ZZZZ354 - Validation of the order MACR_ECREVISSE on the options of friction

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 transfer of heat given (TRANSFERT_CHAL = 2) all options of friction, for 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.

7 modelings are proposed to combine all the types of fluid (air, air saturated vapour and air overheated vapor) and all the acceptable options of friction. 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.

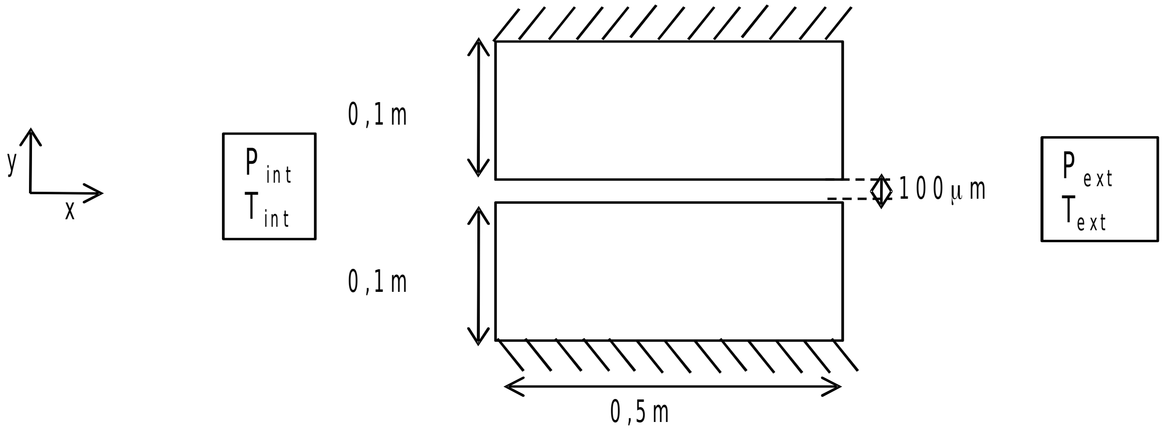

Image 1.1-1 : Geometry of the crack

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: $10\cdot10^5\,Pa$
- Pressure of stagnation at the exit: $10^5\,Pa$
- Temperature at the entry: $180\,°C$ if hot air (for the options of fluid 4 and 6, for the option 5 it is not necessary)
- Pressure partial of air at the entry: $6\cdot10^5\,Pa$
- The type of fluid will depend on modeling, one tests options 4,5,6.

For the case specific of fluid 5 associate to the coefficient of friction 13, one will adopt different conditions of pressure to facilitate the Crayfish convergence:

- Pressure of stagnation at the entry: $6\cdot10^5\,Pa$
- Pressure partial of air at the entry: $4\cdot10^5\,Pa$

Crayfish model :

- Transfer of heat with a correlation of Schmidt into monophasic laminar and a correlation of Mac Adams in the other modes. No smoothing enters the laminar and turbulent mode (`TRANSFERT_CHAL = 2`).

- All the compatible types of friction are tested here (FRICTION = [- 4, - 3, - 2, -1,0,1,2,3,4,11,12,14,21,22,23,24]. If FRICTION is negative, friction is informed by the user starting from a limiting Reynolds who defines the end of the laminar mode. Here, REYNOLDS_LIM = 1000 and FROTTEMENT_LIM = 0.044 .

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.

$E=1.10^{25}\,Pa$
$\nu=0.25$
$\alpha=0\,°K^{-1}$
$\lambda=0\,W/m/°K$
$\rho C_p=2.10^{14}\,J/m^3/°C$

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 in all modelings is presented inImage 1.5-1 :

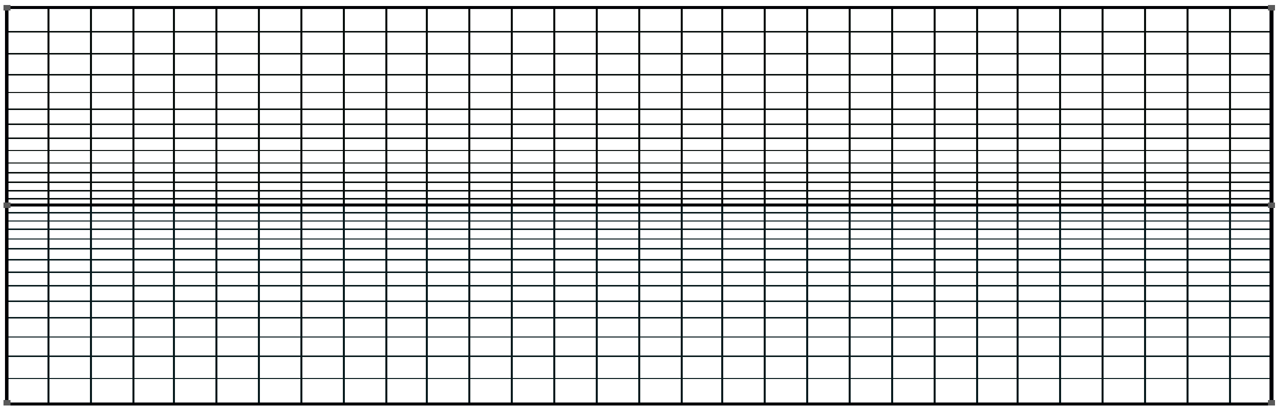

Image 1.5-1 : Complete grid

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. Consequent Pa, the value of temperature is provided to the center of the mesh.*

3 Modeling A - B - C

3.1 Characteristics of modelings

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 friction treated in each modeling are the following ones:
- Modeling a: 0,1,2,3,4
- Modeling b: 11,12,13,14
- Modeling C: -1,-2,-3,-4

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 $5000\mathrm{s}$.

FRICTION	**Value of the flow of exit found by CRAYFISH (kg/s)**	**Tolerance**
0	1.707578E-01	1.E-3
1	1.382555E-03	1.E-3
2	4.453107E-03	1.E-3
3	5.214232E-02	1.E-3
4	5.076335E-02	1.E-3
11	1.382548E-03	1.E-3
12	4.453103E-03	1.E-3
13	3.789439E-02	1.E-3
14	3.809795E-02	1.E-3
-1	1.382550E-03	1.E-3
-2	4.453116E-03	1.E-3
-3	3.820877E-02	1.E-3
-4	3.820877E-02	1.E-3

Table 3.2-1 : Flow of reference for modelings A, B and C.

FRICTION	Value of the temperature (°C) found by CRAYFISH with the dimension 0,475m	Tolerance
0	20,00	1.E-3
1	1.995935E+01	1.E-3
2	1.994827E+01	1.E-3
3	1.989127E+01	1.E-3
4	1.988173E+01	1.E-3
11	1.995935E+01	1.E-3
12	1.994826E+01	1.E-3
13	1.989370E+01	1.E-3
14	1.989488E+01	1.E-3
-1	1.995935E+01	1.E-3
-2	1.994827E+01	1.E-3
-3	1.989439E+01	1.E-3
-4	1.989439E+01	1.E-3

Table 3.2-2 : Temperature of reference for modelings A, B and C.

4 Modeling D - E-F

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 friction treated in each modeling are the following ones:

- Modeling D: 0,1,2,3,4
- Modeling E: 11,12,13,14
- Modeling F: -1,-2,-3,-4

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 $5000\mathrm{s}$.

FRICTION	Value of the flow of exit found by CRAYFISH (kg/s)	Tolerance
0	0.21726	1.E-3
1	0.00235	1.E-3
2	0.00393	1.E-3
3	0.06648	1.E-3
4	0.05275	1.E-3
11	0.00235	1.E-3
12	0.00393	1.E-3
13	0.02845	1.E-3
14	0.05234	1.E-3
-1	0.00235	1.E-3
-2	0.00393	1.E-3
-3	0.05010	1.E-3
-4	0.05010	1.E-3

Table 4.2-1 : Flow of reference for modeling D, E and F.

`FRICTION`	**Value of the temperature (°C) found by CRAYFISH with the dimension** $0{,}475\,m$	**Tolerance**
0	20	1.E-3
1	19.9695	1.E-3
2	19.9662	1.E-3
3	19.9226	1.E-3
4	19.9223	1.E-3
11	19.9695	1.E-3
12	19.9662	1.E-3
13	19.9287	1.E-3
14	19.9226	1.E-3
-1	19.9695	1.E-3
-2	19.9662	1.E-3
-3	19.9243	1.E-3
-4	19.9243	1.E-3

Table 4.2-2 : Temperature of reference for modeling D, E and F.

5 Modeling G

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 $5000\,s$.

FRICTION	Value of the flow of exit found by CRAYFISH (kg/s)	Tolerance
0	0.18851	1.E-3
1	0.04579	1.E-3
2	0.04579	1.E-3
3	0.04579	1.E-3
4	0.04579	1.E-3
11	0.03163	1.E-3
12	0.03163	1.E-3
13	0.03163	1.E-3
14	0.03163	1.E-3
-1	0.03195	1.E-3
-2	0.03195	1.E-3
-3	0.03195	1.E-3
-4	0.03195	1.E-3

Table 5.2-1 : Flow of reference for modeling G.

FRICTION	Value of the temperature (°C) found by CRAYFISH with the dimension $0{,}475\,m$	Tolerance
0	20	1.E-3
1	19.0640	1.E-3
2	19.0640	1.E-3
3	19.0640	1.E-3
4	19.0640	1.E-3
11	19.0798	1.E-3
12	19.0799	1.E-3
13	19.0799	1.E-3
14	19.0798	1.E-3
-1	19.0671	1.E-3
-2	19.0671	1.E-3
-3	19.0671	1.E-3
-4	19.0671	1.E-3

Table 5.2-2 : Temperature of reference for modeling G.

6 Modeling H

6.1 Characteristics of modeling

Here too the flow corresponds to a fluid made up of air and overheated vapor: `FLUIDE_ENTREE = 4.` The options of friction tested (21, 22,23,24) correspond to the law of Greiner and RAM for the crack in the concrete (see [U7.03.41]).

6.2 Sizes and results

One tests the significant sizes of this calculation namely: flow, as well as the temperature with a given dimension ($0{,}5\,m$) at the final time of simulation, that is to say $5000\mathrm{s}$.

`FRICTION`	**Value of the flow of exit found by CRAYFISH (kg/s)**	**Tolerance**
21	1.376802E-03	1.E-3
22	1.609028E-03	1.E-3
23	1.609028E-03	1.E-3
24	1.609028E-03	1.E-3

Table 6.2-1 : Flow of reference for modeling H.

`FRICTION`	**Value of the temperature (°C) found by CRAYFISH with the dimension $0{,}475\,m$**	**Tolerance**
21	1.961232E+01	1.E-3
22	1.960527E+01	1.E-3
23	1.960527E+01	1.E-3
24	1.960527E+01	1.E-3

Table 6.2-2 : Temperature of reference for modeling H.

7 Summary of the results

The results are coherent and validate the chaining between the software Code_Aster and Écrevisse.