WTNP126 - Gas injection in a fractured porous solid mass

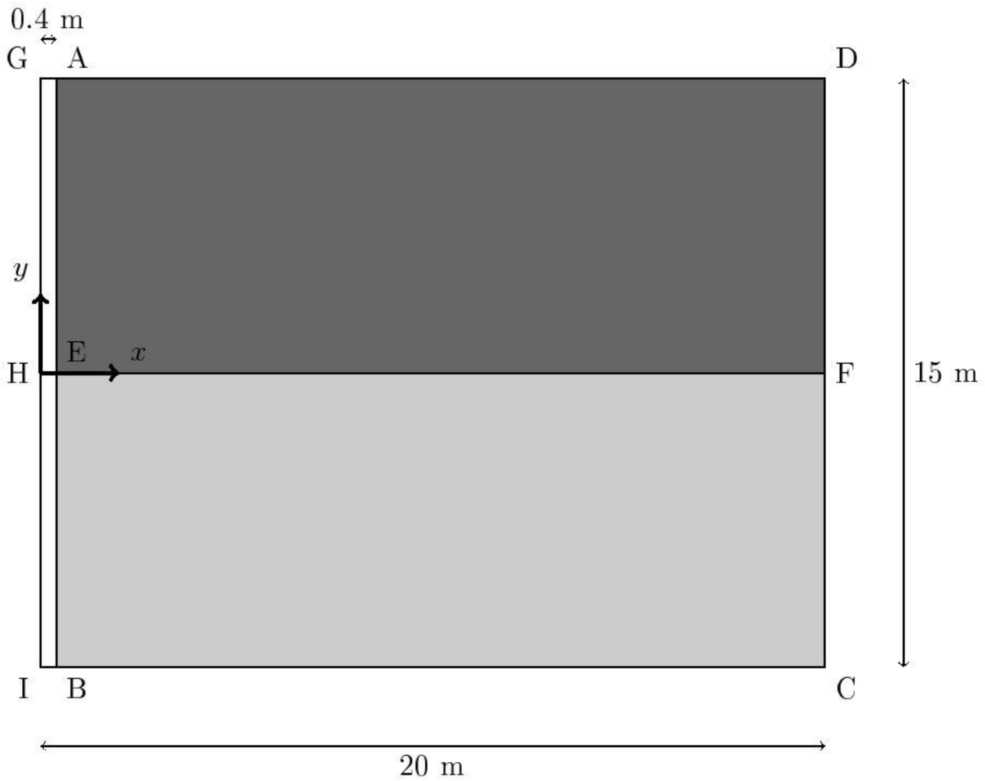
Summary:

The test presented here makes it possible to check the good performance of the elements of joints with coupling-hydromechanics in medium saturated with gas (law THM 'GAS').
One models the injection of dihydrogene in a rock solid mass. This one is composed of two elastic parts of different permeabilities separated by a water seal. The laws of behavior of the interface used are the cubic law for the flow and the law of Bandis for mechanics.

1 Problem of reference

1.1 Geometry

The studied field consists of two porous solid masses ($AEFD$ and $EBCF$) separated by a water seal. One also models the game between the structure and the wall of injection of gas ($AGIB$).



Coordinates of the points (in meters):

	x	y		x	y		x	y
A	0.4	7.5	D	20	7.5	G	0	7.5
B	0.4	-7.5	E	0.4	0	H	0	0
C	20	-7.5	F	20	0	I	0	-7.5

1.2 Properties of material

- Properties of the fluid intersticiel (dihydrogene):

Molar mass	$0{,}002\ kg.m^{-3}$
Viscosity	$9.10^{-6}\ Pa.s$

- Properties of the higher rock matrix:

The matrix is elastic and has the following properties:

Young modulus	$3{,}0\,GPa$
Poisson's ratio	$0{,}12$
Porosity	$0{,}18$
Intrinsic permeability	$2{,}75.10^{-20}m^2$

- Properties of the lower rock matrix:

The lower rock matrix has the same mechanical characteristics that the higher matrix, but has an intrinsic permeability ten times lower.

Young modulus	$3{,}0\,GPa$
Poisson's ratio	$0{,}12$
Porosity	$0{,}18$
Intrinsic permeability	$2{,}75.10^{-21}m^2$

- Properties of discontinuity:

The mechanical behavior of discontinuity is described by the law of Bandis. The hydraulic flow is given by the cubic law.

Initial normal rigidity	$1.10^9\,Pa.m^{-1}$
Initial asymptotic opening	$0{,}4\,mm$
Coefficient γ	2

- Properties of the game:

The game between the walls of emission of the flow of dihydrogene and the rock is a springy medium far from rigid and of very high permeability.

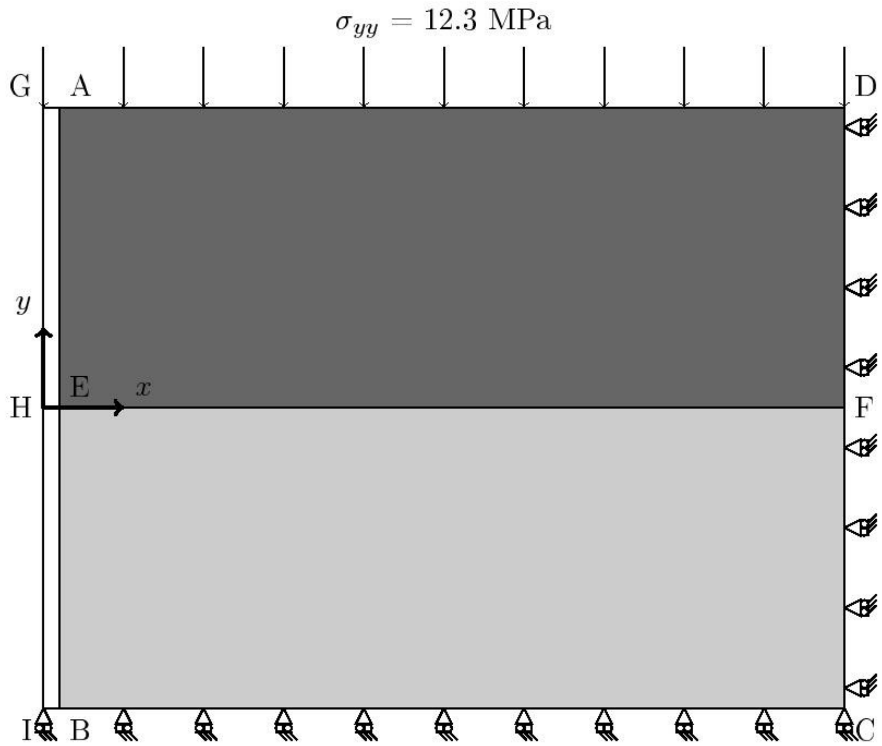
Young modulus	$3{,}0\,MPa$
Poisson's ratio	$0{,}12$
Porosity	1
Intrinsic permeability	$1.10^{-8}m^2$

1.3 Boundary conditions and loading

The boundary conditions hydraulic are the following ones:

On $[GD]$ hydraulic flow no one
On $[DC]$ $p_g=p_0=0{,}1\,MPa$
On $[CI]$ hydraulic flow no one
On $[IG]$ gas flow $F_g=1.10^{-10}kg.s^{-1}.m^{-2}$

The boundary conditions mechanical are given by the figure below.



1.4 Initial conditions

The initial conditions are the following ones:

- initial opening: $3{,}48 . 10^{-6} m$
- initial pressure in the solid mass: $p_0 = 0{,}1\ MPa$
- compressive stress in the direction y : $12{,}3\ MPa$
- temperature: $303\ °K$

2 Reference solution

Tests of nonregression are carried out.

3 Modeling A

3.1 Characteristics of modeling

Modeling is carried out in plane deformation with 100 elements QU4 for the game, 3202 elements TRI3 for the solid mass and 100 elements QU4 for discontinuity.

Discretization in time: 24 pas de time for a 1000 years simulation.

3.2 Sizes tested and results

The figure 3.2.1 watch profiles of pressure on the vertical cut $x=4m$ at various moments. One sees well there the hydraulic influence of the crack. Indeed, in the vicinity of this one one observes very important gradients of pressure who correspond to the flows directed towards each of the two solid masses. In addition, one also sees the effect of the difference in permeability between the two solid masses. In accordance with until one waits, the pressure is standardized more quickly in the higher solid mass, of higher permeability.

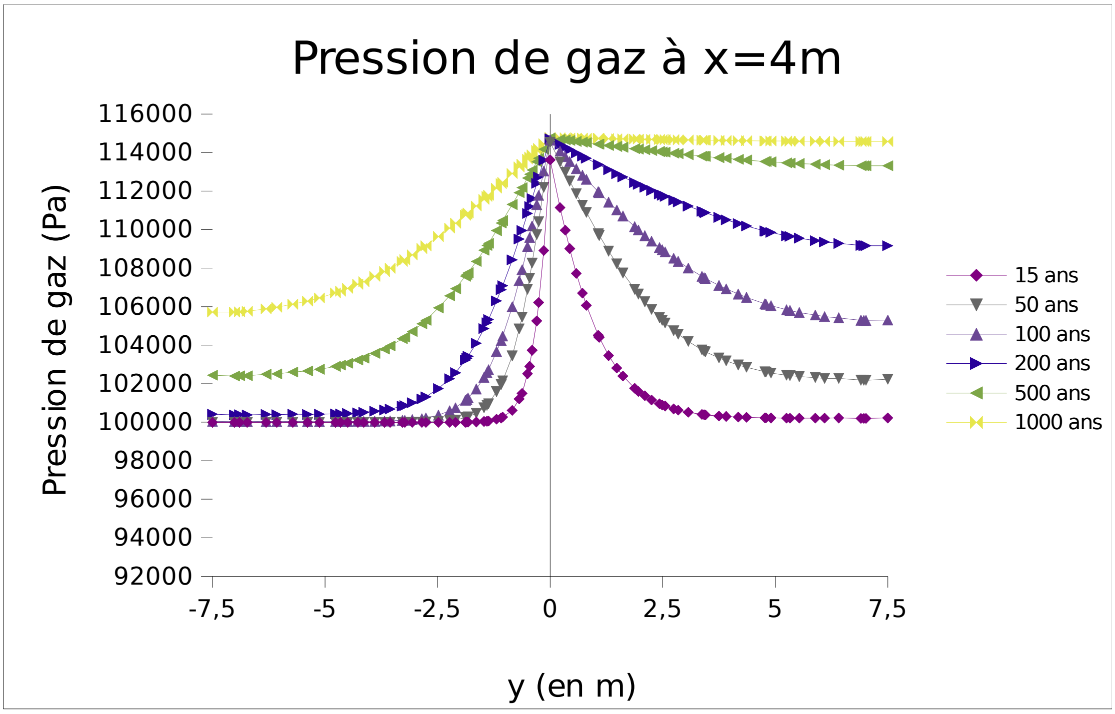


Figure 3.2.1: Profiles of gas pressure along a vertical cut (x=4m)

One carries out the test of not-regression following:

$X(m)$	$Y(m)$	Time (years)	$PRE1(Pa)$ Aster
4.23	2.35	200	1,1159E+05
4.23	2.35	1000	1,1447E+05
3.92	-2.58	200	1,0135E+05
3.92	-2.58	1000	1,0929E+05
4.0	0.0	200	1,1470E+05
4.0	0.0	1000	1,1477E+05

4 Modeling B

4.1 Characteristics of modeling

The characteristics of simulation are identical to those of modeling above but the interface transversely becomes impermeable. One imposes on the hydraulic multipliers of Lagrange which control the equality of pressure through the interface to be equal to zero. For that, the order is used `AFFE_CHAR_CINE` with the keyword `MECA_IMPO` to put the degree of freedom $LH1$ to 0 on the crack.

4.2 Sizes tested and results

The figure 4.2.1 watch profiles of pressure along the cut vertical $x=4m$ at various moments. It is noted well that there is no exchange between the two solid masses and the crack. In addition, the faces of pressure advance at a different speed in each solid mass because of difference in permeability.

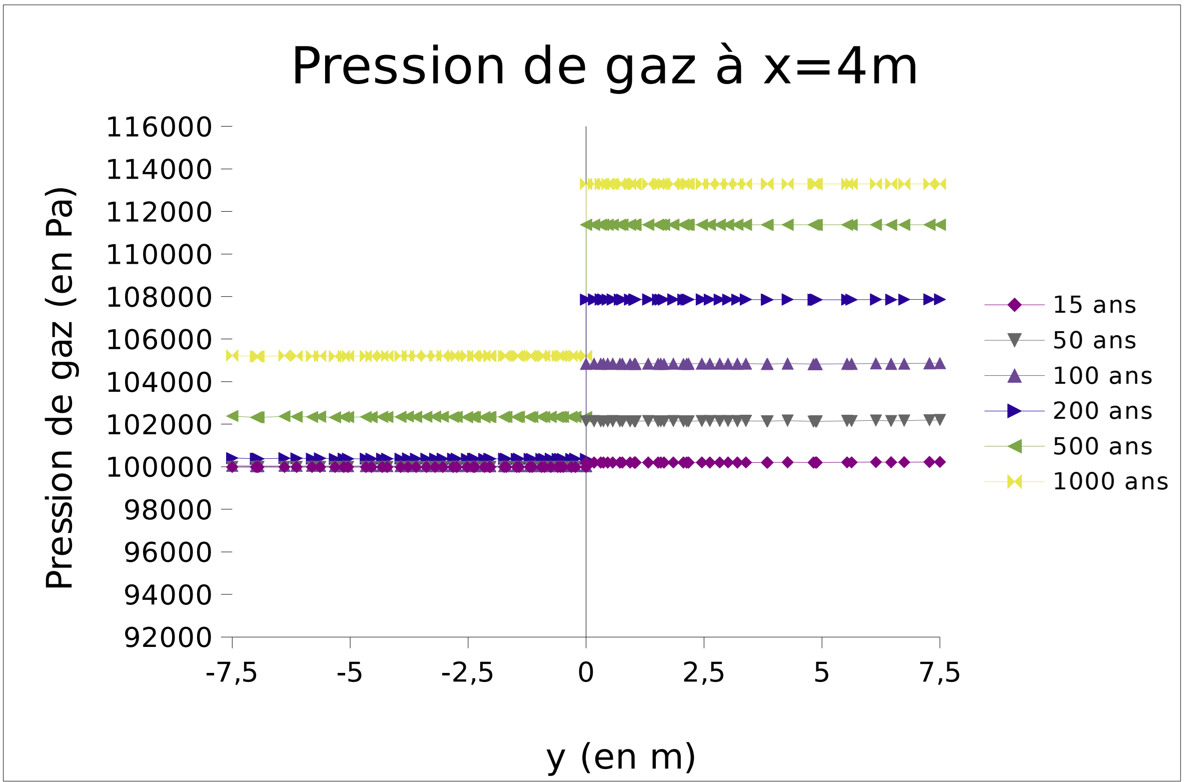


Figure 4.2.1: Profiles of gas pressure along a vertical cut (x=4 m)

One carries out the test of not-regression following:

$X(m)$	$Y(m)$	**Time (years)**	$PRE1(Pa)$ **Aster**
4.23	2.35	200	1,073E+05
4.23	2.35	1000	1,13E+05
3.92	-2.58	200	1,0041E+05
3.92	-2.58	1000	1,0539E+05
4.0	0.0	200	1,1473E+05

4.0	0.0	1000	1,1477E+05

5 Summary of the results

One tests the element of joint with hydraulic coupling and his compatibility with the mixing rate 'GAS'and elements of solid mass HM_DPTR6S. One considers the case where the joint is impermeable or not.

In both cases, one gets the qualitatively expected results.