HSNV123 - Thermo-metal-worker-mechanics EDGAR

Summary:

This test illustrates a mechanical calculation on a material (Zircaloy) undergoing metallurgical transformations.

Concretely, initially, the operator CALC_META calculate the metallurgical evolution associated with a given thermal history. This metallurgical evolution is then provided to STAT_NON_LINE who will carry out a mechanical calculation by taking of account the metallurgical phases (besides mechanical loadings). The material of mechanical calculation is defined with ELAS_META_FO, META_ECRO_LINE and META_VISC_FO.

This case test of not-regression makes it possible to check the coherence of *Code_Aster* from one version to another with regard to the metallurgy.

1 Problem of reference

It is about a cylindrical bar in creep.

1.1 Geometry

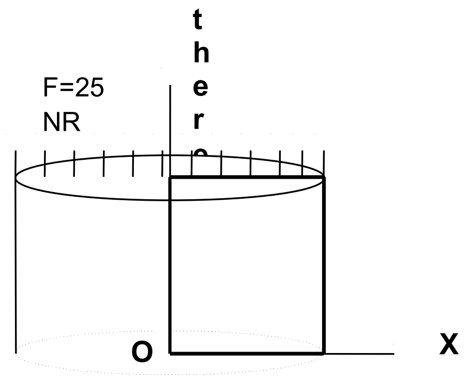

Figure 1.1-a: Geometry and loading of the problem of reference

It is about a cylinder height $H=1.0\,m$, and of ray $R=1.0\,m$.
The square in fat corresponds to axisymmetric modeling used to [§3].

1.2 Material properties

The properties materials are described by the following parameters:

For thermo-metal calculation
(Zircaloy)
$\rho C_p=2000000\,J.m^{-3.}\circ C^{-1}$
$\lambda=9999.9\,W.m^{-1.}\circ C^{-1}$

Coefficients for the metallurgy:
$teqd=809\,°C$, $K=1.135\,E^{-2}$, $n=2.187$
$t1c=831\,°C$, $t2c=0.$, $qsr=14614$, $Ac=1.58\text{E}-4$
$m=4.7$, $t1r=949{,}1\,°C$, $t2e=0.$, $Ar=-5.725$, $Br=0.05$

For calculation thermo-metal-worker-mechanics
- Young modulus: $E=200000\,Pa$
- Poisson's ratio: $\nu=0.3$

Definition of the elastic characteristics, dilation and elastic limits for the modeling of an undergoing material of the metallurgical transformations:
- $T_{ref}=800\,°C$
- Thermal dilation coefficient average of the cold phases: $\alpha_f(T)=0$
- Thermal dilation coefficient average of the hot phase: $\alpha_\gamma(T)=0$
- Temperature of definition of the dilation coefficient: $T_\gamma=800\,°C$
- Choice of the metallurgical phase of reference: heat
- Deformation of the phase not of reference compared to the phase of reference to the temperature T_{ref} : $\Delta\varepsilon=0$
- Elastic limit of the cold phase 1 for a viscous behavior: $F_{sigm_f}(T)=0$
- Elastic limit of the cold phase 2 for a viscous behavior: $F_{sigm_f}(T)=0$

- Elastic limit of the hot phase for a viscous behavior: to see [Figure 1.2-a]

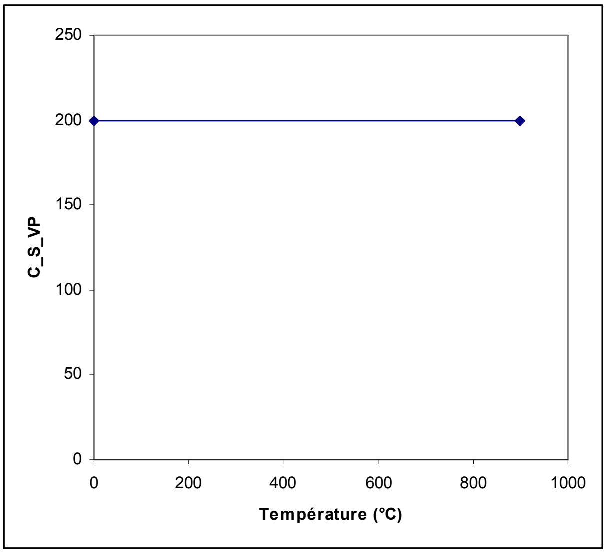

Figure 1.2. - has: Elastic limit of the hot phase for a viscous behavior

1) Function used for the law of mixture on the elastic limit of multiphase material for a viscous behavior: f

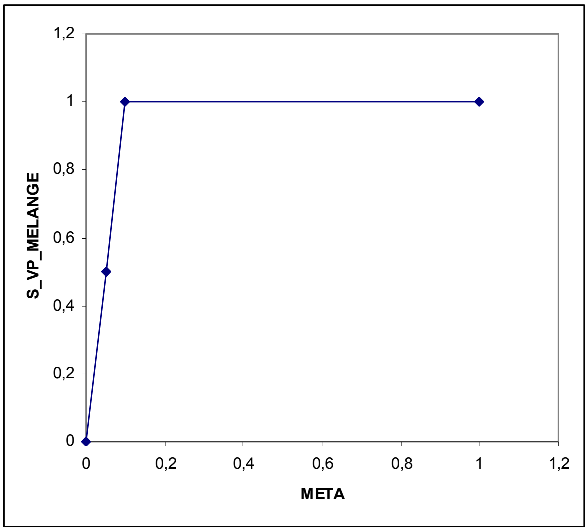

Figure 1.2-b: Law of mixture

Definition of the modules of work hardening used in the modeling of the phenomenon of isotropic work hardening linear of an undergoing material of the metallurgical phase shifts:

1) Slope of the traction diagram for the cold phase 1

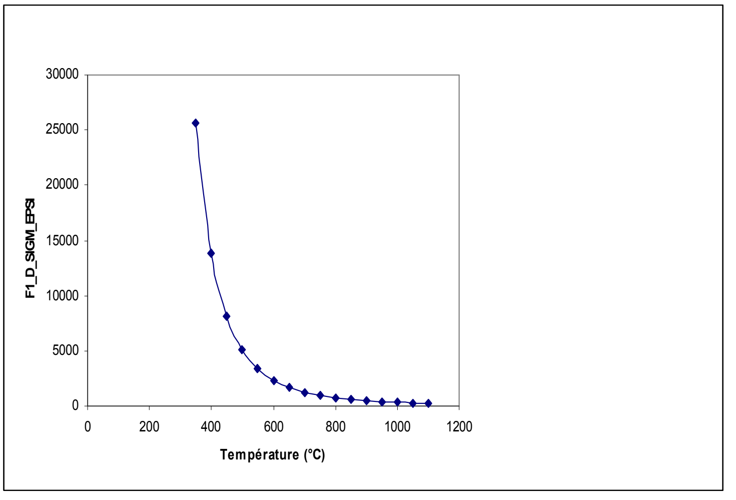

Figure 1.2-c: Traction diagram for the cold phase 1

- Slope of the traction diagram for the cold phase 2:

$$f(T)=0$$

- Slope of the traction diagram for the hot phase:

$$f(T)=0$$

Definition of the viscous parameters of the viscoplastic law of behavior with taking into account of the metallurgy:

1) Parameter η viscoplastic law of flow, for the cold phase 1

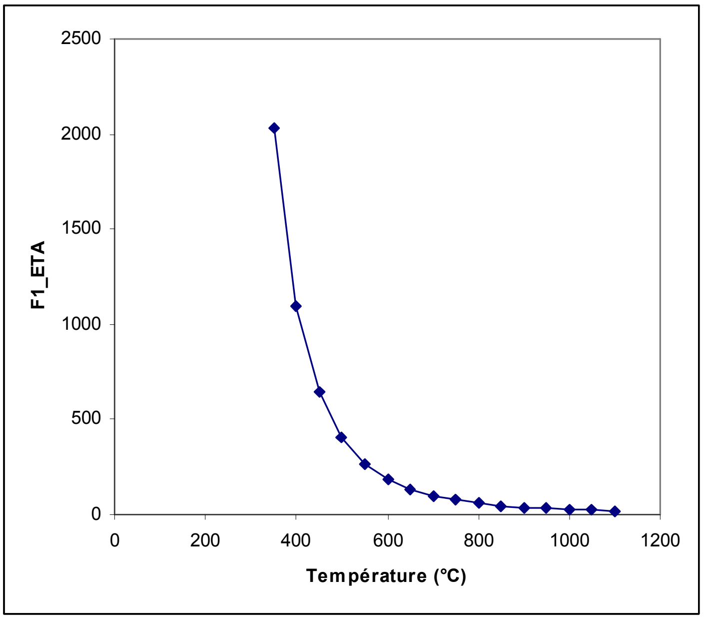

Figure 1.2-d: Parameter η viscoplastic law of flow, for the cold phase 1

1) Parameter η viscoplastic law of flow, for the cold phase 2

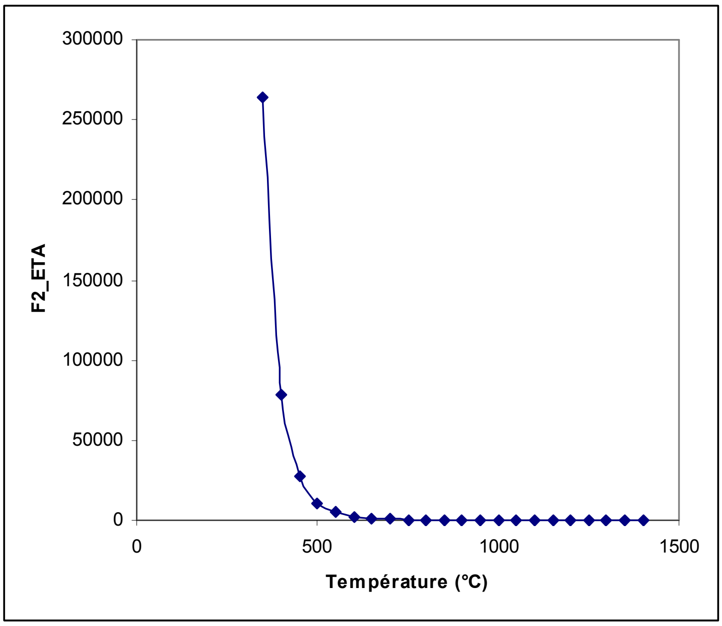

Figure 1.2-e: Parameter η viscoplastic law of flow, for the cold phase 2

- Parameter η viscoplastic law of flow, for the hot phase:
  $f(T)=0$
- Parameter n viscoplastic law of flow, for the cold phase 1:
  $f(T)=5.76$
- Parameter n viscoplastic law of flow, for the cold phase 2:
  $f(T)=2.94$
- Parameter n viscoplastic law of flow, for the hot phase:
  $f(T)=1.0$
- Parameter C relating to the restoration of work hardening of viscous origin, for the cold phase 1:
  $f(T)=13.70539827$
- Parameter C relating to the restoration of work hardening of viscous origin, for the cold phase 2:
  $f(T)=0$
- Parameter C relating to the restoration of work hardening of viscous origin, for the hot phase:
  $f(T)=0$
- Parameter m relating to the restoration of work hardening of viscous origin, for the cold phase 1:
  $f(T)=5.76$
- Parameter m relating to the restoration of work hardening of viscous origin, for the cold phase 2:
  $f(T)=1.0$
- Parameter m relating to the restoration of work hardening of viscous origin, for the hot phase:
  $f(T)=1.0$

1.3 Boundary conditions and loadings

The base of the cylinder is blocked according to y :
$Uy=0$ on the basis of cylinder
A force of traction $F=25\,N$ is imposed on the top of the cylinder

The temperature is imposed on all the cylinder for $t=120\mathrm{s}$.

$$T(x,y,120)=800°C$$

1.4 Initial conditions

The following variables are initialized:

- $T(x, y, 0)=800°C$
- $V1(x, y, 0)=1.0$
- $V2(x, y, 0)=0.0$
- $V3(x, y, 0)=20.$
- $V4(x, y, 0)=0.$

$V1$ *: proportion of the cold phase* α
$V2$ *: proportion of the cold phase* α *, mixed with the phase* β
$V3$ *: temperatures with the nodes*
$V4$ *: time corresponding to or end the initial temperature of the transformation with balance*

2 Reference solution

2.1 Results of reference

The results of reference were got with a previous version of Aster. It is about a test of not-regression.

2.2 Uncertainty on the solution compared to the result of not-regression

Uncertainty is of 10%.

3 Modeling A

3.1 Characteristics of modeling

The modeling used in the case test is the following one:

Elements 2D 'AXIS' (QUA8)

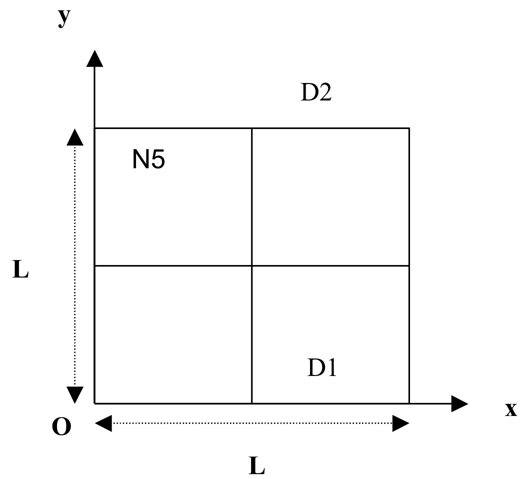

Figure 3.1-a: Geometry and grid of modeling

Cutting: 2 meshs QUAD8 according to the axis of x
2 meshs QUAD8 according to the axis of y

Boundary conditions: $Uy=0$ on $D1$
$F=25\mathrm{N}$ on $D2$

3.2 Characteristics of the grid

Many nodes: 21
Many meshs and types: 4 QUAD8, 8 SEG3.

3.3 Values tested

Identification	Size	Reference	*Aster*	% difference
$t=120\mathrm{s}$ $M3$ $N5$	$EPYY$	-3.1E-2	-2.888E-2	6.8%
$t=120\mathrm{s}$ $M3$ $N5$	$SIYY$	-25.0	-24.99	8.90E-5%