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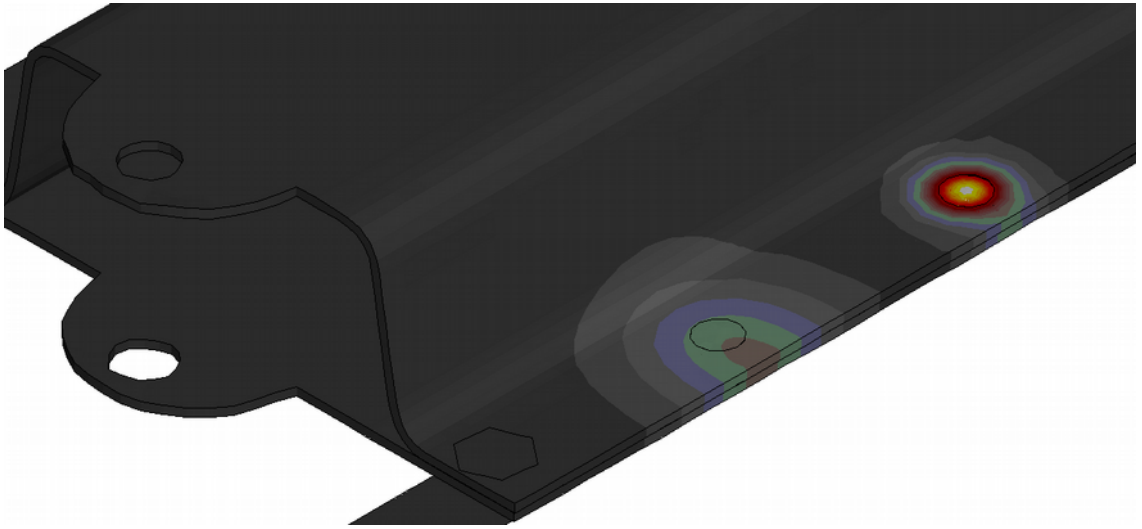
Digital distortion compensation solution for BIW assemblies by reverse simulation of joining process influences



Tobias Loose, DynaWeld GmbH & Co. KG, Germany
Niels Koch, Opel Automobile GmbH, Germany

Fügen im Karosseriebau 2019
Bad Nauheim, 10.04.2019

Motivation

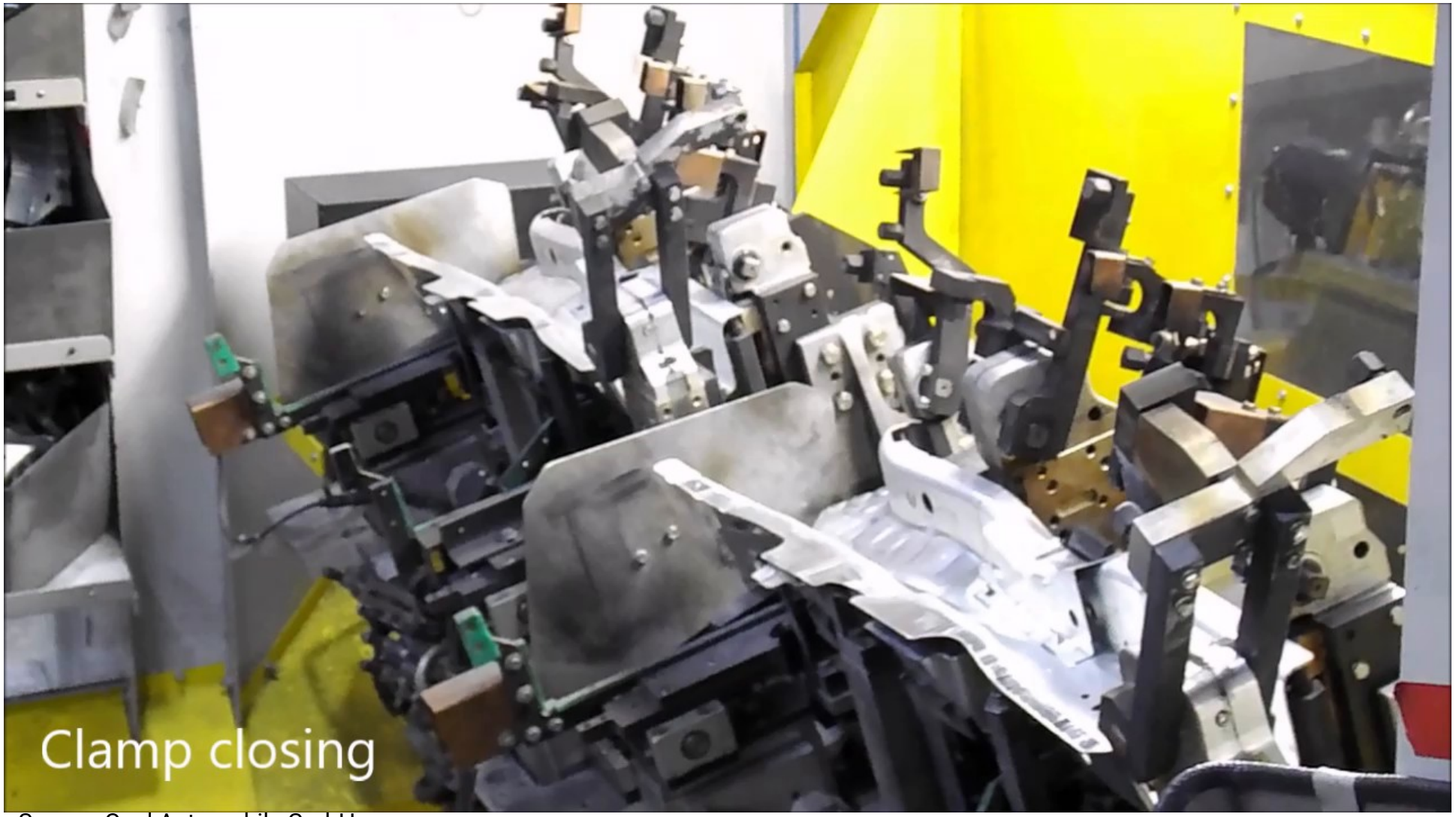
We quest for perfectness ...

- In manufactoring of BIW process steps follow next process steps
- No step is perfect
  - Stamping → imperfect single part
  - Clamping → more imperfections by clamp closing
  - Welding → followed by deviation of weld shrinkage
- But the final assembly shall exact fit the target geometry

... with engineering we shall succeed

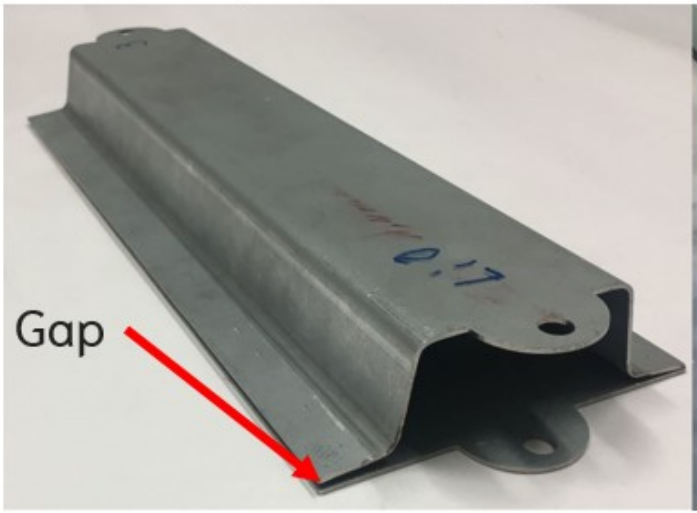
The hat-profile is related to BIW frame structure,
thus we will investigate our engineering in this type of structure

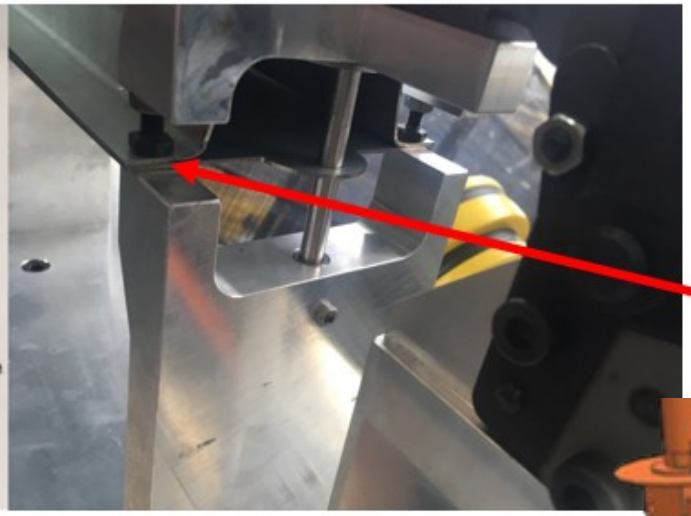
Clamping and Welding in Reality

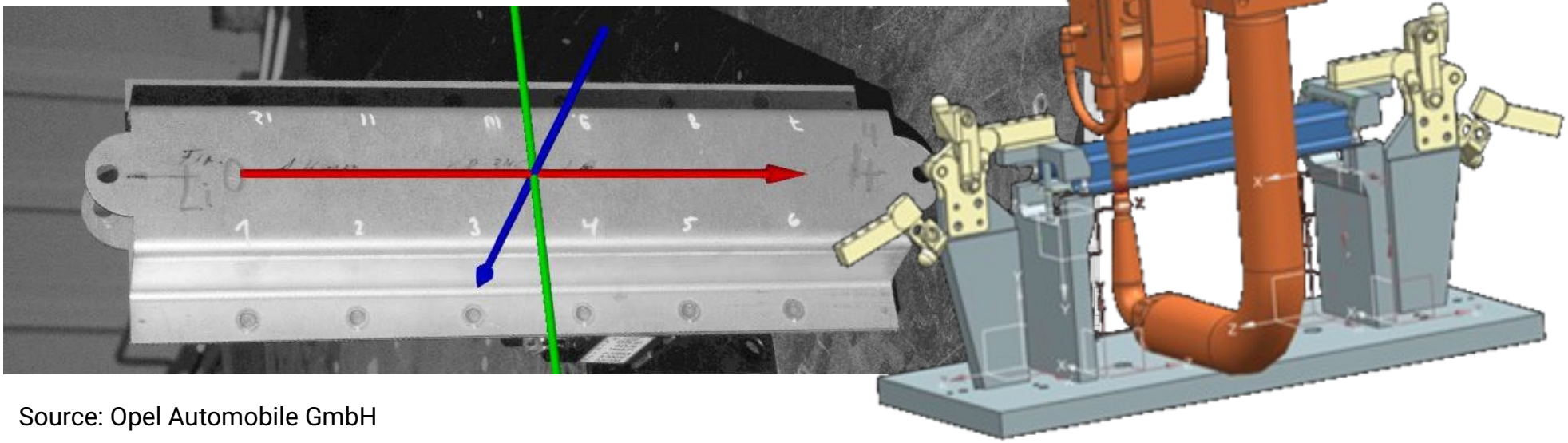


Source: Opel Automobile GmbH

Clamping and Welding of Imperfect Single Parts

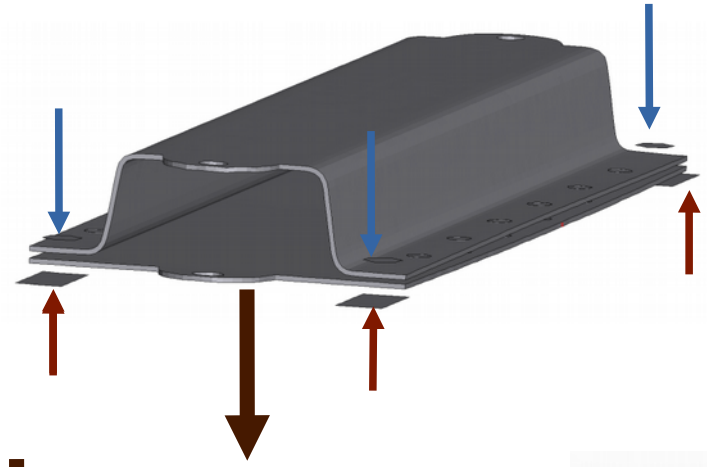






Source: Opel Automobile GmbH

Clamping



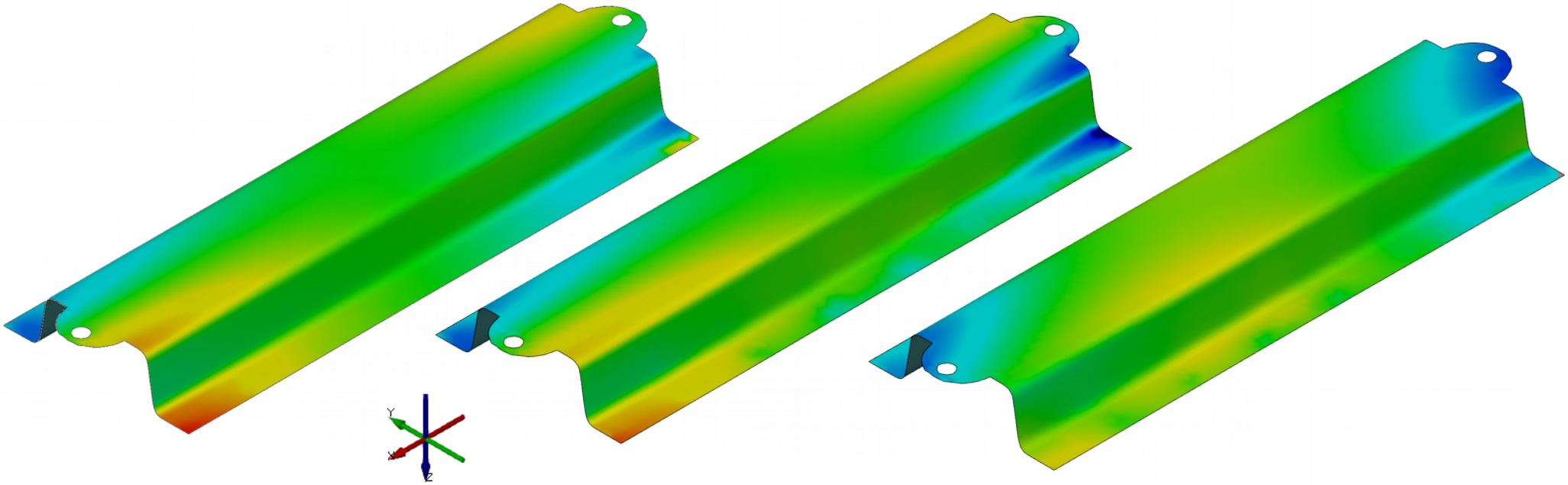
1. Dead Load, (Gravity)

2. Clamp Close

3. Clamp Force

Deviation due to Clamping, Welding, Clamp Release

Deviation of the surfaces to the initial state after stamping which is the state before clamping



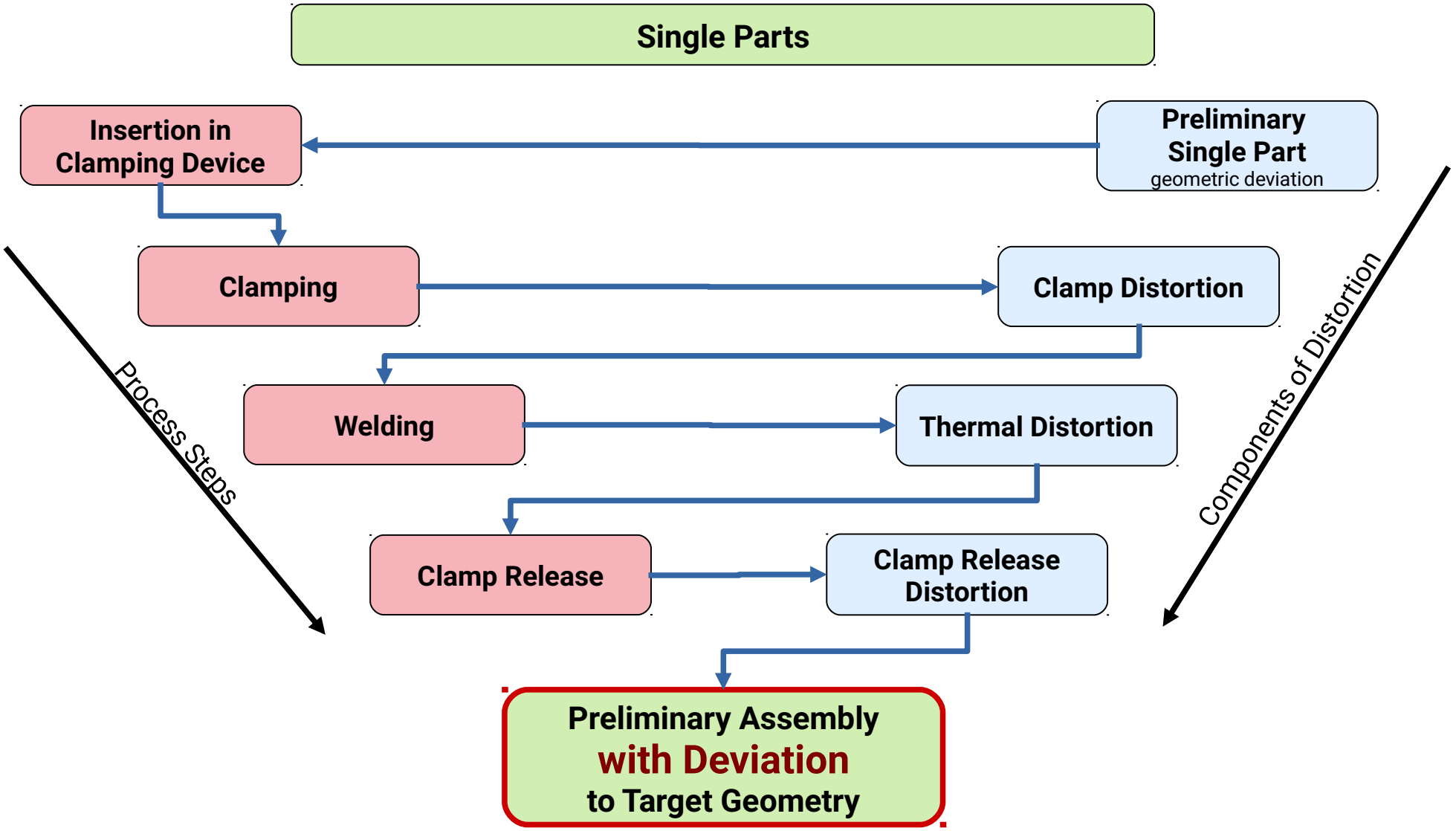
After Clamping

After Welding Before Clamp Release

After Clamp Release and Complete Cooling

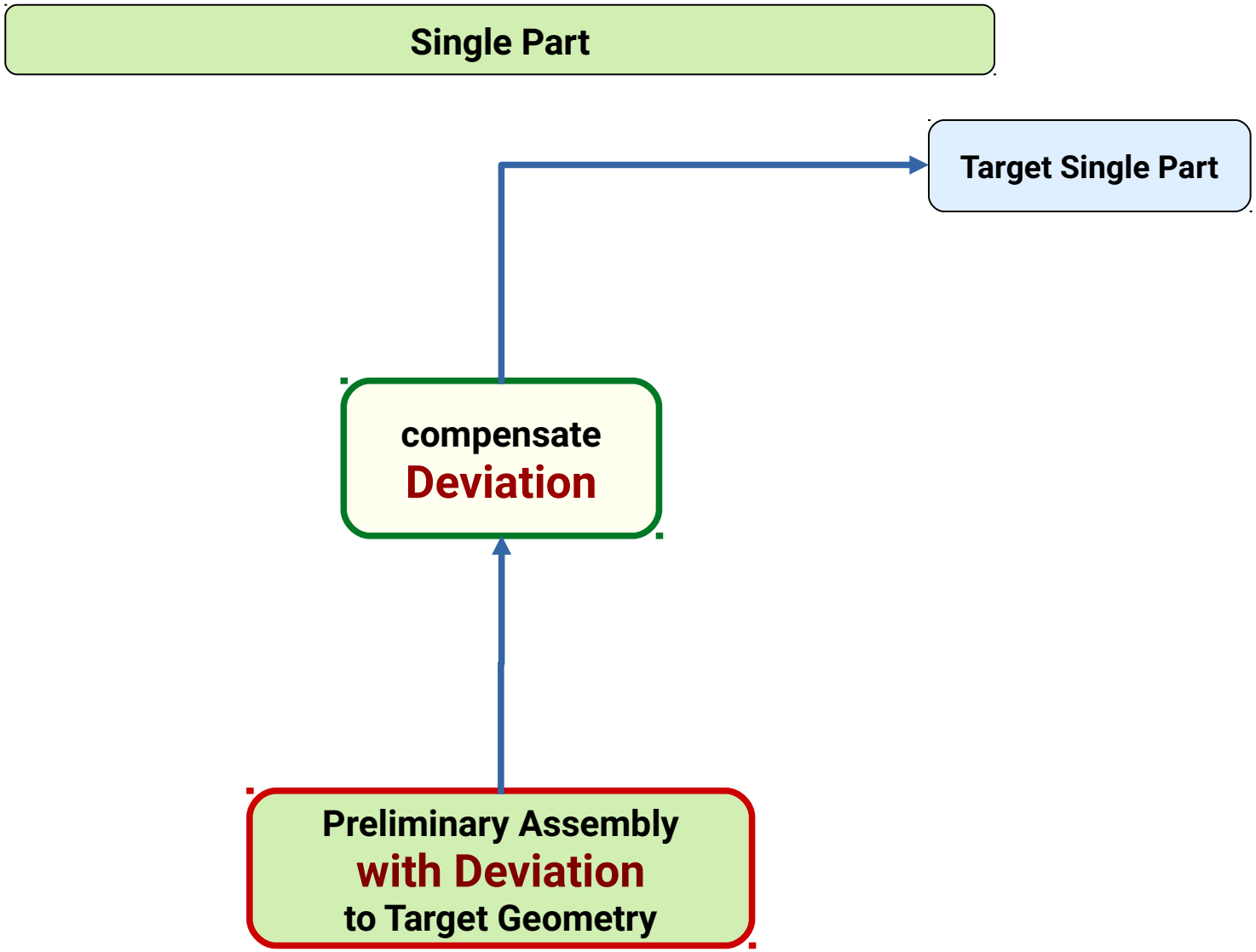
Assembly

Real Sequence of Manufacturing - Forward View



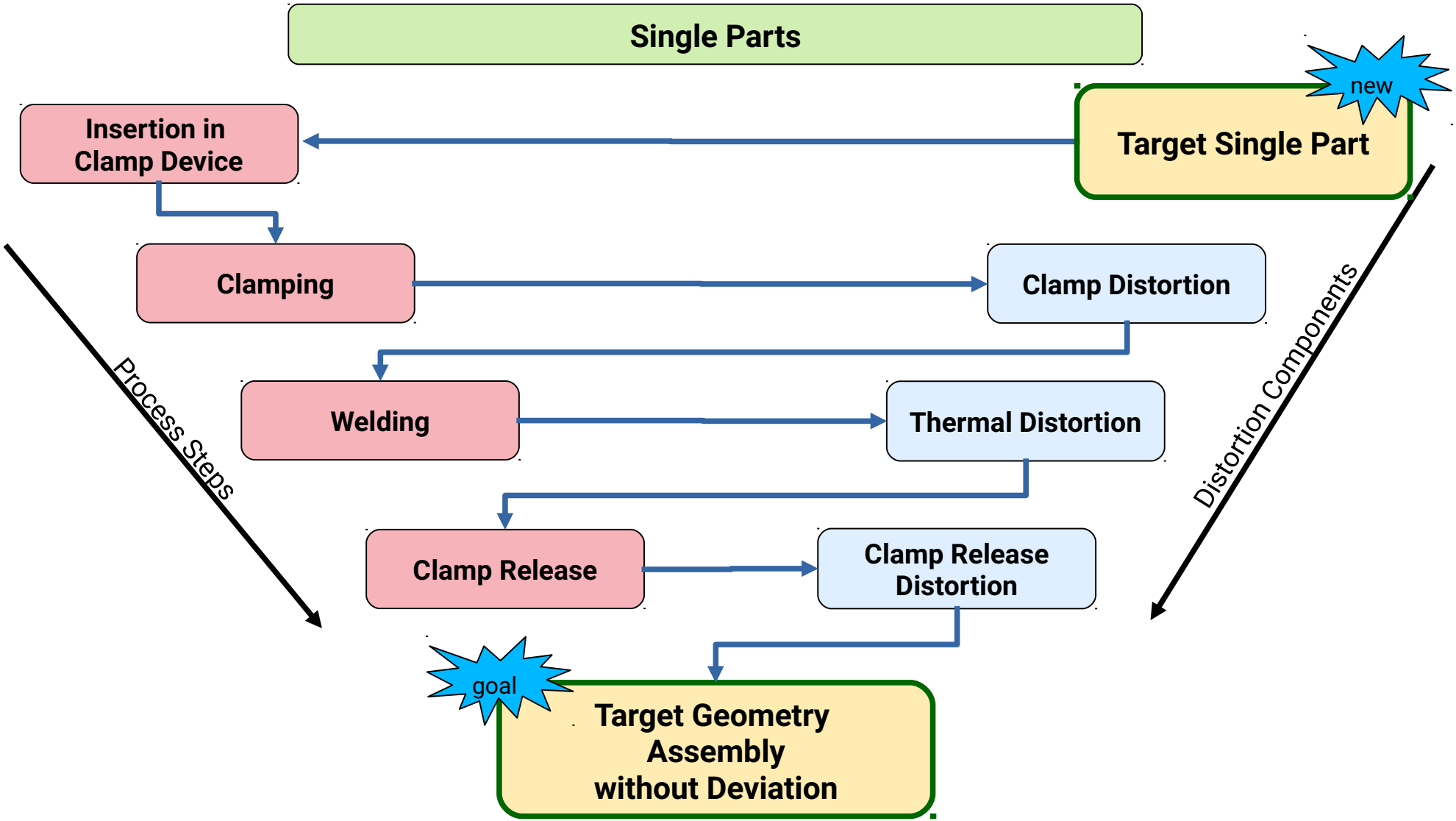
Motivation

Compensation by Track Back of the Deviation of Geometry



Assembly

Manufacturing - Forward View with Compensation

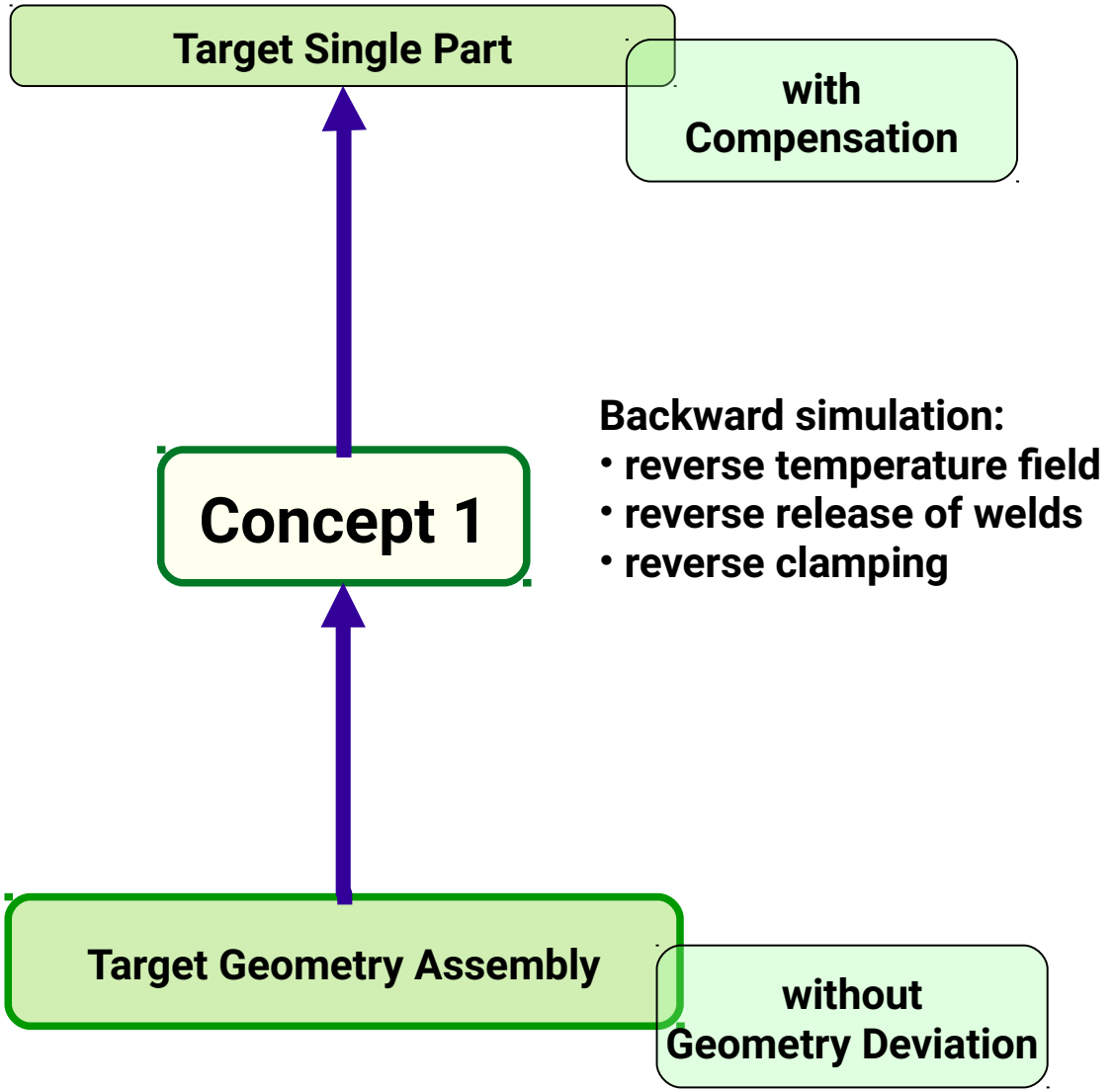


Concept 1

Thermal Compensation

Backward Simulation of Weld Distortion

Concept 1
Thermal Compensation

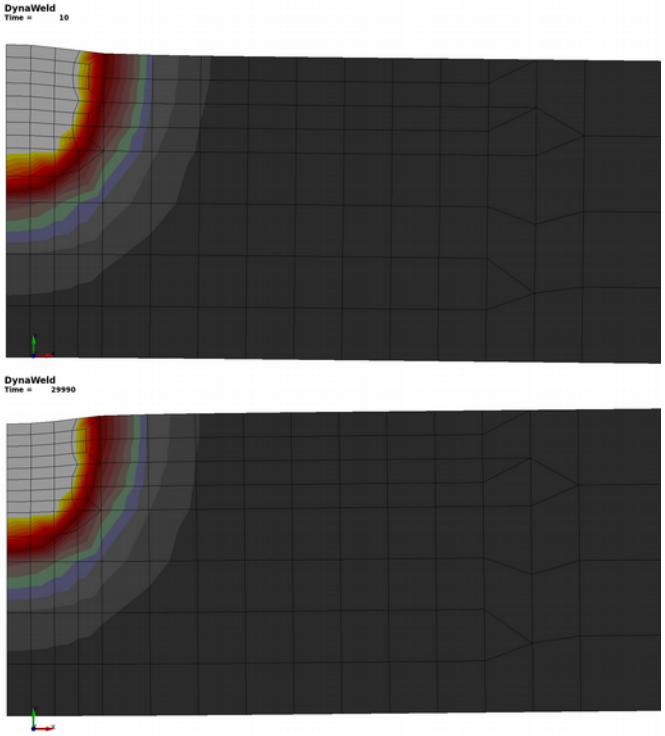


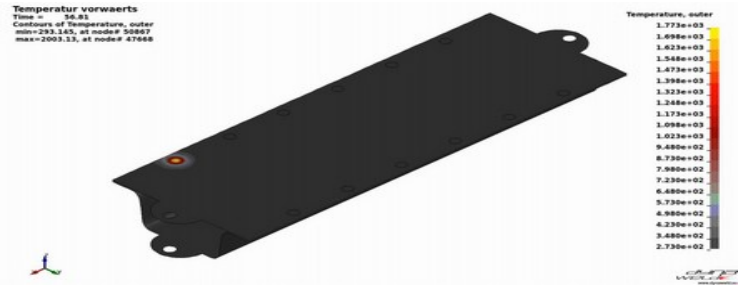
1500
1425
1350
1275
1200
1125
1050
975
900
825
750
675
600
525
450
375
300
225
150
75
0

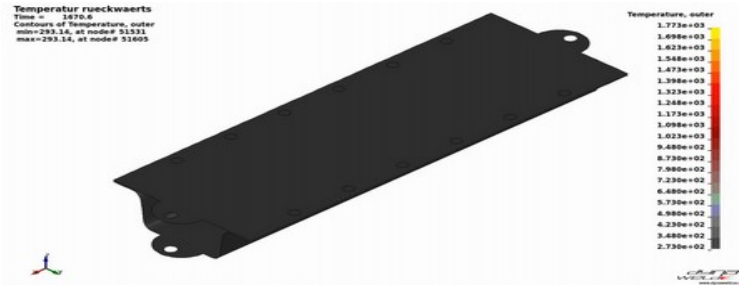
Reverse of Temperature Field

DynaWeld enables the backward simulation of a prior forward simulated Temperature field.

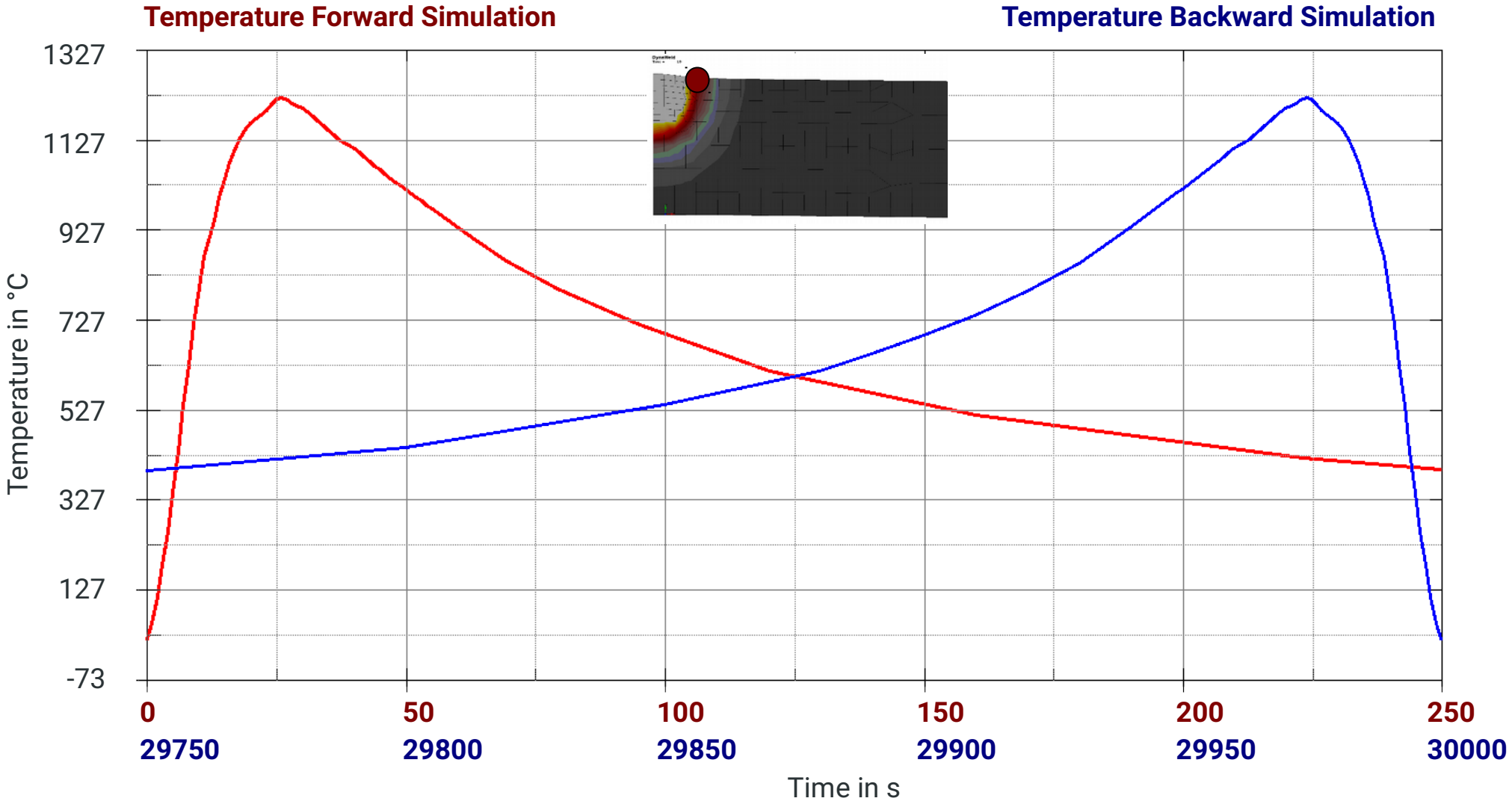
This method consideres also the reverse heat coduction from surface to environment.







Thermal Distortion
Reverse of Temperature Field



Proof of Method
Concept 1

Basis (Start):

•Measured real geometry of the assembly: Geometry A.

Simulation:

•Backward simulation. Initial state is Geometry A.

Result of Simulation:

•Calculated initial geometry of single part,

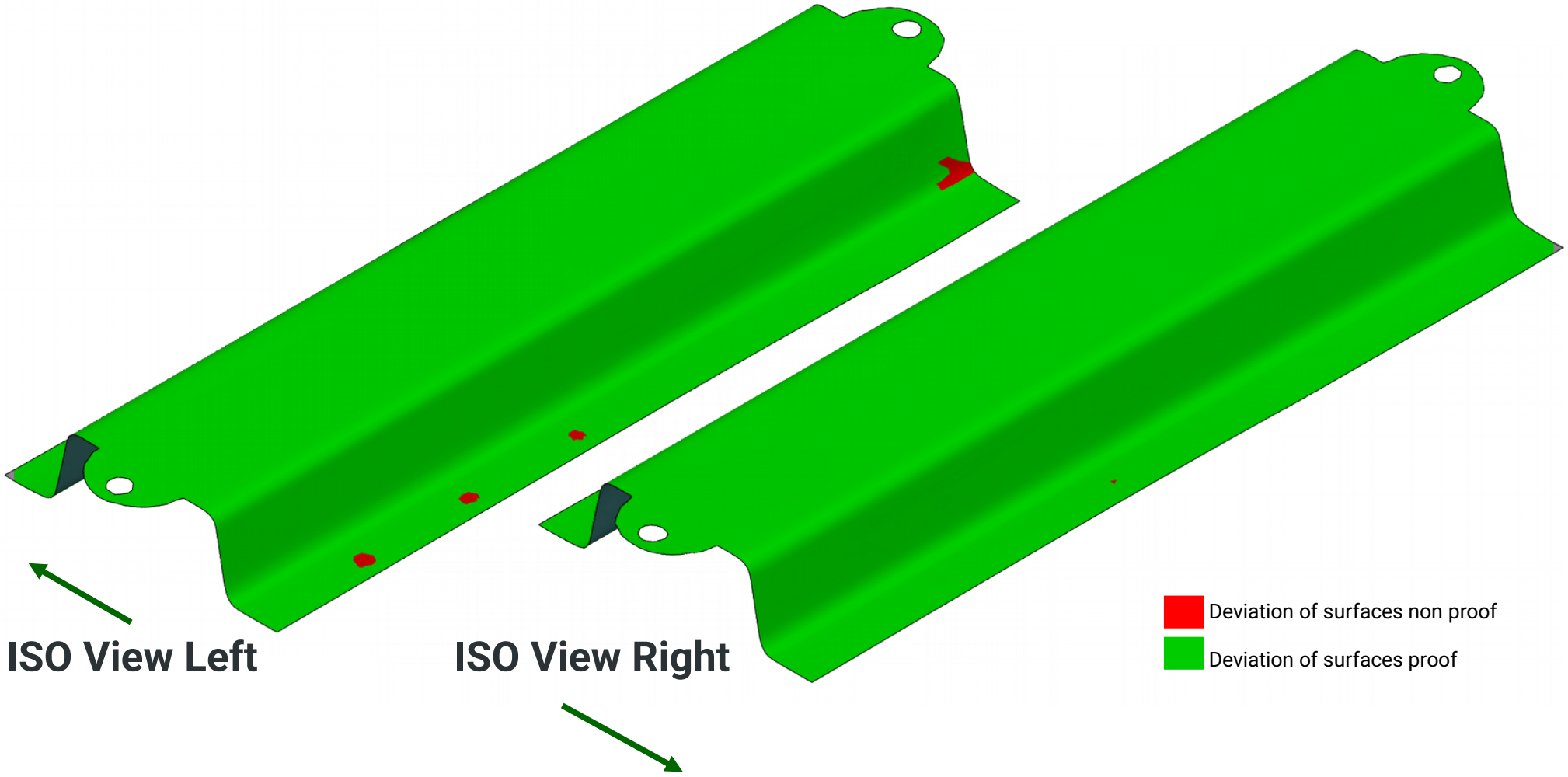
•this is the state before clamping and welding

•this is the imperfect geometry of the single part: Geometry B

Proof:

•The measured geometry of single part before clamping and welding, Geometry C, shall fit best the simulated geometry B to proof the method

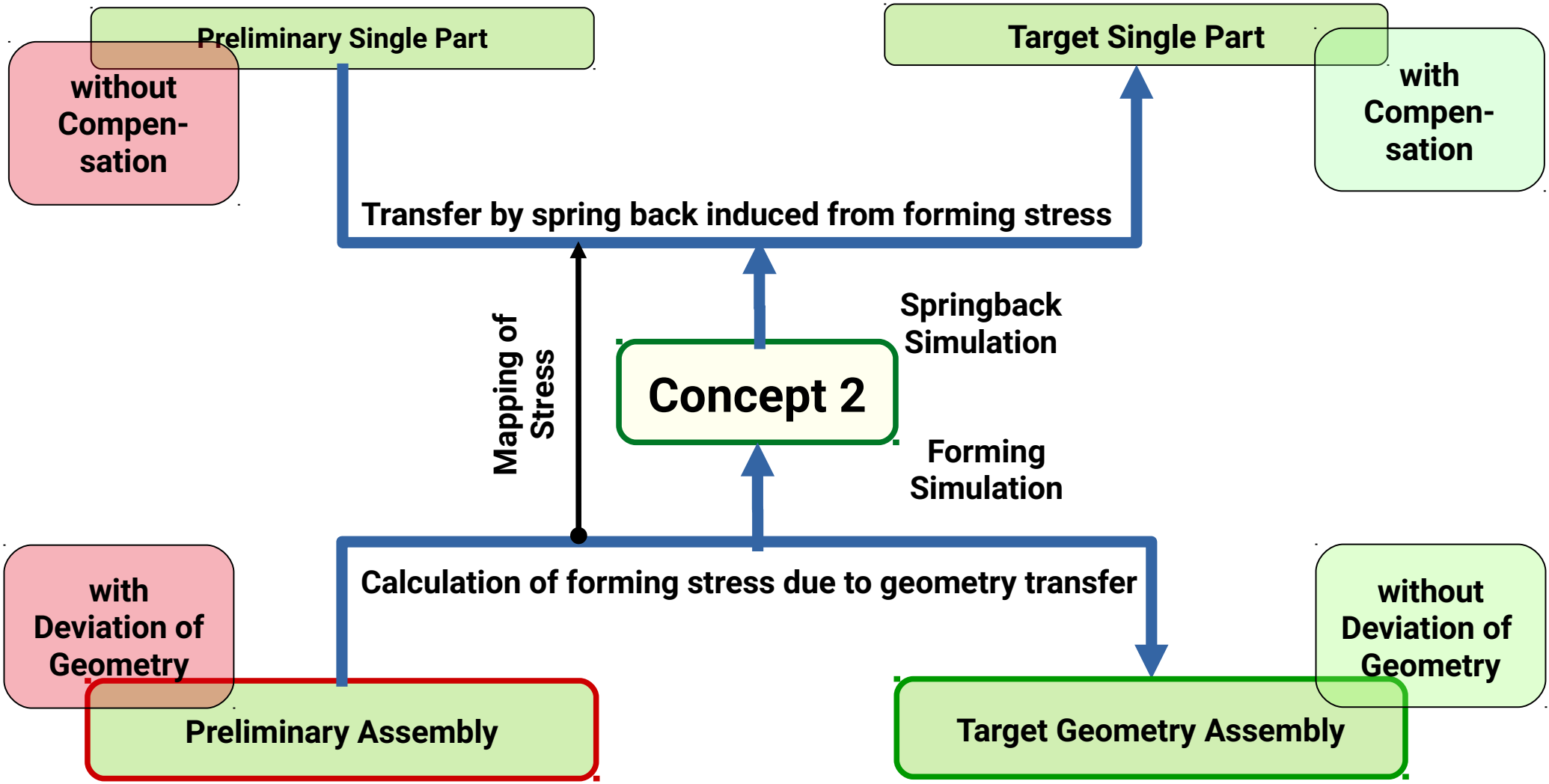
Deviation of the surfaces Geometry B and Geometry C



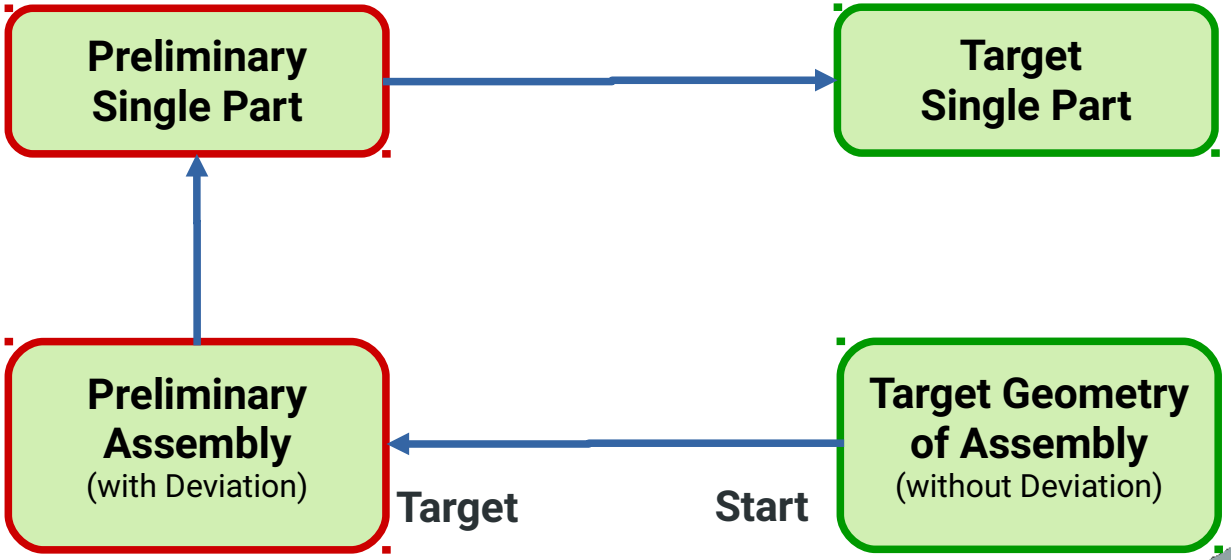
Concept 2

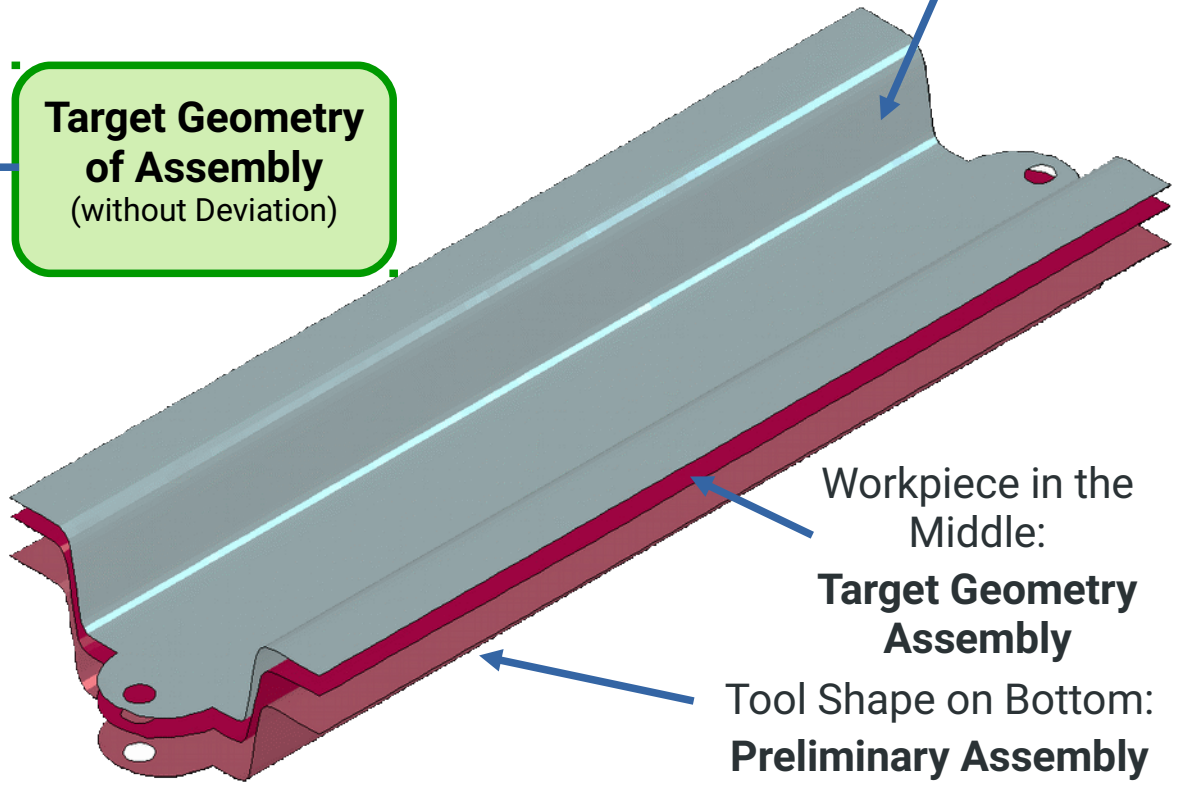
Transfer Simulation with
Transfer of Forming Stress

Concept 2
Compensation via Transfer of Forming Stress



Compensation by Transfer of Forming Stress





Proof of Method
Concept 2

Basis (Start):

•CAD geometry of the single part: Geometry D.

First Simulation:

•Calculate forming stresses

•**from** measured geometry of single part before clamping and welding (Geometry C)

•**to** measured geometry of preliminary assembly (Geometry E)

Second Simulation:

•Initial state is geometry D

•Mapping forming stresses

•Simulation of spring back due to mapped forming stresses

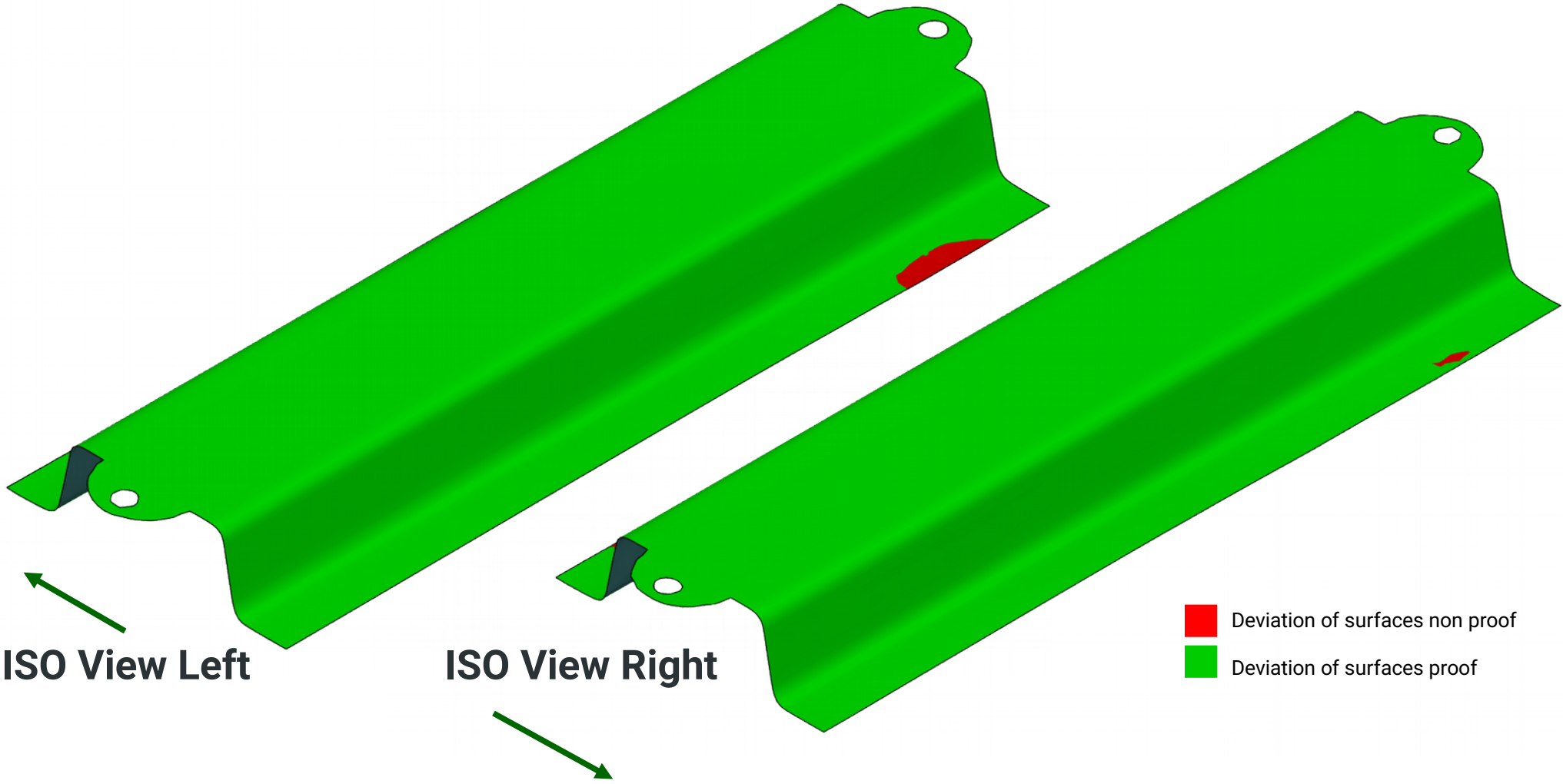
Result of Simulation:

•Calculated initial geometry of single part before clamping and welding: Geometry B

Proof:

•The measured geometry of single part before clamping and welding, Geometry C shall fit best the simulated geometry B to proof the method.

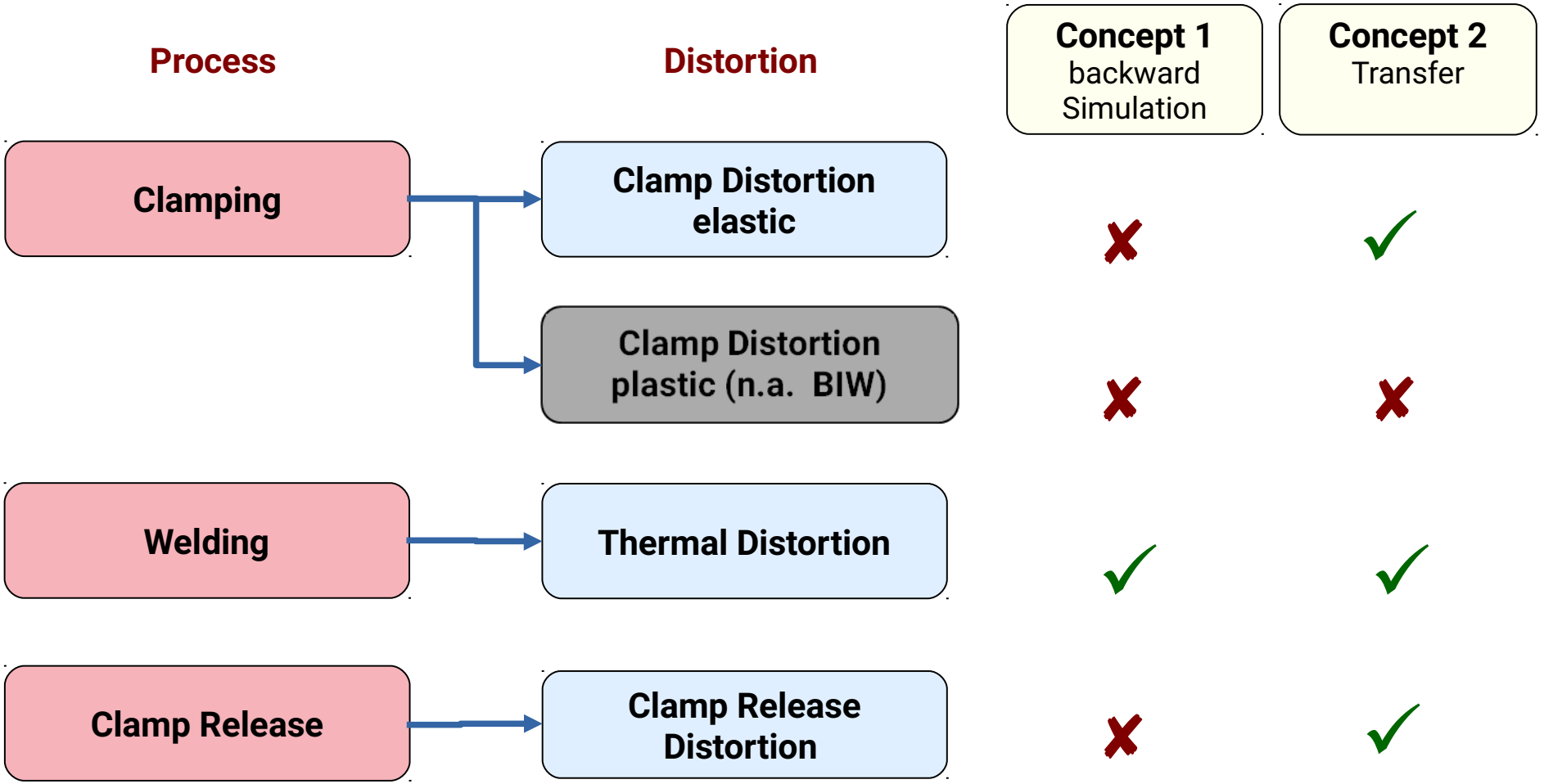
Deviation of the surfaces Geometry B and Geometry C



Comparison

Application Field and Limitation of the Methods

Application Fields



Plastic deformation, which may occur at clamping, can not be covered.
Concept 2 is applicable if the clamping remains only with elastic response of the structure.

Possible Application in BIW

Front Frame

Manufacturing design of a new front frame

Applicable in an early state of the design far before anything is manufacured in reality.
Manufacturing reviewed in the engineering department only.

- Imperfect geometry of single part obtained by forming simulation
- Forward simulation of assembly with imperfect prelimary single parts
  - Analysis of distortion
  - Calculation of deviation from target geometry
  - Detection of parts with major influence on deviation from target geometry
- Design of compensation
  - design of new geometry for mayor single parts with compensation
- Proof of choosen manufacturing design
  - Forward analysis again
  - Single parts with compensation
  - Goal: **Assembly now fits the target geometry**

Benefit

Define compensation in design phase - no need of prototype test

Source: Opel Automobile GmbH

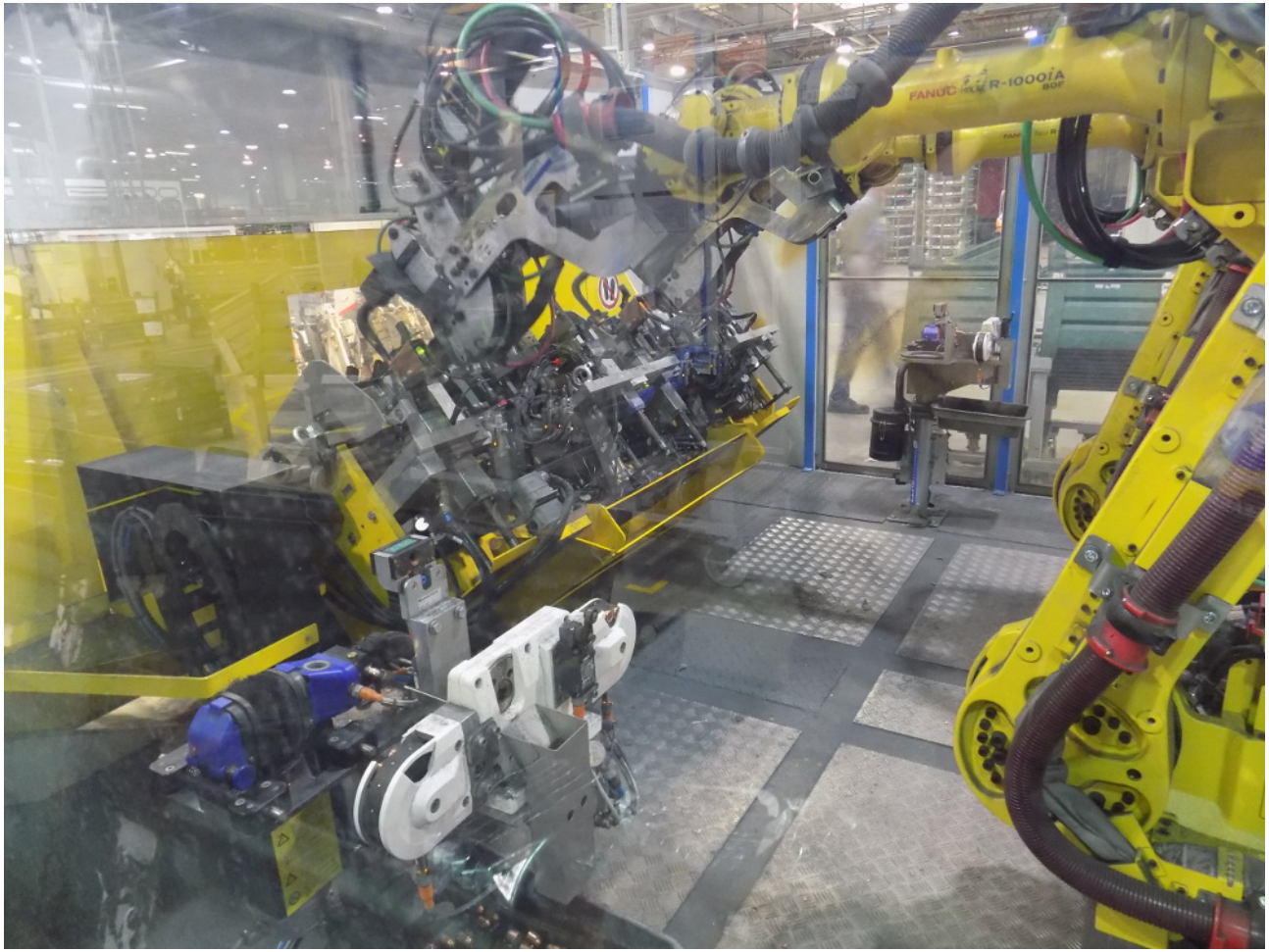
Manufacturing design of a new front frame

Applicable in shop floor during the setup of the production line

- Imperfect geometry of single part obtained by measurement (3D scan)
- Geometry of preliminary assembly obtained by measurement (3D scan)
- Design of compensation
  - design of new geometry for mayor single parts with compensation
- Proof of choosen manufacturing design
  - Forward analysis
  - Single parts with compensation
  - Goal: **Assembly now fits the target geometry**

Benefit

Reduce number of many try out loops to one single loop



Source: Opel Automobile GmbH

Thanks for your Attention!