CAE in Carbody Manufacturing

Experience Based Q.A to Simulation Based Q.A

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▣ Contents

I. Overview

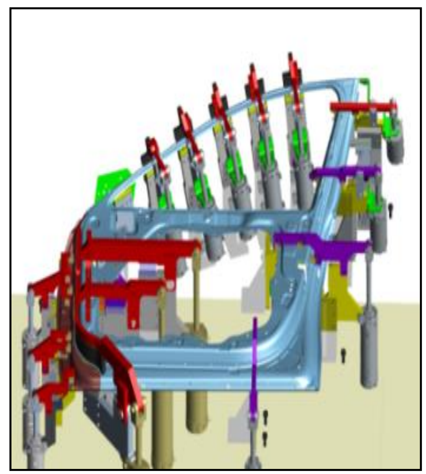
- We can guess a deformation of sheet metal during assembly(joining) process.
- Nevertheless, generally deformation of sheet metal is very hard to predict in design stage.
- Using CAE TOOLS we want to develop a process that can predict deformation and based on result optimizing assembly plan.

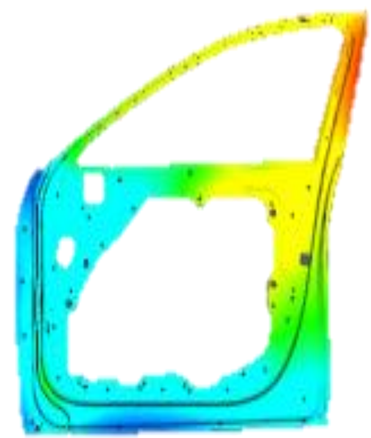
As – Is

▣ Take a 3~4 times T/O in Q.A Process

To – Be

▣ Predicting deformation in design stage
Reducing T/O cost, Build a best production plan

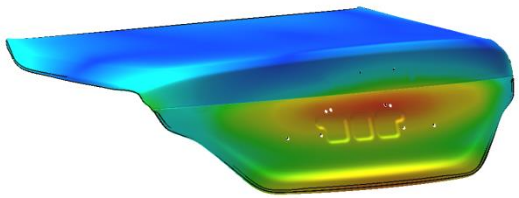

<Clamp Locations>

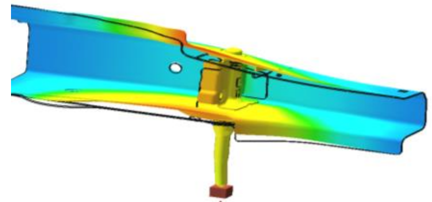

<Simulation Result>

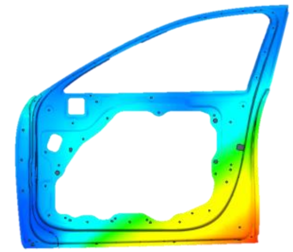
I. Overview

Part A. Practical Case

- Cases that apply in real parts (Roof, T/LID, DOOR, MEMBER

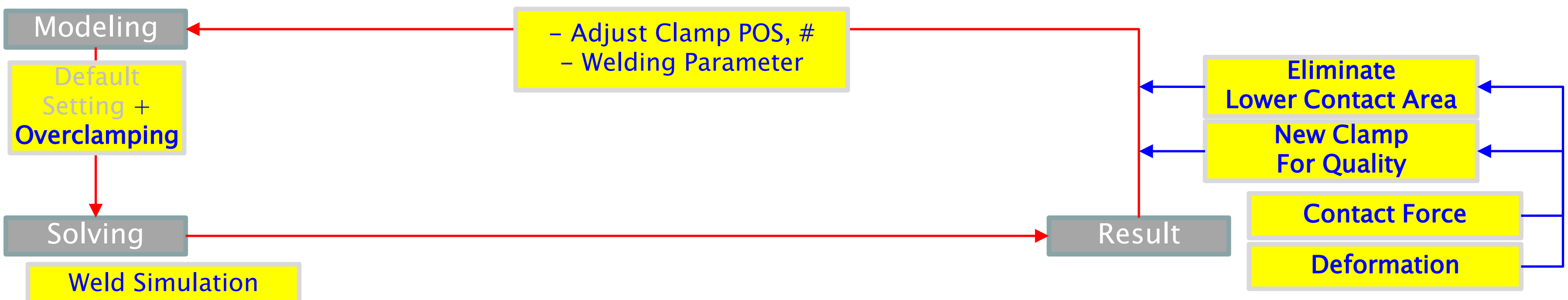




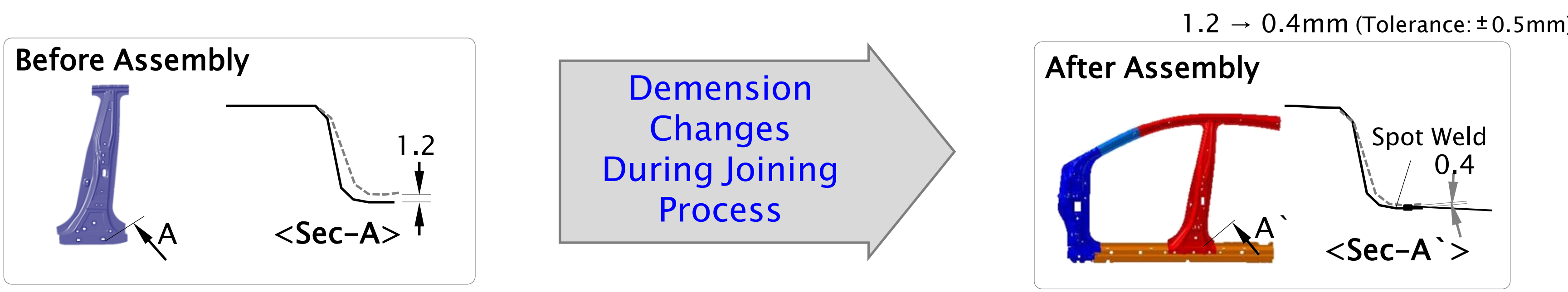


Part B. Clamp Optimization Development

- Developing algorithm to optimize # of clmap, location



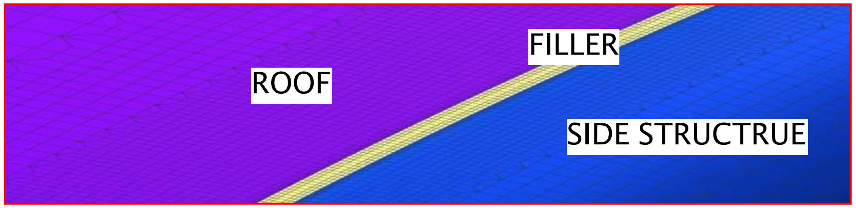
Part C. Future Plan



II. Practical Case in Welding Simulation

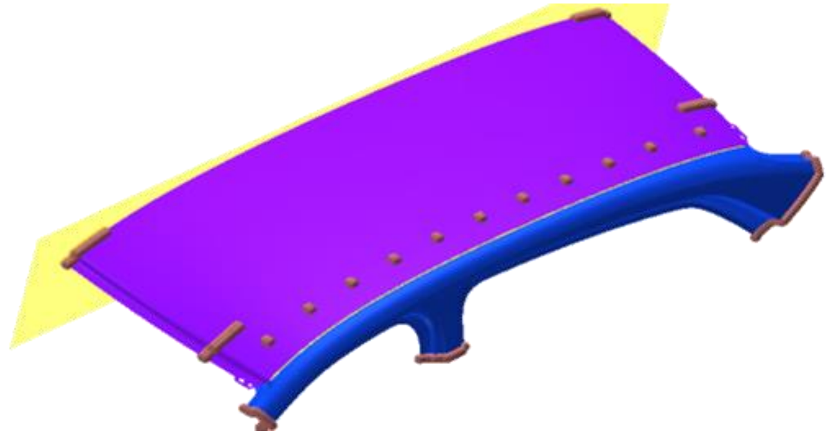
1) Roof LASER Brazing

- Building a Model

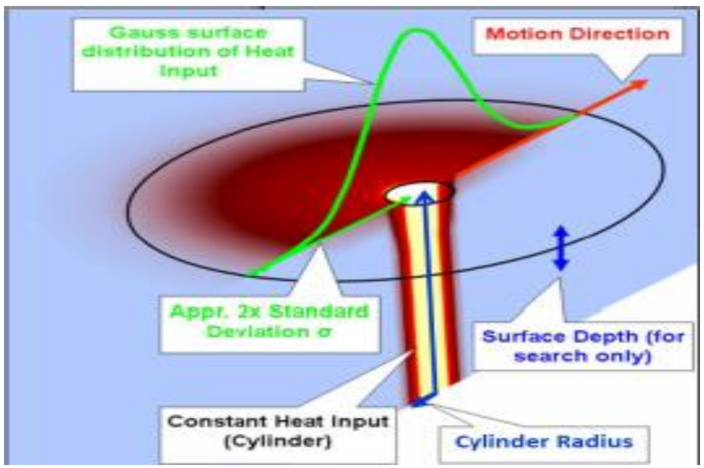


PART	MATERIAL	THICK.	TYPE OF MESH	# OF ELEM
ROOF	-	0.8t	SOLID SHELL	80,866
FILLER	-	0.7t		64,288
S/STRUCT	-	n/a		18,148
Total				163,302

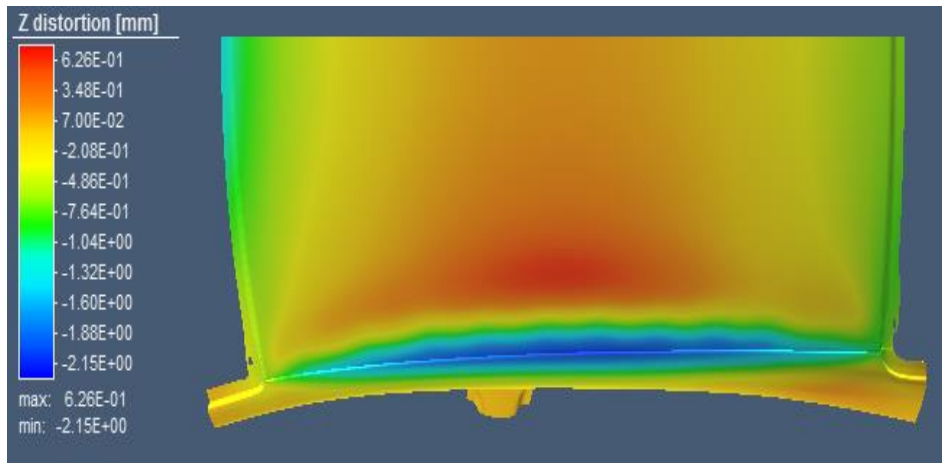
- Solve using Symmetry model



- Heat Source



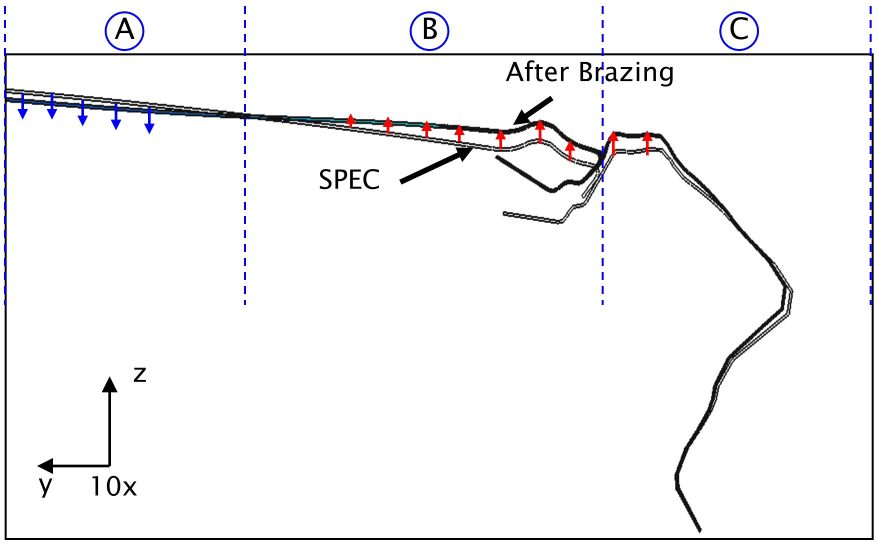
- Result



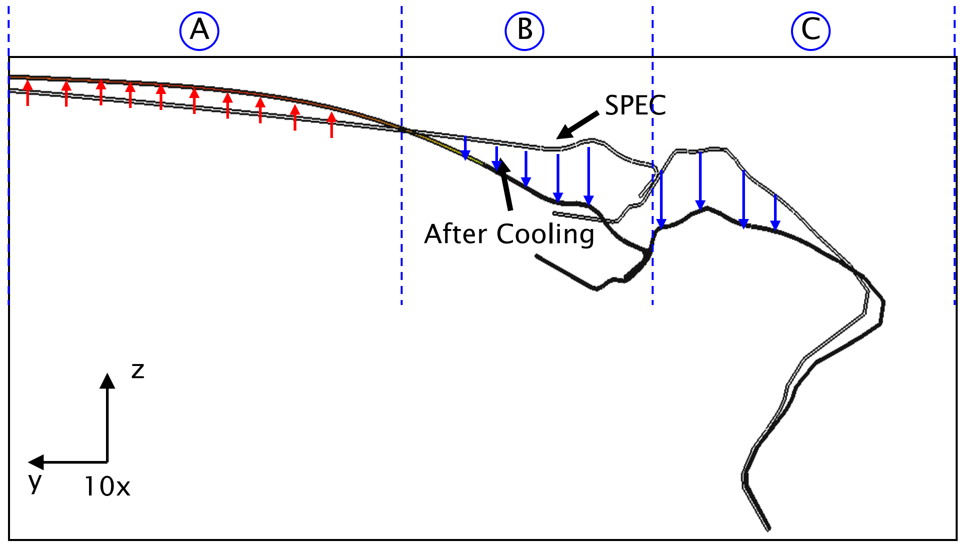
II. Practical Case in Welding Simulation

1) Roof LASER Brazing

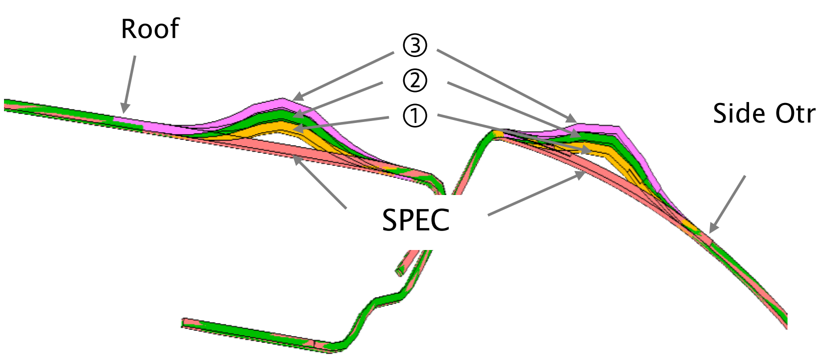
- Brazing Stage



- Cooling Stage



- There are big difference between Brazing and Cooling

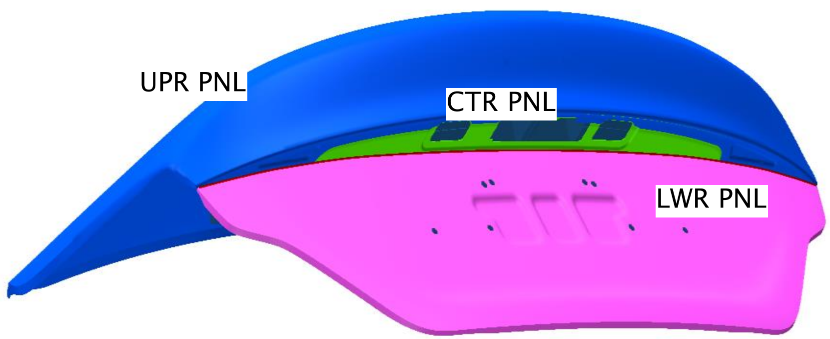


- Add a forming shape on roof
  We can get a more fine result

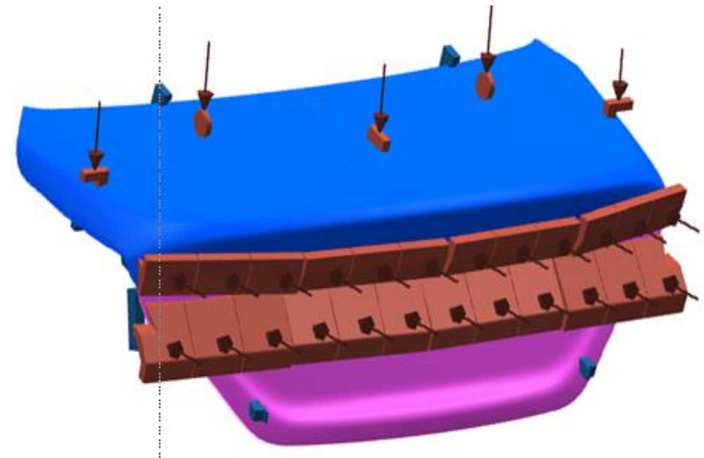
II. Practical Case in Welding Simulation

2) T/LID LASER Brazing

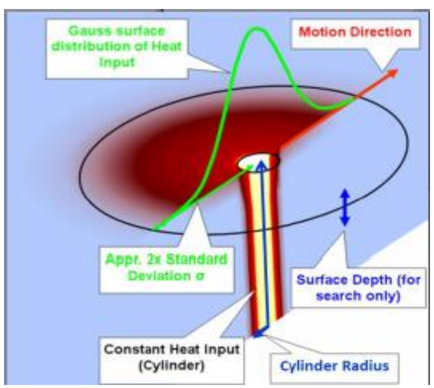
- Building a Model

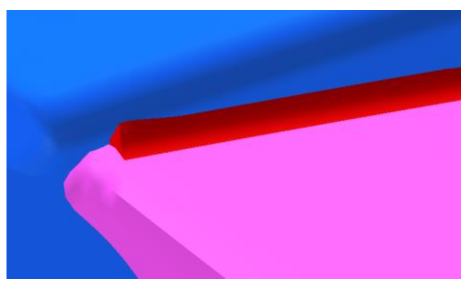


- Solve using full model

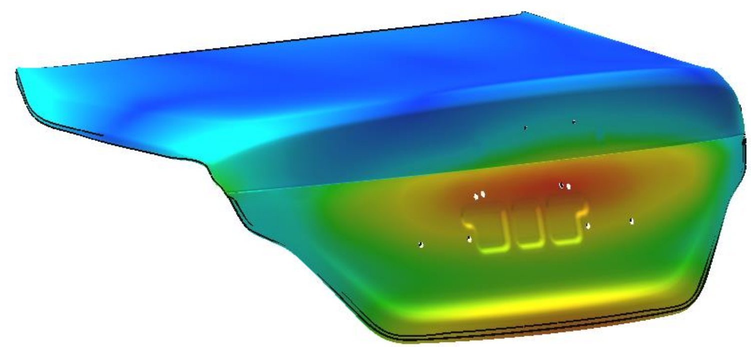


- Heat Source and weld bead





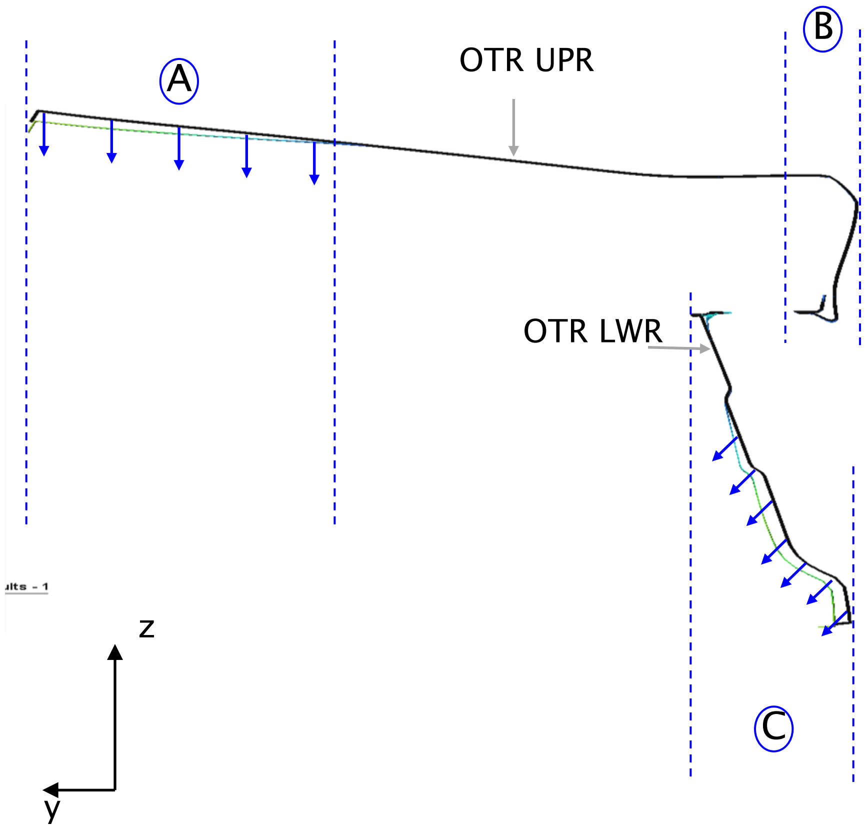
- Result



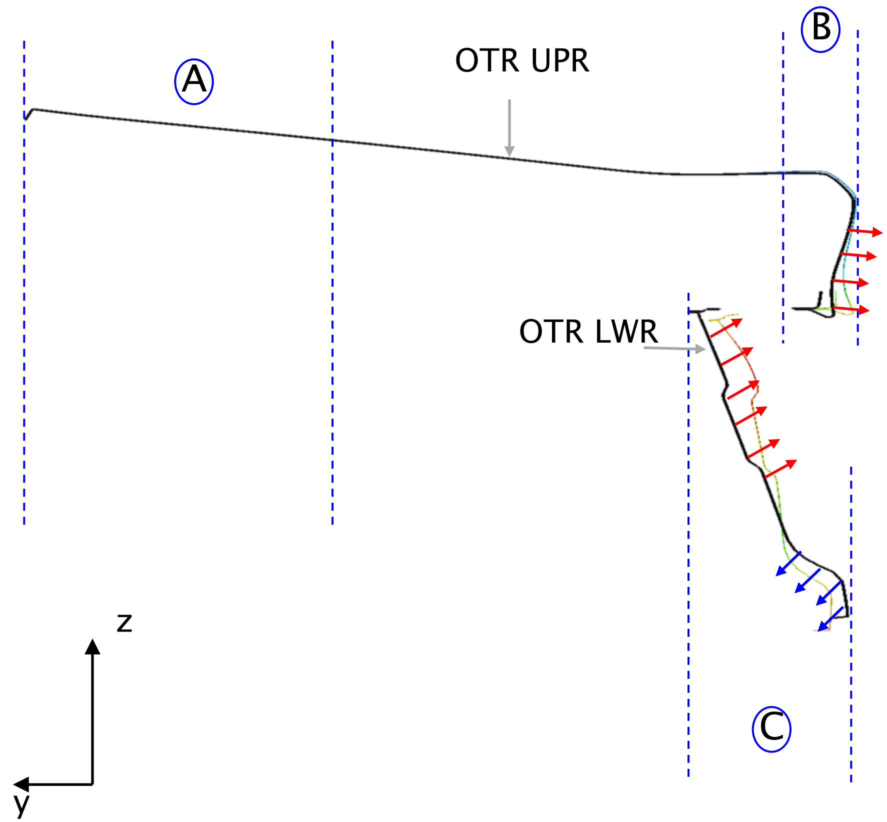
II. Practical Case in Welding Simulation

2) T/LID LASER Brazing

- Brazing Stage



- Cooling Stage

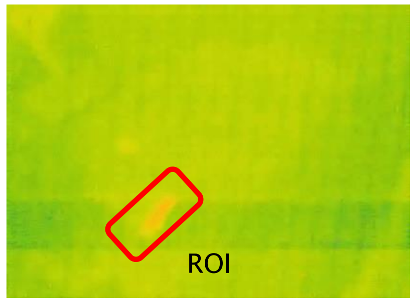


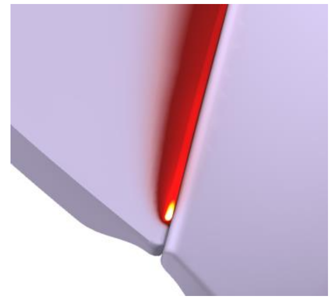
- There are big difference between Brazing and Cooling

II. Practical Case in Welding Simulation

2) T/LID LASER Brazing

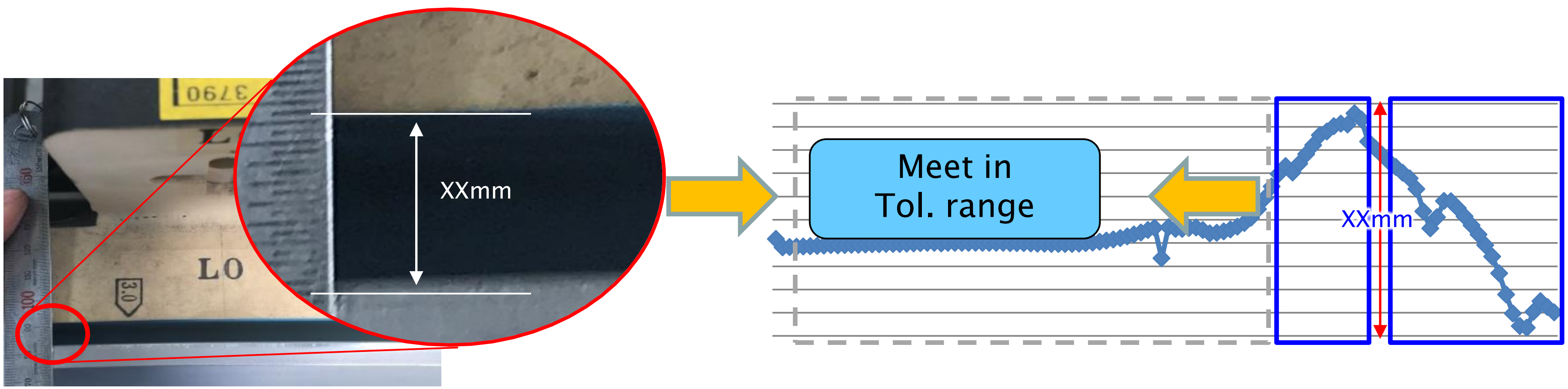
- Check accuracy by measuring temperature using thermal camera





-	Temp. Range
In-line	900 ℃ ~ 1100℃
CAE	1100 ℃ ~ 1300℃

- Check deformation using gauges.

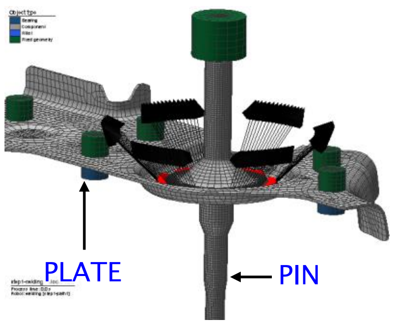


II. Practical Case in Welding Simulation

3) Sub Frame CO2 Weld

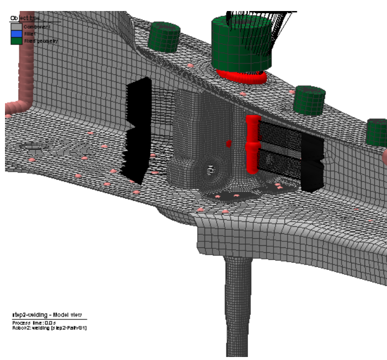
- 2-Step Welding Process

  - Step 1 : Plate + Pin Welding



Part	Material	Thick	Elem #
PLATE	-	2t	4,636
PIN	-	20Φ	22,632
CO2	-	5mm	756
Total			28,024

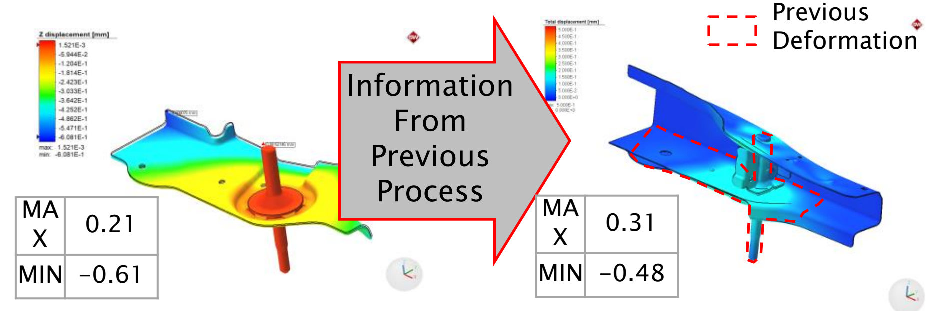
  - Step 2 : Member + Brkt Welding



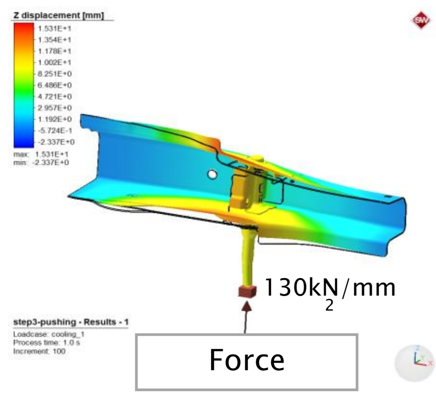
Part	Material	Thick	Elem #
MEMBER	-	1.6t	12,306
BRKT	-	2t	10,651
UPR BRKT	-	2t	1,766
Total			24,723

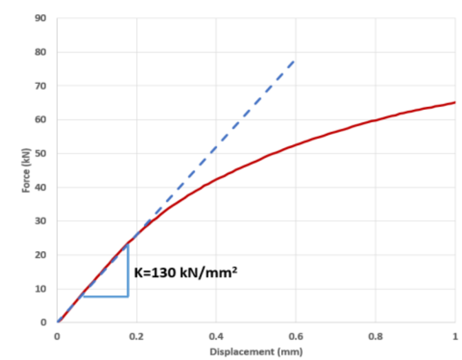
- Consecutive Simulation

  - Step 1
  - Step 2



- Simple Stiffness Test

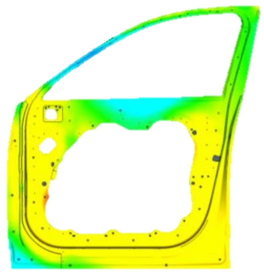
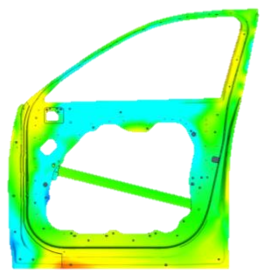
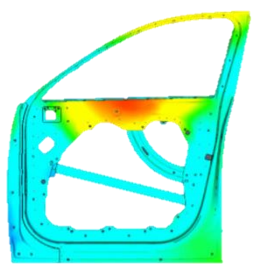




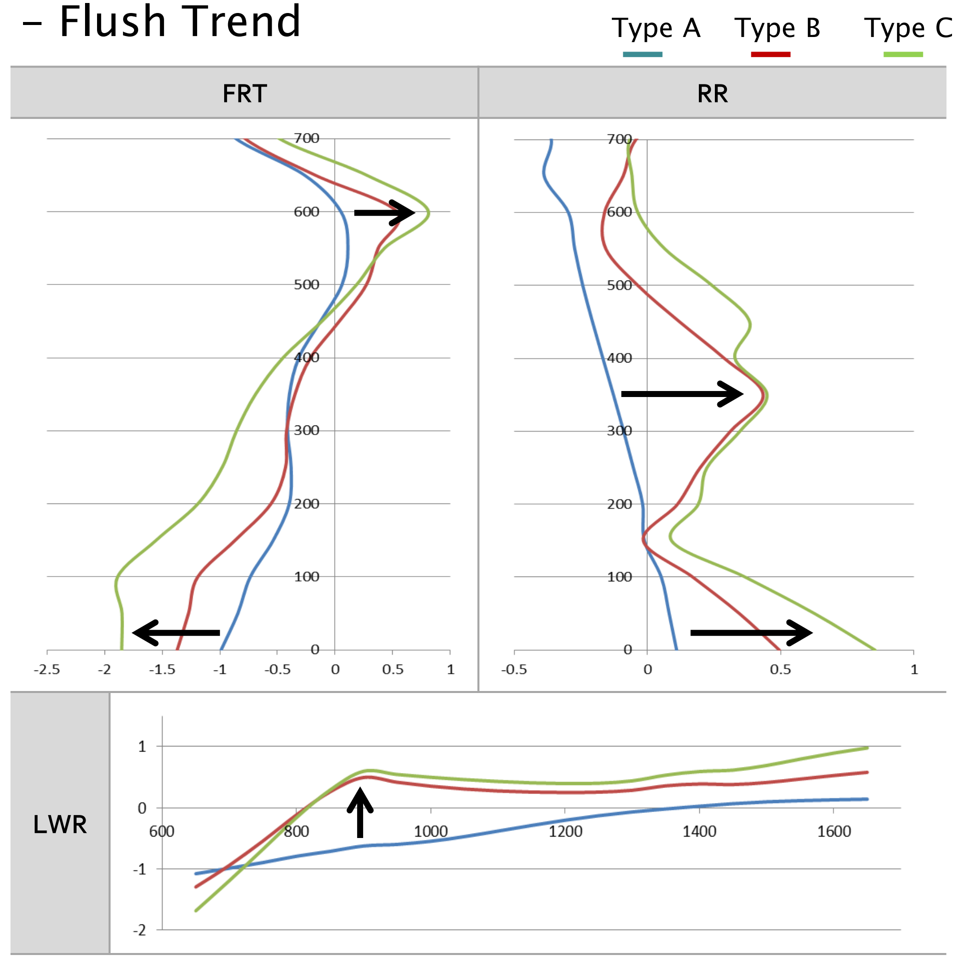
II. Practical Case in Welding Simulation

4) Door Inr LASER weld

– Weld Type Study

Type A	
Type B	
Type C	

– Flush Trend

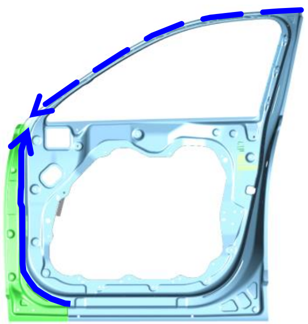


– Full path Laser weld, Stitch Laser weld, Laser weld with filler and without filler

II. Practical Case in Welding Simulation

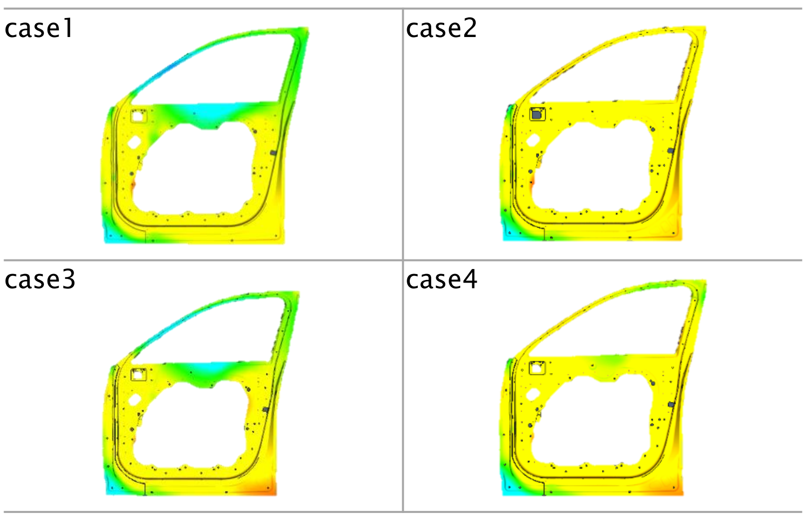
4) Door Inr LASER weld

- Weld Path Study

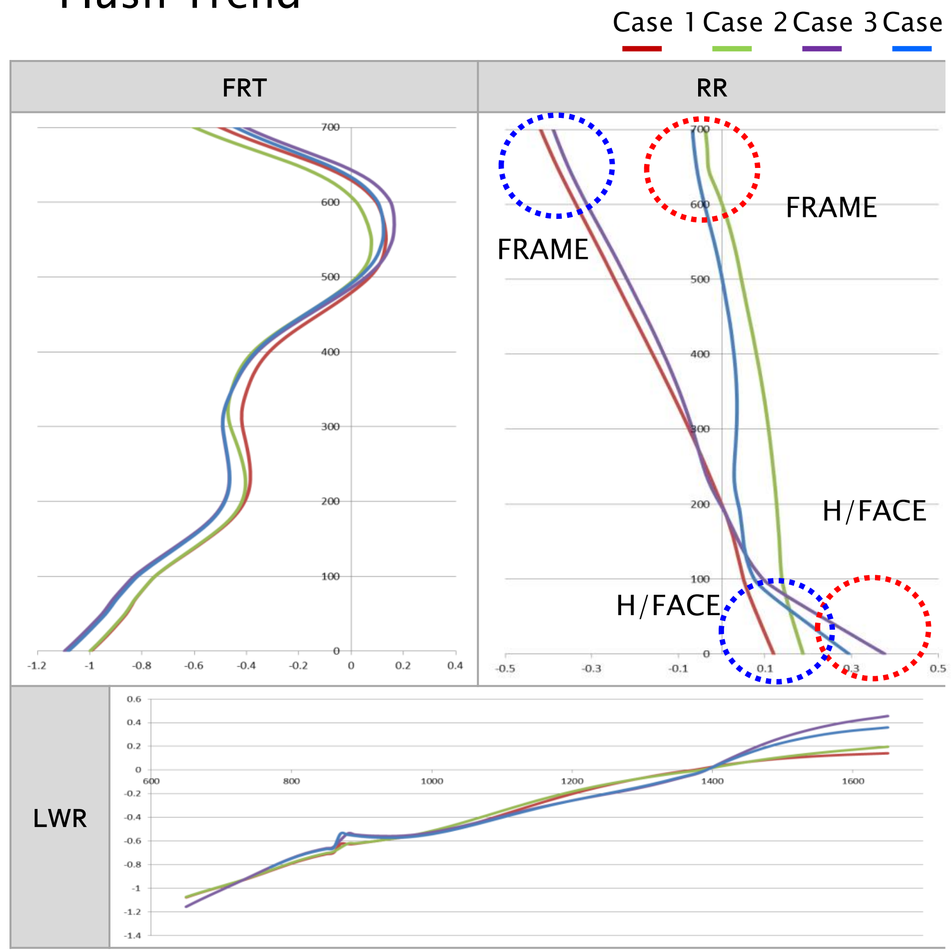


	H/FACE	FRAME
Case 1	Normal	Normal
Case 2	Normal	Reverse
Case 3	Reverse	Normal
Case 4	Reverse	Reverse

- Result



- Flush Trend

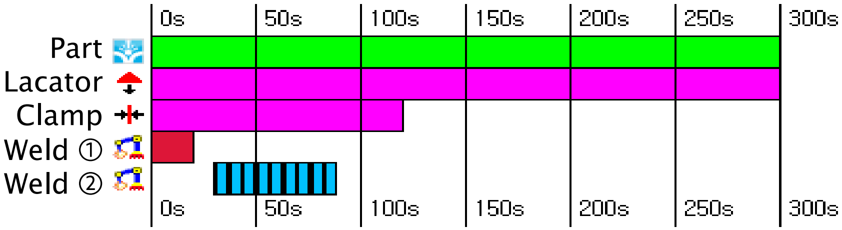


- Deformation caused by weld path, RR area has very different trend

II. Practical Case in Welding Simulation

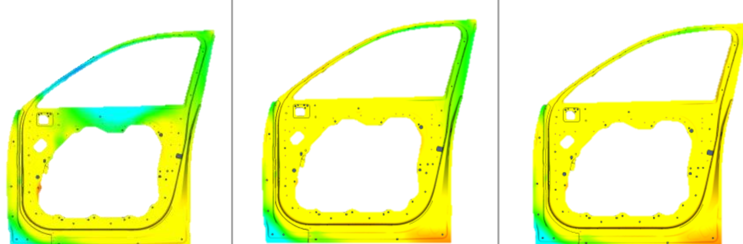
4) Door Inr LASER weld

– Clamping Time Study

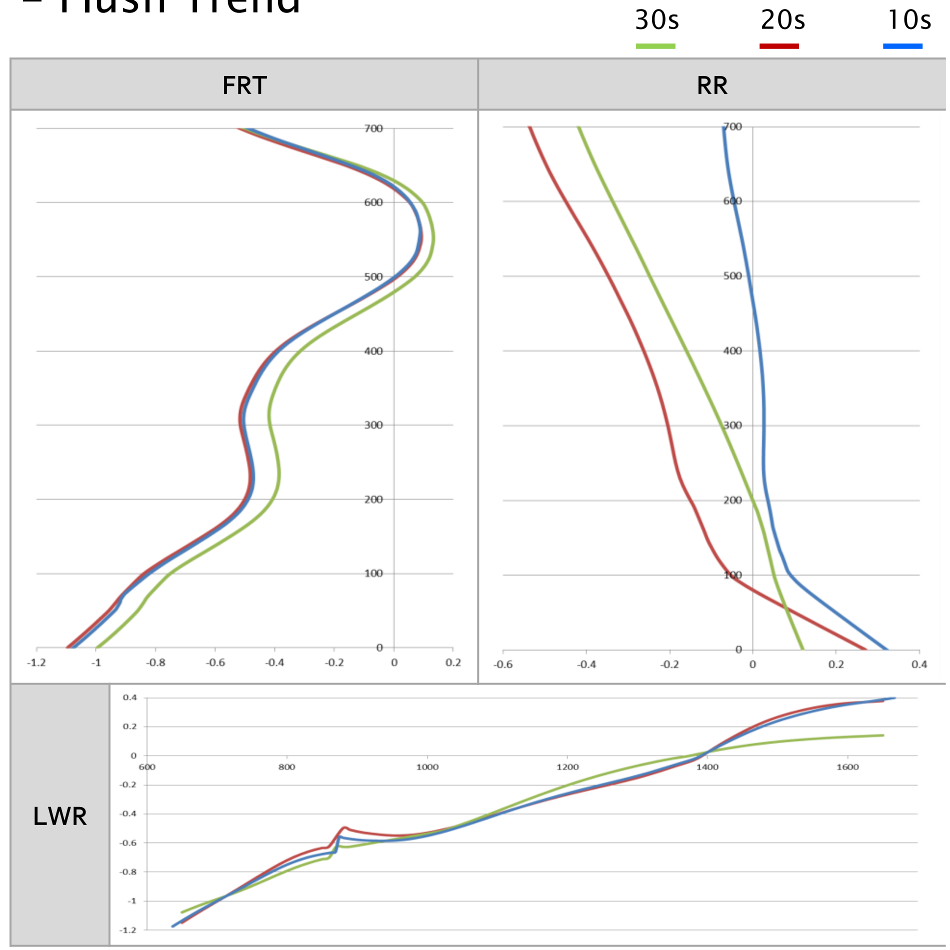


– Result

Case1 (30s)	Case 2 (20s)	Case 3 (10s)



– Flush Trend

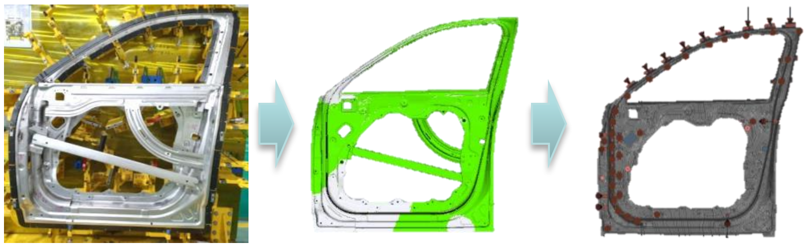


– Unclamp after welding, 30s, 20s, 10s / RR area has different trend

II. Practical Case in Welding Simulation

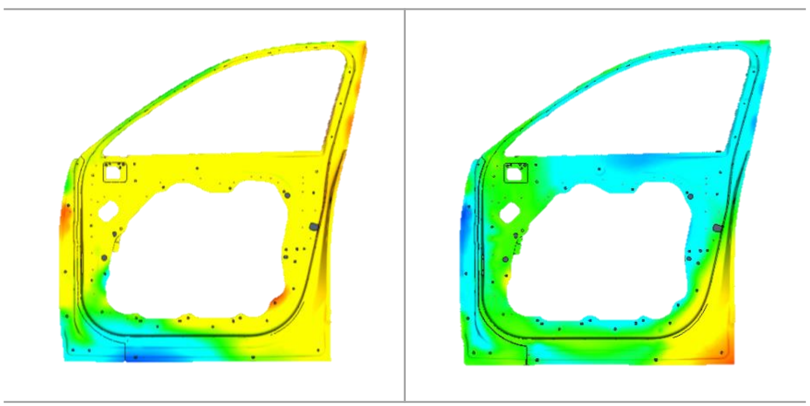
4) Door Inr LASER weld

- Real Part Based Morphing

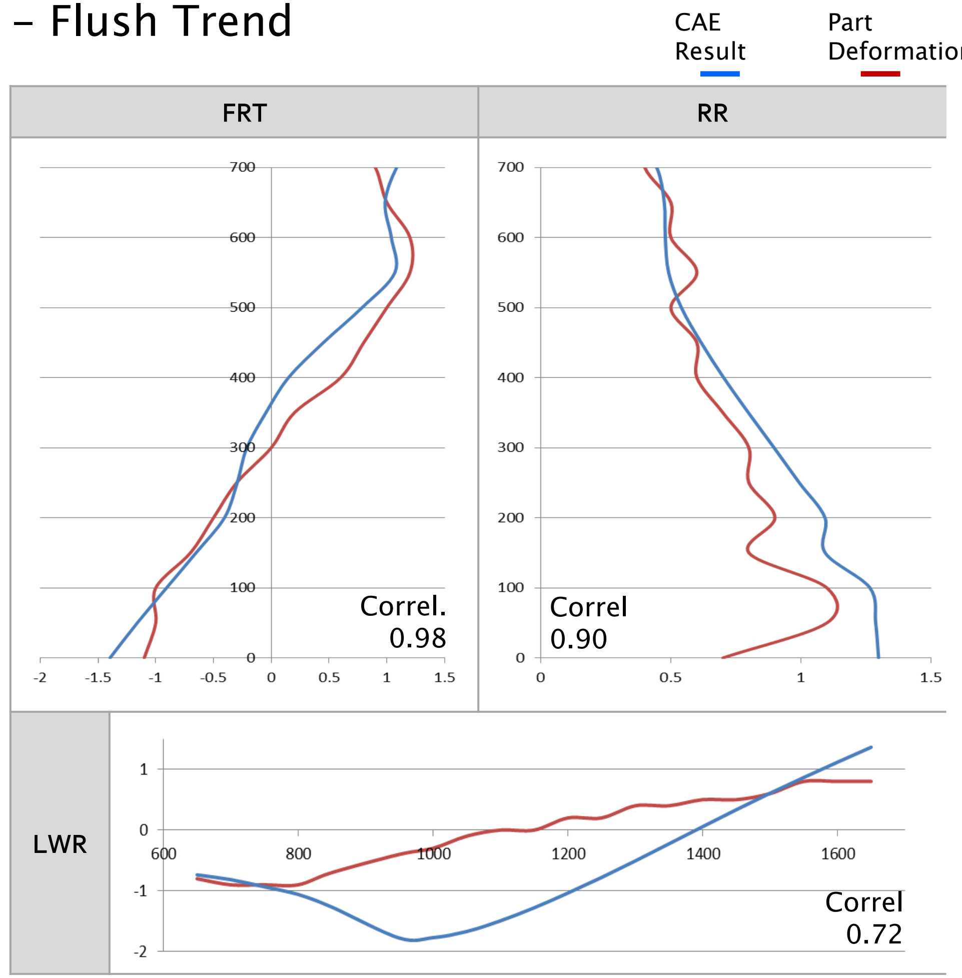


- Measurement Based Morphing (Developed with BETA CAE) → Implemented in ANSA v19~
- Can apply any measurement DATA

- Result



- Flush Trend



With morphed data, compare between CAE result and Real Part Deformation.

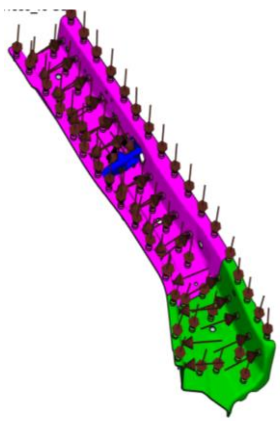
III. Clamping Optimization Development

1) Concept

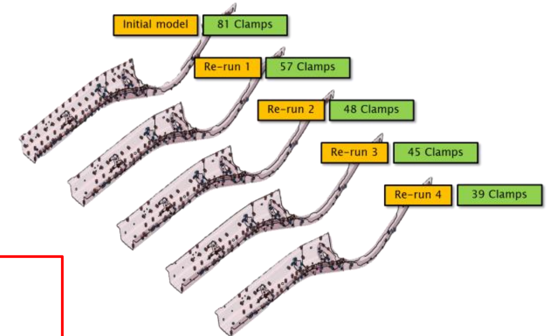
– Welding Process Optimization

Modeling

Default Setting
+
Overclamping



– Adjust Clamp Position, #
– Welding Parameter



Eliminate Lower Contact Area

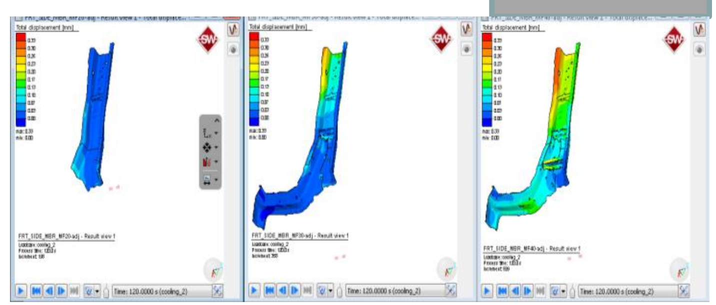
New Clamp For Quality

Iteration
For
Best Process

Solving

Weld Simulation

Result



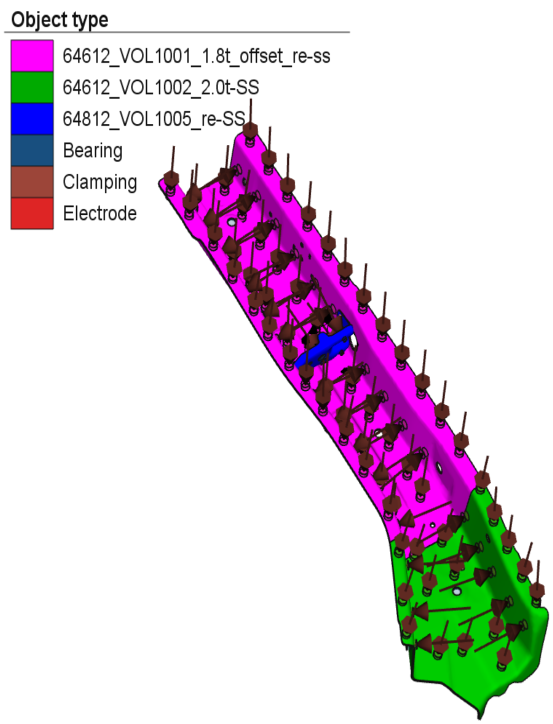
Contact Force

Deformation

III. Clamping Optimization Development

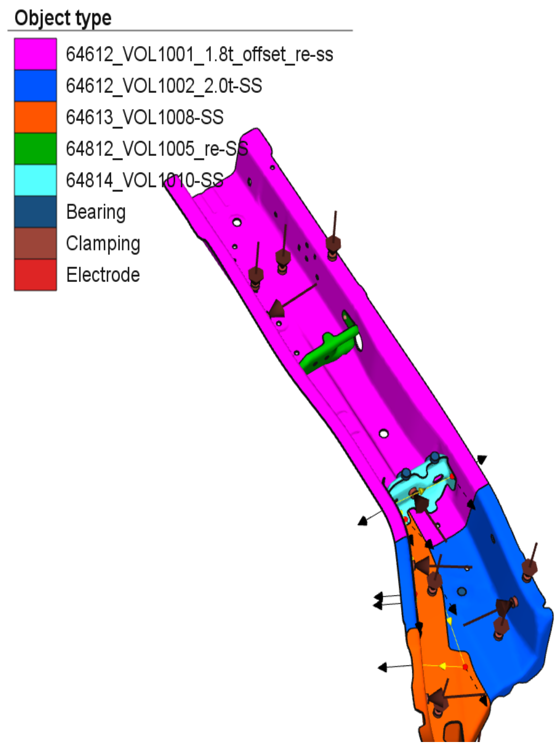
2) BASE MODEL

MF20



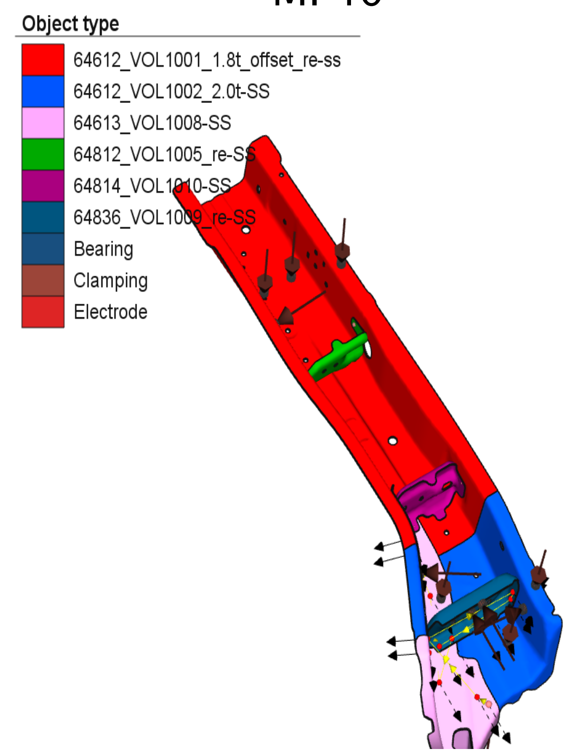
- 3 Parts
- 99 bearings
- 94 clamps
- 0 local joint
- 4 Spots
- Size: 13460 Elements

MF30



- 5 Parts
- 29 bearings
- 18 clamps
- 1 local joint
- 8 Spots
- Size: 24076 Elements

MF40

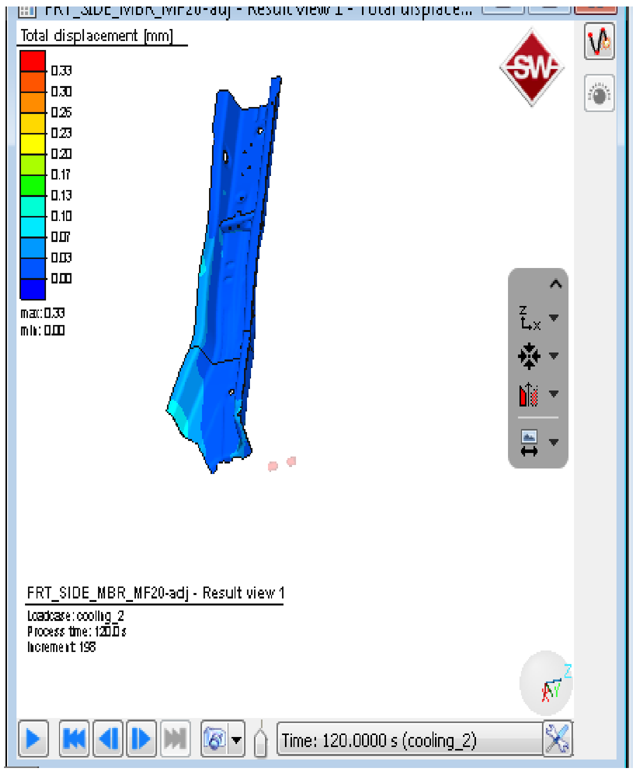


- 6 Parts
- 23 bearings
- 17 clamps
- 1 local joint
- 14 Spots
- Size: 25481 Elements

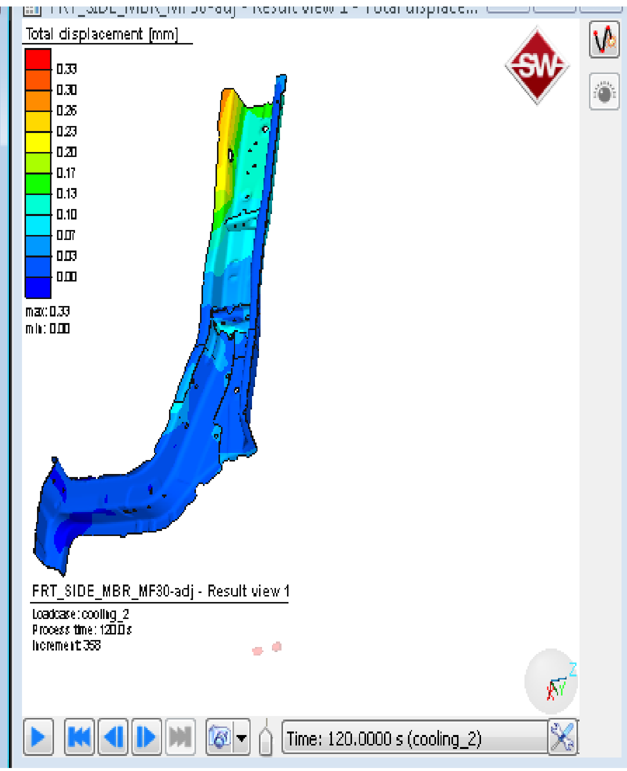
III. Clamping Optimization Development

2) Result of Base Model

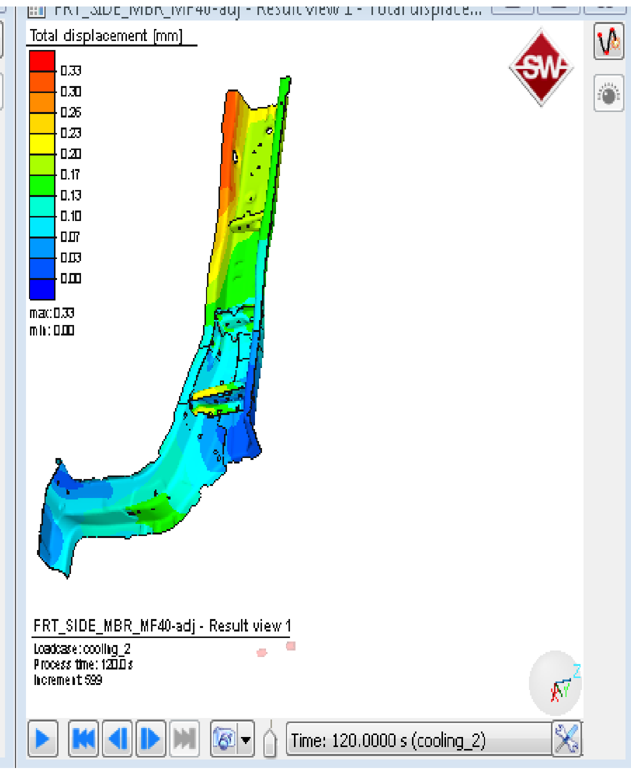
MF20



MF30



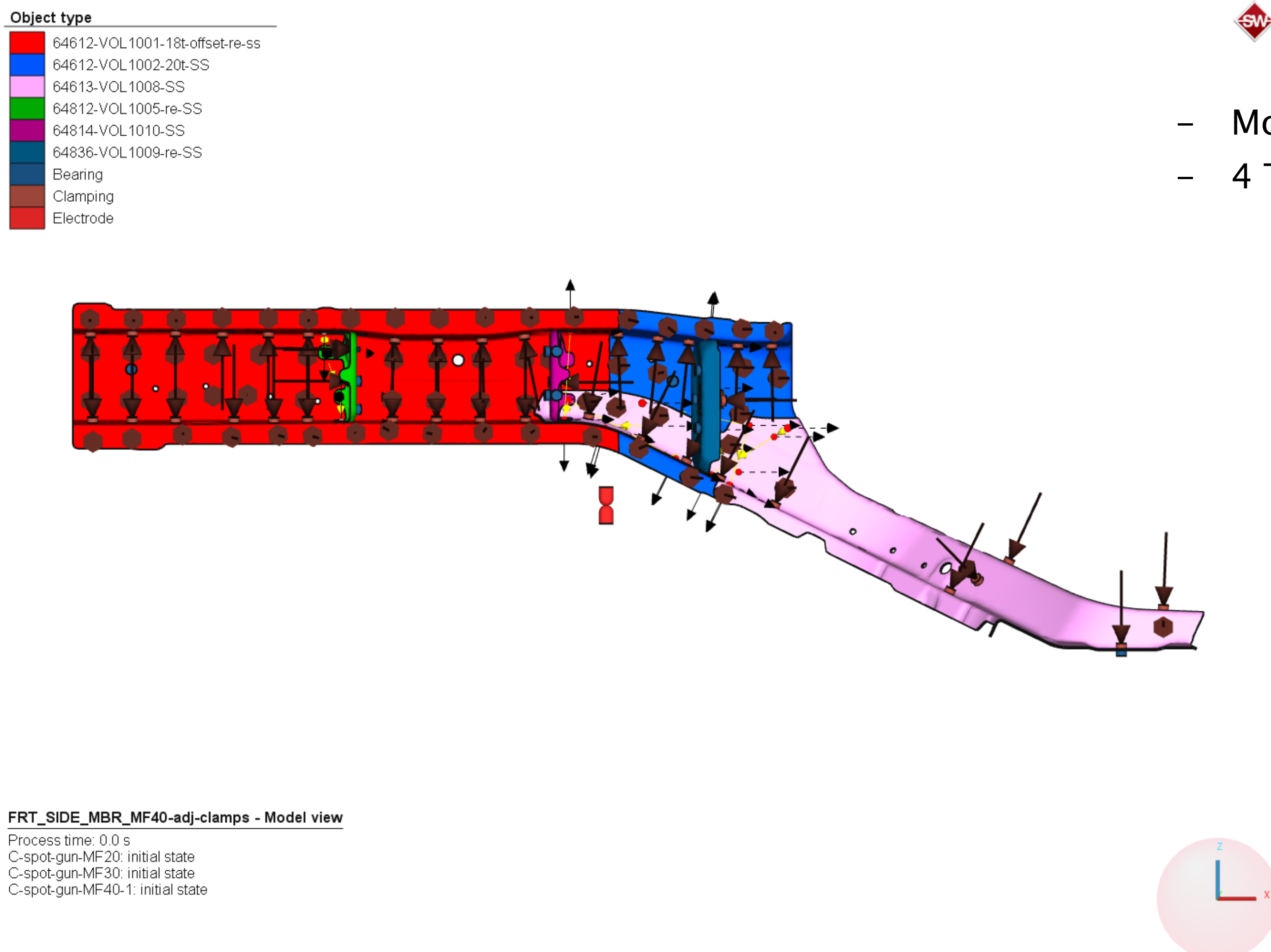
MF40



III. Clamping Optimization Development

4) Overclamped Model

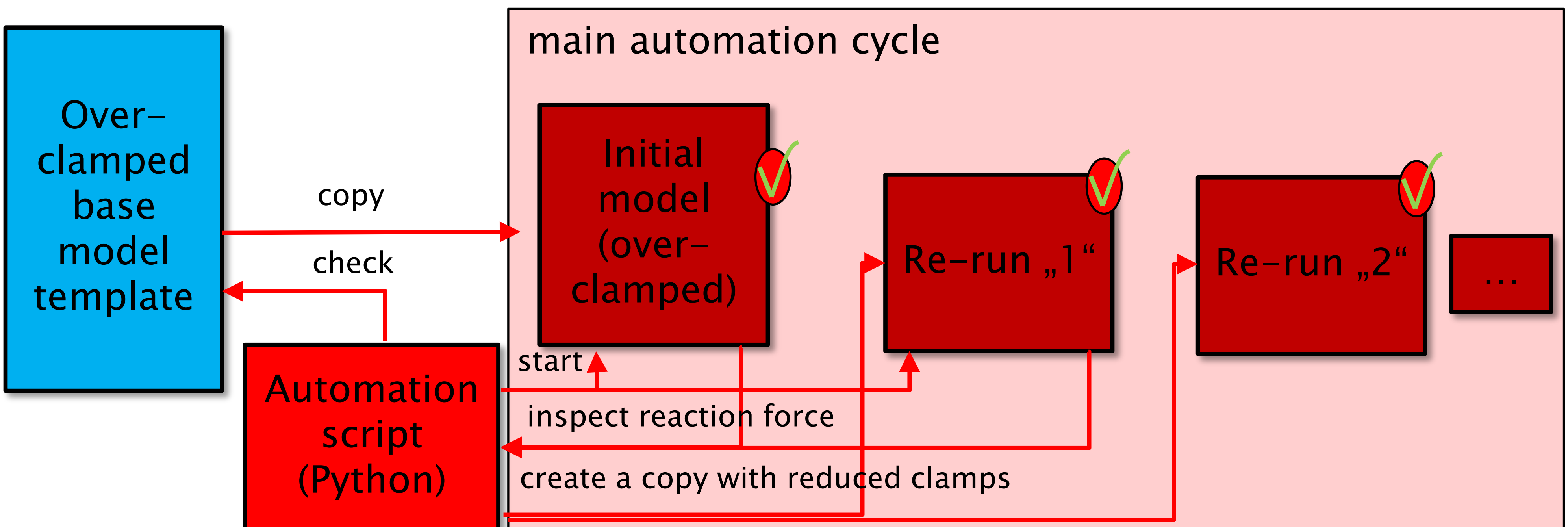
- More Than 81 Clamps
- 4 Tooling Holes



III. Clamping Optimization Development

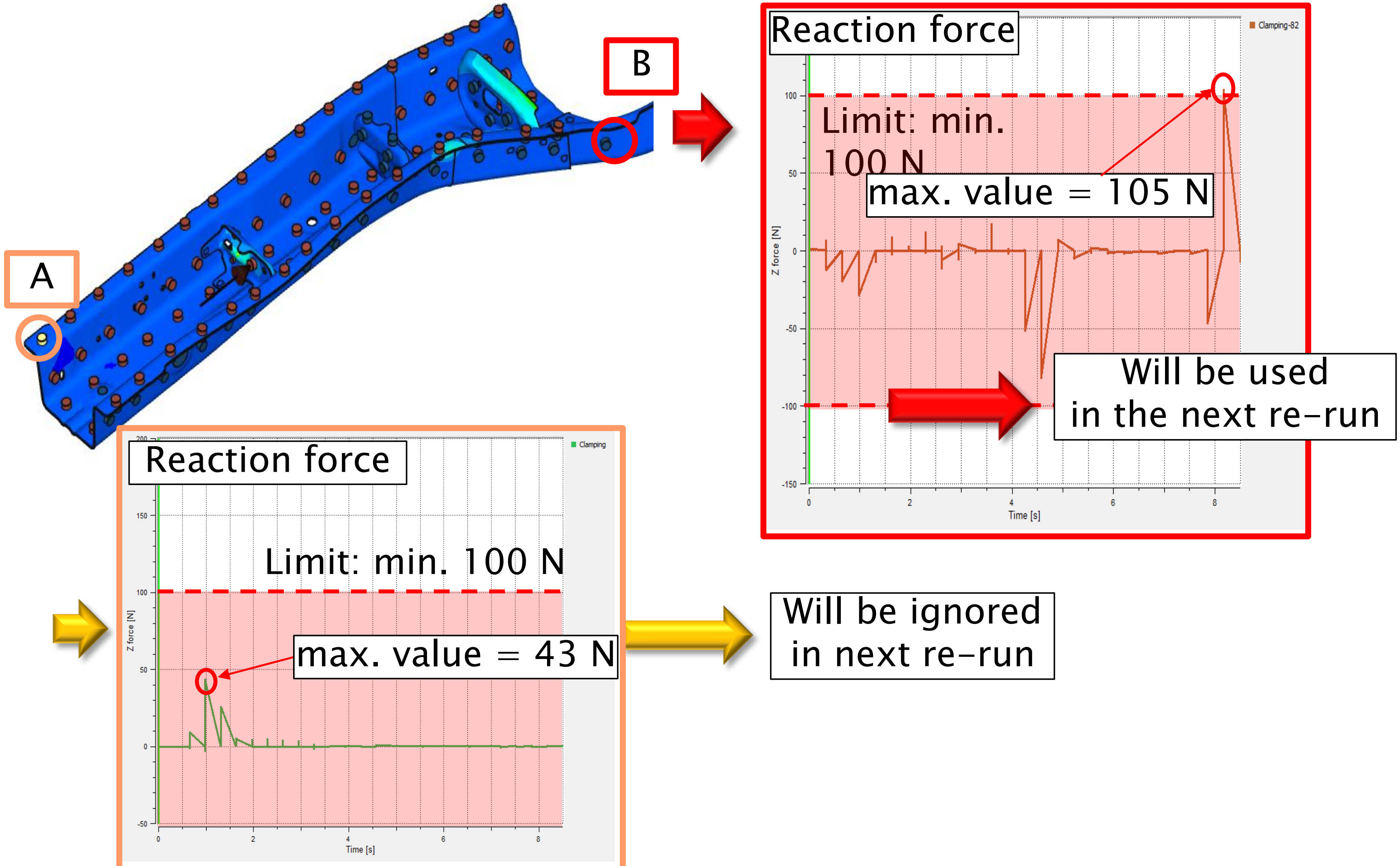
5) Reaction force limit based minimization

- Automation script will start with an over-clamped model
- After finishing the over-clamp simulation, the maximum reaction force on each Clamp/Bearing pair will be inspected
- A rerun of the initial model will be performed reduced by the number of clamps that are below the reaction force value
- This will be repeated several times



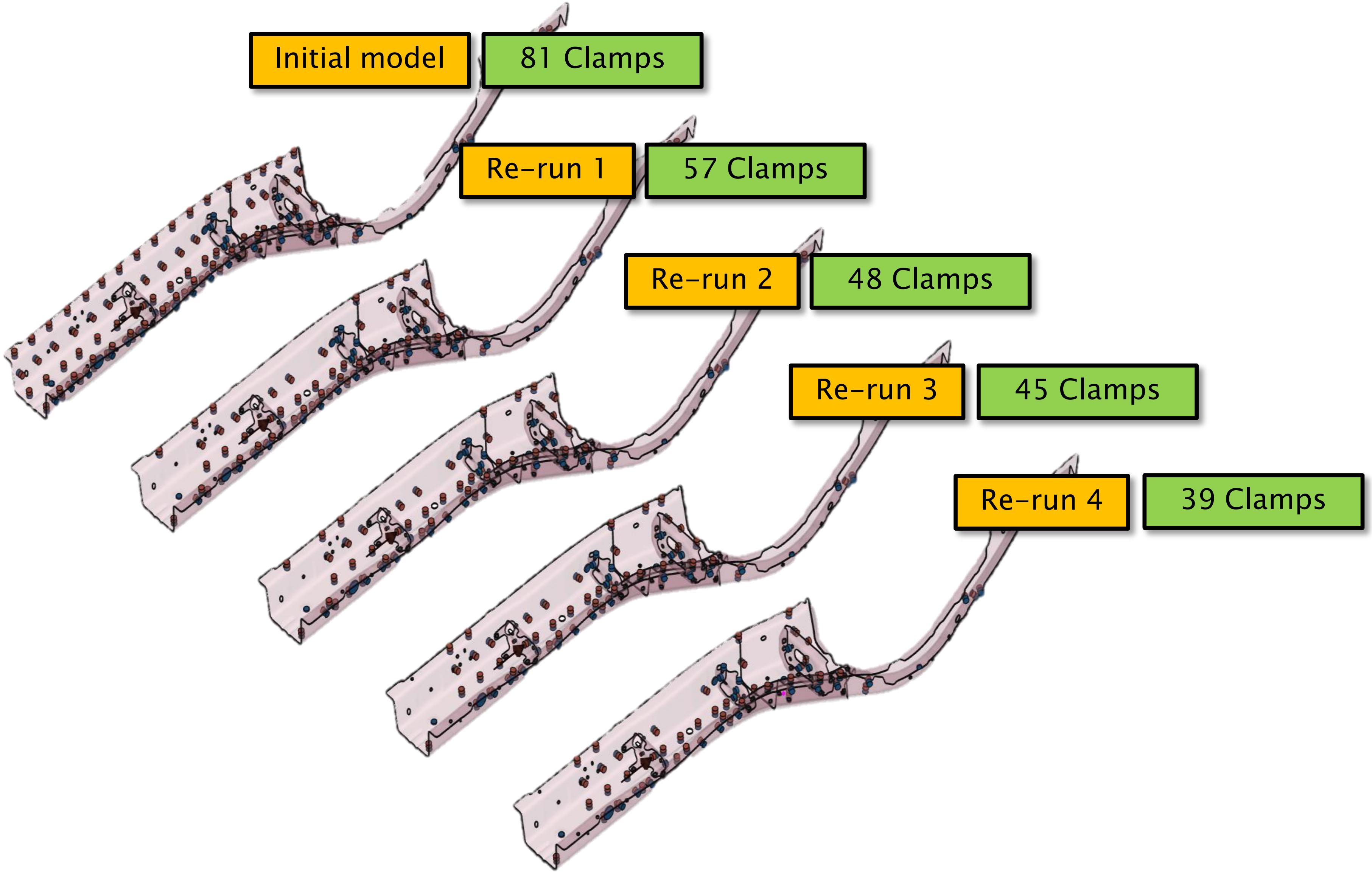
III. Clamping Optimization Development

6) Reaction Force



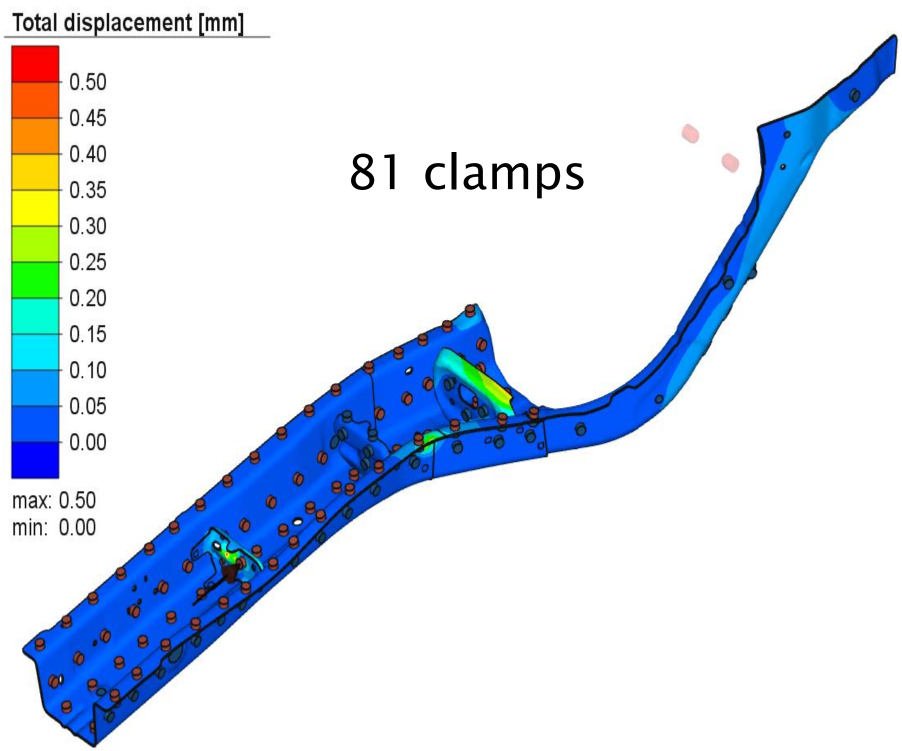
III. Clamping Optimization Development

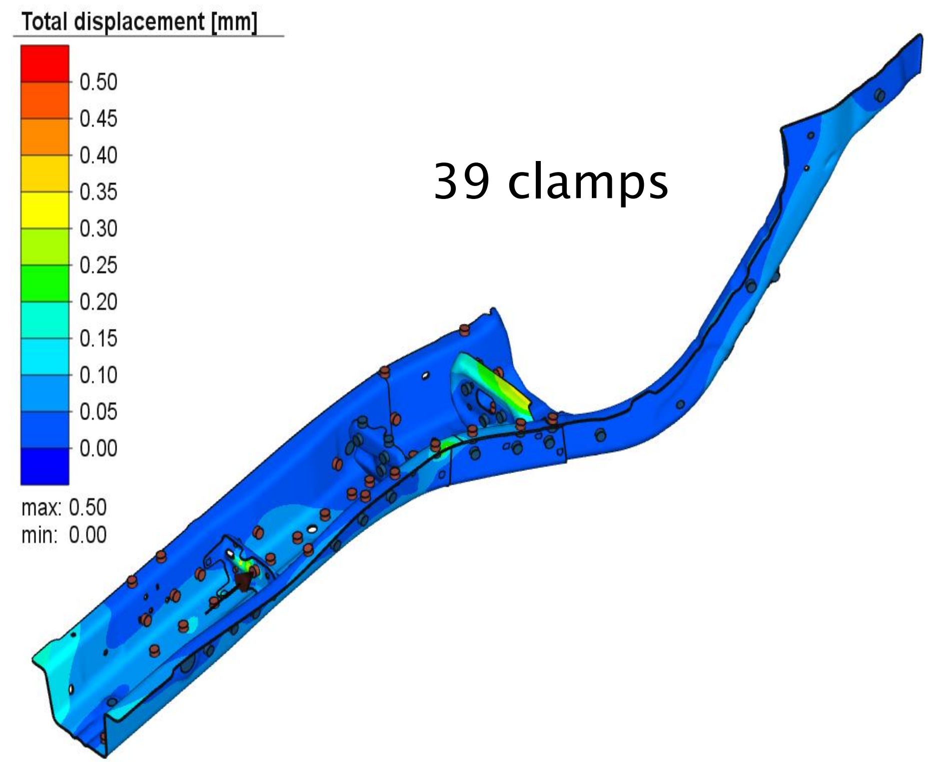
7) CASE STUDY – 100N Limitation



III. Clamping Optimization Development

7) CASE STUDY – 100N Limitation



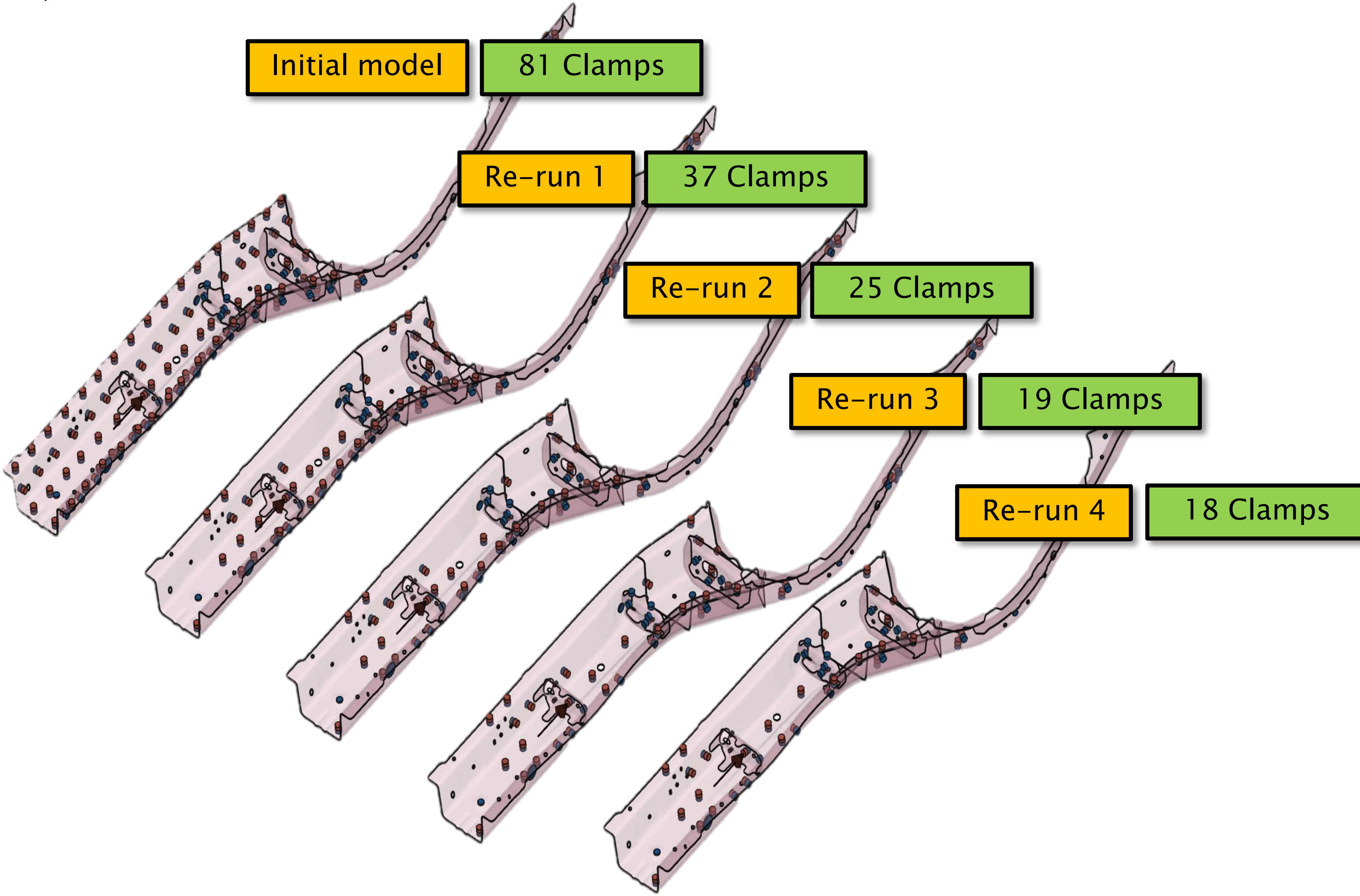


Over-clamped (initial state)

with reduced clamps (after 4 re-runs)
For a force limit of 100 N

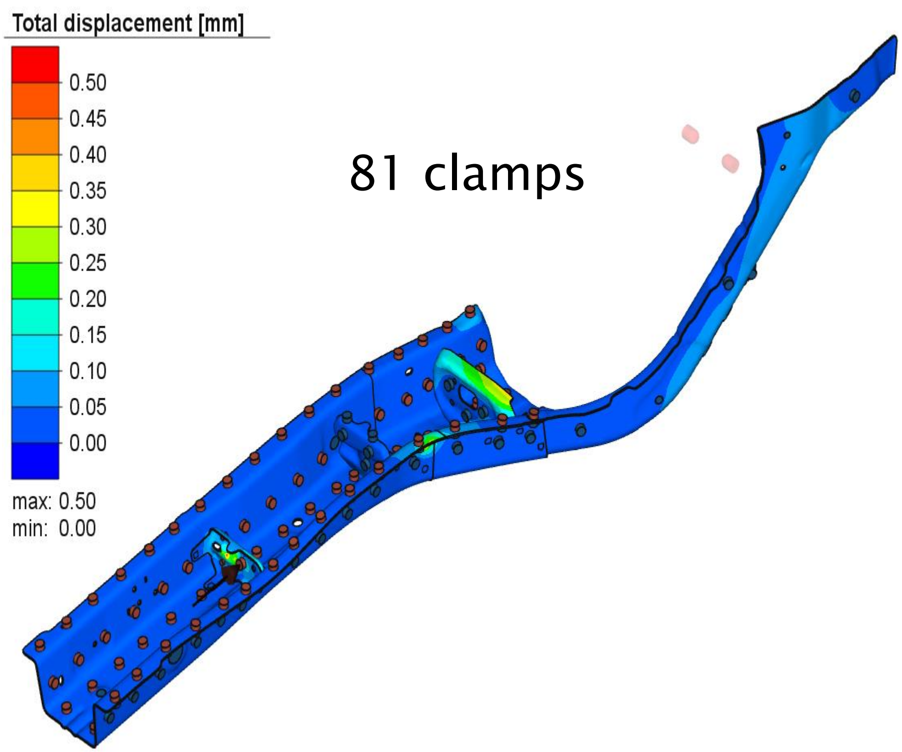
III. Clamping Optimization Development

8) CASE STUDY – 300N Limitation

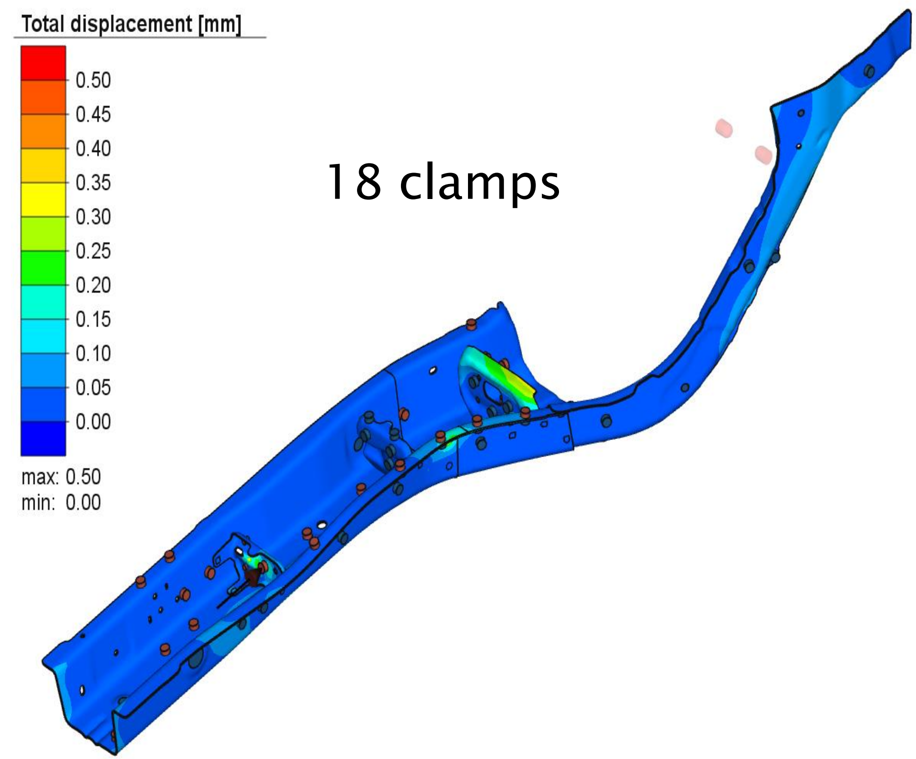


III. Clamping Optimization Development

8) CASE STUDY – 300N Limitation



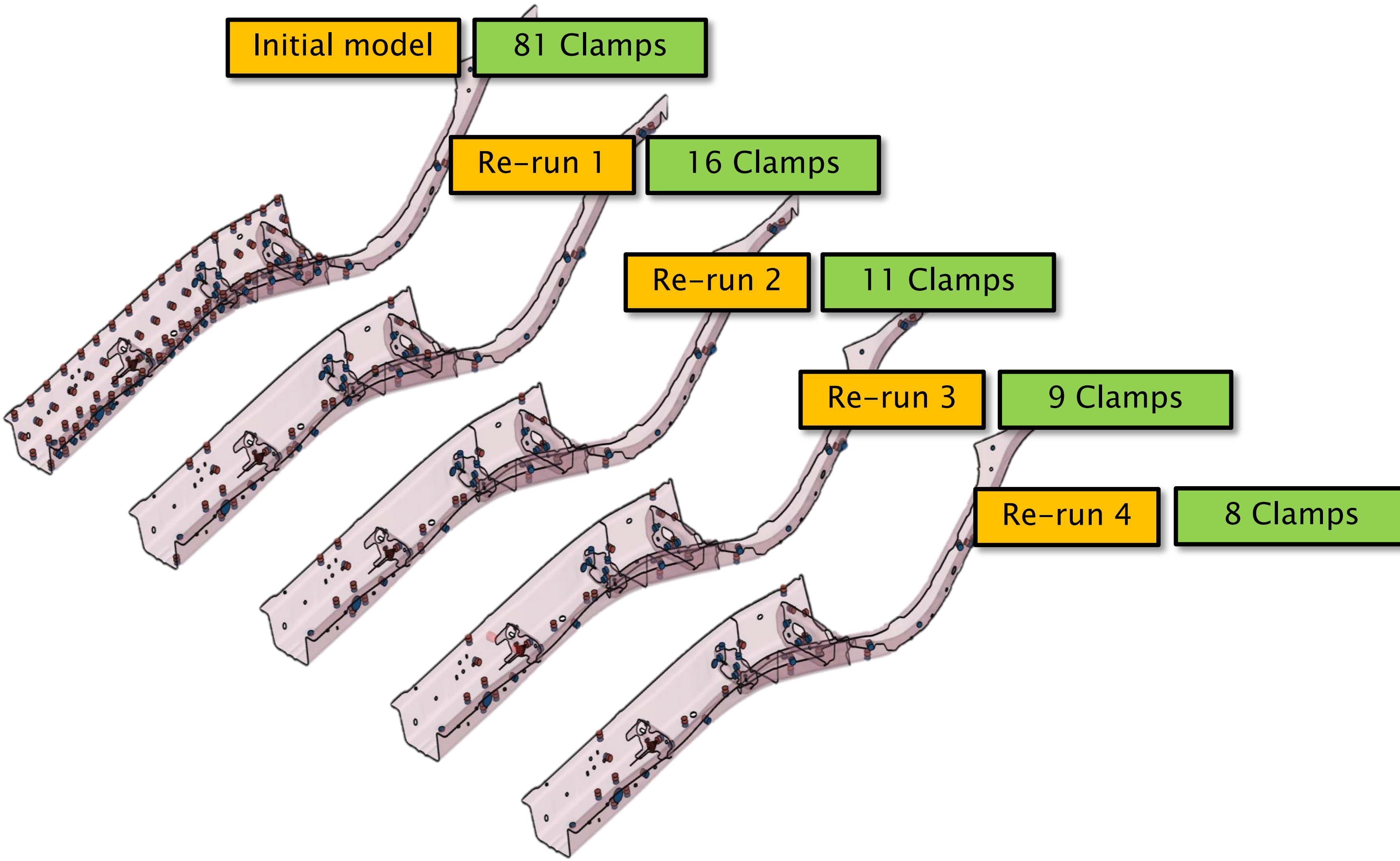
Over-clamped (initial state)



with reduced clamps (after 4 re-runs)
For a force limit of 300 N

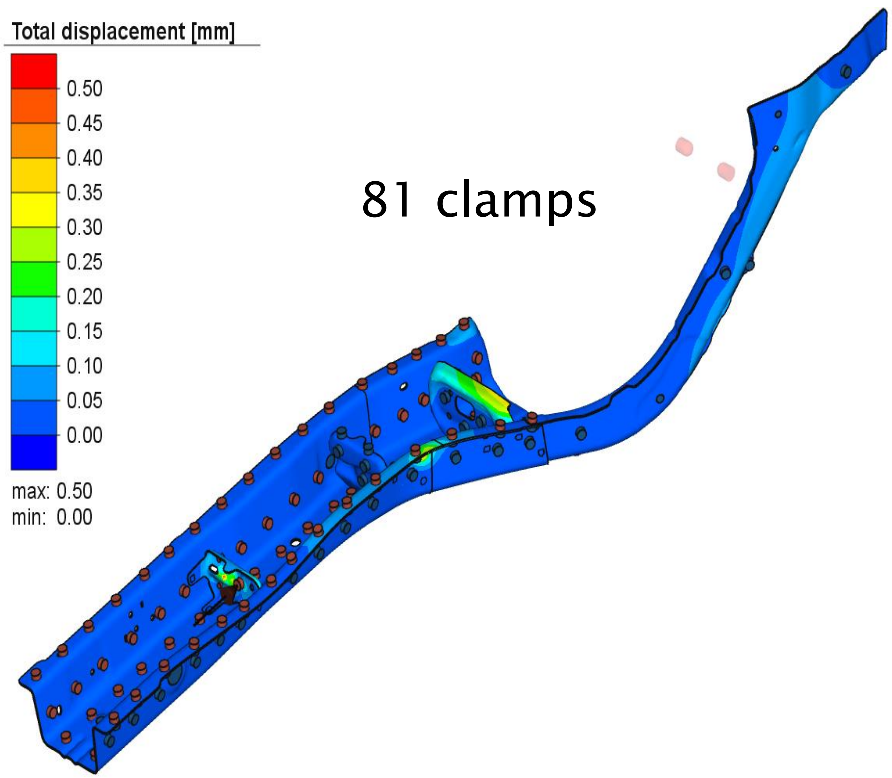
III. Clamping Optimization Development

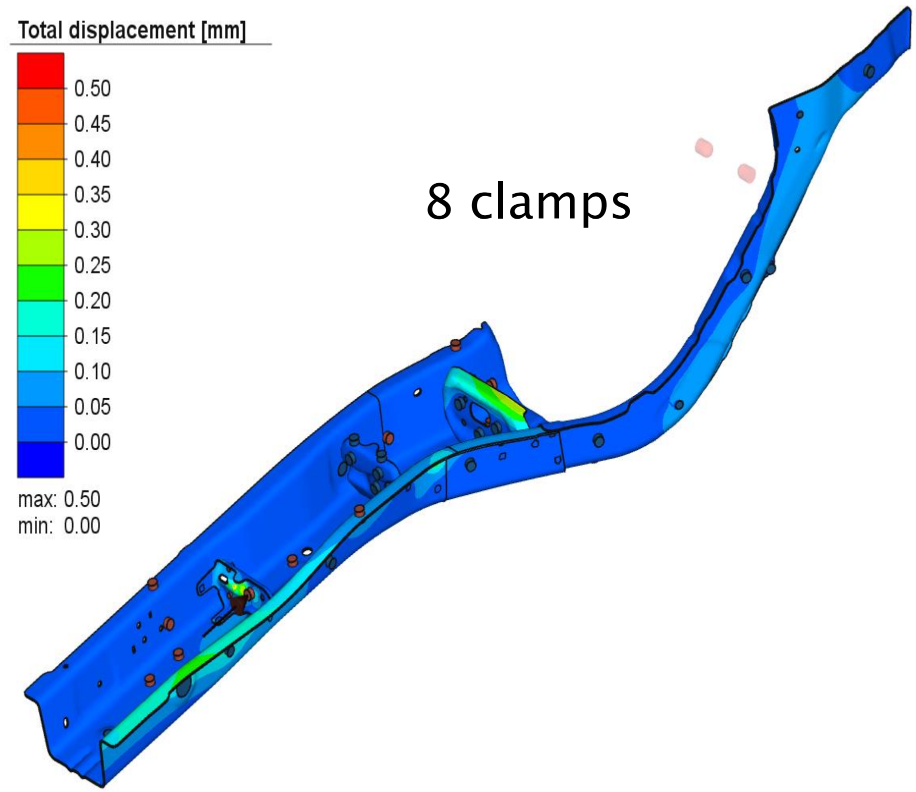
8) CASE STUDY – 1000N Limitation



III. Clamping Optimization Development

8) CASE STUDY - 1000N Limitation





Over-clamped (initial state)

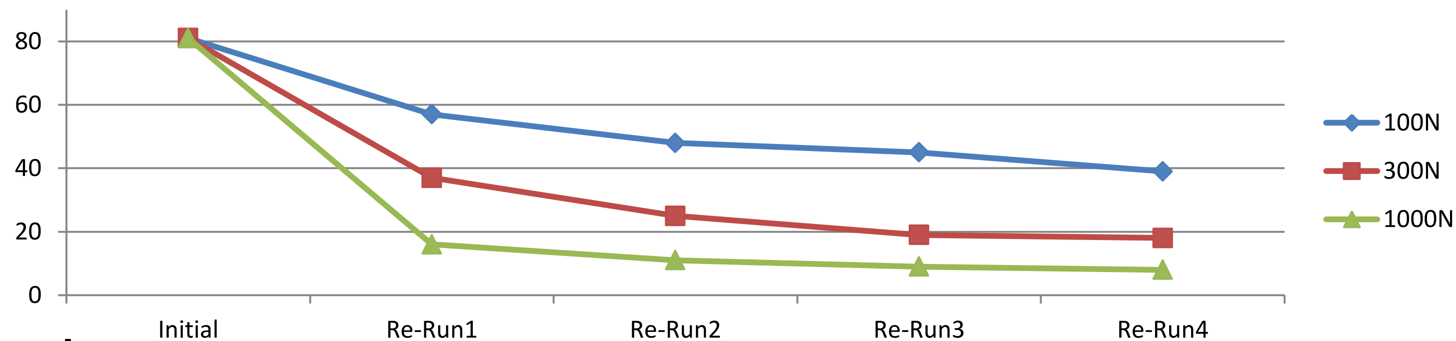
with reduced clamps (after 4 re-runs)
For a force limit of 1000 N

III. Clamping Optimization Development

9) Summary

① Developing Clamp Optimization

- Originally, it has 43 clamps
- Based on Reaction Force Limitation We can figure out the possibility of reducing # of Clamps
- # of Clamps decrease based on value of limitation force



② Futher more

- In development.

  a. Deformation Based Limitation Rules

  b. Reaction Force + Deformation Based Limitation Rules

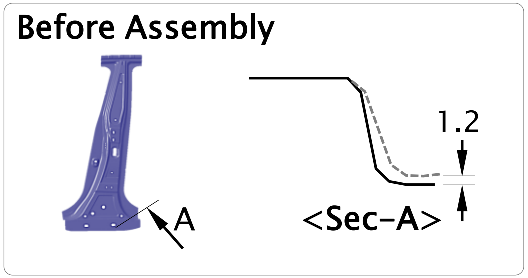
③ Future works

- In 2020 we check V&V with real model and improving algorithms.
- Base model will be a Scan data, Morphed Model(in ANSA)

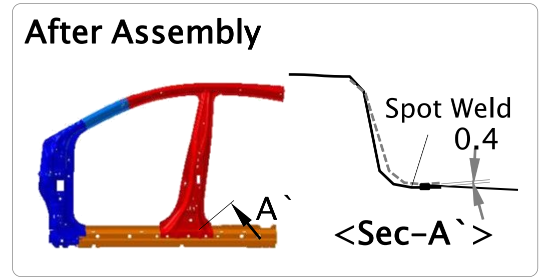
IV. Another Strategy

- Flexible Tolerance

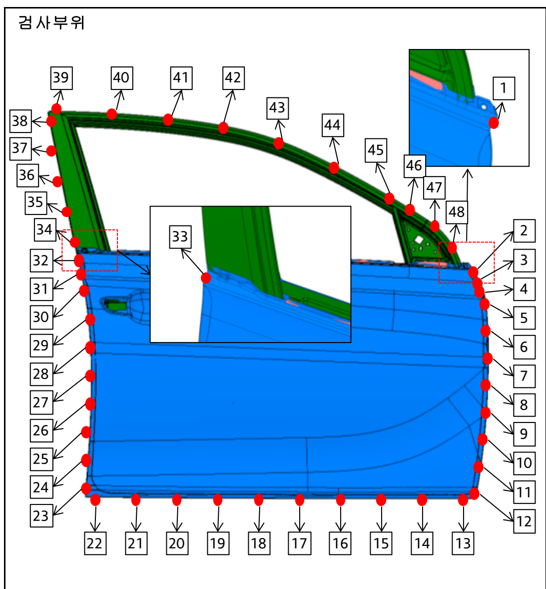
1.2 → 0.4mm (Tolerance: ±0.5mm)



Demension Changes During Joining Process

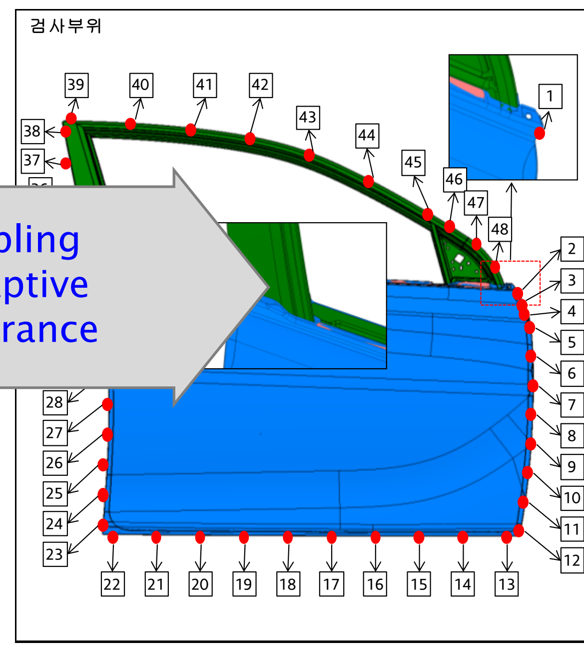


- Traditional Quality Check Sheet will be changed based on Flexible Tolerance



23	3.0 GAP	0.5	-0.5	-0.1
24	3.0 GAP	0.5	-0.5	-0.1
25	3.0 GAP	0.5	-0.5	0.0
26	3.0 GAP	0.5	-0.5	0.0
27	3.0 GAP	0.5	-0.5	0.1
28	3.0 GAP	0.5	-0.5	0.1
29	3.0 GAP	0.5	-0.5	-0.1
30	3.0 GAP	[illegible]	[illegible]	[illegible]
31	3.0 GAP	[illegible]	[illegible]	[illegible]
32	3.0 GAP	[illegible]	[illegible]	[illegible]
33	3.0 GAP	[illegible]	[illegible]	[illegible]
평행도(//):23~33		[illegible]	[illegible]	[illegible]
34	3.0 GAP	[illegible]	[illegible]	[illegible]
35	3.0 GAP	[illegible]	[illegible]	[illegible]
36	3.0 GAP	[illegible]	[illegible]	[illegible]
37	3.0 GAP	[illegible]	[illegible]	[illegible]
38	3.0 GAP	0.5	-0.5	0.0
평행도(//):34~38		0.5	0.0	0.0
39	3.0 GAP	0.5	-0.5	0.1
40	3.0 GAP	0.5	-0.5	0.0
41	3.0 GAP	0.5	-0.5	0.3
42	3.0 GAP	0.5	-0.5	0.8
43	3.0 GAP	0.5	-0.5	0.8
44	3.0 GAP	0.5	-0.5	0.2
45	3.0 GAP	0.5	-0.5	0.2

Appling Adaptive Tolerance



23	3.0 GAP	0.5	-0.5	-0.1
24	3.0 GAP	0.5	-0.5	-0.1
25	3.0 GAP	0.5	-0.5	0.0
26	3.0 GAP	0.5	-0.5	0.0
27	3.0 GAP	0.5	-0.5	0.1
28	3.0 GAP	0.5	-0.5	0.1
29	3.0 GAP	0.5	-0.5	-0.1
30	3.0 GAP	0.5	-0.5	-0.1
31	3.0 GAP	0.5	-0.5	0.0
32	3.0 GAP	0.5	-0.5	-0.1
33	3.0 GAP	0.5	-0.5	-0.2
평행도(//):23~33		0.5	0.0	0.3
34	3.0 GAP	0.5	-0.5	0.0
35	3.0 GAP	0.5	-0.5	0.0
36	3.0 GAP	0.5	-0.5	0.0
37	3.0 GAP	0.5	-0.5	0.0
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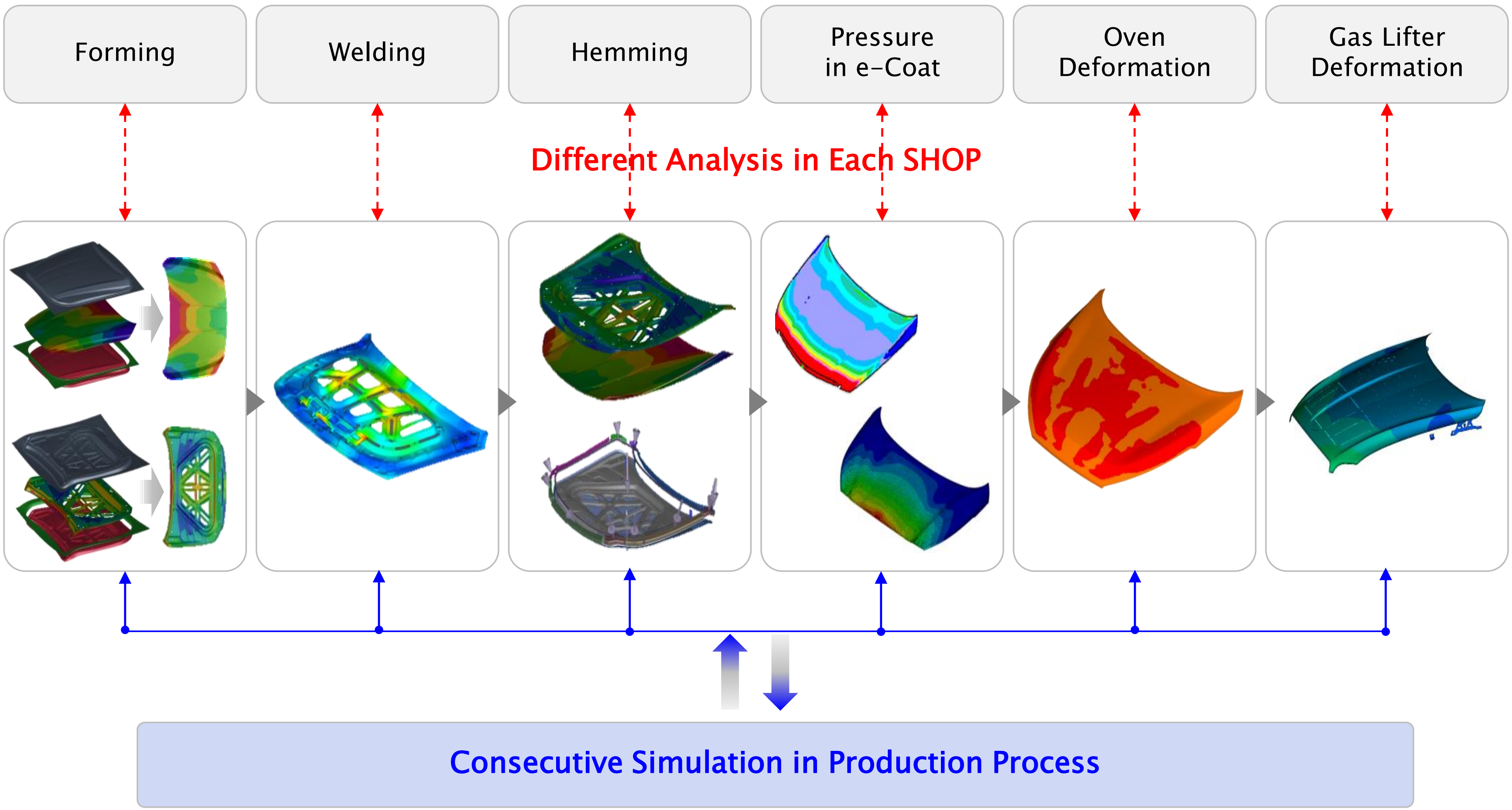
45	3.0 GAP	0.5	-0.5	0.2

IV. Another Strategy

– Process Chain Analysis in Production Line

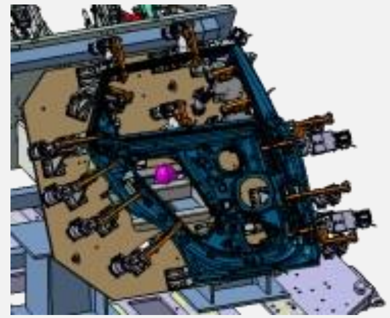


IV. Another Strategy

- Simulation Based Quality Assurance

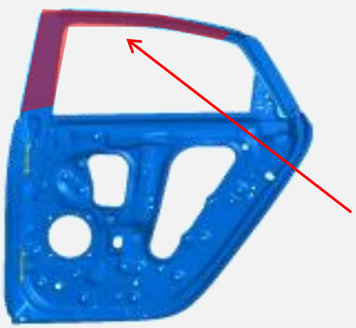
Measuring

B.C



Clamp
Weld Sequence

Simulation

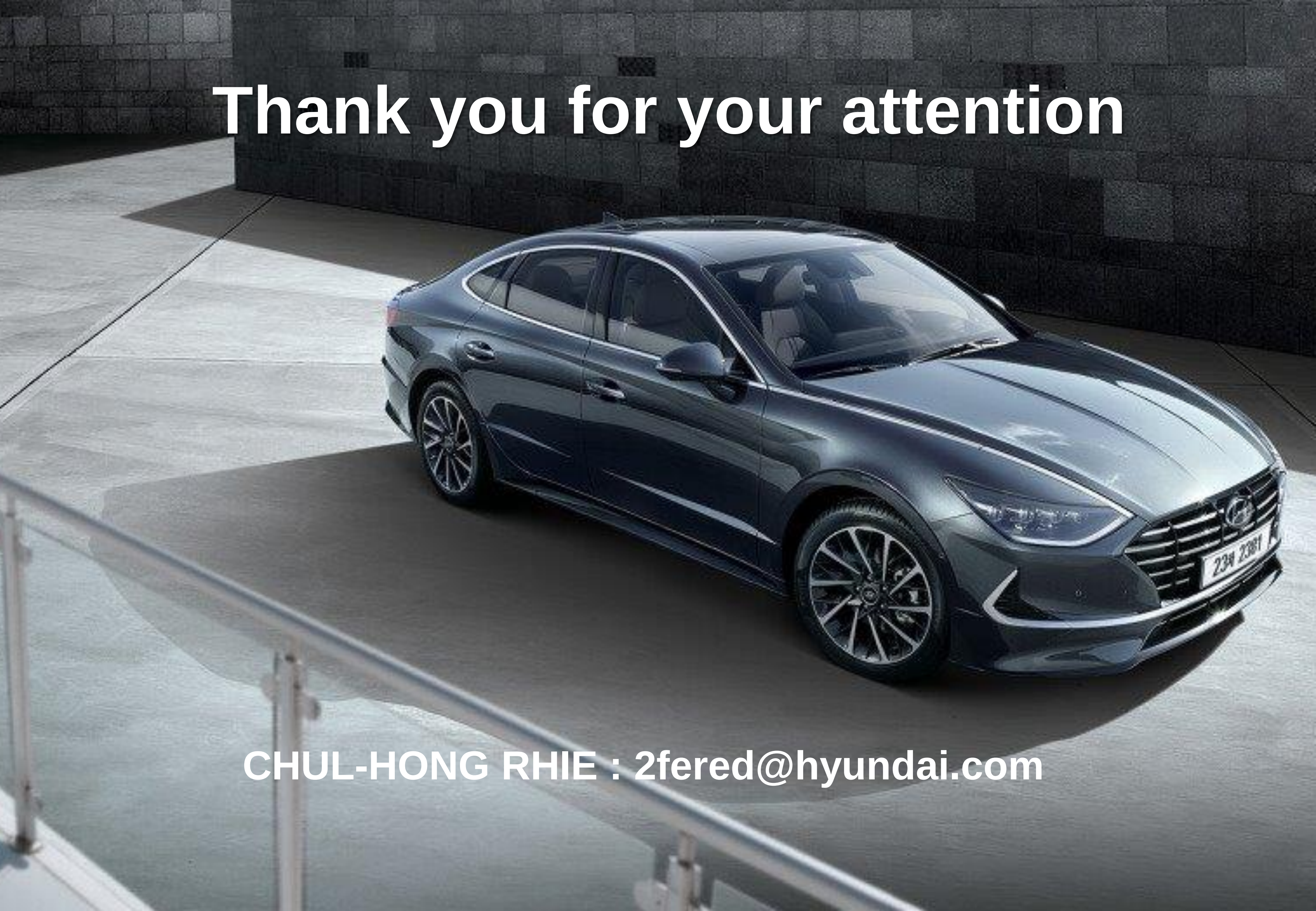


Check
Deformation

Quality Assurance

New
Build
Process

Adjust
Dimensi
on


Thank you for your attention
CHUL-HONG RHIE : 2fered@hyundai.com