Thermal TTNP201-transfer with conductivity dependent on time

Summary:

This test consists in imposing a variable conductivity function of time during a heat transfer. One applies to an edge of the wall a condition of imposed flow and on the opposite edge the temperature remains constant. Conductivity increases with time and one observes a jump of temperature on the edge where flow is imposed.

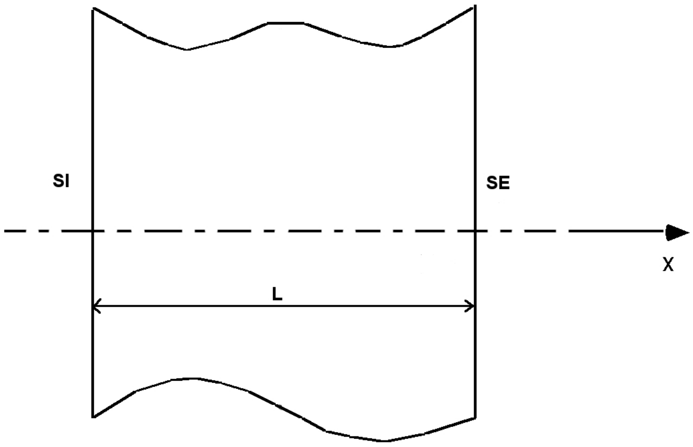
With the problem is dealt in PLAN, AXIS and 3D.
The reference solution is obtained by the iterative method of Crank-Nicholson.

One tests the taking into account of a conductivity function of time.

1 Problem of reference

1.1 Geometry

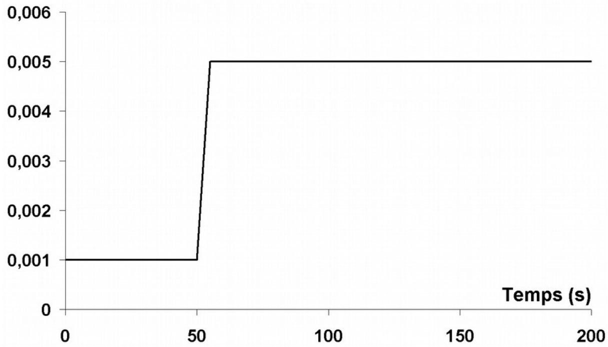
A wall thickness is considered $L=2\,m$.



1.2 Properties of material

The thermal properties are:

- $\rho\,Cp=1\,J/m^3\,°C$
- $\lambda(W/m\,°C)$ vary as follows:



1.3 Boundary conditions and loadings

On the edge SI , one imposes a flow cooling of $-1\,W/m^2$.
On the edge SE , one imposes a temperature of $100\,°C$.

1.4 Initial conditions

At the initial moment, the temperature is uniform and equal to $100\,°C$.

1.5 Temporal discretization

Calculation proceeds on $200\mathrm{s}$ with a step of time of: $0{,}1\,s$ between 0 and $40\mathrm{s}$ then $0{,}05\,s$ enter $40\mathrm{s}$ and $80\mathrm{s}$ and finally $0{,}1\,s$ until $200\mathrm{s}$.

2 Reference solution

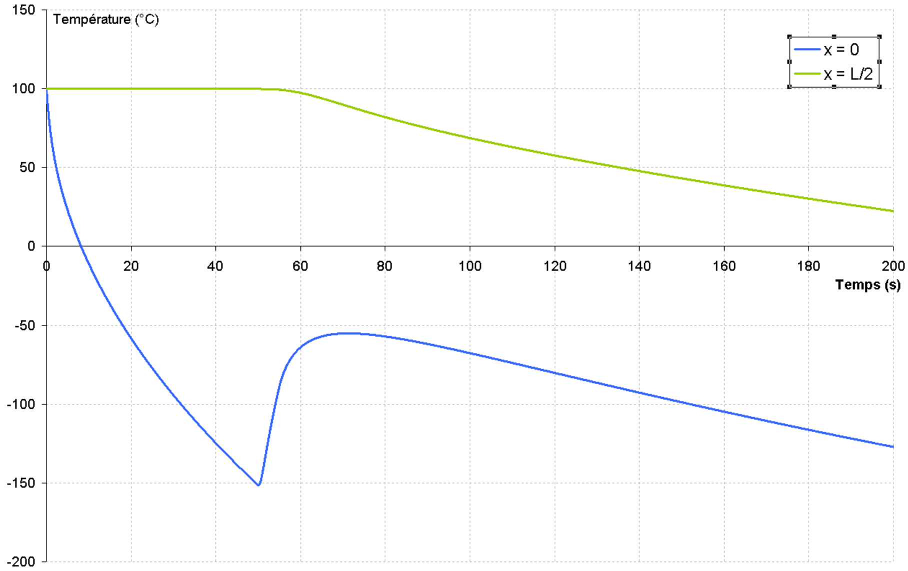
2.1 Method of calculating

It is necessary to solve: $\rho\, Cp \frac{dT(x,t)}{dt} = \lambda(t) \frac{dT(x,t)}{dx}$ with the initial condition $T(x,0)=100$ and boundary conditions: $-\lambda(t) \left.\frac{\partial T}{\partial x}\right|_{x=0} = -1$ and $T(L,t)=100$

One solves this differential equation with an iterative diagram of Crank-Nicholson [1] under scilab.

2.2 Sizes and results of reference

One observes the temperature at the edge $x=0$ and in the middle of the wall $x=\frac{L}{2}$. When conductivity increases between 50 and 55 seconds, the temperature in the medium decreases more quickly. The waste heat is propagated towards the edges where a warming is observed. This phenomenon is also observed during calculation of drying when the coefficient of diffusion depends on the temperature. A d-humidification of the edge then is seen.



For the reference of the case test, one records the values of the temperature in $x=0$ and in $x=\frac{L}{2}$ at various moments corresponding to the appearance of the jump of temperature to the peak and calculation.

	50s	51s	72s	200s
x=0	0,0000	0,0000	0,0000	0,0000
x=L/2	0,0000	Not tested	0,0000	0,0000

2.3 Uncertainties on the solution

The method of resolution requires steps in times and space sufficiently small to collect the peak of temperature correctly. Here one used $dx=0{,}05\,m$ and $dt=0{,}01\,s$.

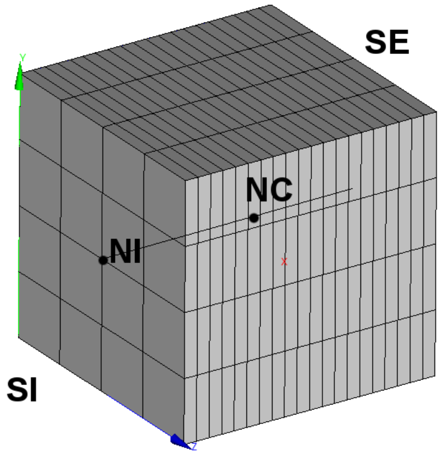
2.4 Bibliographical references

[1] J. Crank, The mathematics of diffusion, Oxford University Close, second edition 1975.

3 Modeling A

3.1 Characteristics of modeling

A modeling is used 3D_DIAG.



3.2 Characteristics of the grid

The grid contains 320 elements of the type HEXA8.

3.3 Sizes tested and results

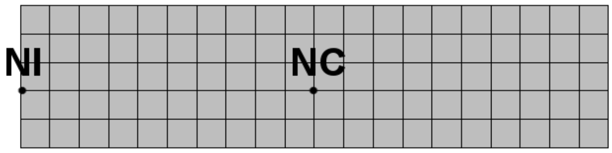
Identification	Type of reference	Value of reference	Tolerance
Not Ni - $TEMP$	'SOURCE_EXTERNE'		
t=50s		-151,52	2,00%
t=51s		-143,51	2,00%
t=72s		-55,17	0,50%
t=200s		-127,18	0,50%
Not NC - $TEMP$	'SOURCE_EXTERNE'		
t=50s		99,85	0,50%
t=72s		88,24	0,50%
t=200s		22,43	0,50%

Values obtained with *Code_Aster* in version 10.3.18 are tested in 'NON_REGRESSION' with a precision of $0{,}1\%$.

4 Modeling B

4.1 Characteristics of modeling

A modeling is used PLAN_DIAG.



4.2 Characteristics of the grid

The grid contains 100 elements of the type QUAD4.

4.3 Sizes tested and results

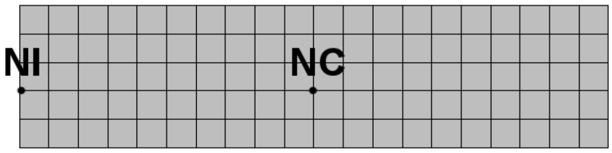
Identification	Type of reference	Value of reference	Tolerance
Not Ni - $TEMP$	'SOURCE_EXTERNE'		
t=50s		-151,52	2,00%
t=51s		-143,51	2,00%
t=72s		-55,17	0,50%
t=200s		-127,18	0,50%
Not NC - $TEMP$	'SOURCE_EXTERNE'		
t=50s		99,85	0,50%
t=72s		88,24	0,50%
t=200s		22,43	0,50%

Values obtained with *Code_Aster* in version 10.3.18 are tested in 'NON_REGRESSION' with a precision of $0,1\%$.

5 Modeling C

5.1 Characteristics of modeling

A modeling is used AXIS_DIAG.



5.2 Characteristics of the grid

The grid contains 100 elements of the type QUAD4.

5.3 Sizes tested and results

Identification	Type of reference	Value of reference	Tolerance
Not Ni - $TEMP$	'SOURCE_EXTERNE'		
t=50s		-151,52	2,00%
t=51s		-143,51	2,00%
t=72s		-55,17	0,50%
t=200s		-127,18	0,50%
Not NC - $TEMP$	'SOURCE_EXTERNE'		
t=50s		99,85	0,50%
t=72s		88,24	0,50%
t=200s		22,43	1,00%

Values obtained with *Code_Aster* in version 10.3.18 are tested in 'NON_REGRESSION' with a precision of $0,1\%$.

6 Summary of the results

The quality of the results is satisfactory, one represents the peak of temperature at the edge. The errors remain lower than $1,6\%$ compared to the reference solution. The results can be improved by a temporal and space refinement.