TTNL100 - Non-linear thermal source, homogeneous solution in space

Summary:

This test checks thermal calculation in the presence of a loading of non-linear source, depend on the temperature.

The reference solution is analytical. The part considered in modelings consists of only one element whose dimensions do not import on the solution.

The following meshs are checked:

- Modeling a:
  - TRIA3, TRIA6, QUAD4, QUAD8 and QUAD9 for modeling PLAN,
  - TRIA3, QUAD4 for modeling PLAN_DIAG ,
- Modeling b: PENTA6 for modeling 3D

The temperature being homogeneous in the element, calculation can be regarded as 0D.

1 Problem of reference

1.1 Geometry

The part considered in two modelings is a single element.

The temperature being homogeneous in the element, calculation can be regarded as 0D.

1.2 Properties of material

$\lambda=0$	thermal conductivity
$\rho C=2$	voluminal heat

1.3 Boundary conditions and loadings

Loading of voluminal source non-linear, function of the temperature:
$s(T)=2-2\times w\times T$ with $w=2$

The boundary conditions are adiabatic, which corresponds to the defect in *Code_Aster* .

The temporal beach $[0.;1.]$ is discretized in 100 pas de time (lasted of each step of time equalizes with 0.01).

1.4 Initial conditions

$T0=0$ in all the element.

2 Reference solution

2.1 Method of calculating used for the reference solution

In this problem, the boundary conditions are adiabatic, the initial temperature is constant equal to T_0 and the loading is tiny room to the function source of heat of the temperature $r(T)=r_0-r_1 T$ where r_1 is positive for questions of thermal stability. These conditions ensure well a homogeneous solution in space. The equation of heat is reduced to:

$$\rho C_p \dot{T}=r_0-r_1 T \;;\; T(0)=T_0$$ [éq1]

By standardisation, one can be reduced without loss of general information to the following equation:

$$\dot{u}=1-\omega u \;;\; u(0)=0$$ [éq2]

The solution of this first order differential equation is then:

$$u(t)=\frac{1}{\omega}(1-e^{-\omega t})$$

Rather than to go up u solution of [éq2] with T solution of [éq1], one prefers to adopt the set of following parameters, without lending guard to the units, which leads to $T=u$: $T_0=0$, $r_0=\rho C$ and $r_1=\omega r_0$.

2.2 Results of reference

The cas-test is carried out with $\omega=2$ and one examines the temperature with $t=1$ in an unspecified node of the element. The data are the following ones:

Thermal conductivity	LAMBDA	0.
Voluminal heat-storage capacity	RHO_CP	2.
Initial temperature	T_0	0.
Source of heat	r_0 r_1	2. 4.

Size tested	T ($t=1$)
Value of reference	0.432332

3 Modeling A

3.1 Characteristics of modeling

A modeling is used `PLAN` then `PLAN_DIAG` .

3.2 Characteristics of the grid

The grid consists of only one nets for each one of type S following .

Modelings	Meshs
PLAN	TRIA3 TRIA6 QUAD4 QUAD8 QUAD9
PLAN_DIAG	TRIA3 QUAD4

3.3 Largeeurs tested and results

The temperature is tested with $t=1$ in an unspecified node of the element.

The solution is in conformity with the analytical value with less than 0.1 %.

4 Modeling B

4.1 Characteristics of modeling

A modeling is used 3D .

4.2 Characteristics of the grid

The grid consists of only one nets of type PENTA6 .

4.3 Largeeurs tested and results

The temperature is tested with $t=1$ in an unspecified node of the element.

The solution is in conformity with the analytical value with less than 0.1 %.

5 Summary of the results

The results are in conformity with the analytical solution.