Numerical simulation in welding process: Optimizing structures with sequence and inertial study

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OBJECTIVES:

To design and test a numerical simulation methodology, which can to use in industrial applications in shipbuilding sector.

STRUCTURE OF THE WORK:

Study of experimental and simplified cases

Numerical model validation in simple cases

Validation in complex cases

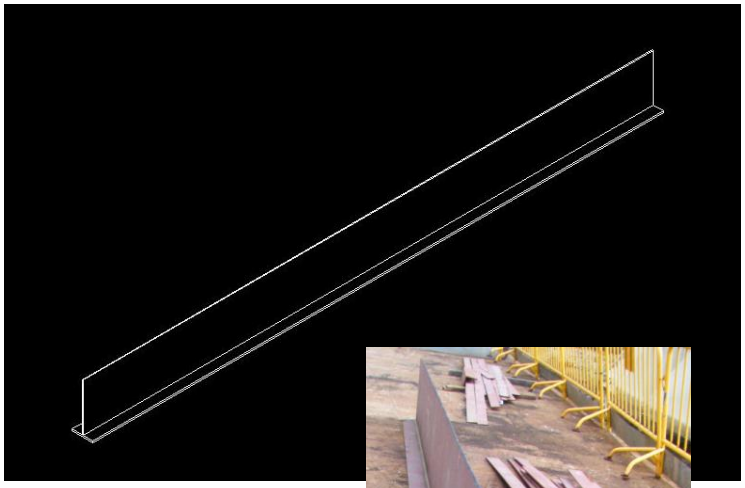
Simplification of numerical models

Validation of simplified numerical models

Parametric studies and optimization

Design specifications - PREVIAS

- 90% of joints in a ship
- Stiffeners
- “Tee” joints
- Different thickness between flange/web
- Different length
- Not clear a sequence methodology
- Structural importance

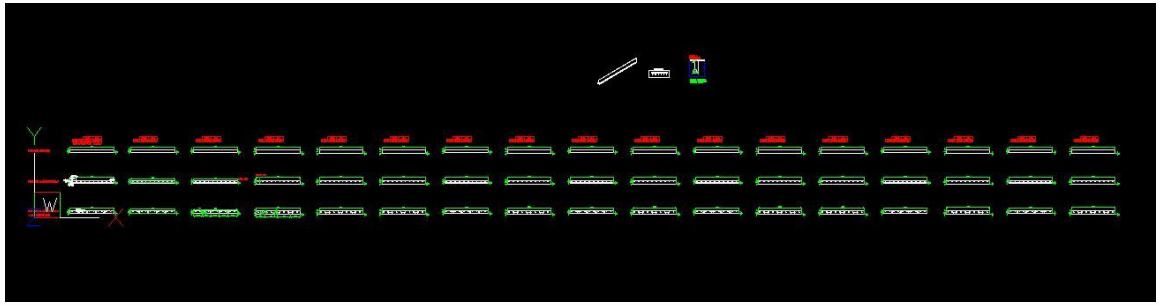


Material selection

- Naval A/AH36
- Ferritic structural steel

Worktest´s planetscape

- High geometry variability
- High adaptability and flexibility
- Low efficient and standardization



- 4 geometric variables
  - Flange (height – thickness)
  - Web (height – thickness)

→ – 16 specimens

Battery test

- Flange
  - Height 120-220
  - Thickness 12-20
- Web
  - Height 350-500
  - Thickness 8-12

16 cases

Nº Test	WEB		FLANGE		Nº Test	WEB		FLANGE	
	Thickness	*Height*	*Thickness*	*Height*		*Thickness*	*Height*	*Thickness*	*Height*
1	8	350	12	120	**9**	12	350	12	120
2	8	350	12	220	**10**	12	350	12	220
3	8	350	20	120	**11**	12	350	20	120
4	8	350	20	220	**12**	12	350	20	220
5	8	500	12	120	**13**	12	500	12	120
6	8	500	12	220	**14**	12	500	12	220
7	8	500	20	120	**15**	12	500	20	120
8	8	500	20	220	**16**	12	500	20	220

Battery test conditions

- Same longitude
- Same loads
- Same conditions

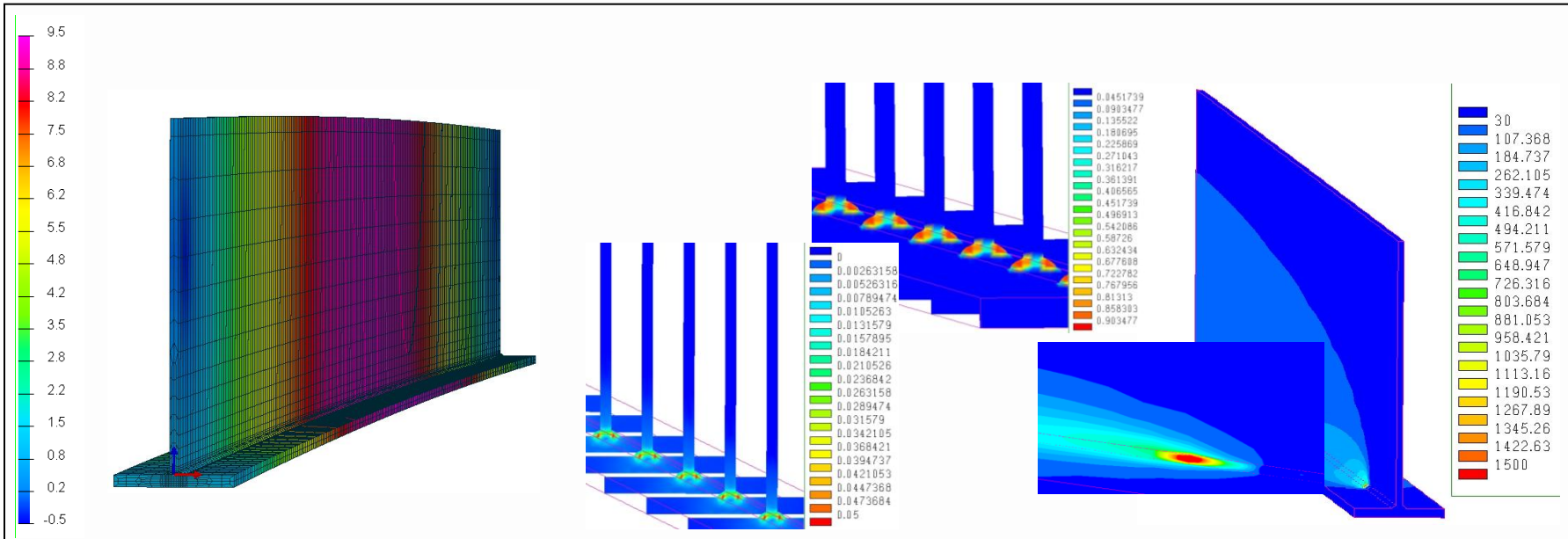
Nº Tes	WEB		FLANGE		Nº Test	WEB		FLANGE	
	Thicknes	Heigh	Thickness	Heigh		Thicknes	Heigh	Thickness	Heigh
1	8	350	12	120	9	12	350	12	120
2	8	350	12	220	10	12	350	12	220
3	8	350	20	120	11	12	350	20	120
4	8	350	20	220	12	12	350	20	220
5	8	500	12	120	13	12	500	12	120
6	8	500	12	220	14	12	500	12	220
7	8	500	20	120	15	12	500	20	120
8	8	500	20	220	16	12	500	20	220

Numerical simulation

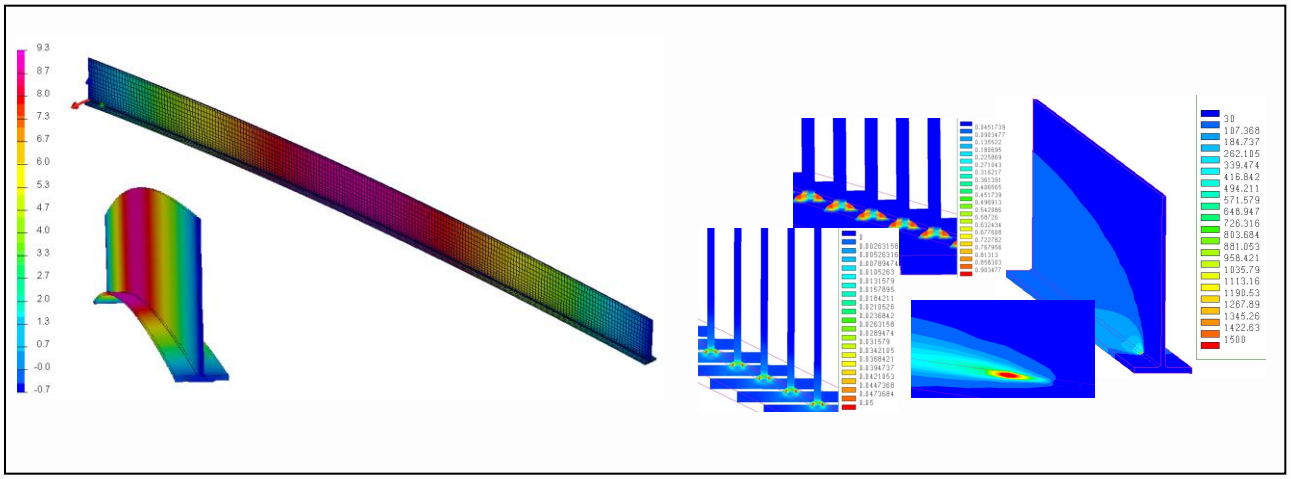
- General thermo-mechanic code
- Thermo-metallurgy coupling
- Sequential thermometallurgy-mechanical calculation
- Elastic-plastic with *kinematic hardening* and *Von Mises* formulation
- Transient calculation
- Material properties changing with temperature and phase

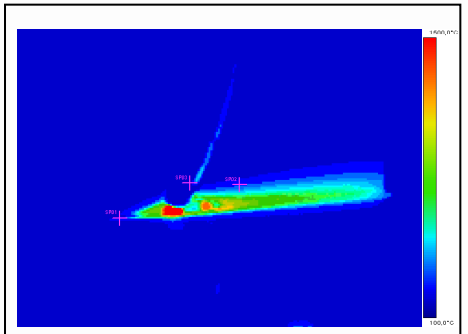
Test 1

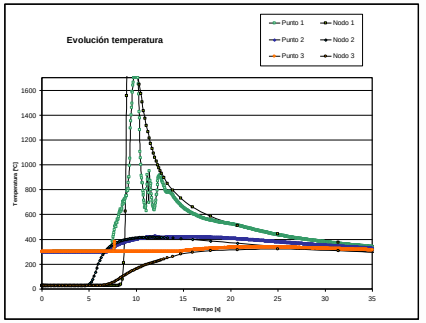
- Geometry: 8x350 – 12x120 – 6000mm
- Heat input: *Goldak* approximation – double sided welding
- Clamp condition: free
- Cooling: convection and radiation



Test 1

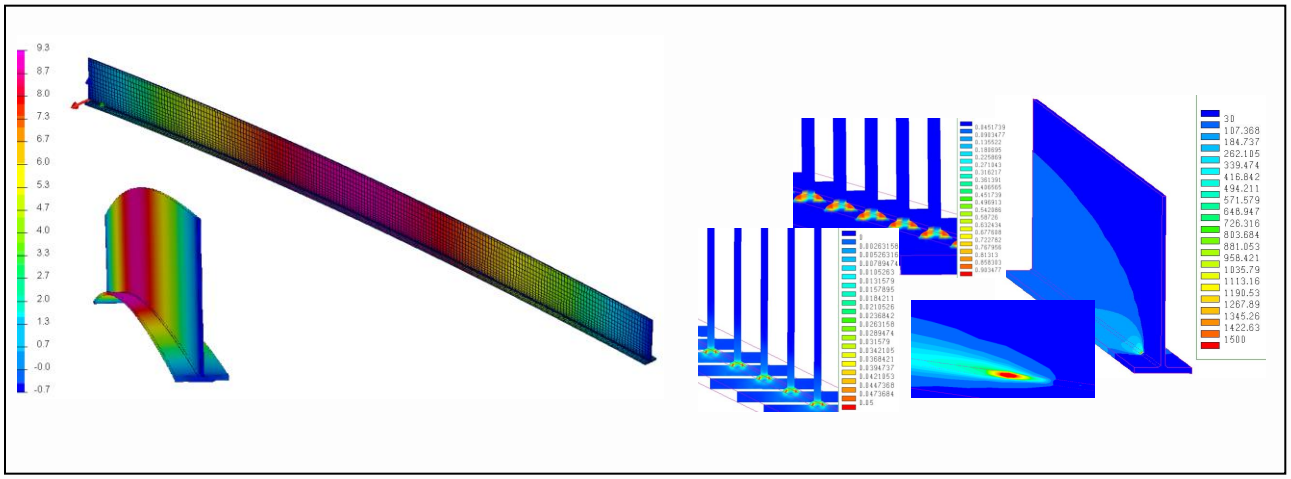


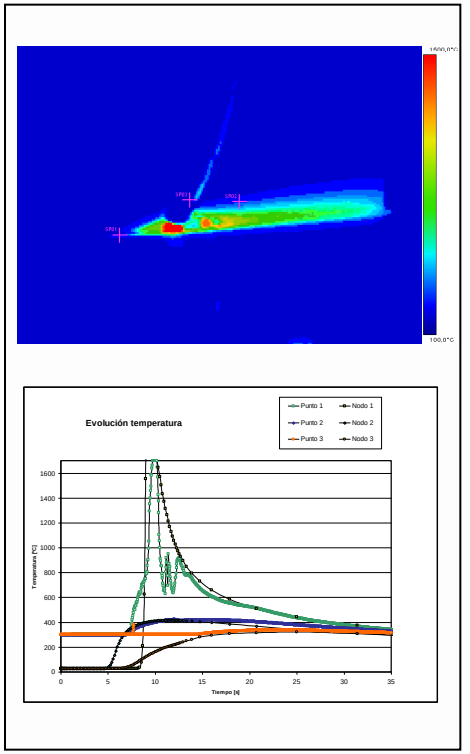




- Solid mesh highly optimized, but dense
- Hexahedral elements, 56000
- Good thermal trend, thermocam validation
- Good trend, saddle shape

Test 1





- Solid mesh highly optimized, but dense
- Hexahedrons elements, 56000
- Good thermal trend, thermocam validation
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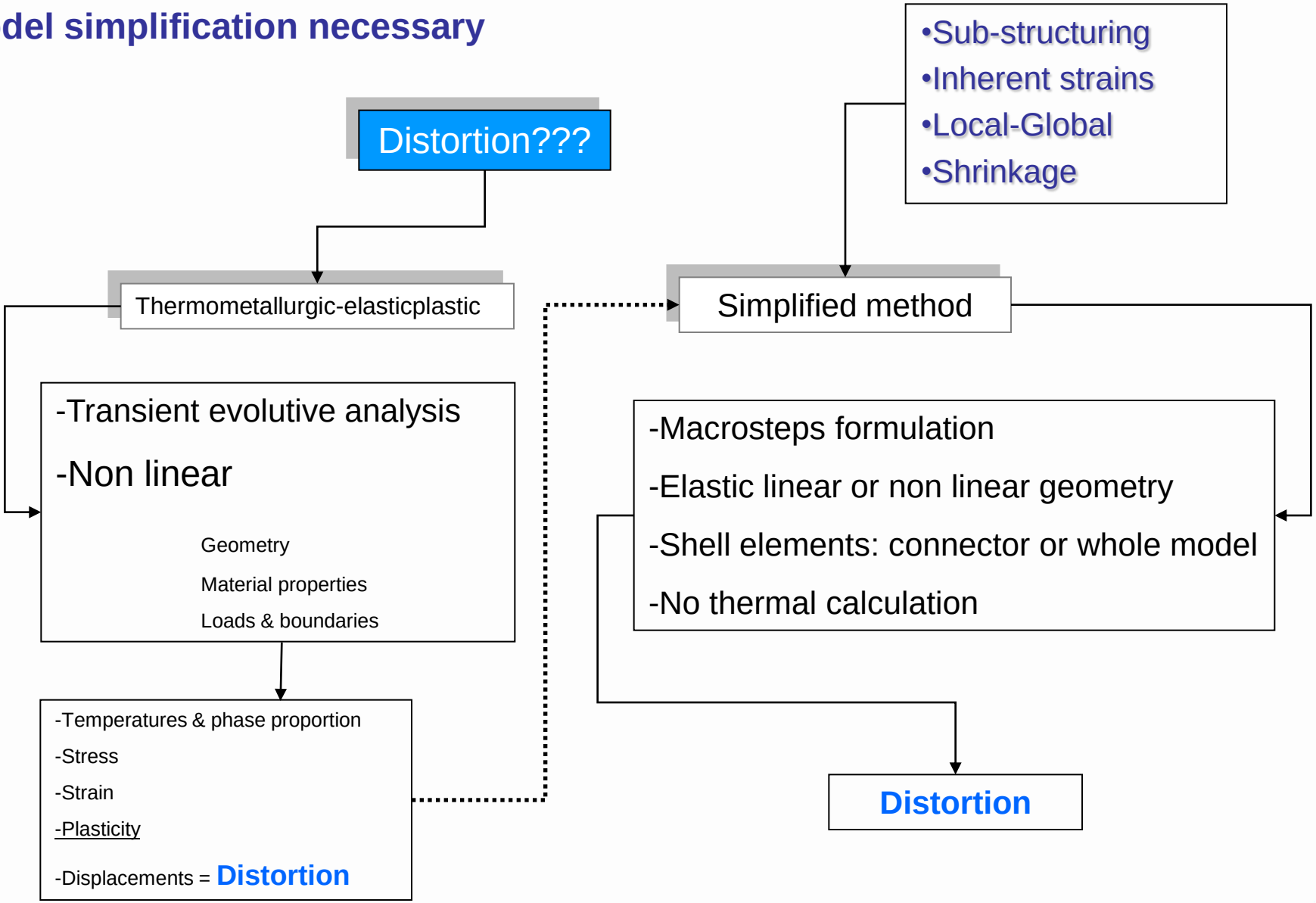
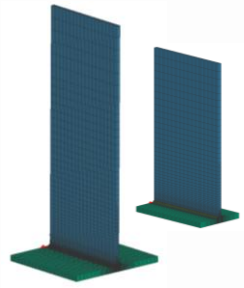
- **Over one week CPUclock¡¡¡**

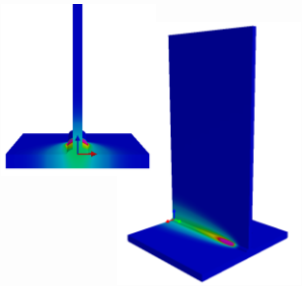
Model simplification necessary



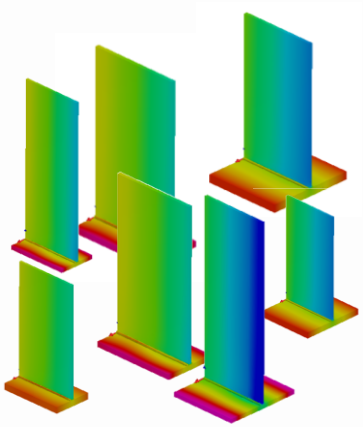
Sequence of modeling



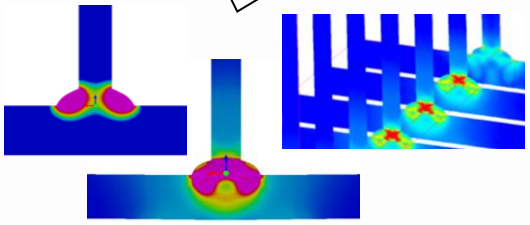
Geometry models for 1-16 cases



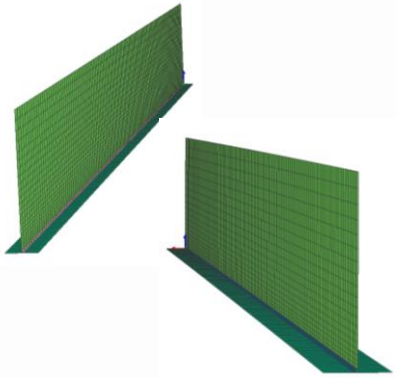
Thermal calculation



Mechanical calculation



Postprocessing

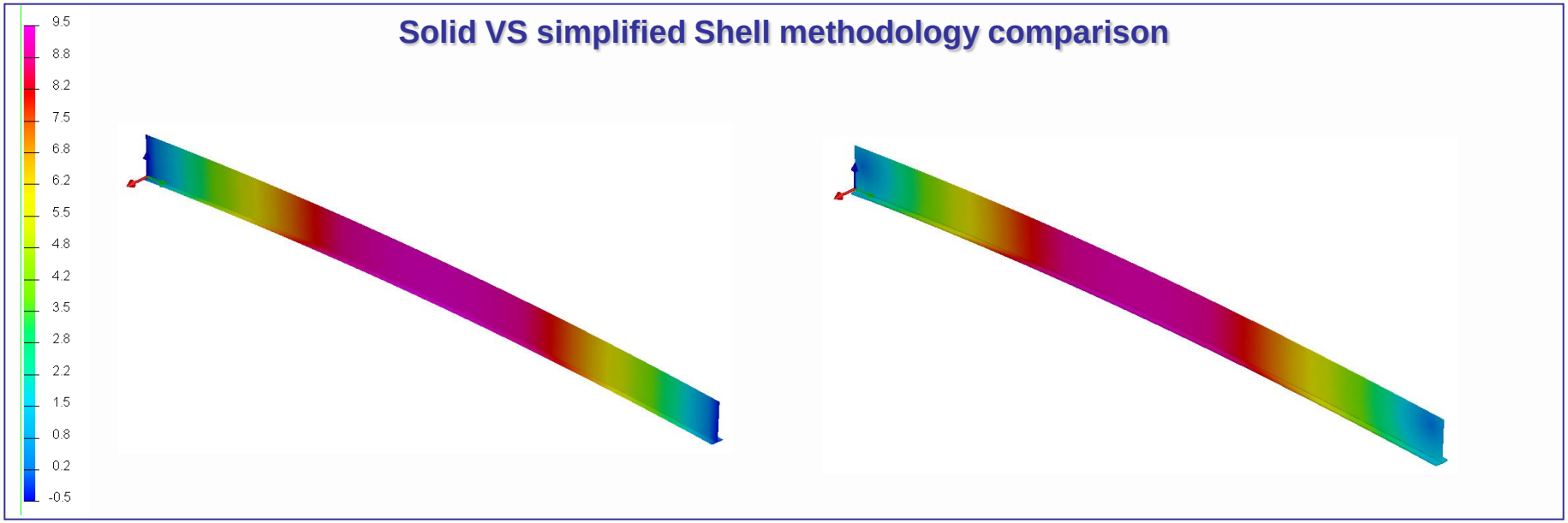


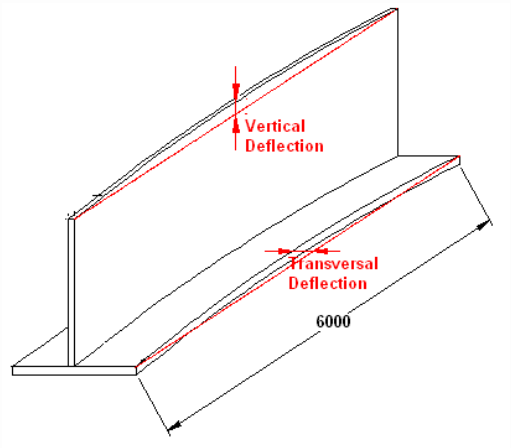
Global geometry models for
4 cases (no-thickness)

Assembly

Calculation

Solid VS simplified Shell methodology comparison





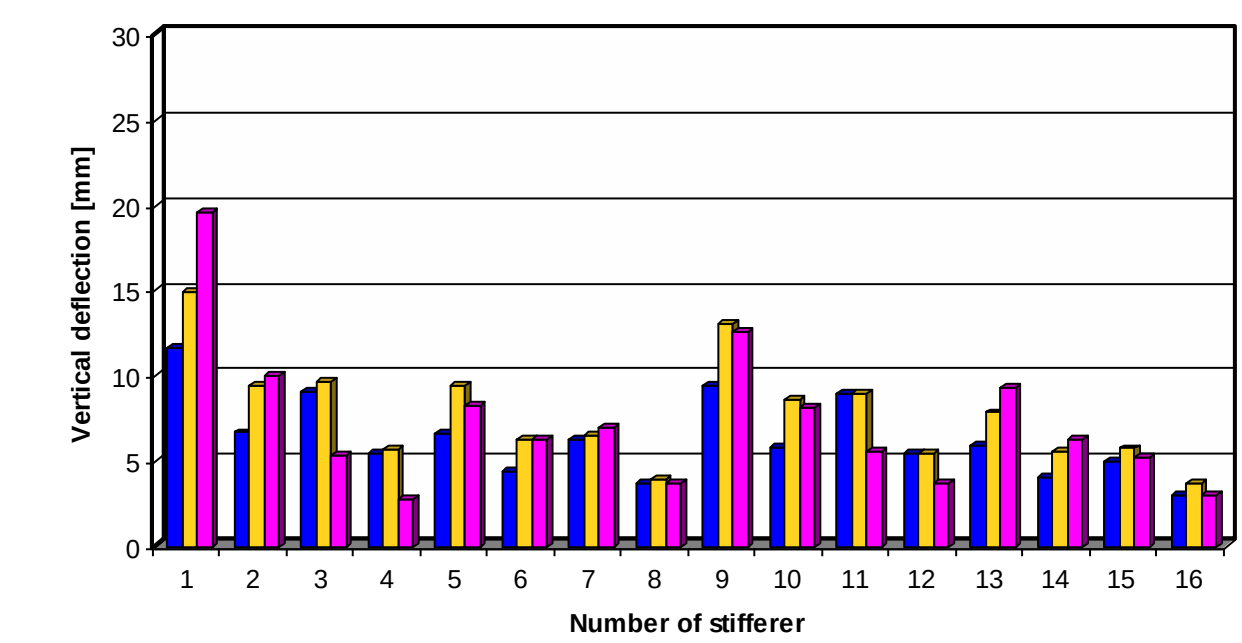
Vertical deflection comparison

- Right Solid, left Shell
- 56000 Vs 5000 elements

Correlation	90%
Computational time saved	115200%

Results

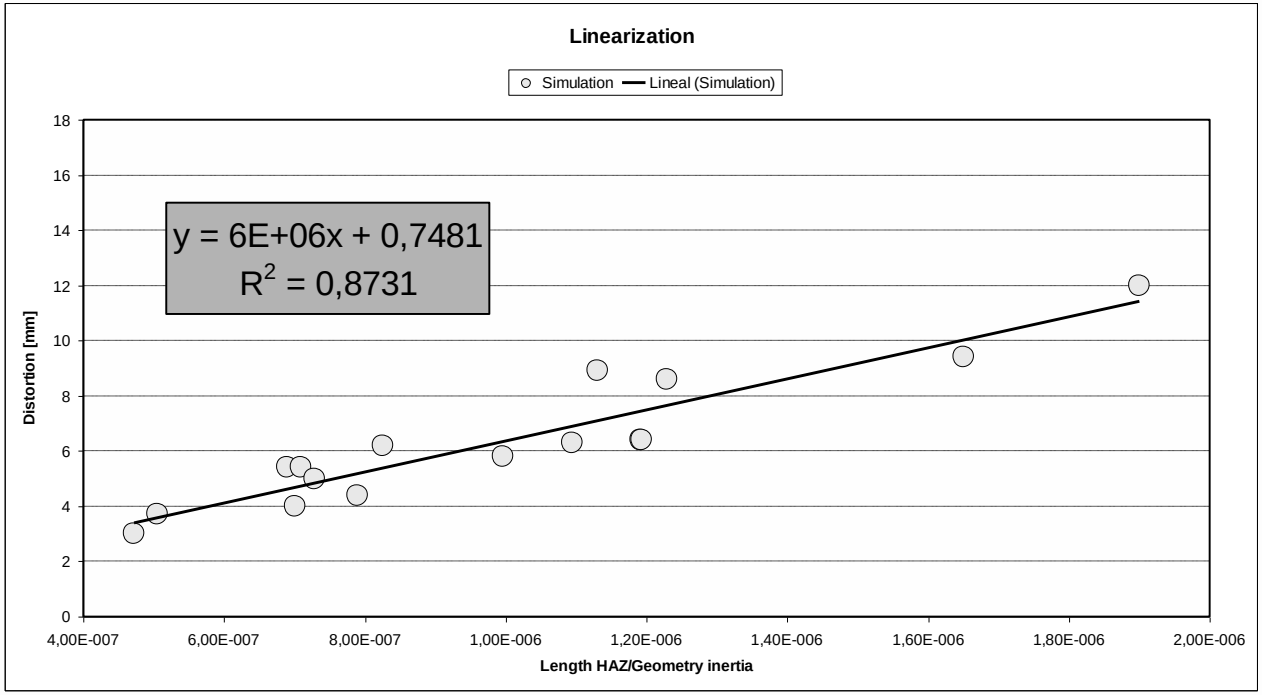
Vertical deflection comparison



$$f = 0.335 * \eta * [\frac{q}{v} * \frac{\alpha}{pc} * \frac{y}{J} * \frac{L^2}{8}]$$

Results

Vertical deflection linearization

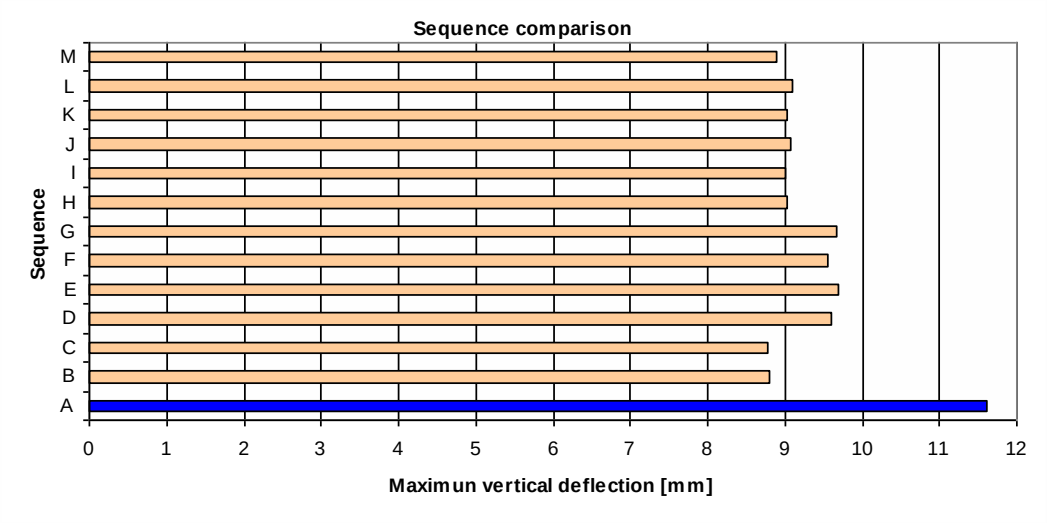


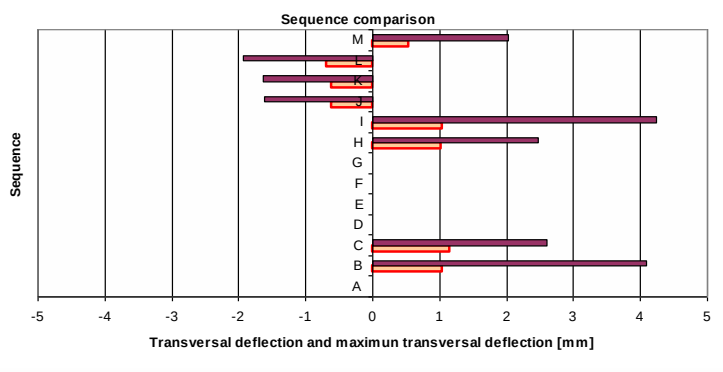
Okerblom model

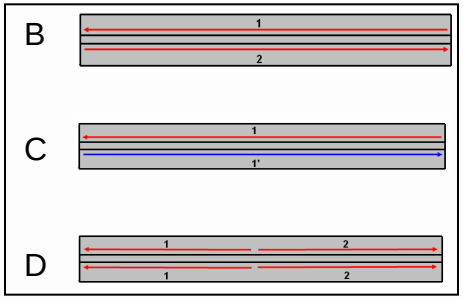
$$f = Q\frac{y}{J}$$

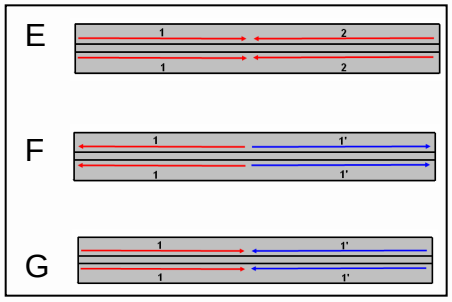
Sequence results

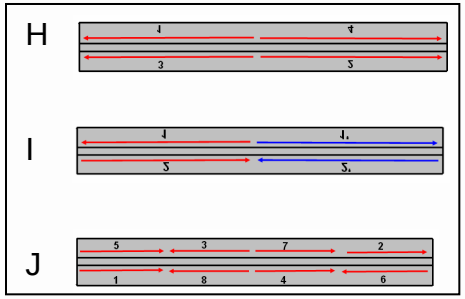
Deflection comparison

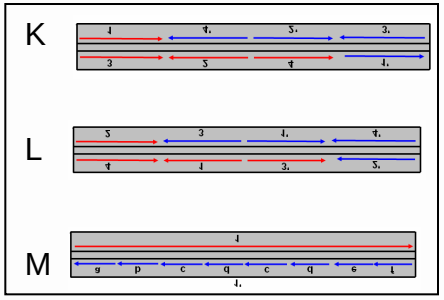












Conclusions

1.- After the performed studies, the selected mathematical models can get the distortion's effect in a right way.

2. – The complex model can not be used in big assemblies due to high time of computation.

3.- Due to economization of time, a simplified method is used. Their accuracy after calibrations is good and it become useful with their low time of computation.

4.- The results compared, under the fixed conditions, shows a great agreement between three methodologies. The trends are similar showing a good behaviour.

5.- The Okerblom analytical model shows a great performance but it is limited to simple joints.

6.- Sequence study is possible in simulation methodology.

7.- Simultaneous welding is useful because it improves the time process.

8.- The welding with a bead in continuous reverse welding is a better choice, showing less vertical deflection, low transversal deflection as well as easy and quickly process for two welders.

Thank you
for your
attention