TTNL100 – Nonlinear thermal source, homogeneous solution in Summarized

space:

This test checks thermal computation in the presence of a loading of nonlinear source, depend on the temperature.

The reference solution is analytical. The part considered in the two modelizations is a single element:

- an element TRIA3 for a modelization planes
- an element PENTA6 for a modelization 3D

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

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1 Problem of reference

1.1 Geometry

the part considered in the two modelizations is a single element:

- an element TRIA3 for a modelization planes
- an element PENTA6 for a modelization 3D

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

1.2 Properties of the thermal

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

1.3 Boundary conditions and loadings

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

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

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

1.4 Initial conditions

$T0=0$ in all the element.

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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 heat source 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:

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

By standardization, one can be reduced without loss of generality to the following equation:

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

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 benchmark 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	LAMBDA0	.
Voluminal heat capacity	RHO_CP	2.
Initial temperature	T_0	0.
Heat source	r_0 r_1	2. 4.

Quantity tested	T ($t=1$)
Value of reference	$0.432\,332$

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3 Modelization A

3.1 Characteristic of the modelization

The mesh of this modelization is composed of a single element TRIA3 in modelization `PLANE` , whose dimensions do not import since the solution is homogeneous in space.

4 Results of the modelization A

4.1 Values tested

the solution is in conformity with the analytical value with less than 0.05 %.

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5 Modelization B

5.1 Characteristic of the modelization

The mesh of this modelization is composed of a single element PENTA6 in modelization `3D` , whose dimensions do not import since the solution is homogeneous in space.

6 Results of the modelization B

6.1 Values tested

the solution is in conformity with the analytical value with less than 0.05 %.

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7 Summary of the results

the results are in conformity with the analytical solution.

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