_{\text{int}}=180\,°C$ and $P_{\text{int}}=1\,MPa$.

1.4 Initial conditions

The concrete is at rest, with $20\,°C$, with a crack crossing of $100\,\mu m$ of opening.

1.5 Characteristics of the grid

The grid used is presented inImage 1.5-1 :

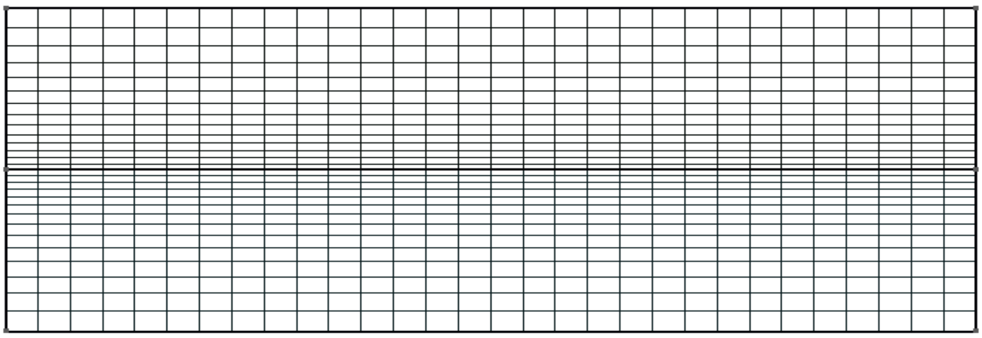

Image 1.5-1 : complete grid.

Dimensions are those of the geometry described previously.

Many Nœuds: 930
Many meshs: 1024 `QUAD4`

2 Reference solution

The data materials cancel the coupling here. As, the solutions obtained must be same as those obtained with Crayfish only.

The results of Crayfish were got with the same dimensions as starter as the nodes of the grid of Code_Aster. Indeed, that has an impact on the digital integration of the solution in Crayfish (method of Runge-Kutta), its precision is about 1 %. The results in temperature are especially sensitive.

Notice : for the results of Crayfish one looks at the file *pour_aster* and not the file *promin.mat*, so that they are comparable to the results provided in Code_Aster. Consequently, the value of temperature is provided to the center of the mesh.

3 Modeling A - B - C - D

3.1 Characteristics of modeling

Here the flow corresponds to a fluid made up of air and overheated vapor: `FLUIDE_ENTREE = 4.` Pressure partial of air as starter: $0,6\,MPa$.

The values of option of heat transfer treated in each modeling are the following ones:
- Modeling a: 0,1,2
- Modeling b: 11.12
- Modeling C: -1,-2
- Modeling D: -11,-12

3.2 Sizes and results

One tests the significant sizes of this calculation namely: flow, as well as the temperature at a given coast ($0,475\,m$) at the final time of simulation, that is to say $5000\,\mathrm{s}$.

`TRANSFERT_CHAL`	Value of the flow of exit found by CRAYFISH (kg/s)	Tolerance (%)
0	0.0244739	1.E-3
1	0.0045221	1.E-3
2	0.0044531	1.E-3
11	0.0045221	1.E-3
12	0.0044531	1.E-3
-1	0.0051948	1.E-3
-2	0.0045273	1.E-3
-11	0.0051948	1.E-3
-12	0.0045273	1.E-3

Table 3.2-1 : flow of reference for modeling A, B, C and D.

`TRANSFERT_CHAL`	Value of the temperature (°C) found by CRAYFISH with the dimension $0,475\,m$	Tolerance (%)
0	169.198	1.E-3
1	19.9482	1.E-3
2	19.9483	1.E-3
11	19.9482	1.E-3
12	19.9483	1.E-3
-1	19.9401	1.E-3
-2	19.9411	1.E-3
-11	19.9401	1.E-3
-12	19.9411	1.E-3

Table 3.2-2 : temperature of reference for modeling A, B, C and D.

4 E-F modeling - G

4.1 Characteristics of modeling

Here the flow corresponds to a fluid made up of air and saturated vapour: FLUIDE_ENTREE = 5. Pressure partial of air as starter: $0{,}6\,MPa$ and the mass title (water vapor on total water) is of $0{,}3$.

The values of option of heat transfer treated in each modeling are the following ones:
- Modeling E: 0,1,2
- Modeling F: 11.12
- Modeling G: -1,-2, -11,-12

4.2 Sizes and results

One tests the significant sizes of this calculation namely: flow, as well as the temperature with a given dimension ($0{,}475\,m$) at the final time of simulation, that is to say $5000\mathrm{s}$.

TRANSFERT_CHAL	Value of the flow of exit found by CRAYFISH (kg/s)	Tolerance (%)
0	0.01028	1.E-3
1	0.00393	1.E-3
2	0.00393	1.E-3
11	0.00393	1.E-3
12	0.00393	1.E-3
-1	0.00393	1.E-3
-2	0.00393	1.E-3
-11	0.00393	1.E-3
-12	0.00393	1.E-3

Table 4.2-1 : flow of reference for modeling E, F and G.

TRANSFERT_CHAL	Value of the temperature (°C) found by CRAYFISH with the dimension $0{,}475\,m$	Tolerance (%)
0	105.133	1.E-3
1	19.9662	1.E-3
2	19.9662	1.E-3
11	19.9662	1.E-3
12	19.9662	1.E-3
-1	19.9662	1.E-3
-2	19.9662	1.E-3
-11	19.9662	1.E-3
-12	19.9662	1.E-3

Table 4.2-2 : temperature of reference for modeling E, F and G.

5 Modeling H

5.1 Characteristics of modeling

Here the flow corresponds to a fluid made up of air alone: FLUIDE_ENTREE = 6.

5.2 Sizes and results

One tests the significant sizes of this calculation namely: flow, as well as the temperature with a given dimension ($0{,}475\,m$) at the final time of simulation, that is to say $5000\mathrm{s}$.

TRANSFERT_CHAL	Value of the flow of exit found by CRAYFISH (kg/s)	Tolerance (%)
0	0.02409	1.E-3
1	0.04579	1.E-3
2	0.04579	1.E-3
11	0.04579	1.E-3
12	0.04579	1.E-3
-1	0.04579	1.E-3
-2	0.04579	1.E-3
-11	0.04579	1.E-3
-12	0.04579	1.E-3

Tablwater 5.2-1 : flow of reference for modeling H.

TRANSFERT_CHAL	Value of the temperature (°C) found by CRAYFISH with the dimension 0,475m	Tolerance (%)
0	173.522	1.E-3
1	19.0641	1.E-3
2	19.0641	1.E-3
11	19.0641	1.E-3
12	19.0641	1.E-3
-1	19.0641	1.E-3
-2	19.0641	1.E-3
-11	19.0641	1.E-3
-12	19.0641	1.E-3

Table 5.2-2 : temperature of reference for modeling H.

6 Summary of the results

The results are coherent and show that the connection of the software Crayfish in Code_Aster functions.