

## TPNA01 - Steady axisymmetric problem with Summarized

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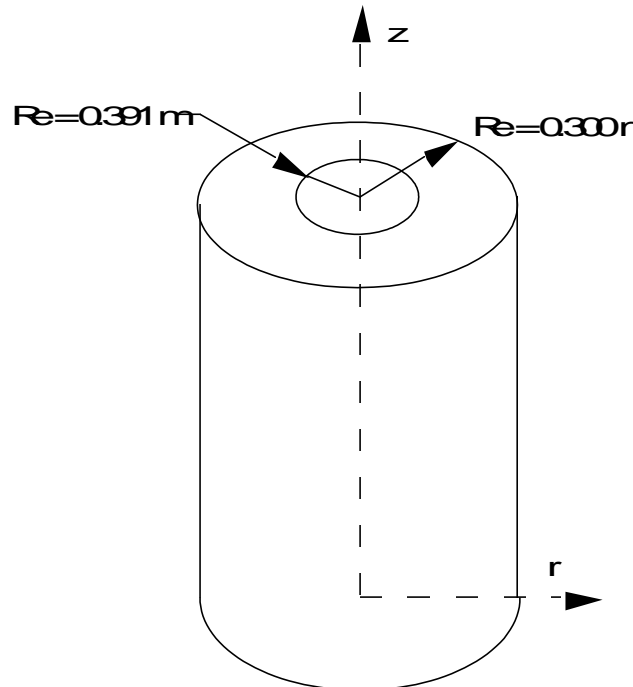
### radiation:

This elementary test makes it possible to deal with an axisymmetric problem in steady thermal with a boundary condition of type radiation. The solution is analytical. With the problem is dealt into axisymmetric and voluminal.

For the modelizations presented here, the variations of the results got by *Code\_Aster* range between 1 and 2% of the analytically calculated reference.

## 1 Problem of reference

### 1.1 Geometry



the hollow roll is supposed infinitely long.

### 1.2 Material properties

Only the coefficient of conductivity intervenes. *The Code\_Aster* makes compulsory the supply of a function representing the given voluminal enthalpy starting from the voluminal coefficient of heat.

$$\begin{array}{ll} \text{voluminal heat} & \rho C_p = 1.00 \text{ J / m}^3 \text{ }^\circ\text{C} \\ \text{thermal conductivity} & k = 40 \text{ W / m}^3 \text{ }^\circ\text{C} \end{array}$$

### 1.3 Boundary conditions and loadings

Condition of type radiation on surface interns cylinder, condition of type convection (exchange with the external medium) on external surface.

No the boundary condition on the ends of the cylinder (what amounts imposing a null flux).

$$\begin{array}{l} \text{Surface intern} \quad k \frac{\partial T}{\partial n} = \varepsilon \sigma [ (T + 273.15)^4 - (T_{ext}^i + 273.15)^4 ] \\ \text{with } \varepsilon = 0.6, \sigma = 5.7310^{-8} \text{ W / m}^2 \text{ K}^4 \text{ and } T_{ext}^i = 500. \text{ }^\circ\text{C}, T \text{ on the Centigrade} \end{array}$$

$$\begin{array}{l} \text{external Surface} \quad k \frac{\partial T}{\partial n} = h_e [ T_{ext}^e - T ] \\ \text{with } h_e = 142. \text{ W / m}^2 \text{ }^\circ\text{C} \text{ and } T_{ext}^e = 20. \text{ }^\circ\text{C} \end{array}$$

## 2 Reference solution

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### 2.1 Method of calculating used for the reference solution

One in the case of lays out of an analytical solution a cylinder infinite length:

$$T(r) = \frac{T_e - T_i}{\log\left(\frac{R_e}{R_i}\right)} \log(r) + \frac{T_i \log(R_e) - T_e \log(R_i)}{\log(R_e) - \log(R_i)}$$

### 2.2 Results of reference

$r(m)$	$T(^{\circ}C)$
.30000	105.55
.32275	99.21
.34550	93.30
.36825	87.76
.39100	82.56

Value of the temperature according to  $r$

$r(m)$	$\phi(W / m^2)$
.300	11577.49
.391	8822.98

Value of flux according to  $r$

### 2.3 Uncertainty on the solution

exact Solution.

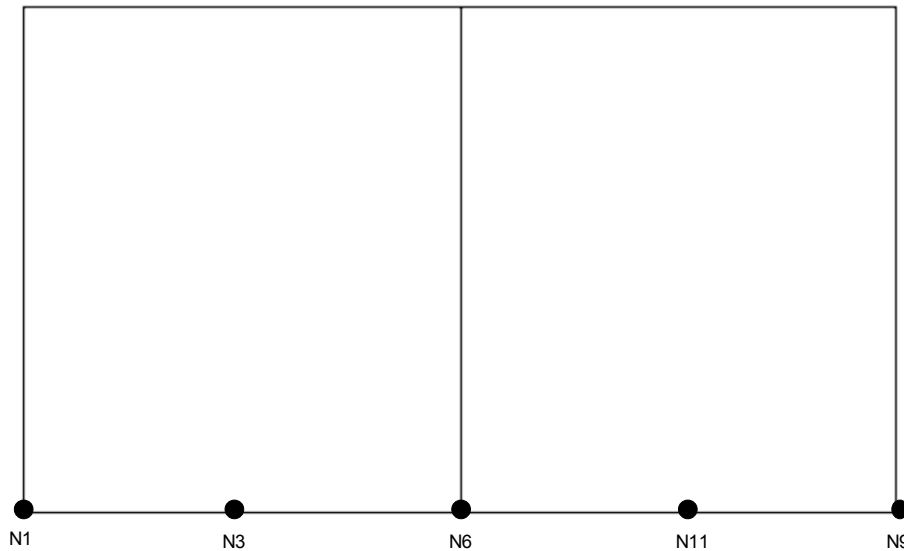
### 2.4 Bibliographical references

- Guides validation of the software packages of structural analysis. French company of Mechanics AFNOR 1990 ISBN 2-12-486611-7

## 3 Modelization A

### 3.1 Characteristic of the modelization

Modelization 2D:



### 3.2 Characteristics of the mesh

2 QUAD8

### 3.3 Values tested

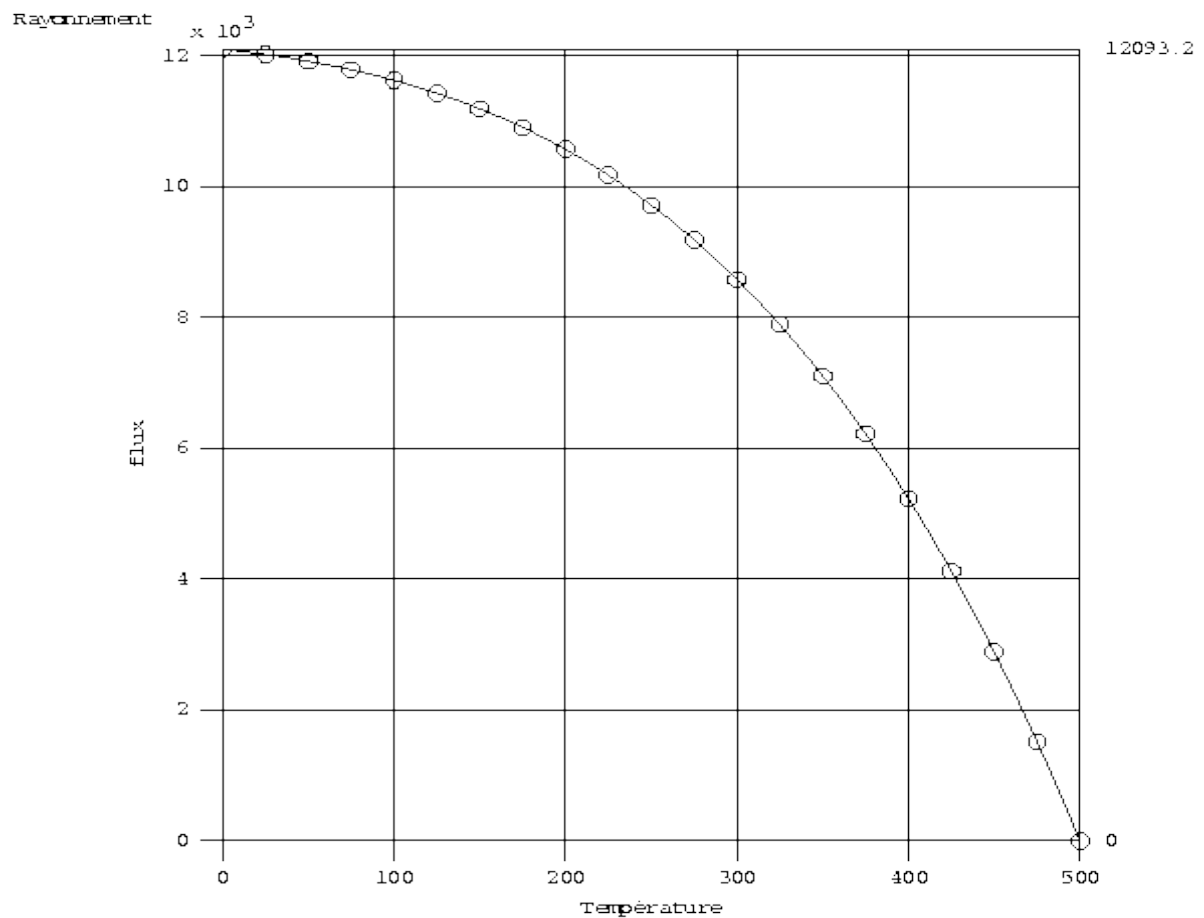
the nodes observed have as a coordinate  $z = 0.0$

Identification temperature		Reference
<i>N1</i>	( $r = .30000$ )	105.55
<i>N3</i>	( $r = .32275$ )	99.21
<i>N6</i>	( $r = .34550$ )	93.30
<i>N11</i>	( $r = .36825$ )	87.76
<i>N9</i>	( $r = .39100$ )	82.56

Identification flux		Reference
nets <i>M1</i>	node <i>N1</i>	11577.49
nets <i>M2</i>	node <i>N9</i>	8822.98

### 3.4 Remarks



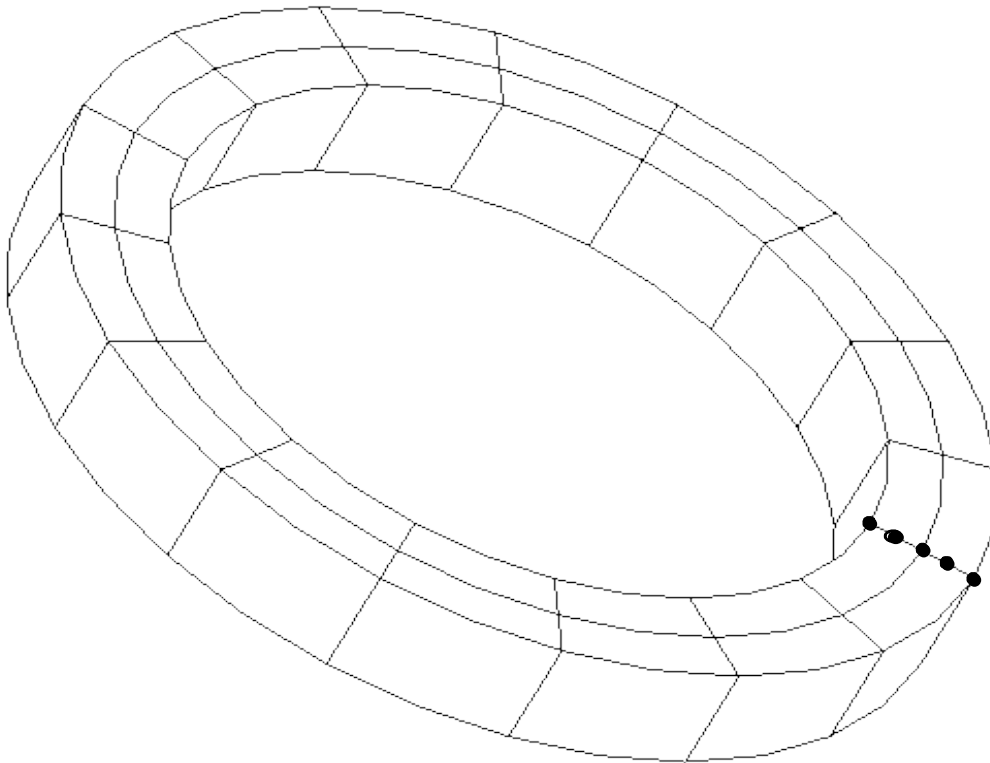
the boundary condition of type radiation is provided in the form of a function of the temperature interpolated linearly between each point (one discretized here the curve using 101 points).

## 4 Modelization B

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### 4.1 Characteristic of the modelization

Modelization 3D:



### 4.2 Characteristics of the mesh

32 HEXA20

### 4.3 Values tested

the nodes observed have as coordinates:  $y = z = 0.0$

	Identification temperature	Reference
NO106	(x=.30000)	105.55
NO105	(x=.32275)	99.21
NO115	(x=.34550)	93.30
NO125	(x=.36825)	87.76
NO123	(x=.39100)	82.56

Identification flux	Reference
nets MA17 node NO106	11577.49
nets A MA16 node	NO123

## 4.4 8822.98

Remarks the flux function used in the modelization is also used here.

## 5 Summaries of the results

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the taking into account of the conditions of radiation is completely correct in this steady case. Let us note that this test utilized a coefficient of thermal conductivity constant, only not the - linearity thus relates to the boundary conditions.

The errors are higher on the computation of flux, which one can explain by the use of the lissages to the nodes, carried out starting from the computed values at the points of integration (Gauss points).