TPLL101 - Joule effect heating of a Summarized hollow roll

:

One imposes electric currents inside and outside a hollow roll finite length, then one calculates the temperature established under the effect of a heat source produced by Joule effect. The reference solution is analytical.

The scope of application is the steady linear thermal.

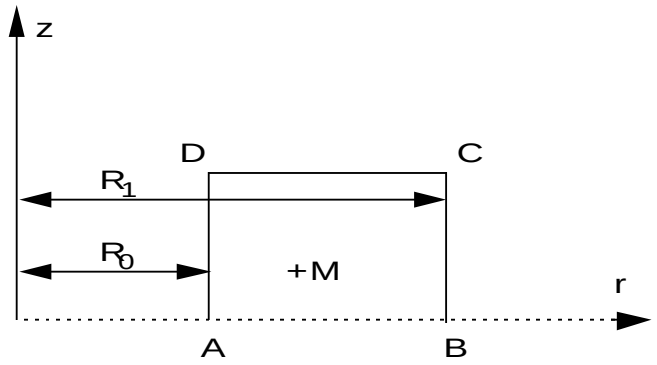
The model is axisymmetric.

The test is carried out on elements QUAD8 and TRIA6 for the first modelization, axisymmetric (AXIS). With elements TETRA4 for the second modelization, 3D.

1 Problem of Axisymmetric

1.1 reference

Geometry



	A	B	C	D	M
R	1.	2.7182	2.7182	1.	1.8591
Z	0.	0.	0.1.0.1		0.025

1.2 Material properties

electric Characteristic: electric conductivity $\sigma = 1.\Omega^{-1} m^{-1}$

thermal Characteristics: $\lambda = 2.10^{-2} W/m°C$ $C_P = 0.$

1.3 Boundary conditions and loadings

electric Computation:

$j.n = -10$ sur DA
$j.n = 3.6787944$ sur BC

Thermal computation

$T = 0.$ on DA

$T = 0.$ on BC

$FLUX = 0.$ on AB

$FLUX = 0.$ on CD

1.4 Initial conditions

steady Computation.

2 Reference solution

2.1 Method of calculating used for the reference solution

- electric potential V Problem elastostatic

In volume $\Delta V=0.$

electric Boundary conditions $\begin{cases} j.n=0. & \text{sur } CD \text{ et } AB \\ j.n=-10. & \text{sur } AD \\ j.n=3.6787944 & \text{sur } BC \end{cases}$

NEUMANN conductivity $\sigma=1.$

$$j.n=-\sigma \nabla V$$

axisymmetric Solution

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial V}{\partial r}\right)=0 \Rightarrow V=V_0 \log\frac{r}{A}$$

the boundary conditions on AD and BC impose:

$$V_0=10.$$

Note:

The knowledge of A is not necessary for thermal computation.

- Thermal problem T the temperature

$-\lambda \Delta T=s$ with a Boundary conditions $s=\sigma(\nabla V)^2$

volumic source: $T=0.$ on DA and BC

$$-\lambda \nabla T.n=0 \text{ on } DC \text{ and } AB$$

axisymmetric Solution:

$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial T}{\partial r}\right)=-\frac{\sigma}{1}\frac{v_0^2}{r^2}$ ⇒ taking into account the boundary conditions

$$T(r)=-\frac{1}{2}\sigma\frac{v_0^2}{\lambda}\log\left(\frac{r}{R_0}\right)\log\left(\frac{r}{R_1}\right)$$

2.2 Results of reference

$T=588.9313\,°C$ (temperature at the point M).

2.3 Uncertainty on the analytical

solution Solution.

3 Modelization A

3.1 Characteristic of the modelization

It acts of a modelization AXIS with elements THAXSE2, THAXTR3 and THAXQU4.

3.2 Characteristics of the mesh

The mesh contains 72 meshes type TRIA3 and 44 meshes of type QUAD4.

3.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
Temperature to point M	"ANALYTIQUE"	588.9313	0.1%

One test the heat source (from an electric potential via the model of Ohm) :

Standard	identification of reference	Value of reference
SOUR_ELGA to the 1st Gauss point of the mesh M67	"NON_REGRESSION"	13.7076

3.4 Remarks

the boundary conditions of the electric problem are all of the conditions of NEUMANN. Nevertheless, the analytical solution is found.

4 Modelization B

4.1 Characteristic of the modelization

It acts of a modelization 3D with elements THER_FACE3 and THER_TETRA4.

4.2 Characteristics of the mesh

The mesh contains 716 meshes type TRIA3 and 910 meshes of type TETRA4.

4.3 Quantities tested and Standard

Identification	results of reference	Value of reference	Tolerance
Temperature to point M	"ANALYTIQUE"	588.9313	1.0%

One of the mesh tests the heat source (from an electric potential via the model of Ohm) at the first Gauss point M_{834} :

Standard	identification of reference	Value of reference
SOUR_ELGA to the 1st Gauss point of the mesh M834	"NON_REGRESSION"	41.7093

5 Summary of the results

Besides the test presented, one carried out a computation on structure (COTHAA). The got results were compared with those obtained using Code CASTEM 2000. Very close results are got.