University of Liège

Laser Cladding Finite Element Modelling

Application to Ti6Al4V

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Outline

1. Introduction
2. Experimental
3. Simulation
4. Validation & Limitations
5. Conclusion & Perspectives

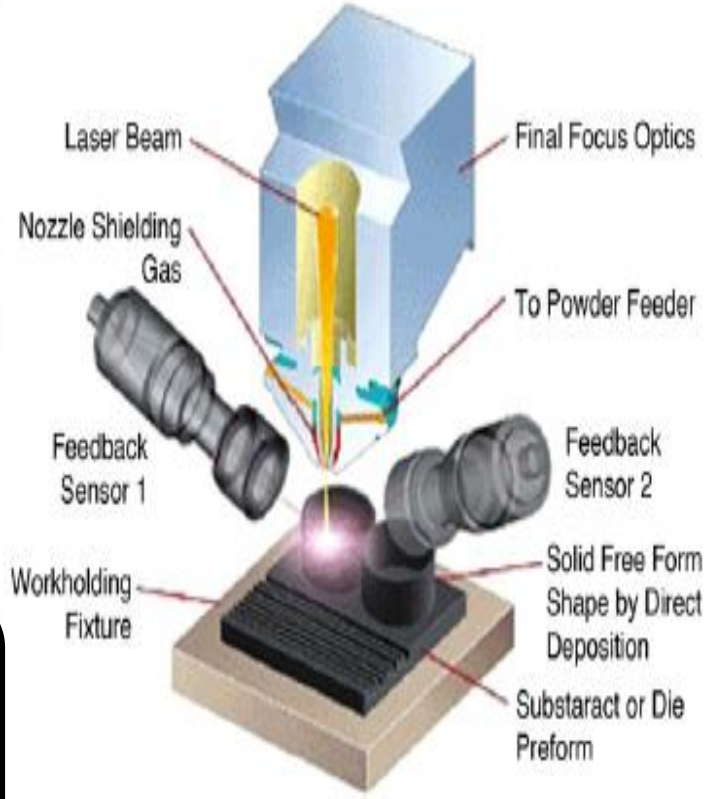
Introduction

Innovative technology

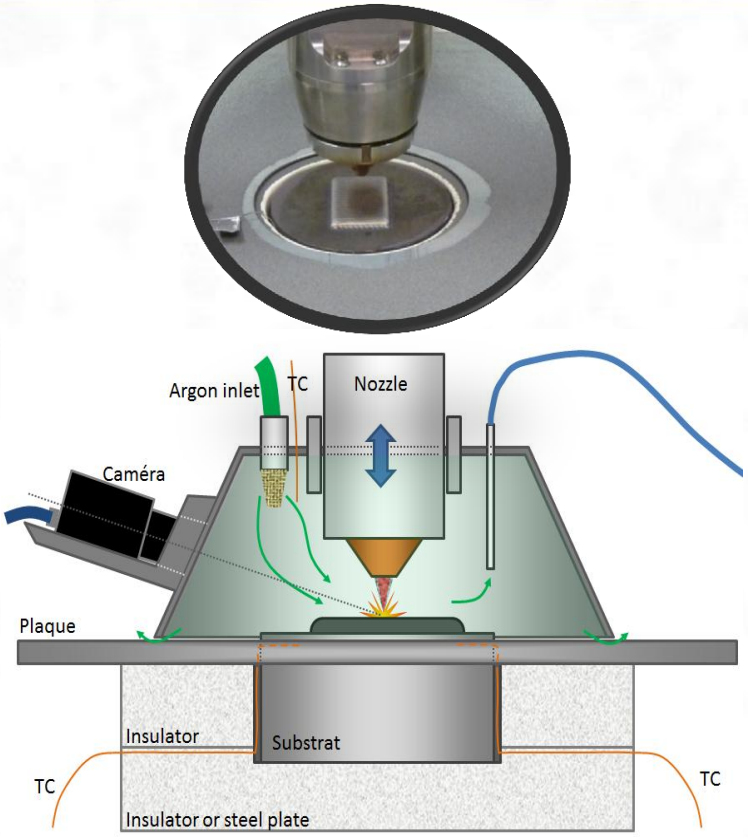
Production of dense parts

Multilayer metal deposit

Very high cooling rates (ultrafine grain microstructure)



Bhattacharya & al. (2011)



Sirris

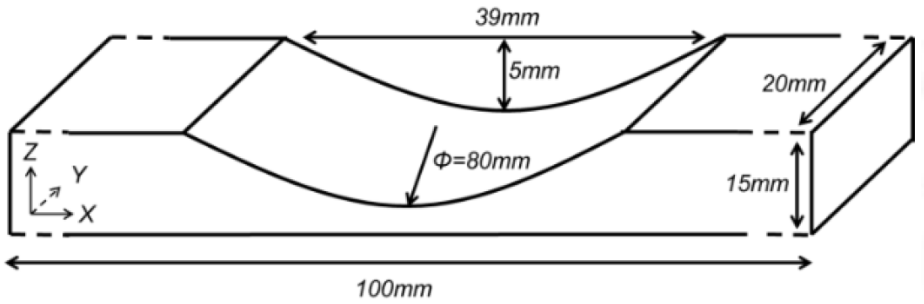
Need of a thermal model:

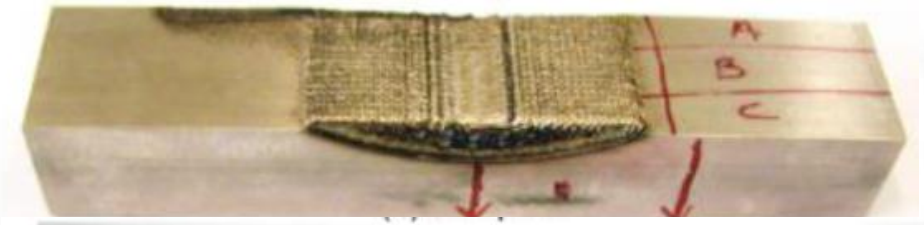
Study of processing parameters:

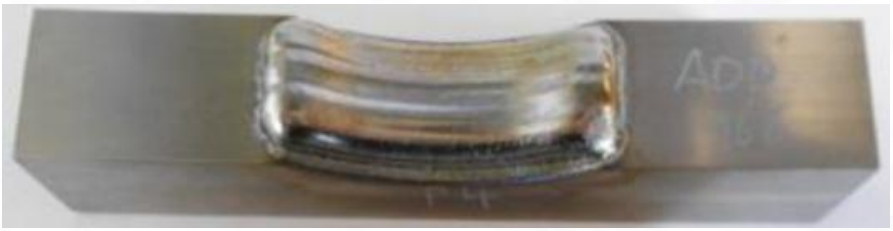
- laser power
- powder flow
- preheating temperature (T°)
- laser beam velocity

Introduction

Reproduction of the experiment described in the article:
Laser claddingas a repair technologyfor Ti6Al4V alloy: influence of incident energy and building strategy on microstructure and hardness. H.Paydas, A.Mertens, R.Carrus, J. Lecompte-Beckers and J.TchoufangTchuindjang.

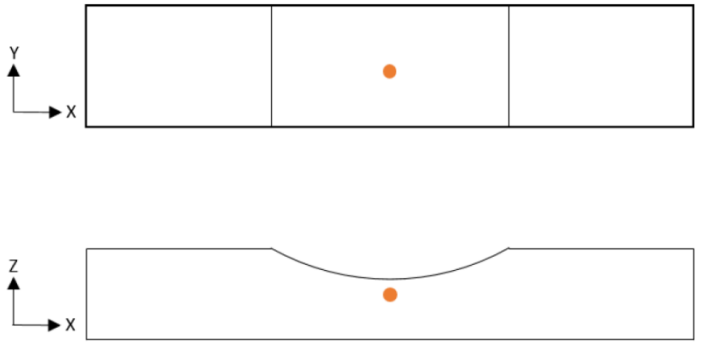




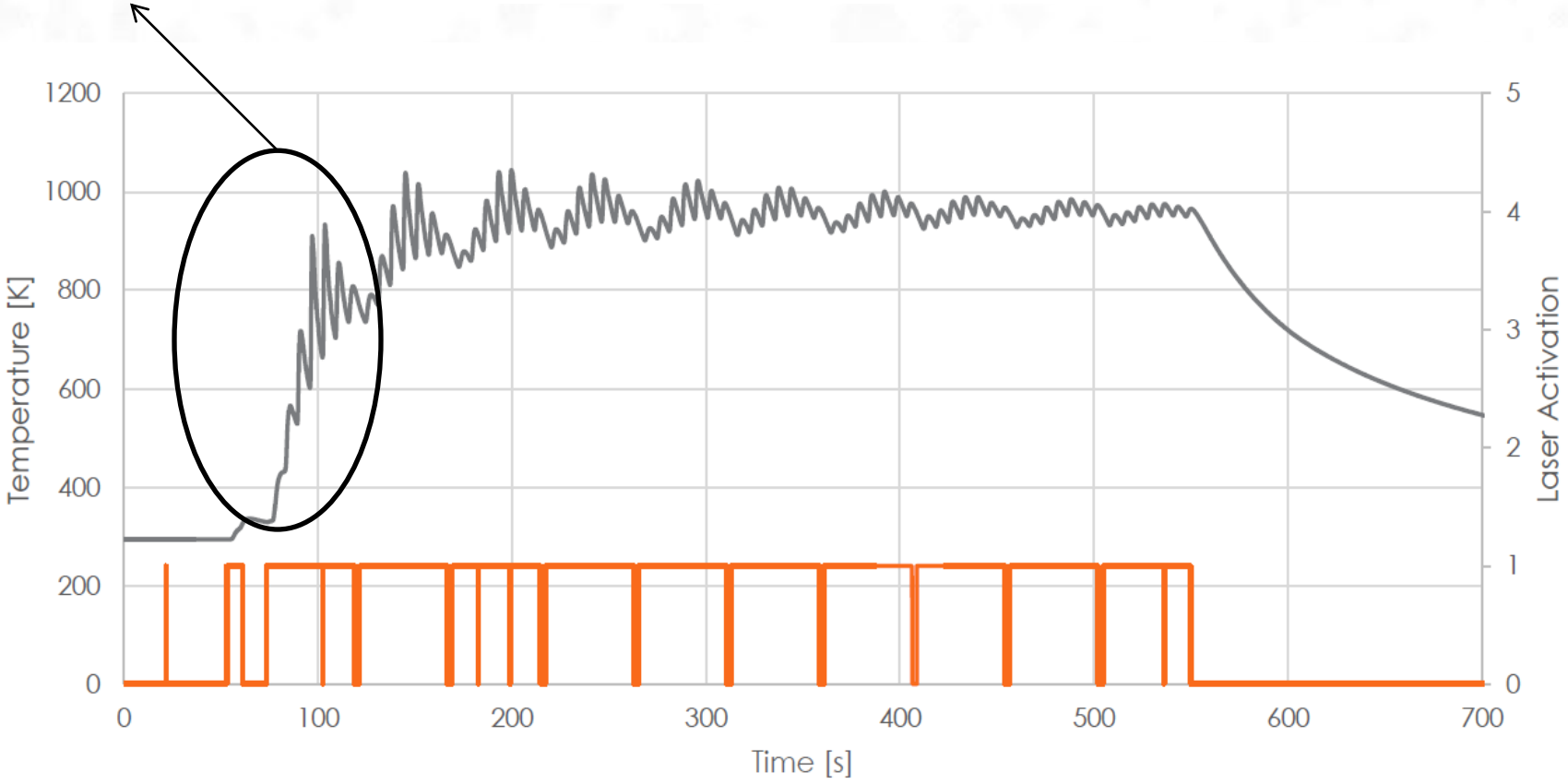


«MacroClad» et «Constant tracklength» building strategy

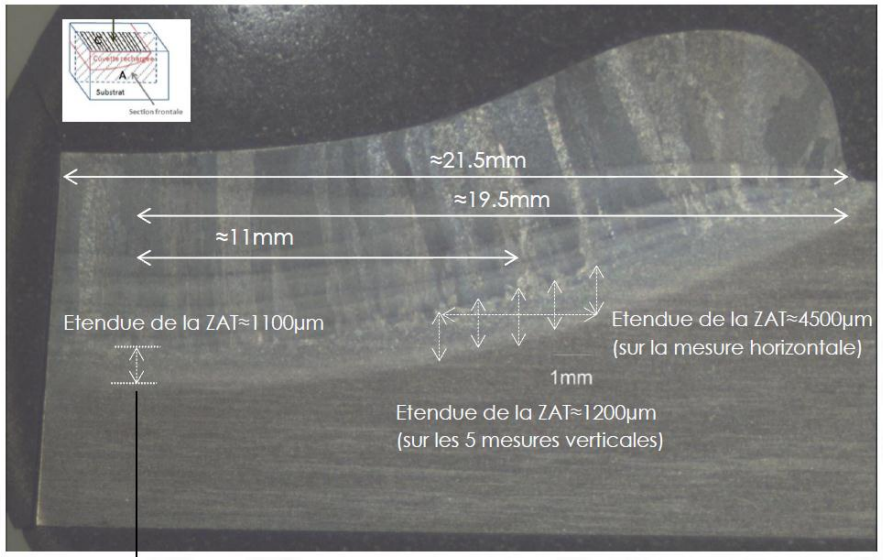
Experimental

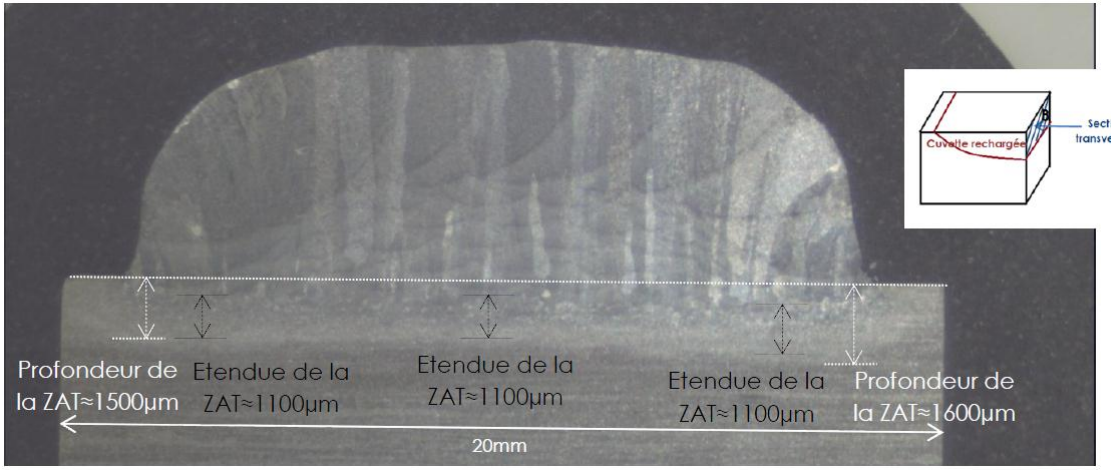


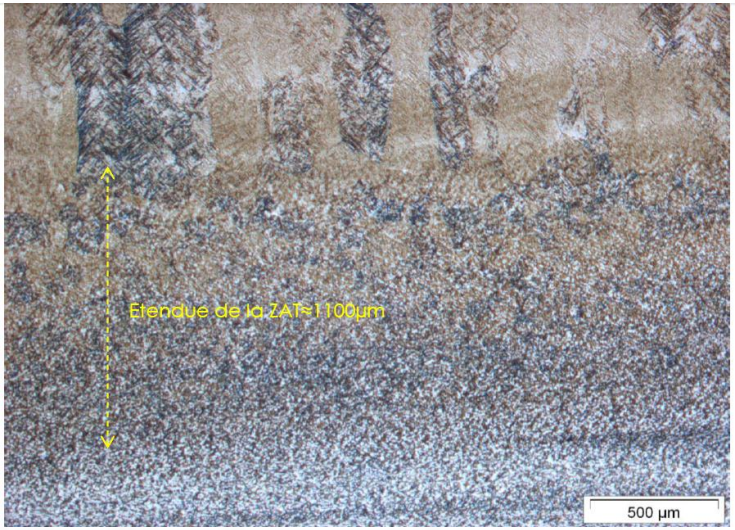
Focus on the first layer

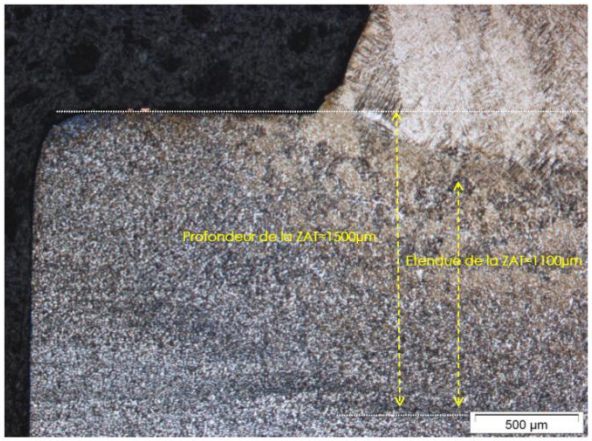


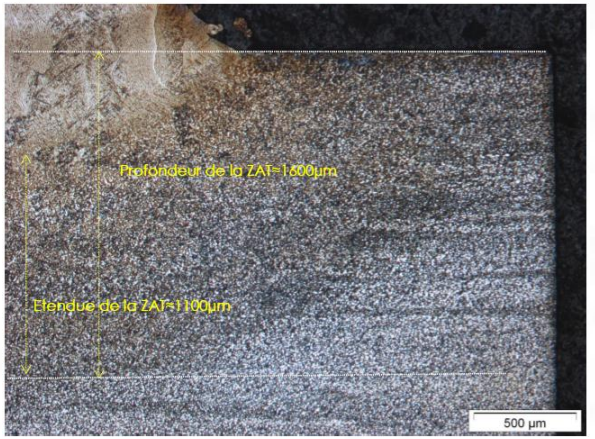
Experimental







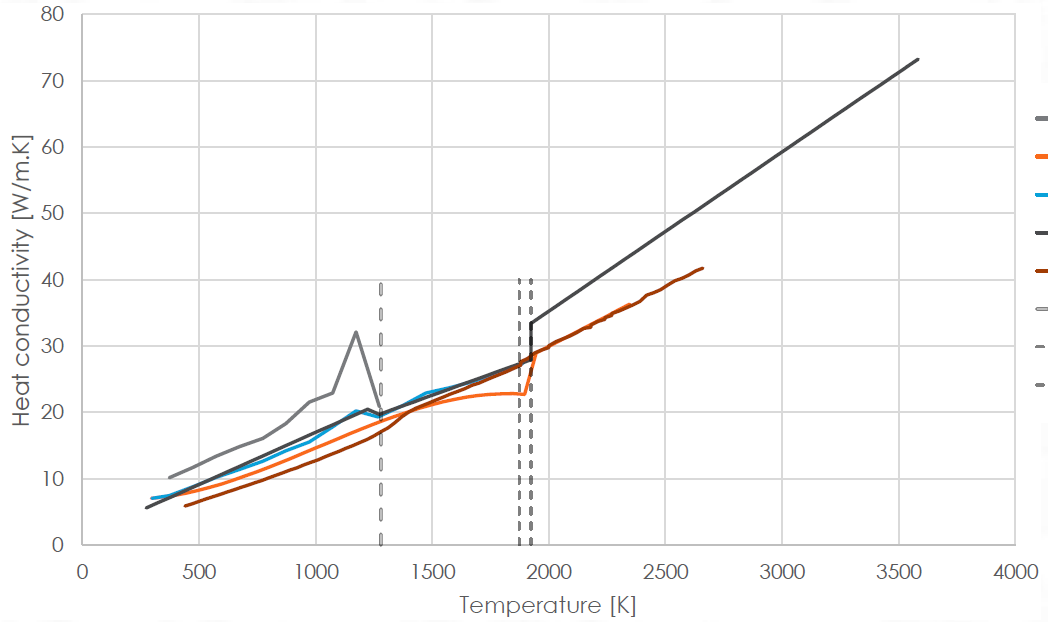


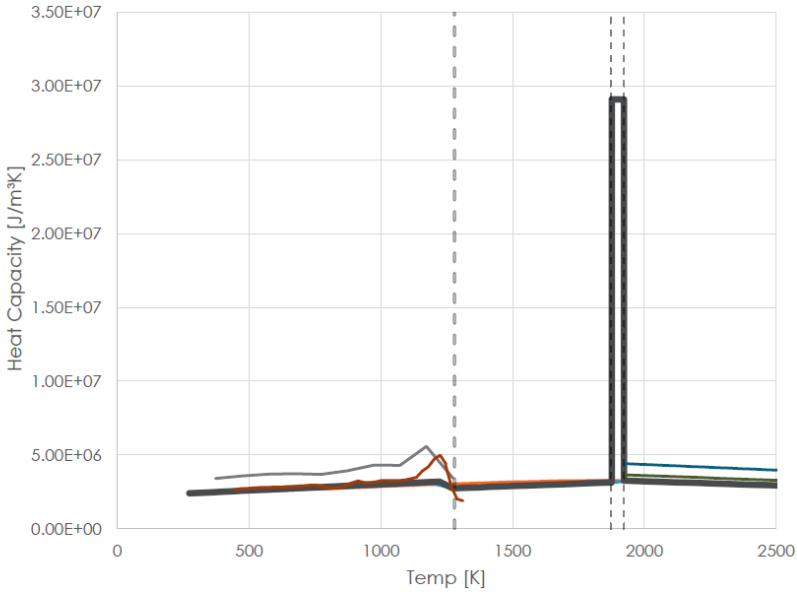


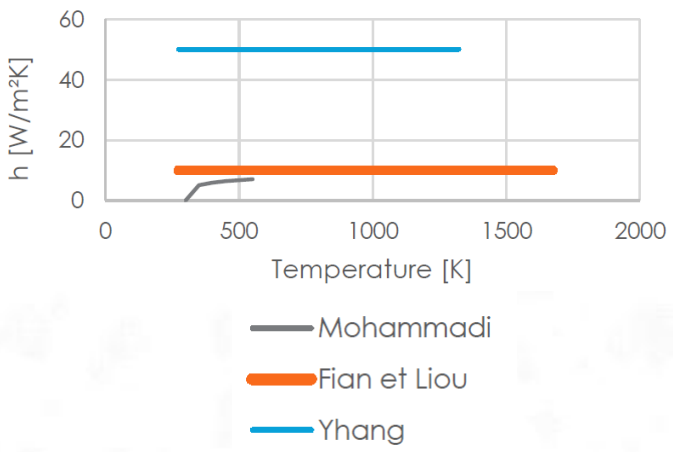
Synthesis of measures of the depth HAZ - ADD166

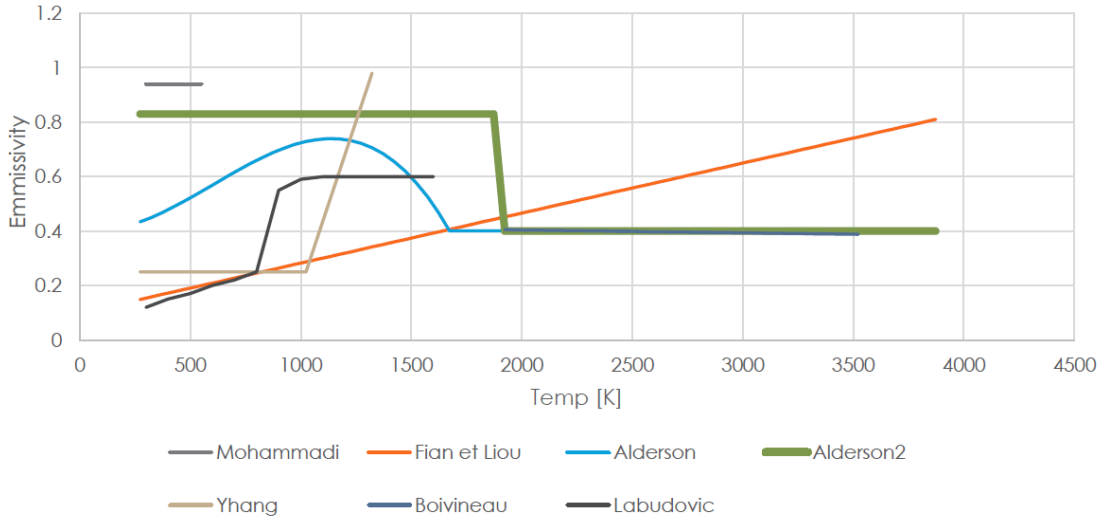
Experimental

Thermo physical properties of materials

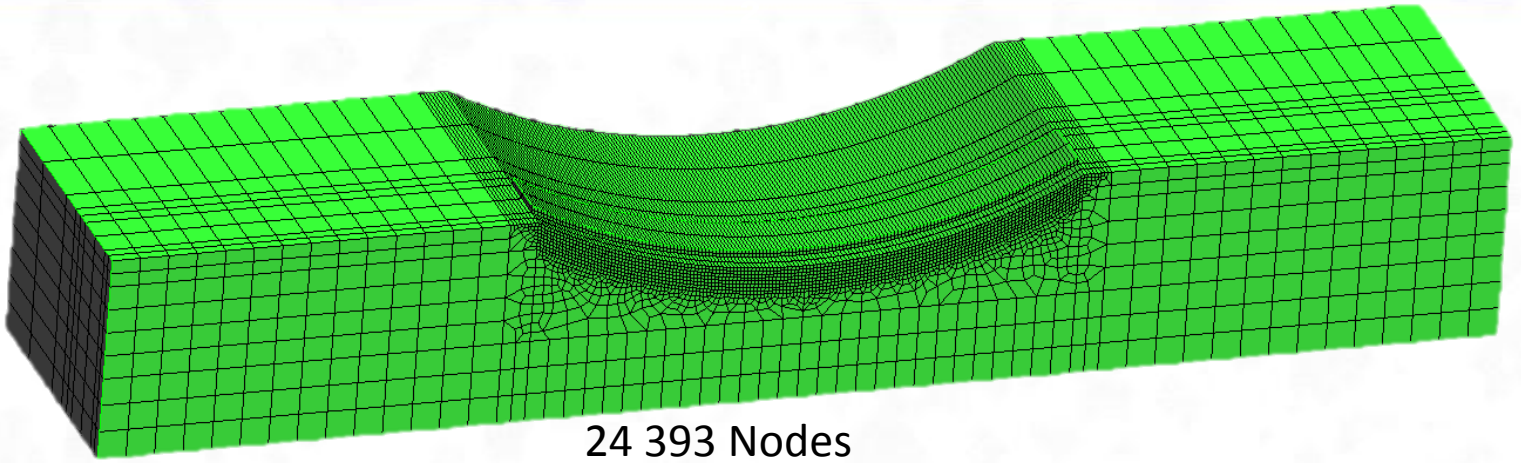




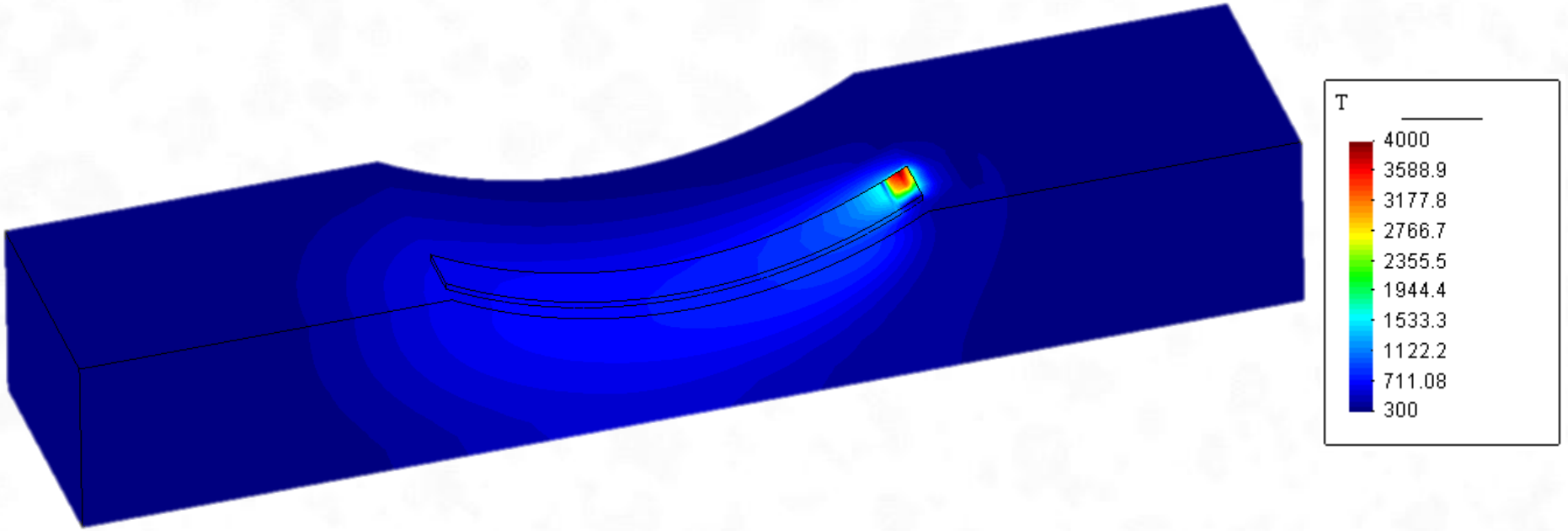




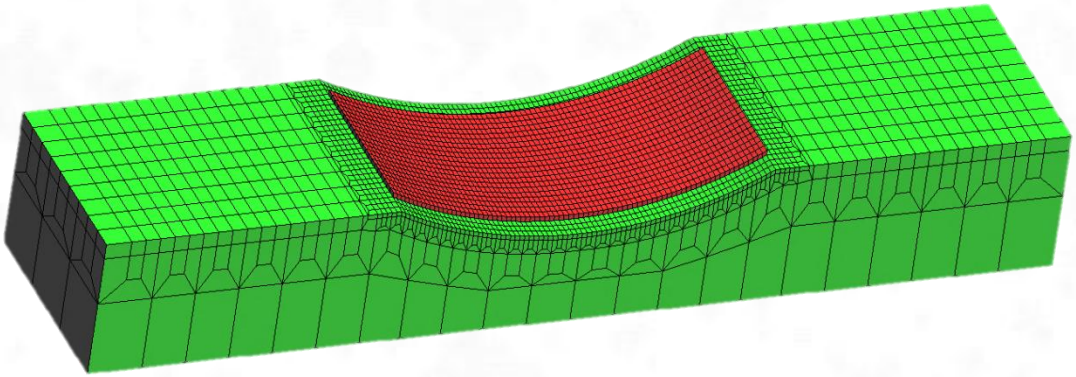
Results of Romain

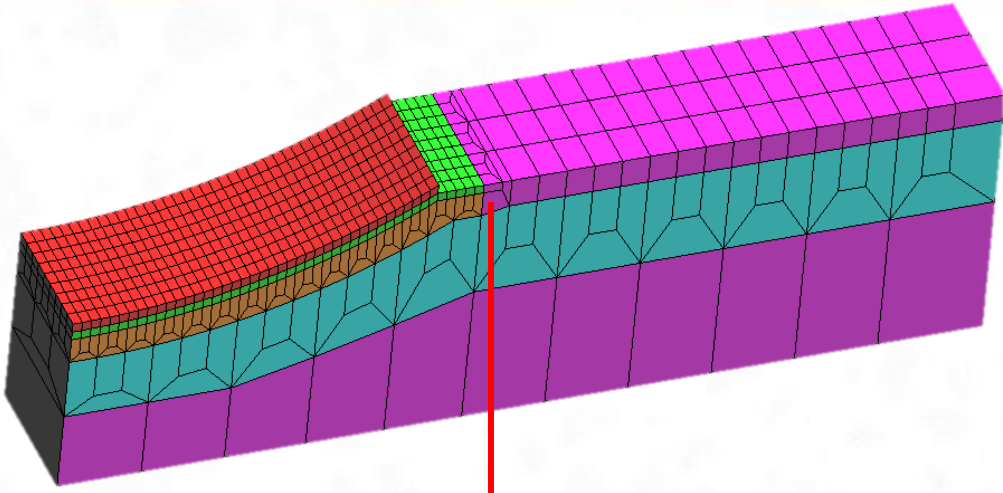


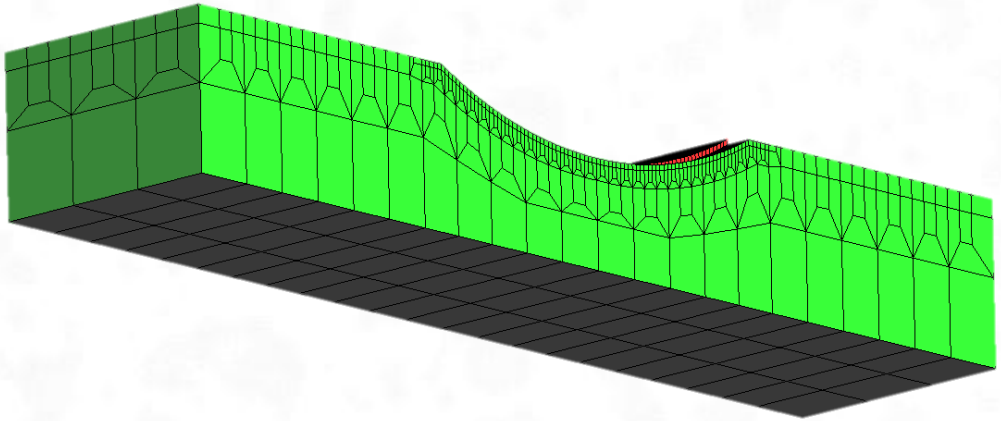
24 393 Nodes
26 991 Elements for 2 tracks

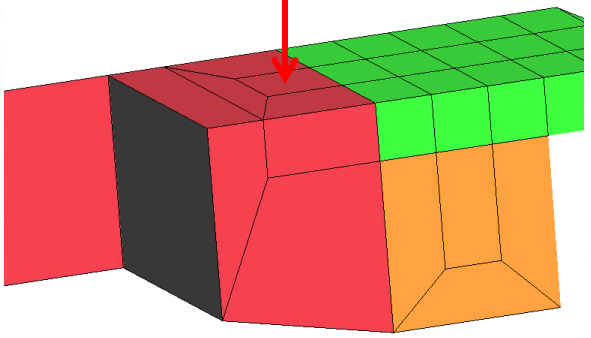


Simulation

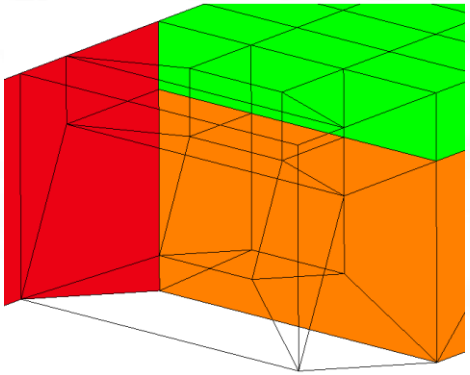






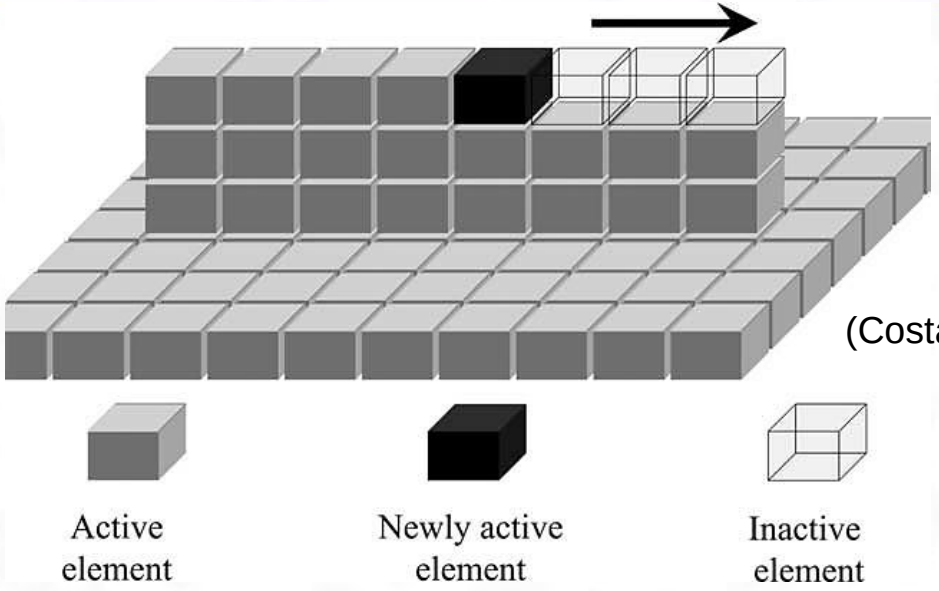


11 056 Nodes
9030 Solid Elements + 5340 CONRA Elements for 7 tracks

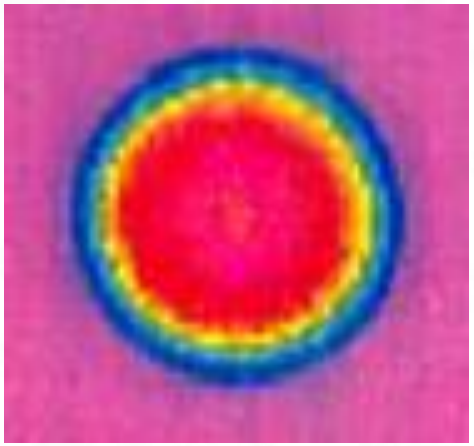


3D finite element mesh

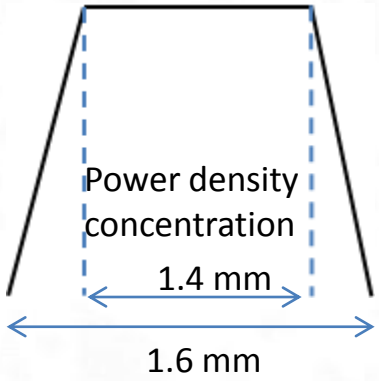
Simulation



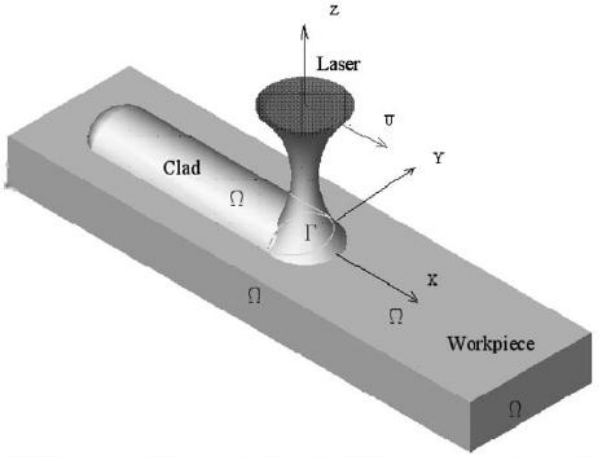
(Costa 2005)



Scheme showing the cylindrical radius of the laser used by Sirris



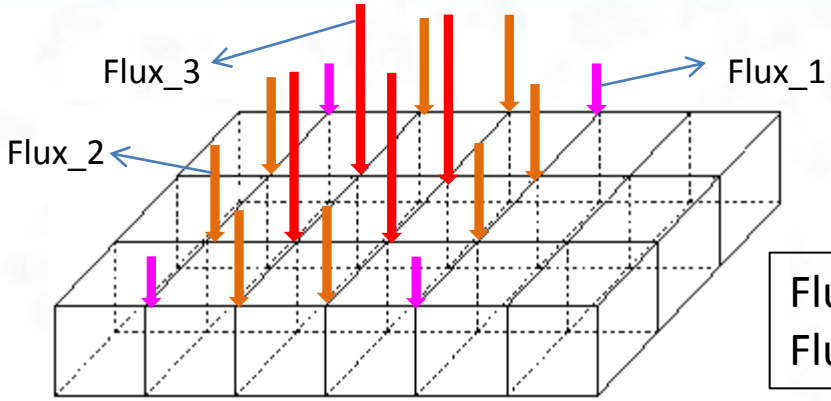
Scheme showing the laser power density of the laser used by Sirris



Schematic showing Gaussian distribution of laser

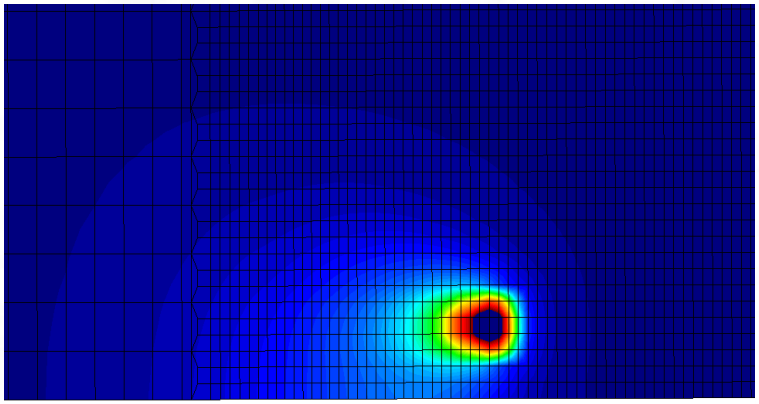
Form of laser beam and its distribution

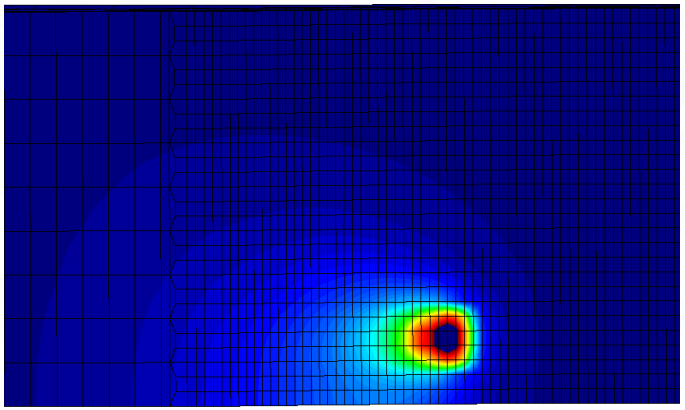
Simulation

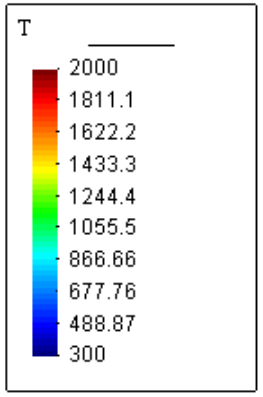


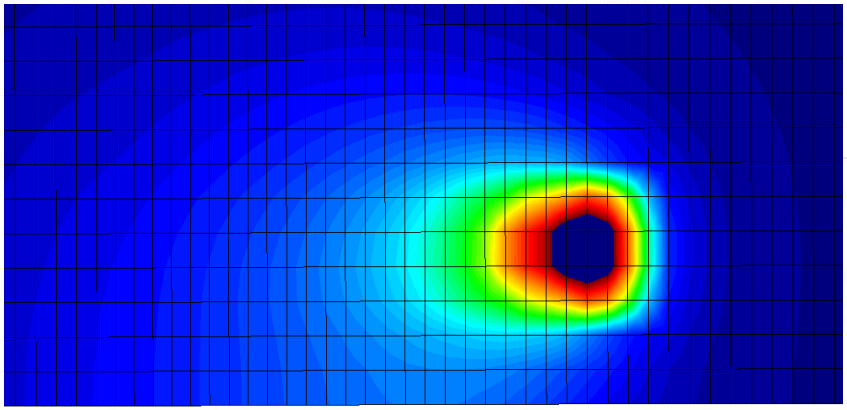
Flux_2=2×Flux_1
Flux_3=4×Flux_1

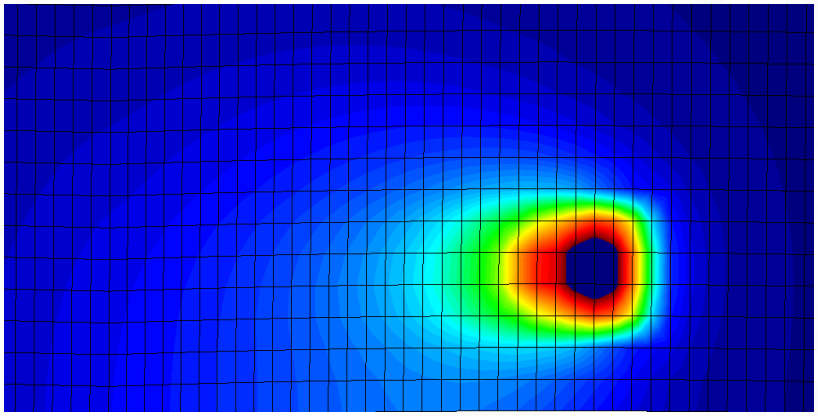
Flux_2=1,5×Flux_1
Flux_3=2×Flux_1



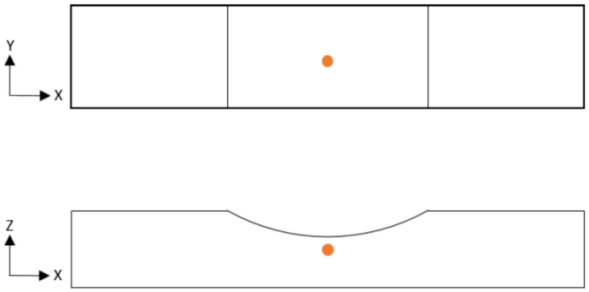




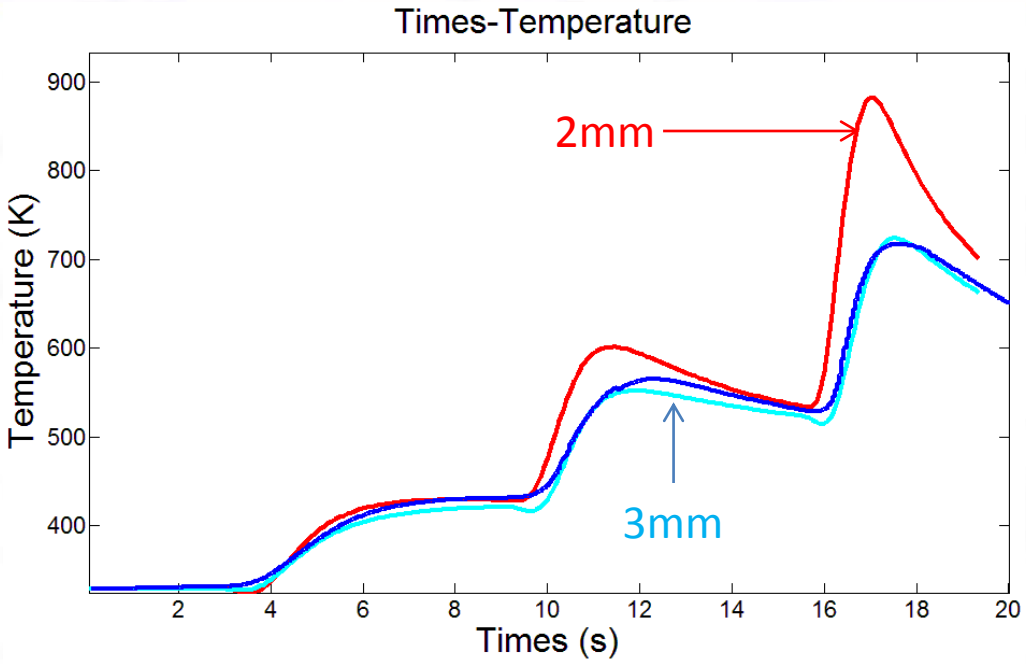




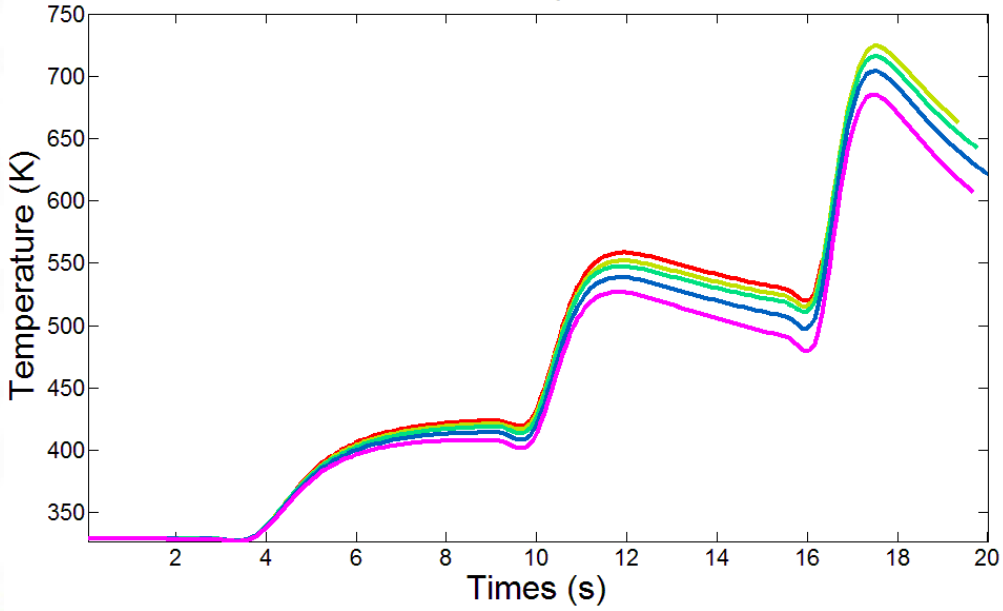
Simulation



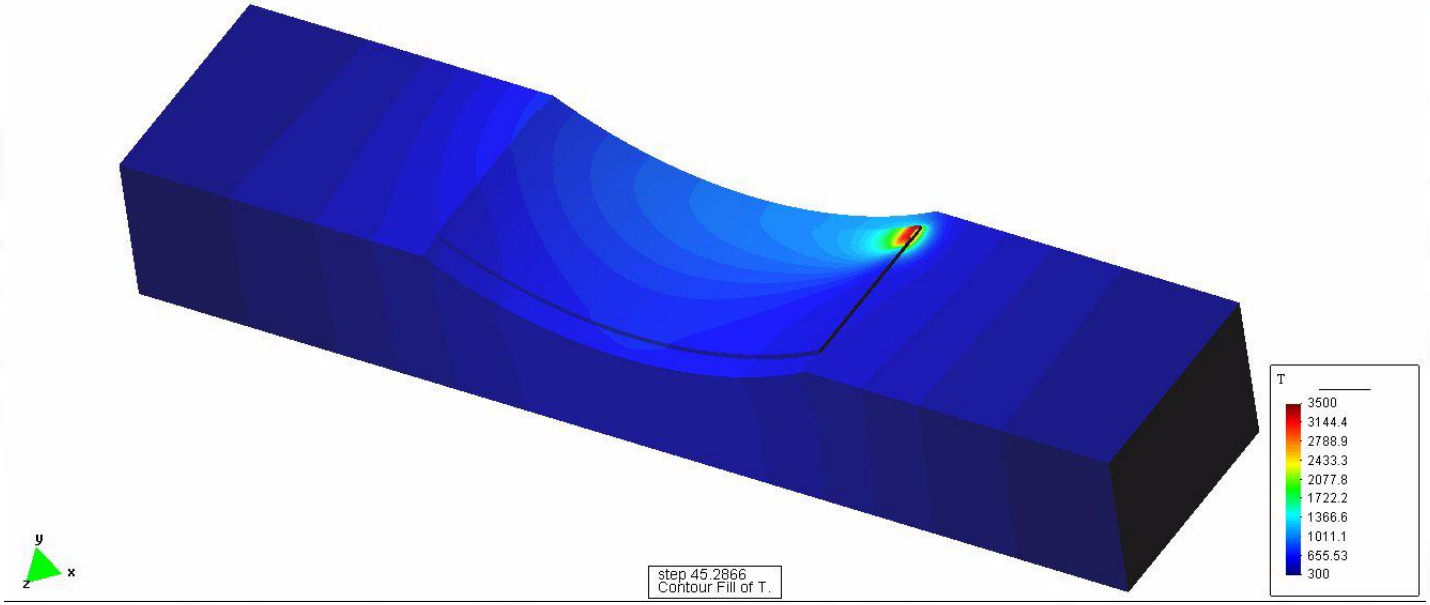
Effect of point positions

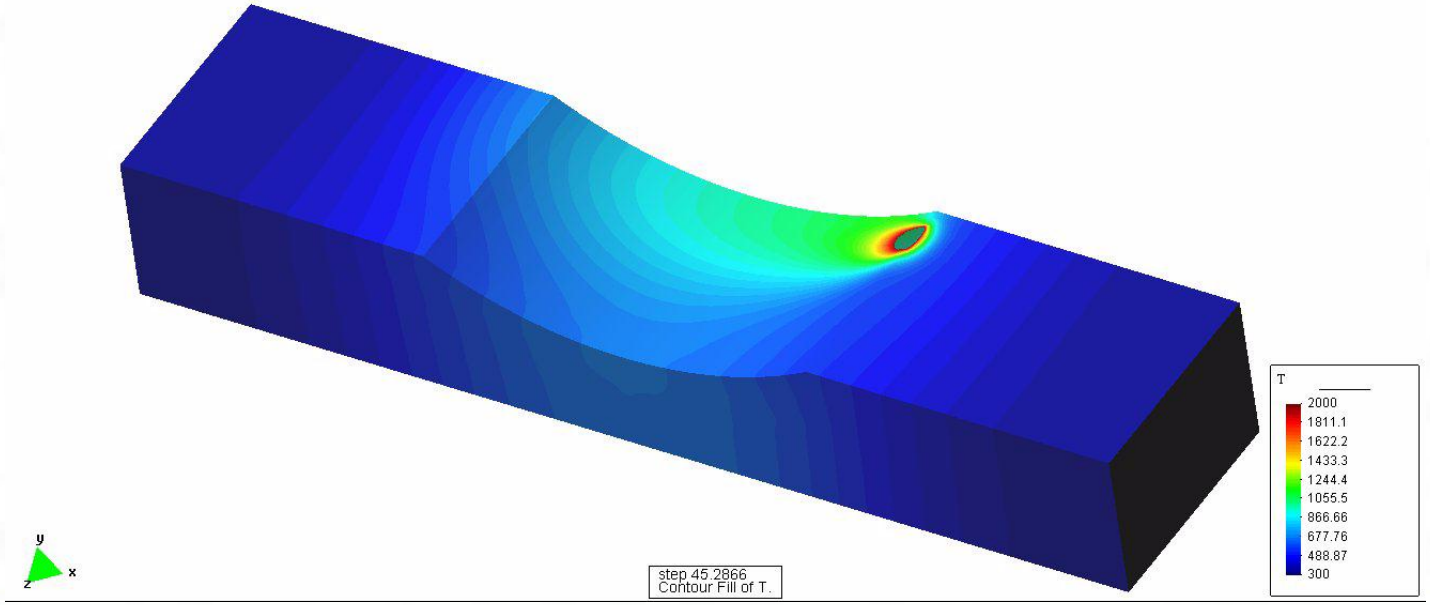


Effect of Convection & Radiation Parameters

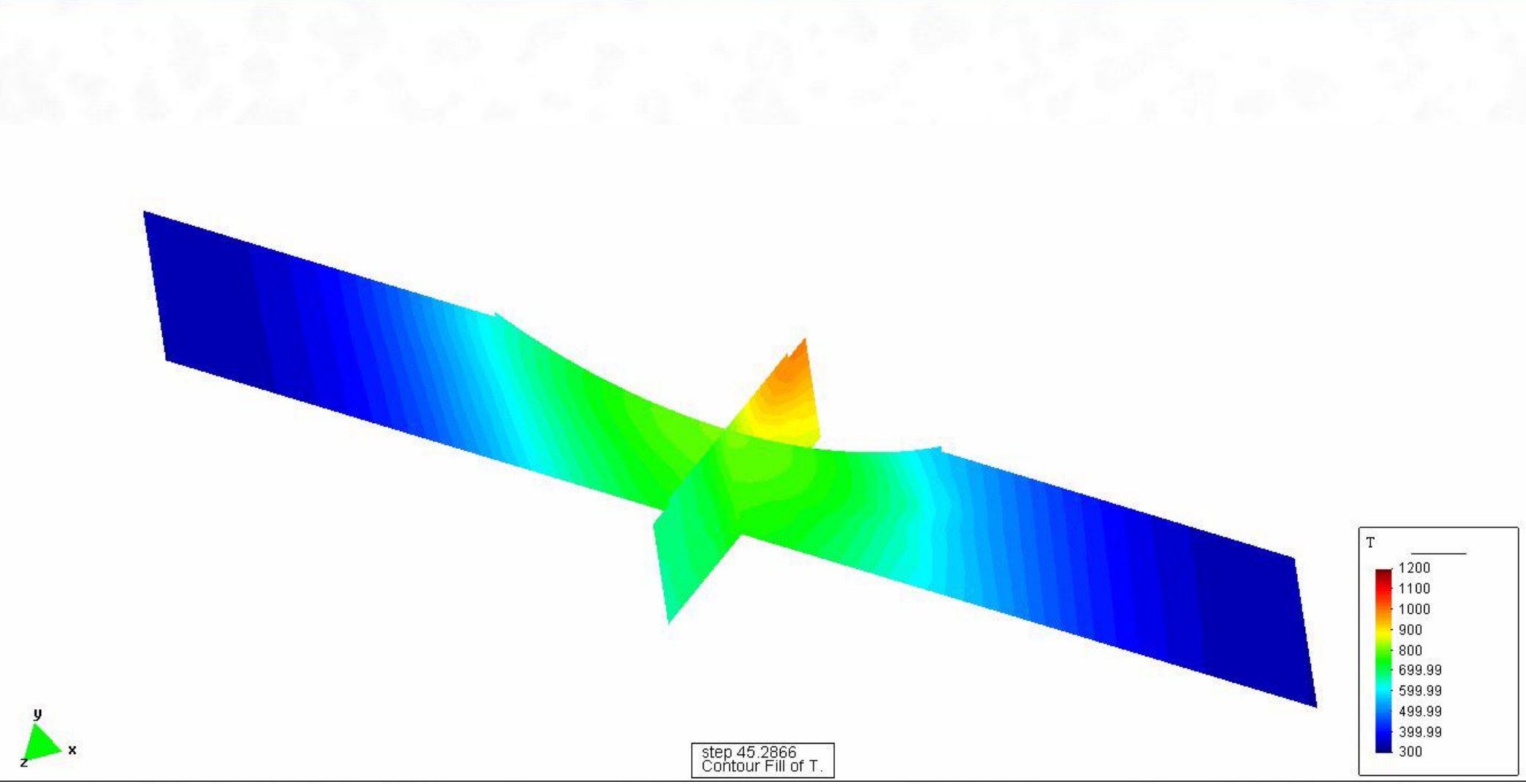


Simulation

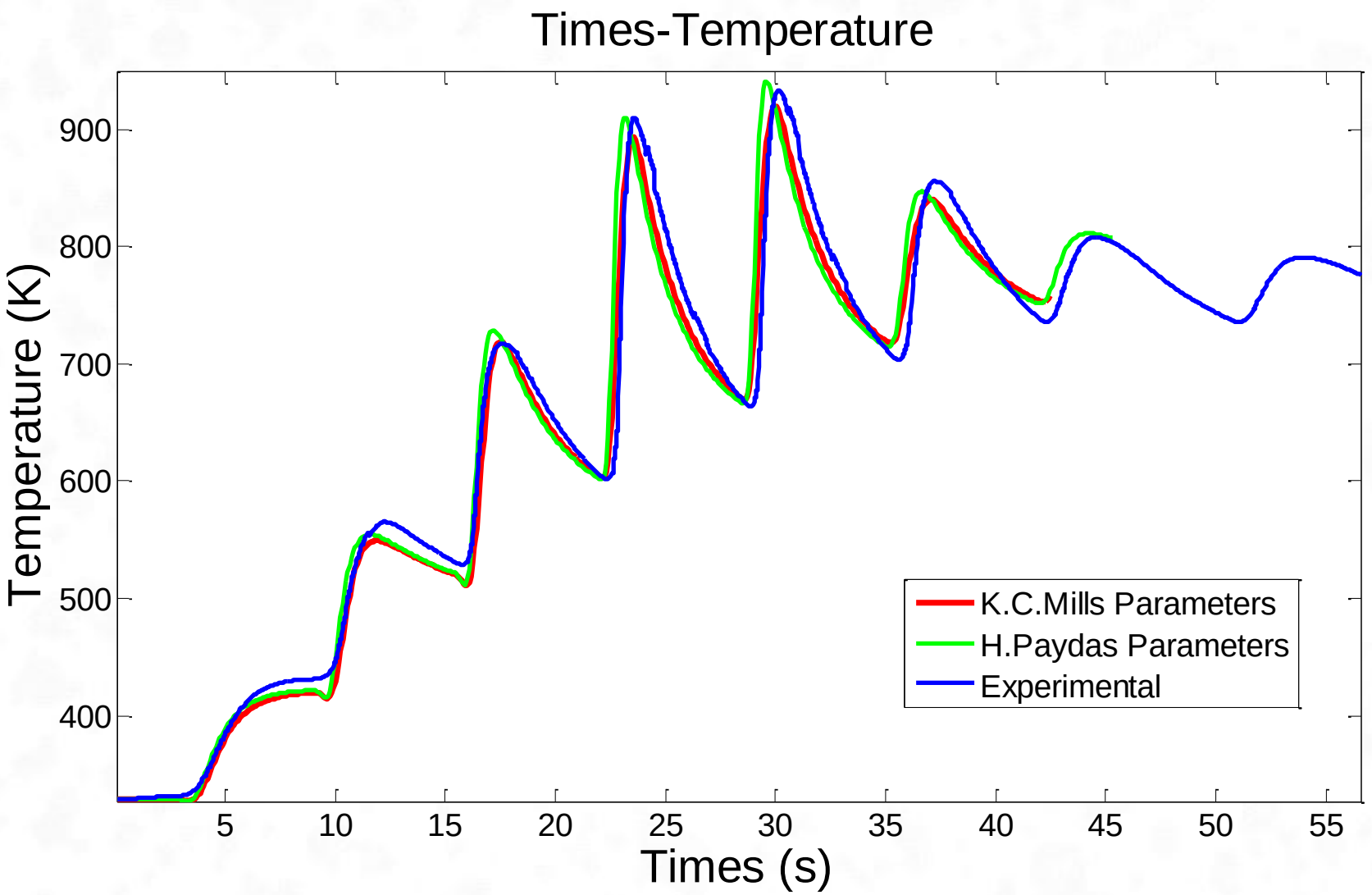

T
3500
3144.4
2788.9
2433.3
2077.8
1722.2
1366.6
1011.1
655.53
300
y
x
z
step 45.2866
Contour Fill of T.


T
2000
1811.1
1622.2
1433.3
1244.4
1055.5
866.66
677.76
488.87
300
y
x
z
step 45.2866
Contour Fill of T.

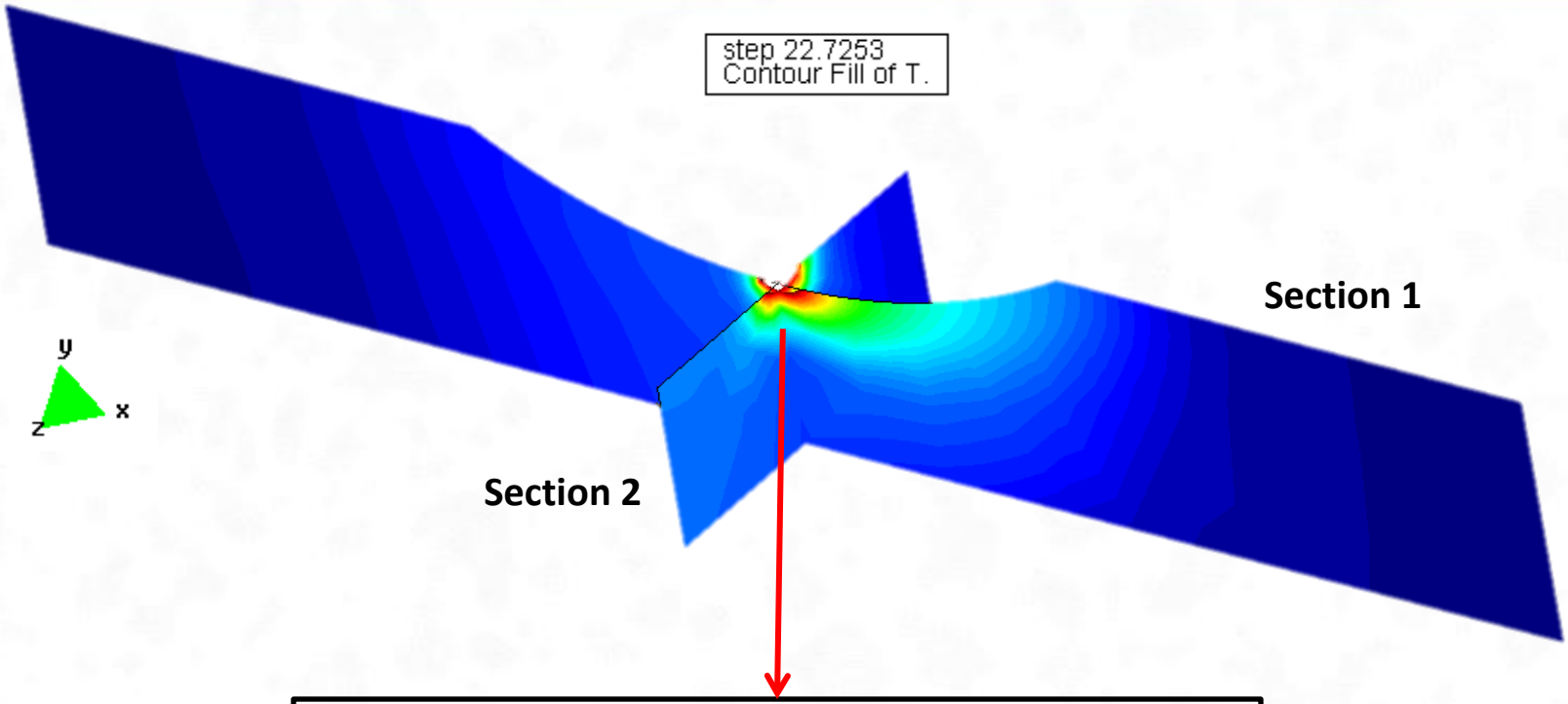
Simulation

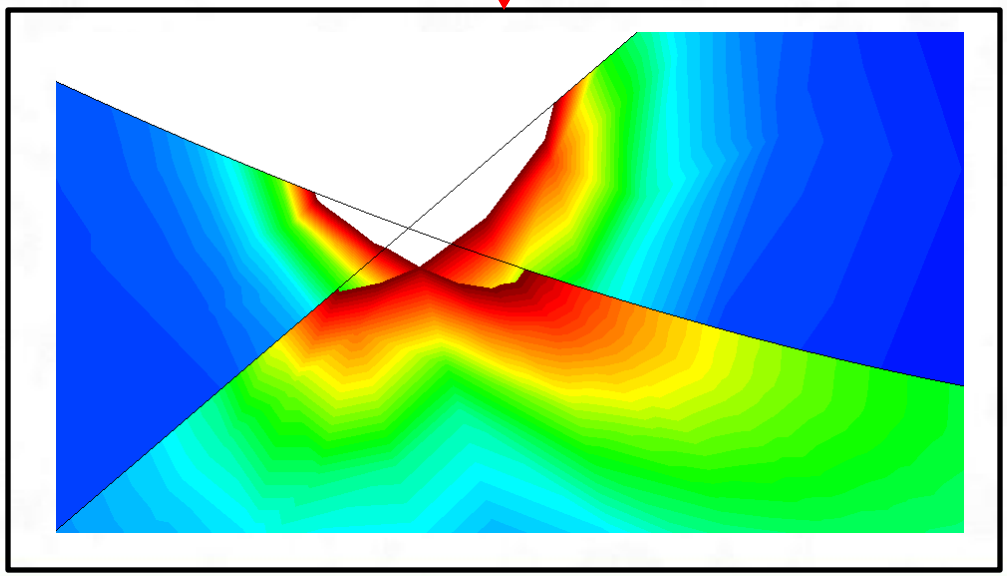

T
1200
1100
1000
900
800
699.99
599.99
499.99
399.99
300
y
x
z
step 45.2866
Contour Fill of T.

Validation

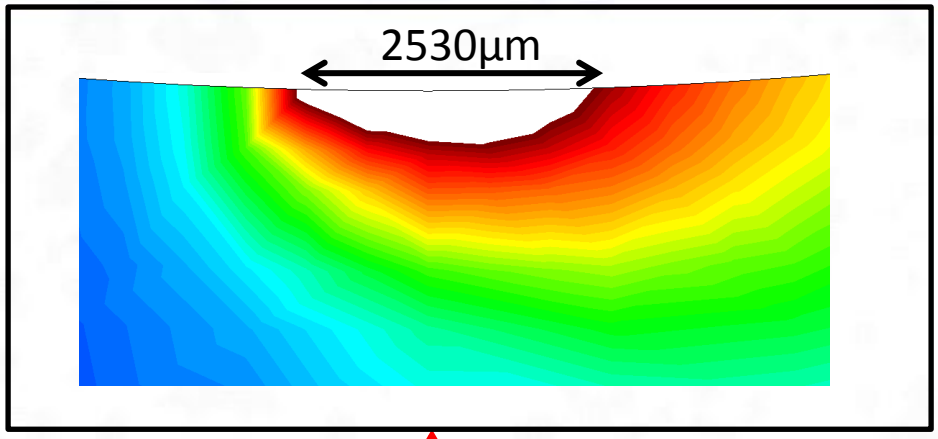

Times-Temperature
Temperature (K)
900
800
700
600
500
400
5
10
15
20
25
30
35
40
45
50
55
Times (s)
K.C.Mills Parameters
H.Paydas Parameters
Experimental

Validation

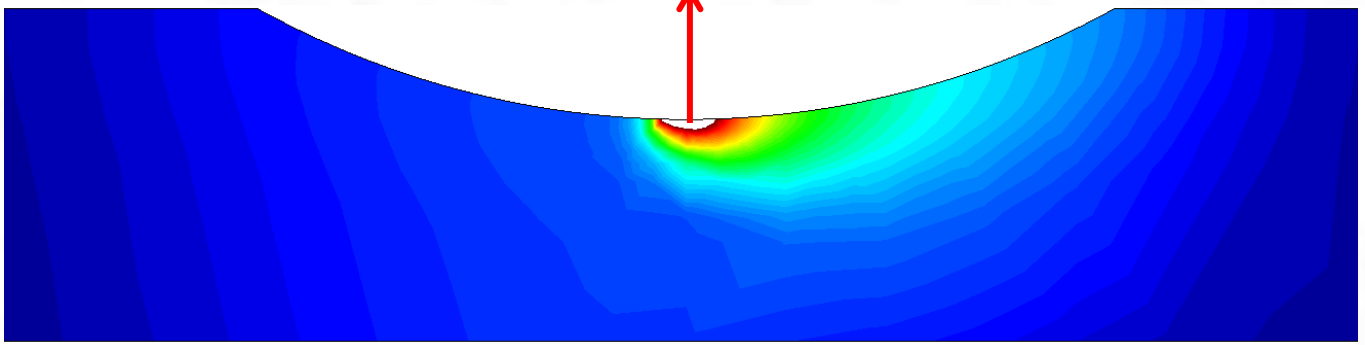

step 22.7253
Contour Fill of T.
y
x
z
Section 1
Section 2
T
2000
1811.1
1622.2
1433.3
1244.4
1055.5
866.66
677.76
488.87
300

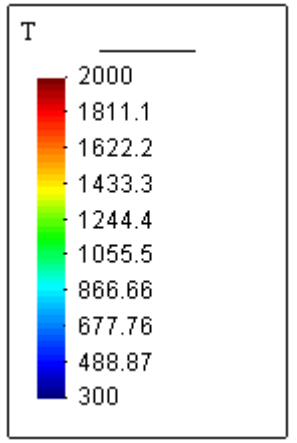


Validation



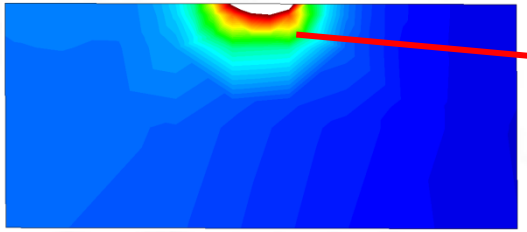
Section 1

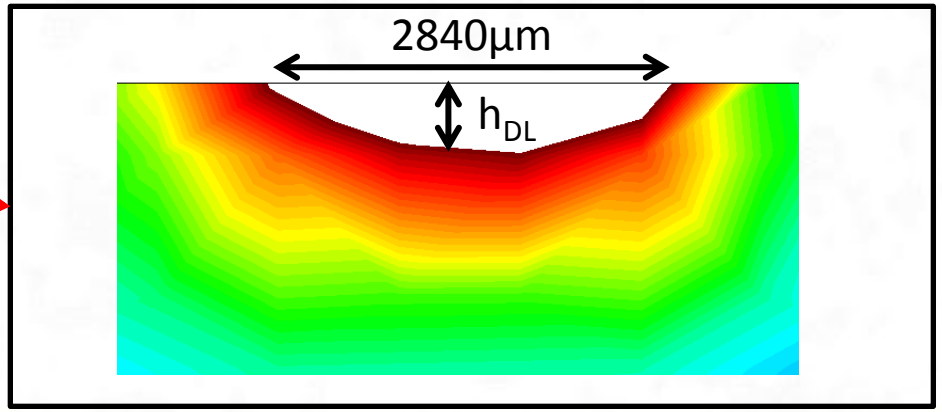




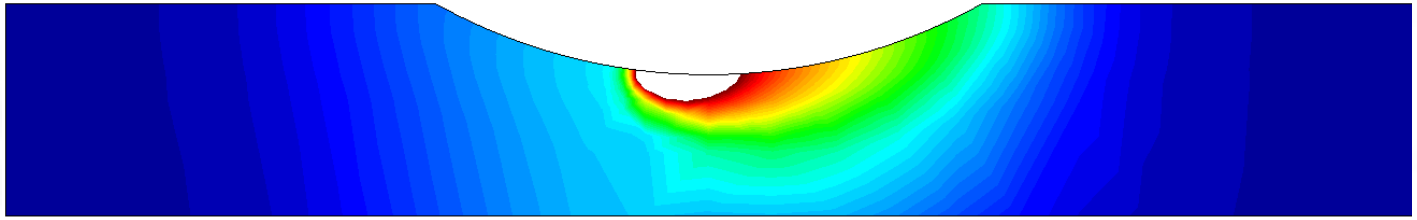
h_{DL} (Dilution depth)=480µm

Section 2

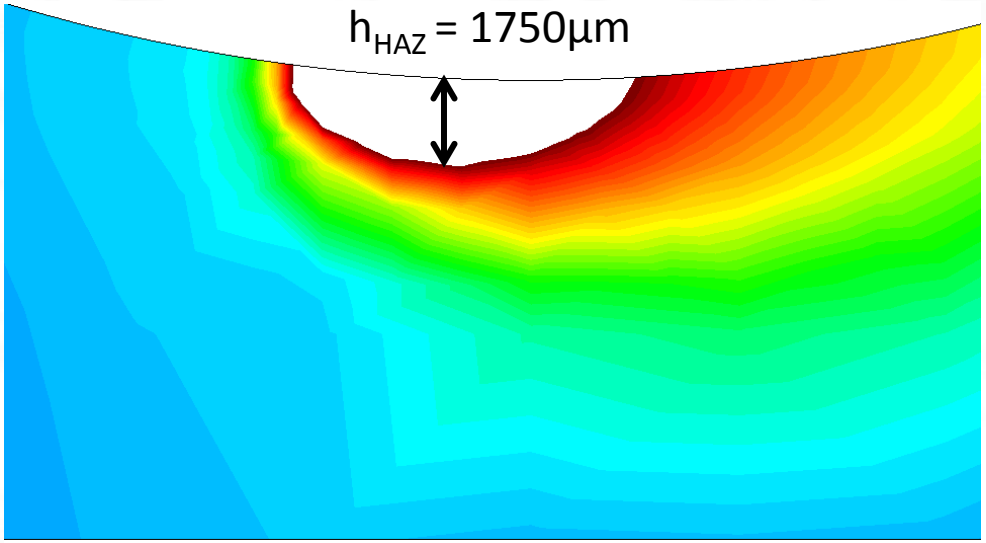


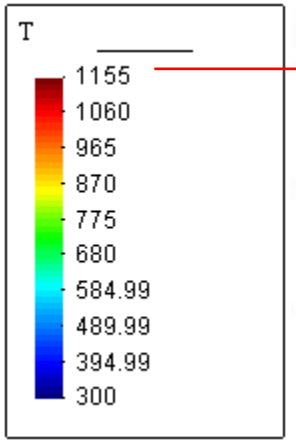


Validation



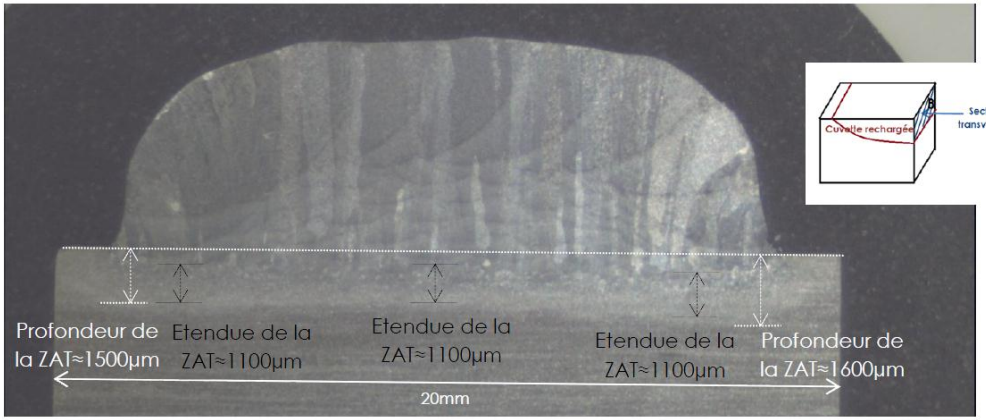
Section 1





Allotropic Transformation
(β→α)

Micrographe - H.Paydas



h_{HAZ} = 1500µm → 1600µm
Dilution depth = 450µm → 500µm

Limitation

Microstructure analysis

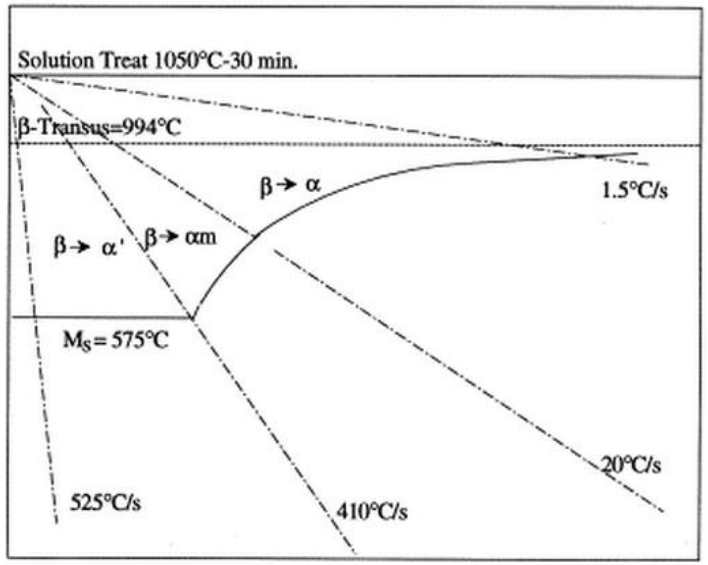
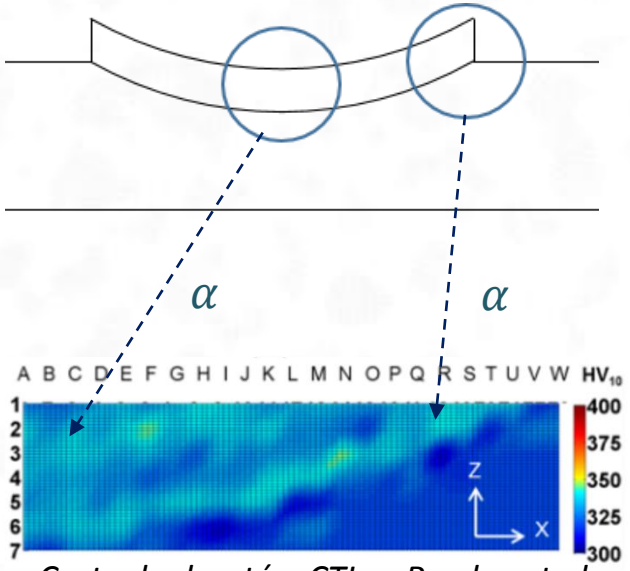


Diagramme de refroidissement – Ahmed et al.



Carte de dureté – CTL – Paydas et al.

Numerical study

Conclusion & Perspectives

Resume

- Simulation results by Lagamine in line with experimental observations.
- Time consuming < 2days for one layers (7 tracks)

Perpective

- Fully couple thermo-mechanical analysis.
- Define the links between the process parameters and the microstructure.