

HSNA104 – Detensioning of heterogeneous joints welded by friction

Summarized:

This benchmark corresponds to part of the study described in the note [bib1]. It constitutes a validation of the thermomechanical models of behavior taking account of the metallurgical transformations with cooling in steels. It is the simulation of the phase of cooling of the detensioning of bimetallic joints Steel 16MND5 – Stainless steel 304L welded beforehand by friction, in order to determine the residual stresses generated at the end of this cooling. The computation of linear thermal of the homogeneous phase of cooling is first of all carried out, then the metallurgical evolution in the 16MND5 is calculated (transformation of the ferritic type). After which the simulation of the mechanical problem taking account of the metallurgical transformations of phases is carried out by applying at the beginning of the phase of cooling a null stress state (released perfectly) in structure.

The modelization mechanical is carried out by taking account of decarburization with interface 16MND5-304L and the plasticity of transformation. The behavior is elastoplastic with linear isotropic hardening for the 16MND5 (all phases), and elastoplastic with nonlinear isotropic hardening for steel 304L.

The results in residual stresses obtained in external skin are compared with results of measurement carried out by diffraction of radius X [bib1].

1 Problem of reference

1.1 Geometry

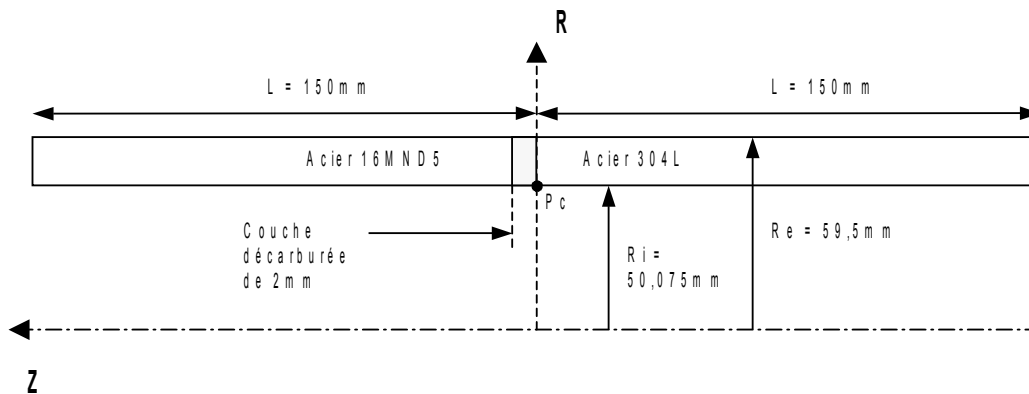


Figure 1. : Geometry of the tubes

Dimension of the tubes:

- Interior radius: 50,075 mm
- External radius: 59,5 mm
- Thickness: 9,425 mm
- Overall length 2L: 300 mm

1.2 Properties of the materials

the welded tubes are out of steel 16MND5 of dimensioned and steel 304L of the other. The mechanical properties vary with the temperature for these two materials. They are given, as well as the metallurgical properties for the 16MND5 in the reference [bib1].

A decarburization is observed with interface 16MND5-304L, which results in experiments in a fall of Vickers pyramid hardness of 250 HV to 2mm interface, until 130 HV on the interface.

1.3 Boundary conditions and loadings

Thermal computation : Continuous homogeneous cooling of 875 °C with 20 °C

metallurgical Computation :

Transformation of austenite out of ferrite in the 16MND5 enters 758,5 °C and 650,5 °C
No transformation stainless.

Mechanical computation :

- 1) PC Not blocked in the direction Z
- 2) Loading in temperature

1.4 Initial conditions

$$T(r, z) = 875 \text{ } ^\circ\text{C}.$$

Steel 16MND5 is entirely austenitic in an initial state is: $Z_f = 0$ $Z_p = 0$, $Z_b = 0$ and $Z_m = 0$.

2 Reference solution

It does not exist of solution analytical. However experimental results are available (measurements of residual stresses in external skin by diffraction of radius X [bib1]).

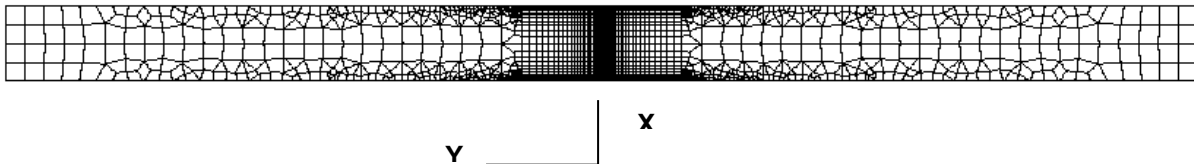
bibliographical **2.1Références**

- [1] A. BEBEY-FOURCOT, F. WAECKEL, Note EDF DER HI-74/97/028/0. Computational simulation of heterogeneous joints welded by friction (January 19th, 1998).

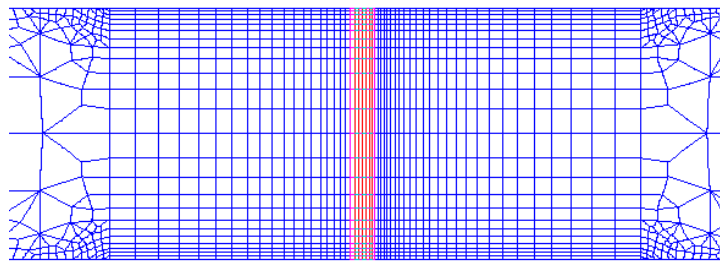
3 Modelization A

3.1 Characteristic of the modelization

axisymmetric Modelization



Appears 4.1-a: Total mesh of the tube



Appears 4.1-b: Enlarged mesh of junction 16MND5-304L and detail of the interface and the decarbonized zone

the elementary density of nodes near the interface is $0,2\text{ mm}$ to allow a good representation of stresses peaks expected this place.

3.2 Characteristics of the mesh

Many nodes: 6513

Number of meshes and types: 2616 including 1908 QUAD8, 204 TRIA6, 504 SEG3

3.3 Remarks

linear isotropic Hardening for steel 16MND5 (any confused phase): the elastic limit defined according to the temperature is the elastic limit with 0% plastic strain. The hardening slope linear (according to the temperature) is the slope with 0,5% plastic strain.

Nonlinear isotropic hardening for steel 304L

the fall of hardness in the decarbonized zone is taken into account in the modelization by a reduction in the elastic limit of steel in this zone. To evaluate the reduction in the elastic limit according to measurements of hardness, one applies that for the same metallurgical structure, the R_m/SY ratio remains constant, and that the value of R_m is worth one the third of measured hardness [bib1].

26 computation steps of 0 to 154000 s (1 step of 9000 s ; 4 steps of 36000 s ; 10 steps of 54000 s ; 7 steps of 118000 s ; 4 of 154000s).

3.4 Quantities tested and results

Standard	Node	Localization of value	Aster	Measures	Variation (%)
external	N674 Skin (X = 59,5mm) Y = + 44,515 mm	SIYY	64,245	60,23	6,7
N882	external Skin (X = 59,5mm) Y = + 30,493 mm	SIYY	113,819	99,58	14,3
N1316	external Skin (X = 59,5mm) Y = + 20 mm	SIYY	141,806	119,07	19,1
N1834	external Skin (X = 59,5mm) Y = + 9,657 mm	SIYY	169,971	109,07	55,8
N2278	external Skin (X = 59,5mm) Y = + 4,739 mm	SIYY	213,459	153,34	39,2
N2719	external Skin (X = 59,5mm) Y = + 1,872 mm	SIYY	258,022	188,54	13,6
N3755	external Skin (X = 59,5mm) Y = - 1,872 mm	SIYY	-230,442	-181,92	26,7
N4199	external Skin (X = 59,5mm) Y = - 4,739 mm	SIYY	-209,876	-220,18	-4,7
N4525	external Skin (X = 59,5mm) Y = - 9,657 mm	SIYY	-180,092	-174,06	3,5
N4742	external Skin (X = 59,5mm) Y = - 20 mm	SIYY	-166,688	-190,52	-12,5
N5458	external Skin (X = 59,5mm) Y = - 30,493 mm	SIYY	-140,201	-145,52	-3,7
N5759	external Skin (X = 59,5mm) Y = - 44,515 mm	SIYY	-81,641	-87,00	-6,2

Node	Standard	Localization of value	Aster	Measure	Variation (%)
external	N674 Skin (X = 59,5mm) Y = + 44,515 mm	SIZZ	30,937	40,35	-23,3
N882	external Skin (X = 59,5mm) Y = + 30,493 mm	SIZZ	23,686	61,39	-61,4
N1316	external Skin (X = 59,5mm) Y = + 20 mm	SIZZ	-9,541	48,03	-119,8
N1834	external Skin (X = 59,5mm) Y = + 9,657 mm	SIZZ	-70,264	7,78	-1003
N2278	external Skin (X = 59,5mm) Y = + 4,739 mm	SIZZ	-104,430	-64,98	60,71
N2719	external Skin (X = 59,5mm) Y = + 1,872 mm	SIZZ	-75,962	-98,83	-23,1
N3755	external Skin (X = 59,5mm) Y = - 1,872 mm	SIZZ	15,857	29,26	-45,8
N4199	external Skin (X = 59,5mm) Y = - 4,739 mm	SIZZ	26,372	-26,56	-199,3
N4525	external Skin (X = 59,5mm) Y = - 9,657 mm	SIZZ	40,284	53,15	-24,2
N4742	external Skin (X = 59,5mm) Y = - 20 mm	SIZZ	9,290	39,47	-76,5
N5458	external Skin (X = 59,5mm) Y = - 30,493 mm	SIZZ	-23,355	-16,58	40,9
N5759	external Skin (X = 59,5mm) Y = - 44,515 mm	SIZZ	-34,912	-40,32	-13,4

4 Summary of the results

Warning : The translation process used on this website is a "Machine Translation". It may be imprecise and inaccurate in whole or in part and is provided as a convenience.

the values of calculated stresses are in concord with the measured profiles of stresses, which comprise them even a rather high uncertainty (cf curves below).

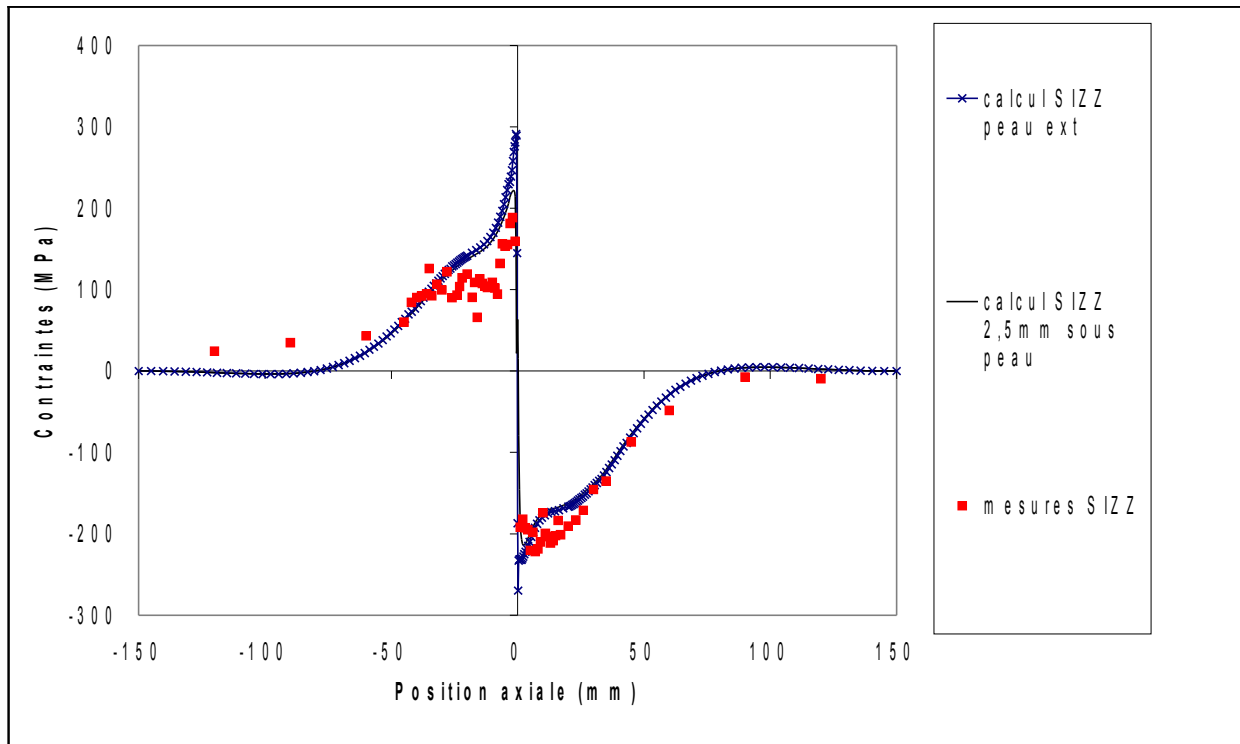


Figure 4.1: Profile of the longitudinal stresses calculated and measured in external skin

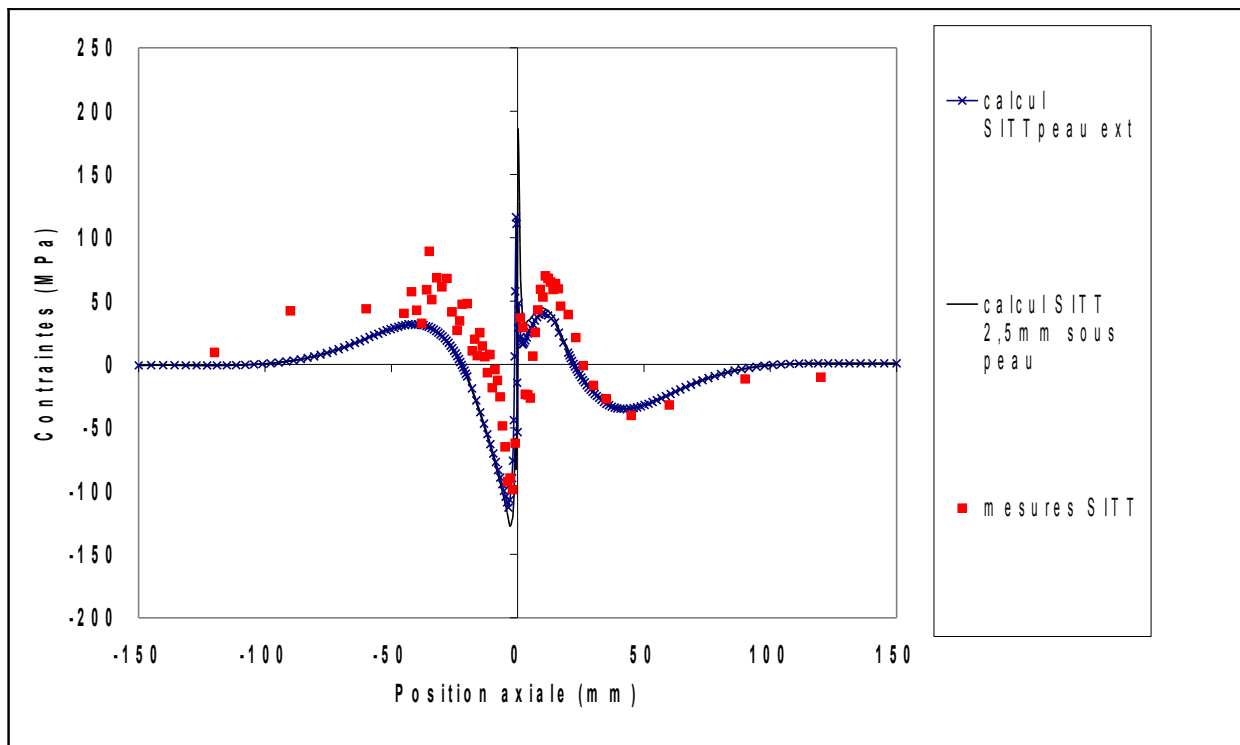


Figure 4.2: Profile of the circumferential stresses calculated and measured in external skin