Numerical Comparison of the Effectiveness of Different Techniques used in the Straightening of Welding Distortion

Adan VEGA

Technological University of Panamá

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Osaka - Japan

ClassIBS
ISTHMUS BUREAU OF SHIPPING

LEPUM

OUTLINE

- Introduction
- Objectives of the study
- Numerical modeling of the straightening process
- Comparison of effectiveness of different techniques
- Analysis of results
- Conclusions

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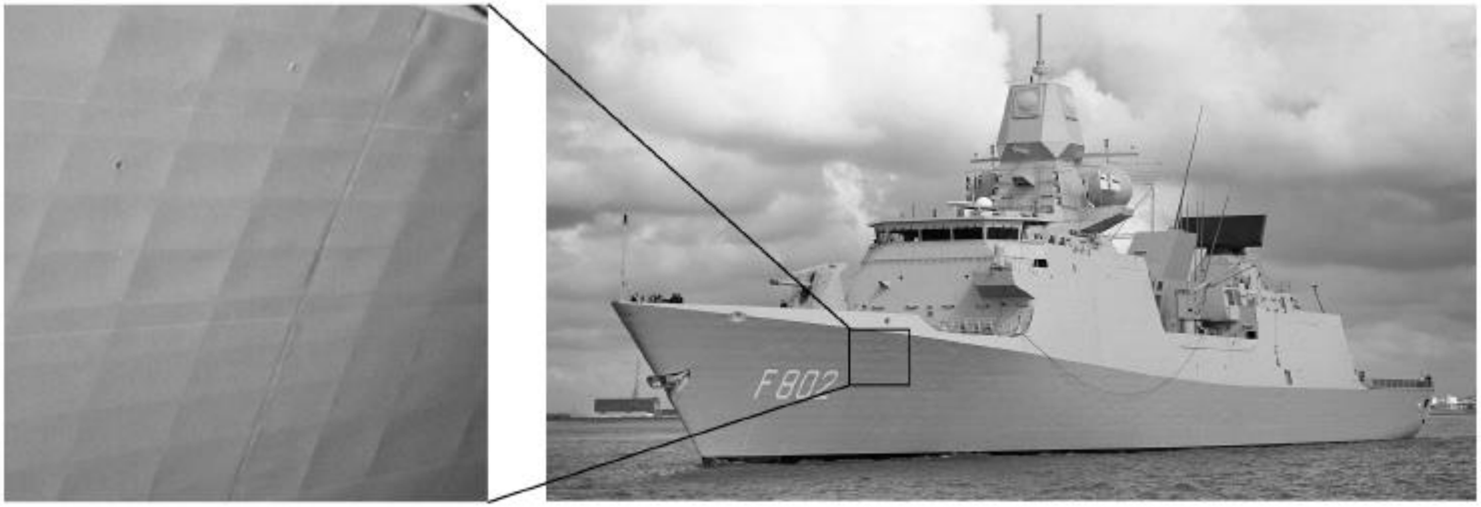
Welcome and other manufacturing processes where heat is introduced will leave stresses in the metal during subsequent cooling, causing distortion or warping

- Despite improvements in manufacturing techniques the ship-building industry is hugely affected by welding distortion
- These distortion need to be repair
- Different straightening techniques are use

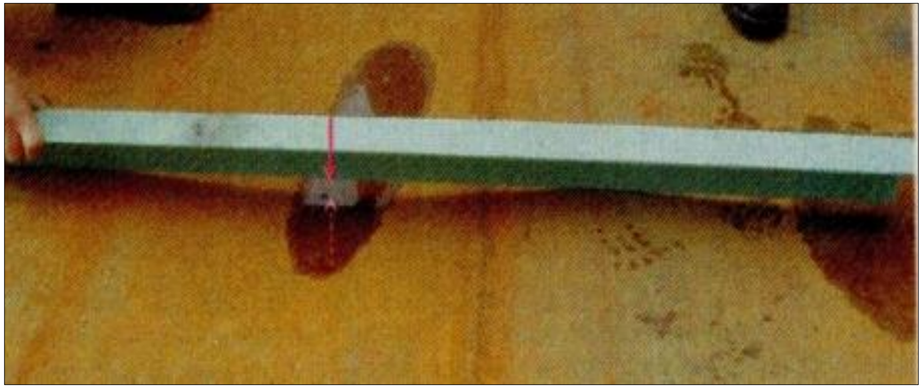


Additional costs for rework caused by weld-induced distortion: $3Mio/ship

It has been estimated that the total could be up to ten times the heat straightening figures, once factors such as schedule interruptions, stripping down equipment, repainting etc are taken into consideration

Distortion in ship repair

- ✓High production costs
- ✓Time consuming
- ✓Increments in downtimes in repairs
- ✓Higher energy consuptiom



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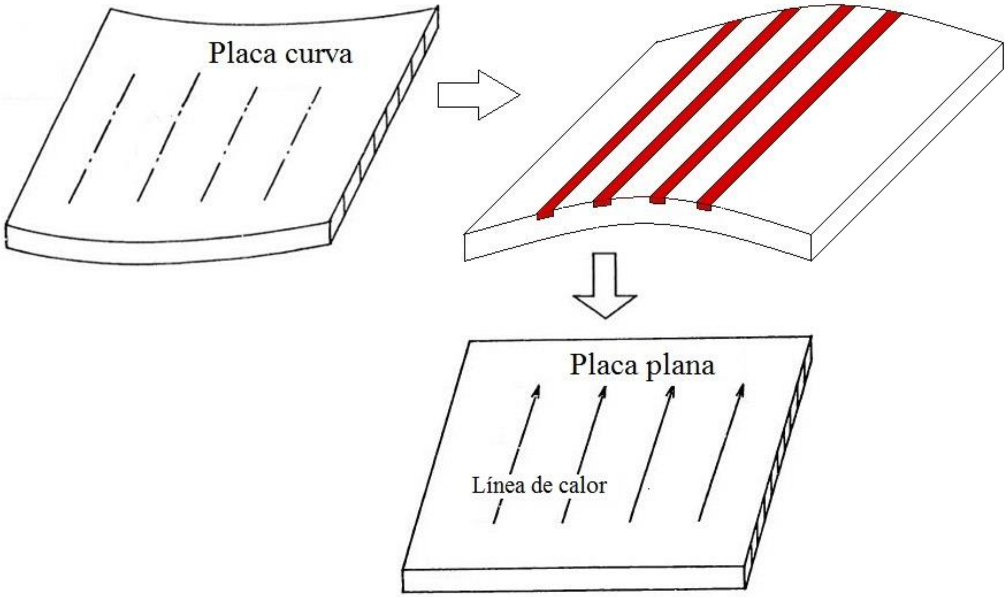
Objective of the study

To numerically compare different techniques usted for straightening deformed welded structure order to choose the most appropiate for specific cases.



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Inherent strain method

✓Step1: Predict the four components of inherent strain at the central region of the plate, by thermoelastoplastic analysis.

✓Step 2: Estimate the equivalent nodal forces.

✓Step 3: Impose the forces at the nodes and determine the resultant displacements.

✓Step 4: Determine deformations and distortion.

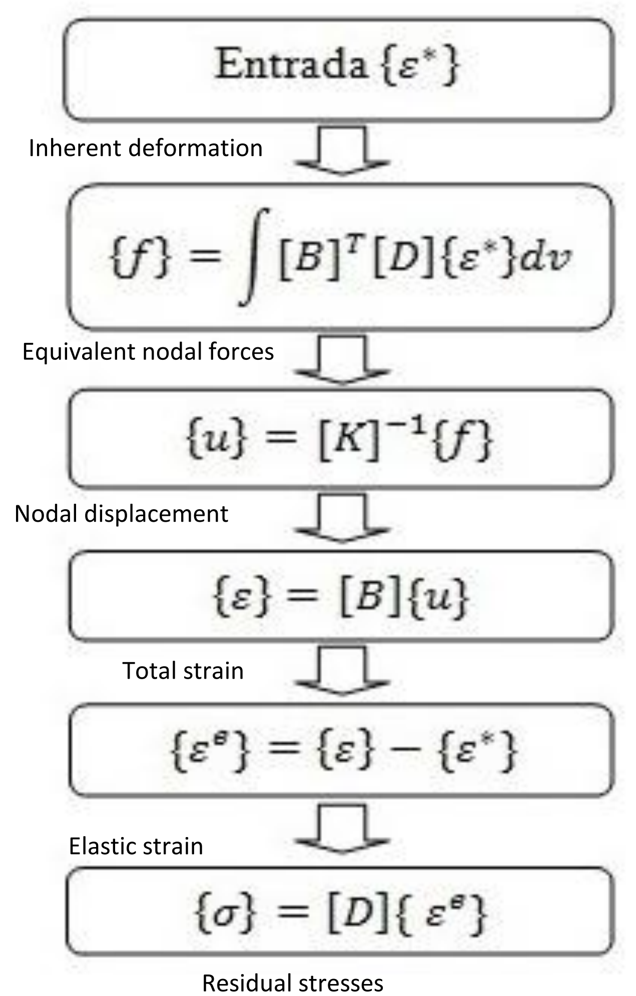
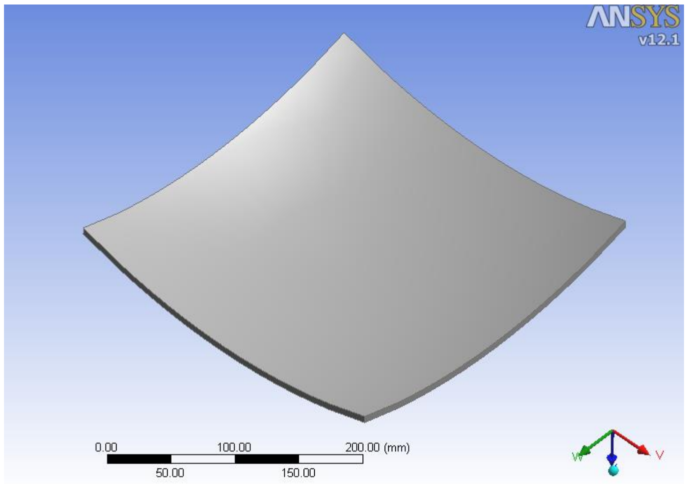
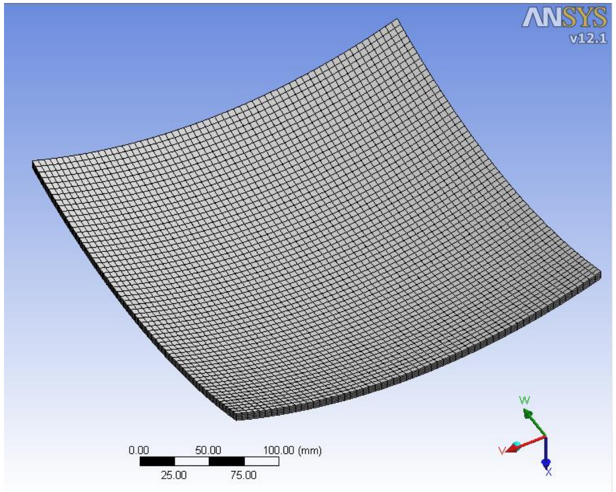
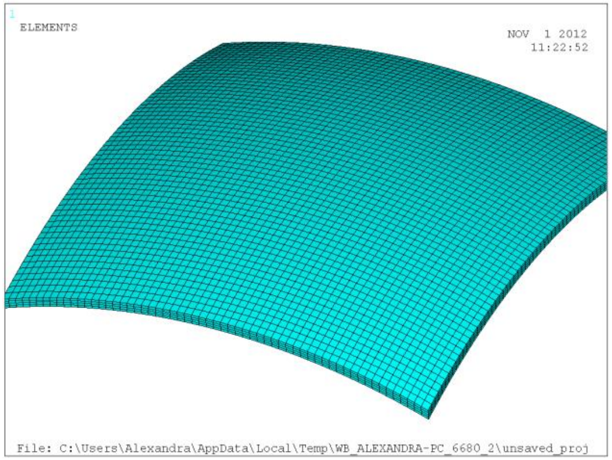


Plate Geometry

Geometry CAD (Inventor – Ansys (Workbench)



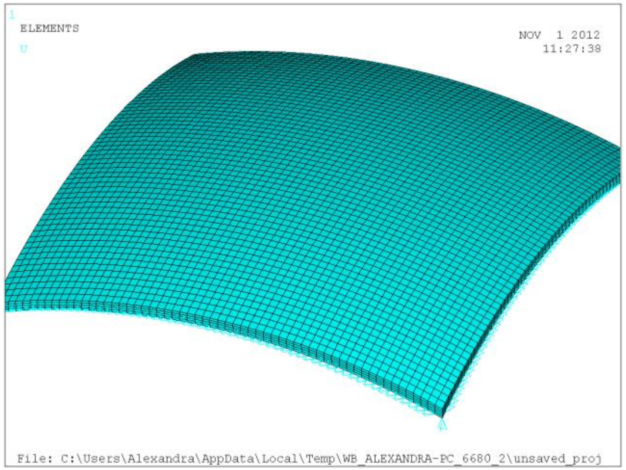


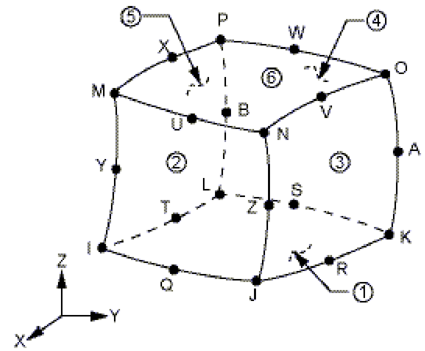


Dimensions: 300 x 300 x 6 (mm)
Element type: Mesh 200 Solid 186
Elements: 14400 (5*5*1.5)
Nodes: 70089

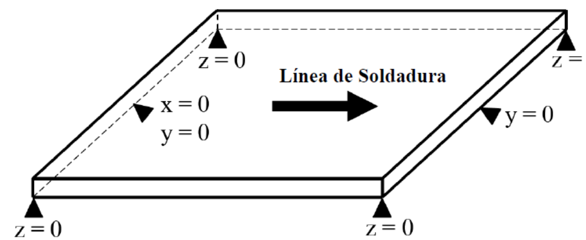
Discretizided Model (Ansys (APDL)

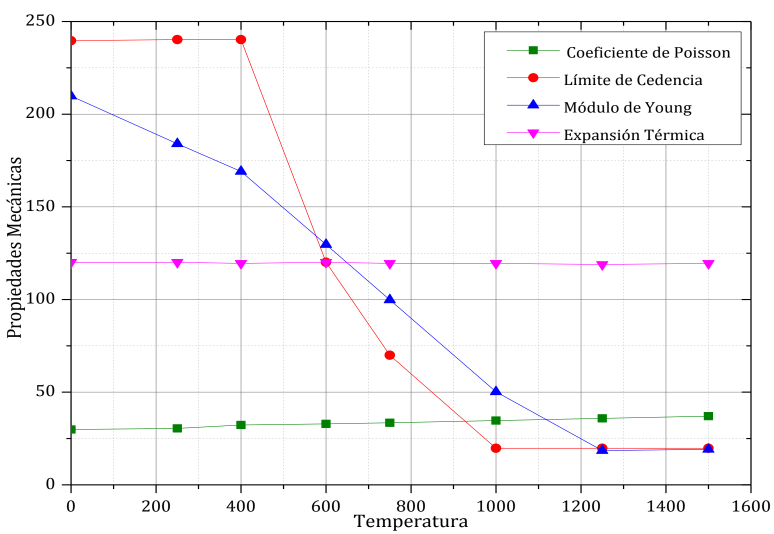
Finite Element Type





Solid 186





Mild steel

- ✓ Homogeneous Material
- ✓ Isotropic Material
- ✓ No rigid body displacements

Experiments

- Good agreement was obtained between experiments and simulation

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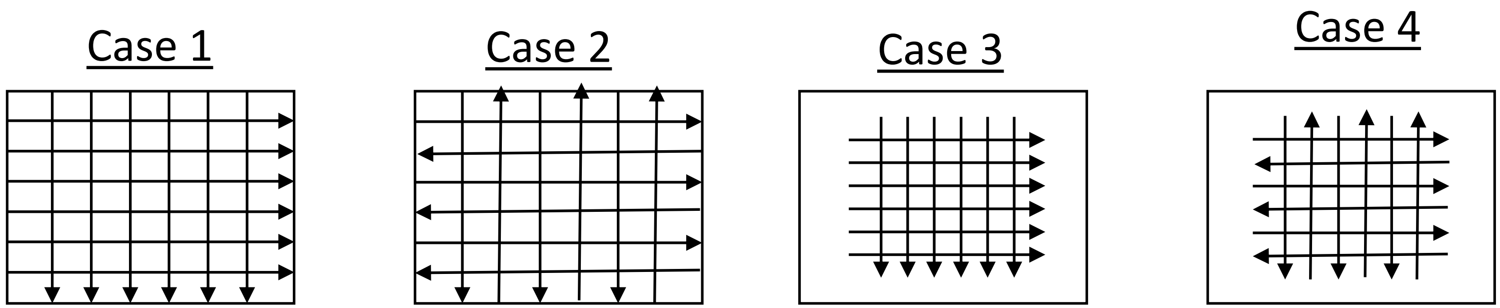
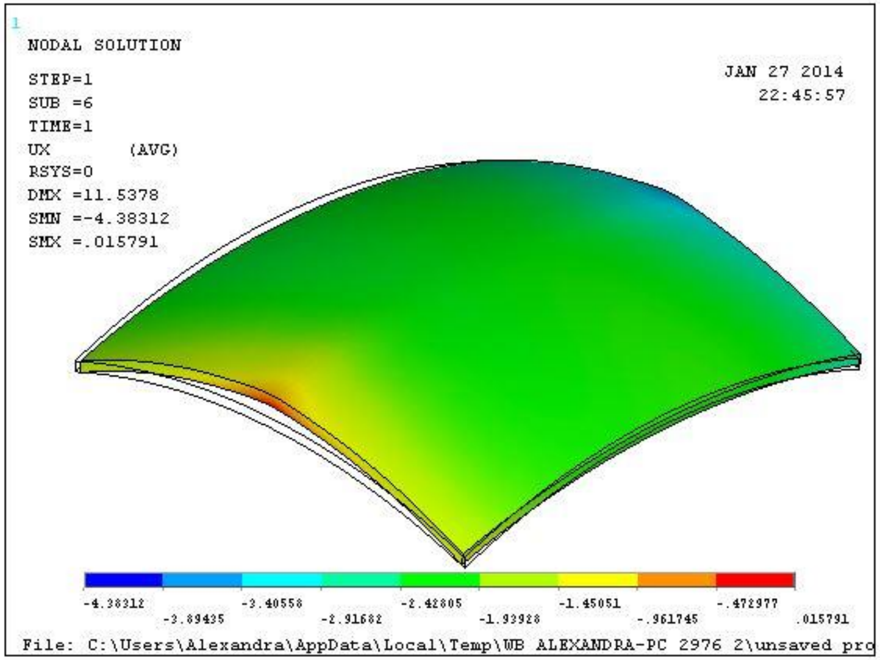
Heating Straightening Techniques

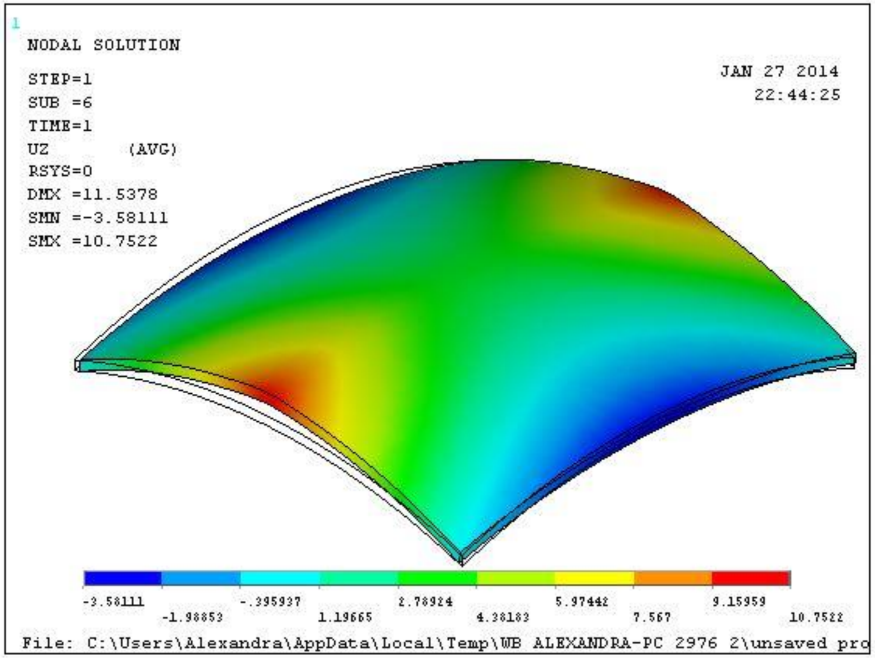


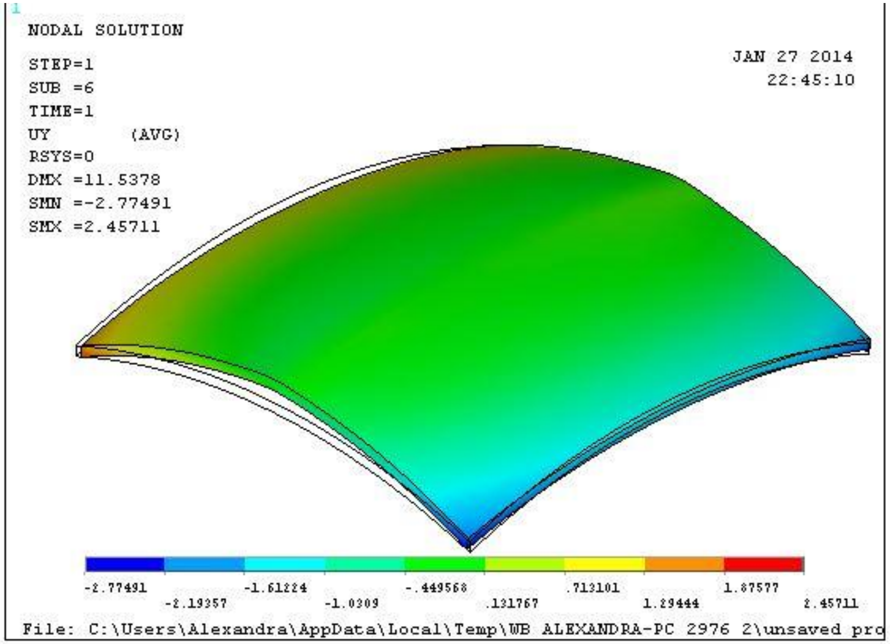
- Same heating and cooling conditions for all the cases
- Plate thickness as well FEM model is the same

- Deformation means Inherent deformation quantified after the last heating line

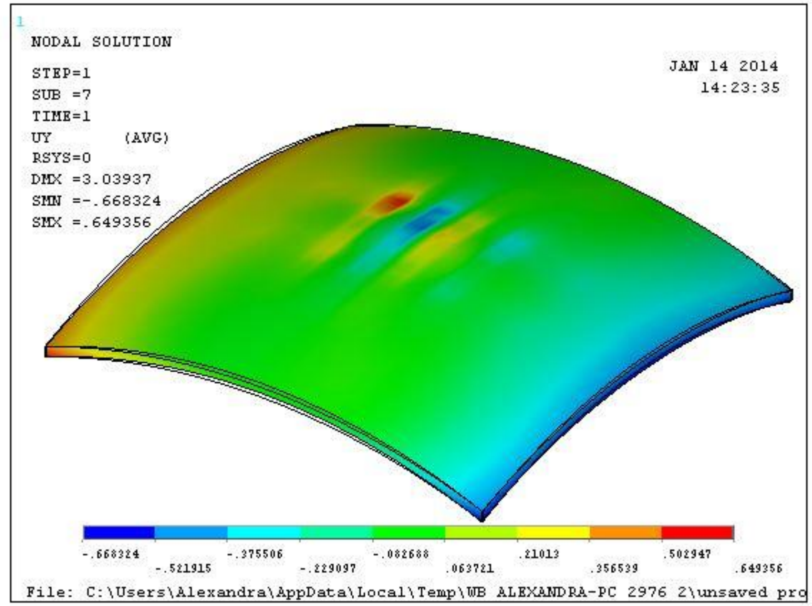
Results of Case 1

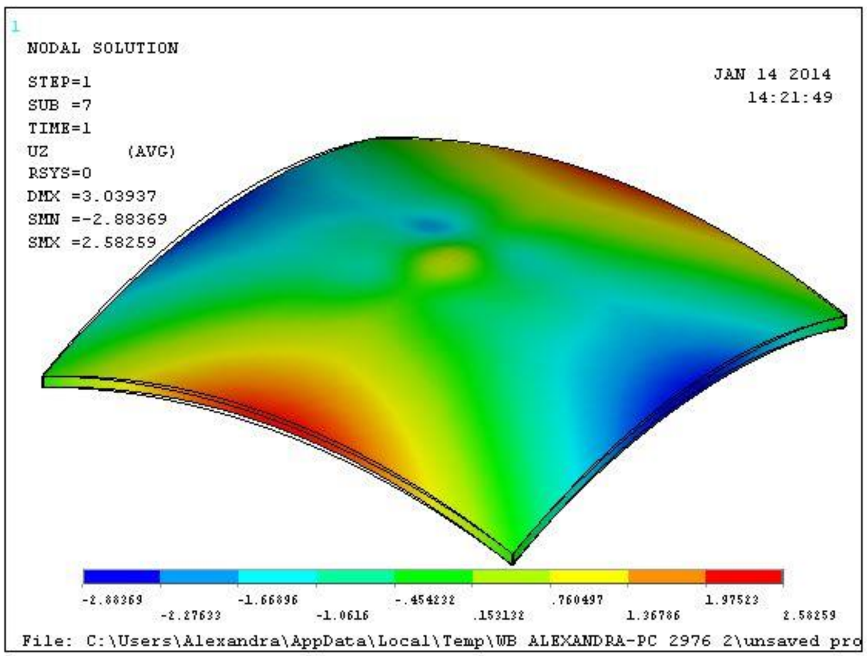


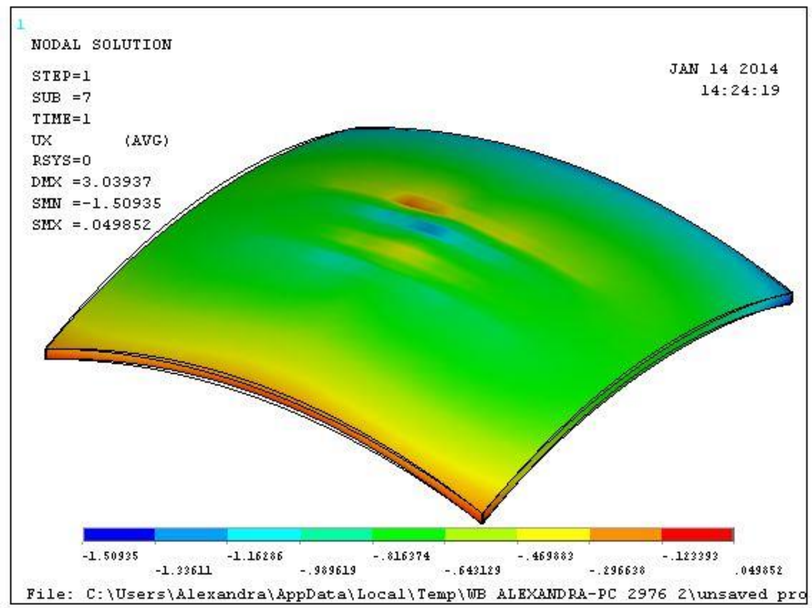




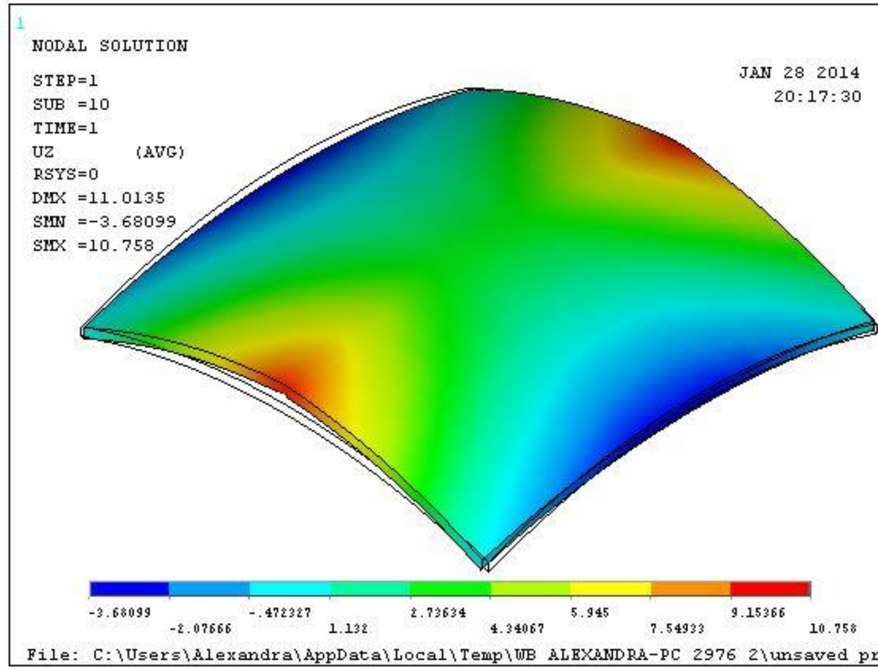
Results of Case 2

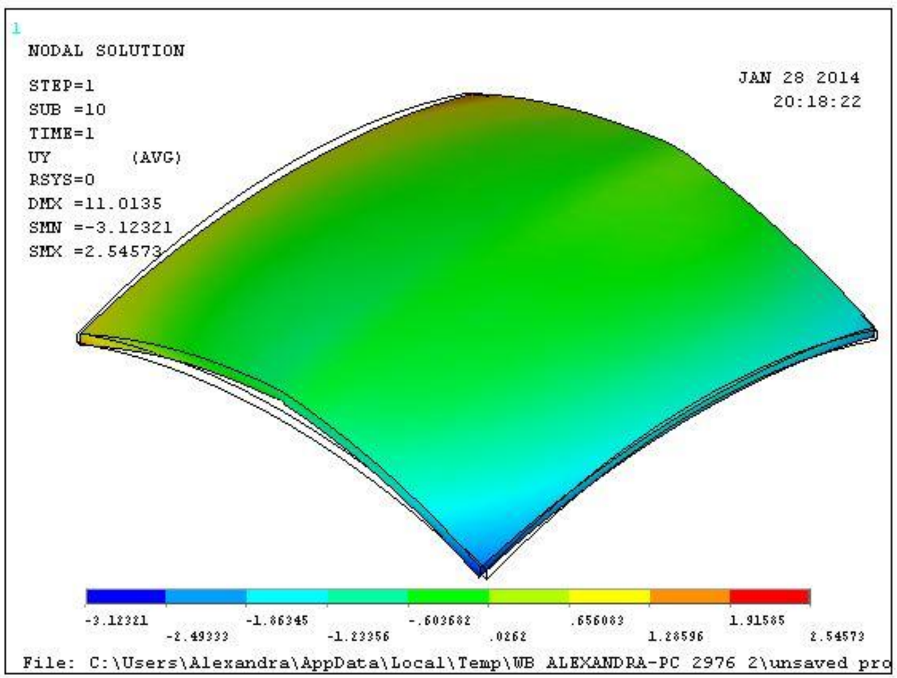


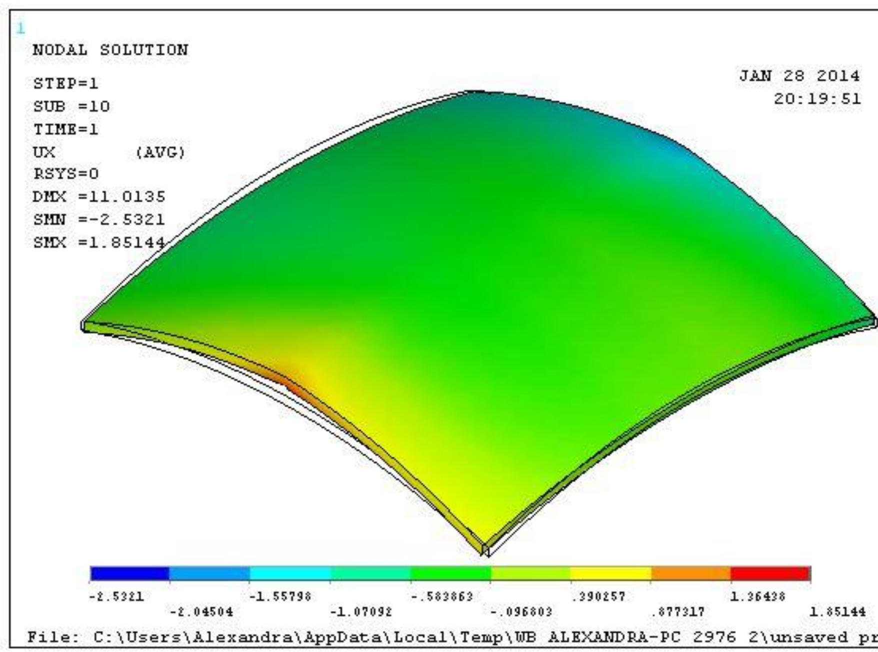




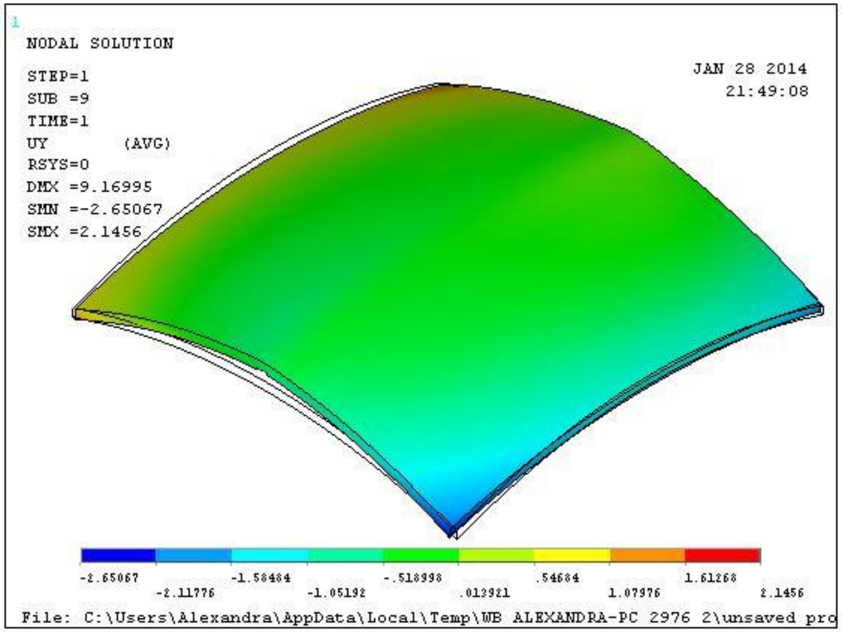
Results of Case 3

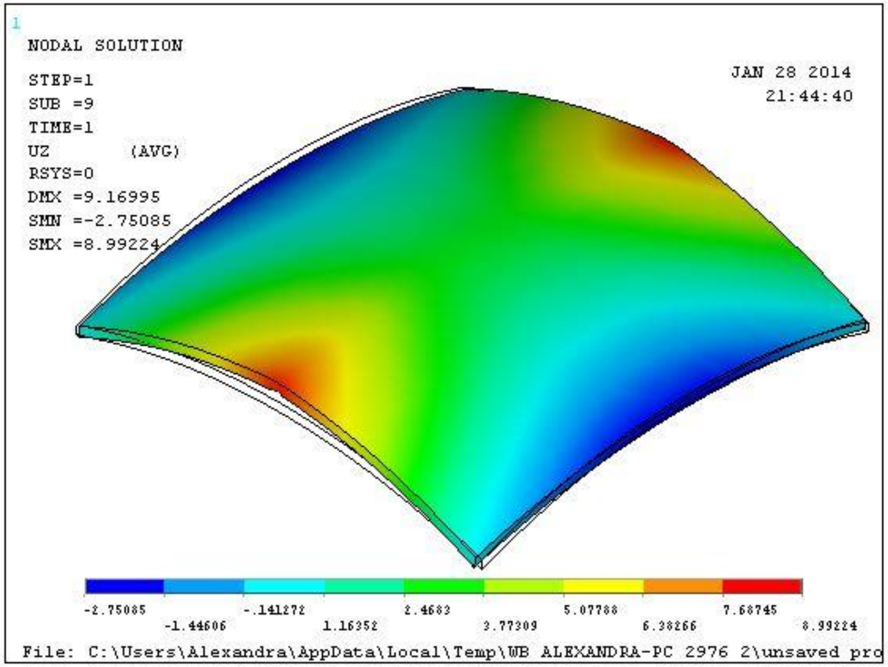


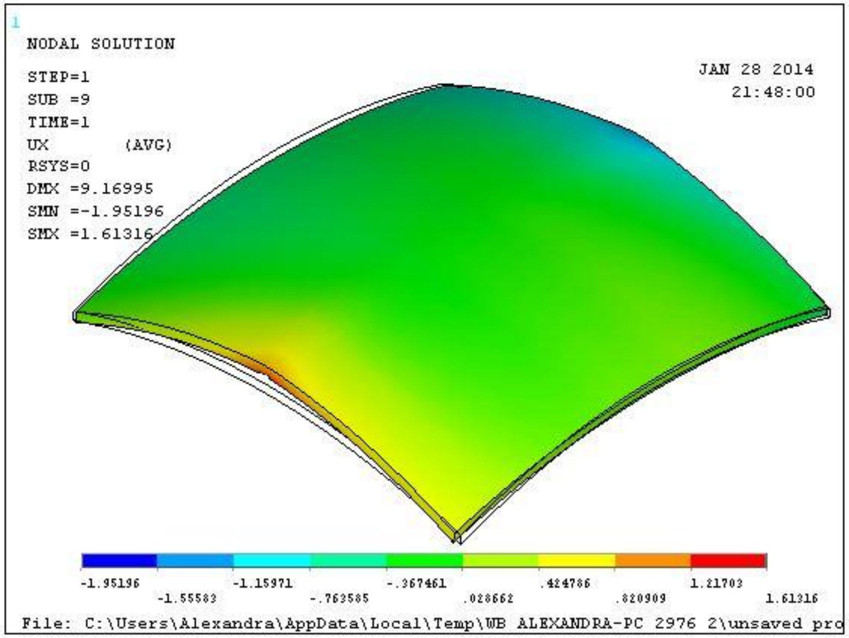




Results of Case 4







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Proposed index

In order to evaluate the effectiveness we compare time and energy consumed in each case. Using two index as follows.

$$\boldsymbol{\alpha}_{1} = \text{deformation} / \text{time}$$

$$\boldsymbol{\alpha}_{2} = \text{deformation} / \text{energy}$$

Comparison of differet cases

Case	Description	α_1	α_2
1	Five parallel lines in X direction followed by five parallel lines in Y direction. In both cases, heating lines are applied over the total length of the plate.	0.135	0.0036
2	Five parallel lines in X direction followed by five parallel lines in Y direction. In both cases, the line heating is applied over the total length of the plate. However, in this case, the sequence was changed, first in X direction, second in Y direction and so on.	0.142	0.0044
3	Five parallel lines in X direction followed by five parallel lines in Y direction. In both cases, the starting and the ending point of each line heating were at 25 mm from the plate edges (considering edge effect)	0.162	0.0047
4	**Five parallel lines in X direction followed by five parallel lines in Y direction. In both cases, the starting and the ending point of each line heating were at 25 mm from the plate edges (considering edge effect). Sequence was changed**	0.168	0.0051

Conclusions

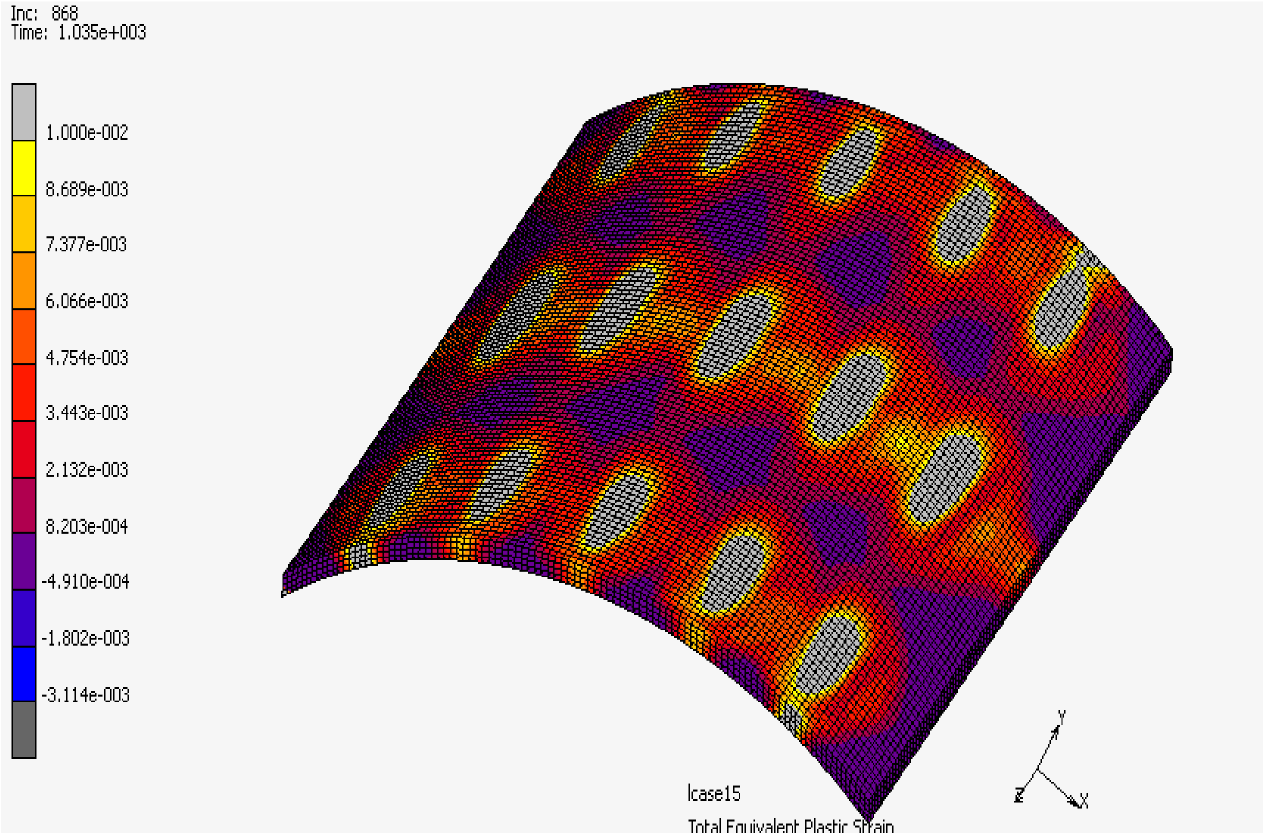
✓ An elastic analysis based on the inherent strain method is performed to study the straightening process. With this, different techniques used for straightening deformed plates are simulated.

✓Through numerical analysis, it has been demonstrated that the heat-induced deformation during the straightening process can be predicted.

✓The effectiveness of different techniques for straightening are evaluated from the point of view of two parameters, time and consumed energy. Both of them related to the amount of deformation straightened.

✓It is shown that using these parameters it is possible to obtain the most effective technique to be used in straightening warped plates during the ships repair process.

Future work


Inc: 868
Time: 1.035e+003
1.000e-002
8.689e-003
7.377e-003
6.066e-003
4.754e-003
3.443e-003
2.132e-003
8.203e-004
-4.910e-004
-1.802e-003
-3.114e-003
lcase15
Total Equivalent Plastic Strain
Y
Z
X

THANK YOU VERY MUCH FOR YOUR KIND ATTENTION

Dr. Adan Vega Saenz
Research Center for Joining and Manufacturing Process (LEPUM)
Technological University of Panama, Panama City, Panama
Email: adan.vega@utp.acpa
www.lepum.utp.ac.pa
Phone: (507) 6019-8076