HYDROFORMING ADVANCED HIGH-STRENGTH STEEL AND GLOBAL IMPLEMENTATION

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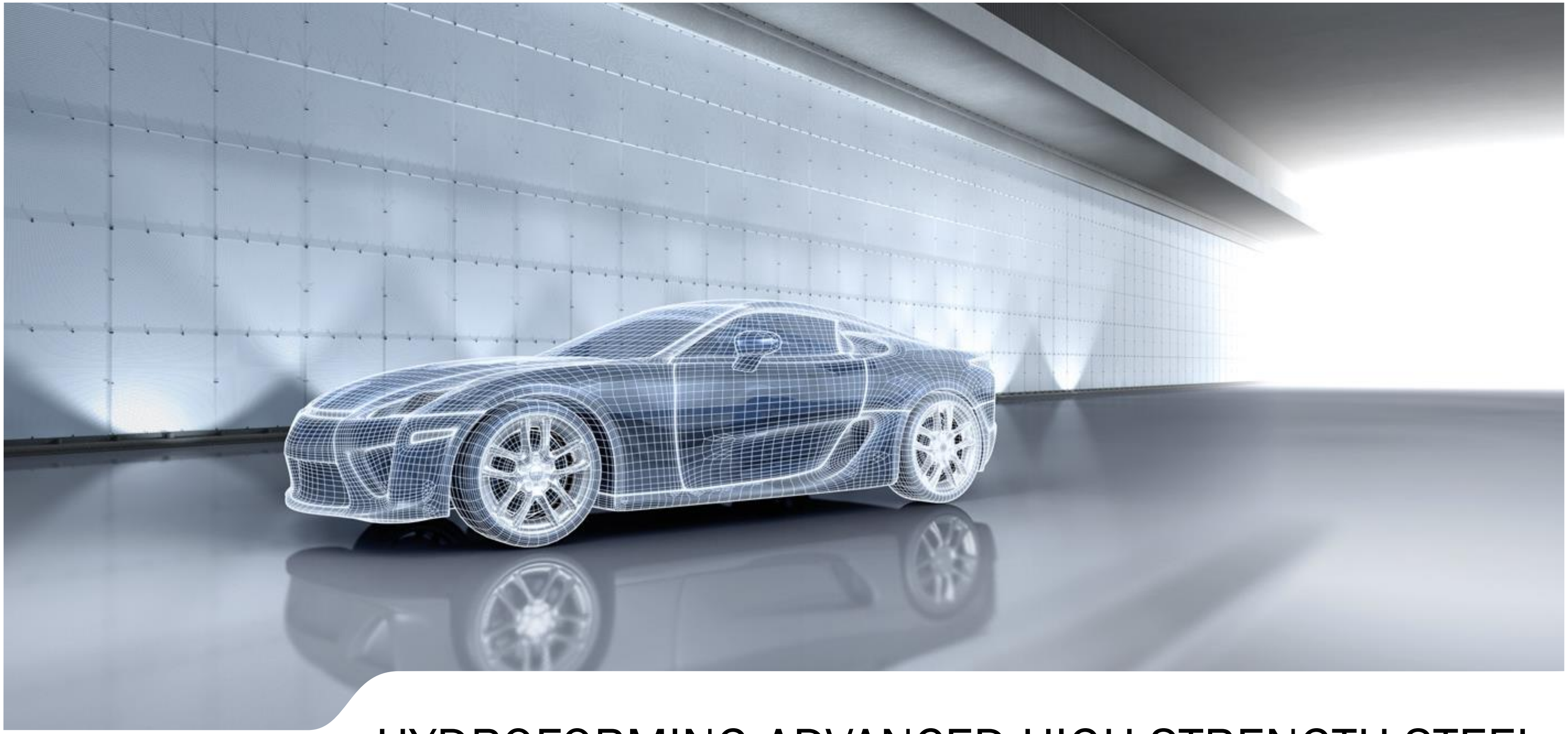
SCHULER

SCHULER
Member of the ANDRITZ GROUP

Steel Matters Demand Nothing Less
www.autosteel.org



HYDROFORMING ADVANCED HIGH-STRENGTH STEEL

KLAUS HERTELL, VICTOR ZAMUDIO, JON BALL, ANDREW DEVITO

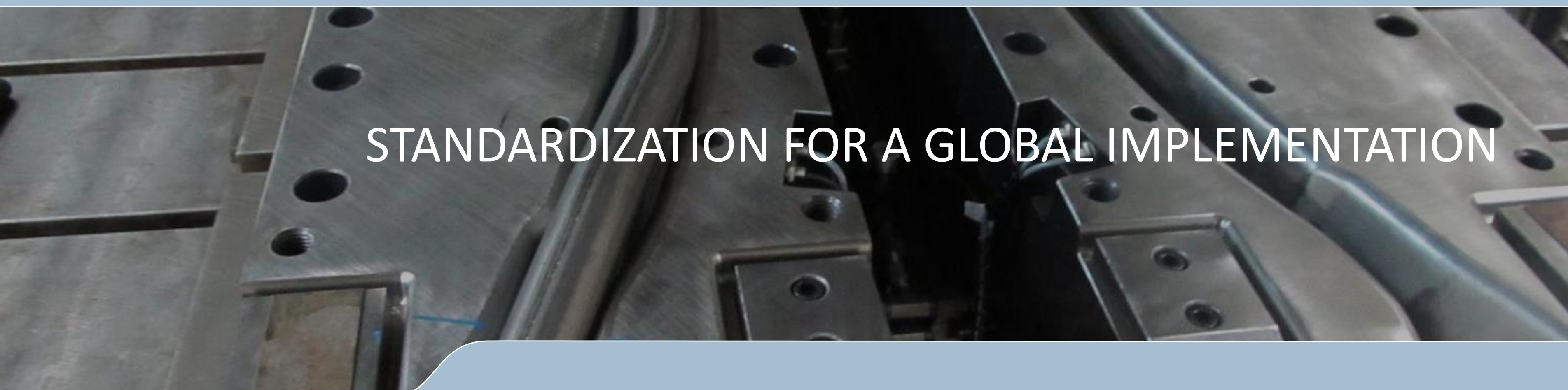
PRESENTATION OVERVIEW

Standardization for a global implementation

Hydroforming DP 1000 material

Springback, Compensation, Experience

Hydroforming Heavy Duty Rollover Protection



STANDARDIZATION FOR A GLOBAL IMPLEMENTATION

EXAMPLE FOR A GLOBAL HYDROFORM IMPLEMENTATION

HYDROFORMED ROOFRAIL IN THE NEW FORD EDGE

Ford Edge (USA):

2015 Model Year

with hydroformed roofrail

HYDROFORMING FOR GLOBAL PLATFORMS

STANDARDIZATION IS THE KEY FOR A GLOBAL PART DEVELOPMENT

" The Need" Efficient development of parts and tools for global platforms

"Same parts – same process – different Tier 1 supplier"

" The Method" ***Standardization*** of tools and process

" The Benefits" ***Reduced costs*** for development

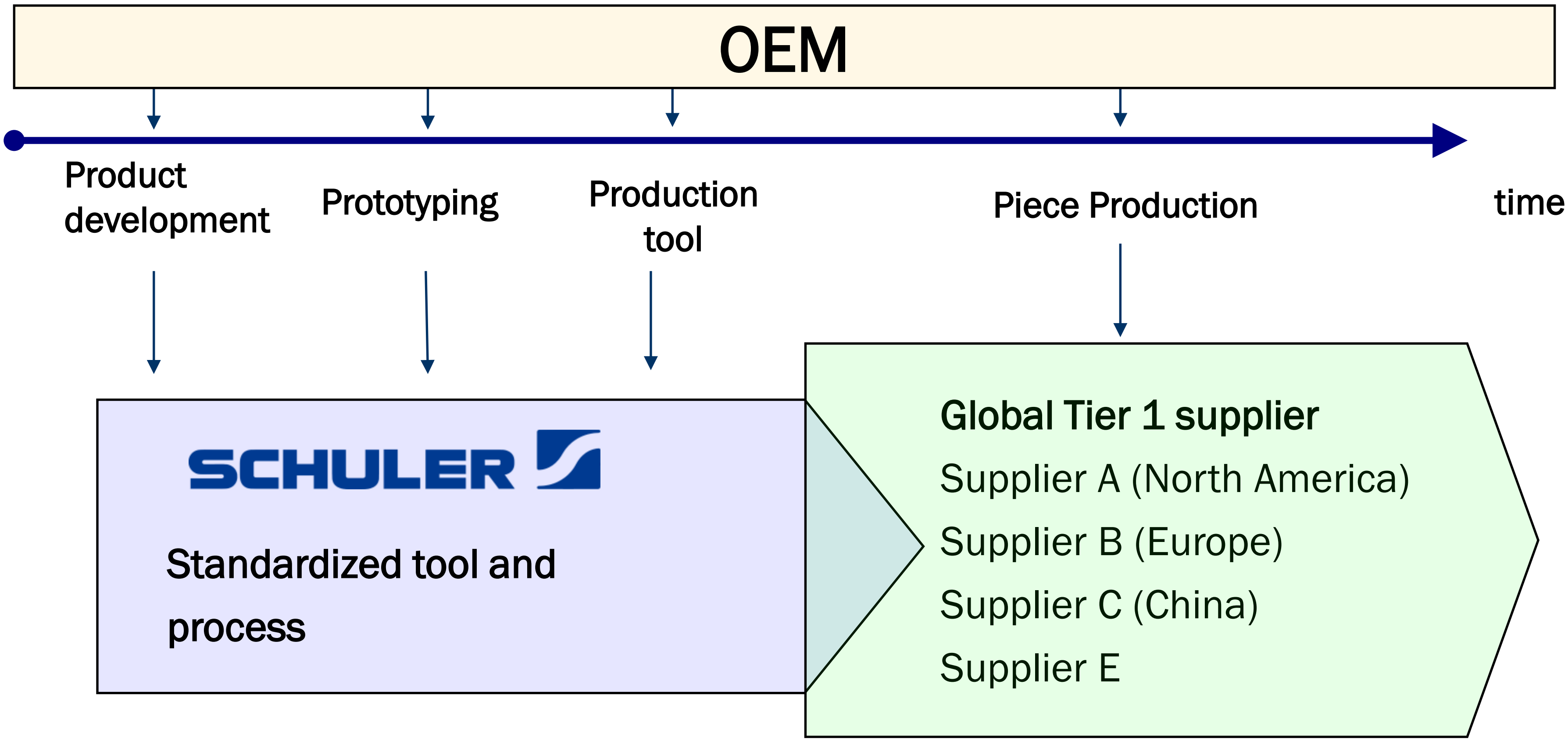
Hydroforming becomes a commodity

Reduced risk at implementation

Utilization of a larger Tier 1 supplier base

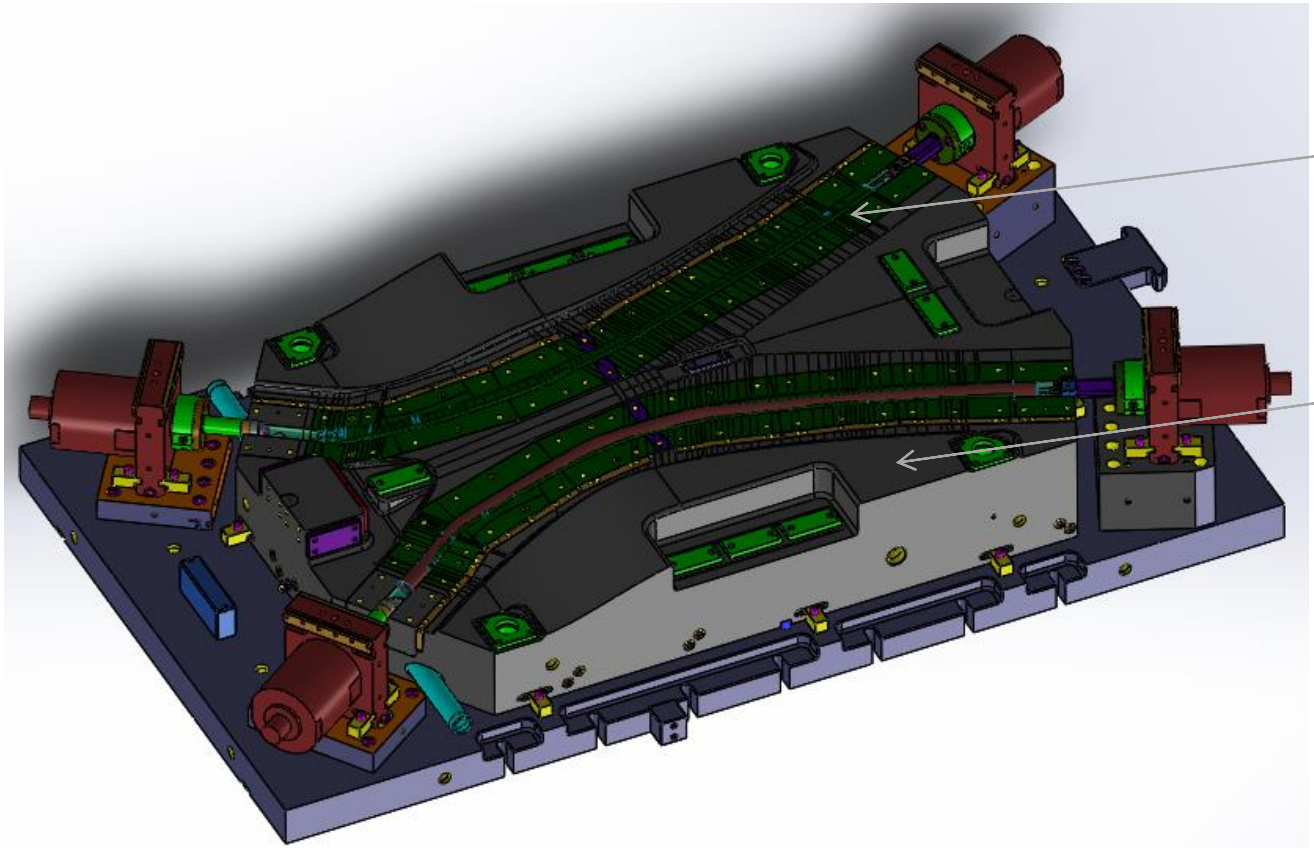
BASIC SETUP TO DEVELOP PARTS AND DIES FOR A GLOBAL PLATFORM

"GLOBAL HYDROFORM FOOTPRINT"



THE CONCEPT OF AN UP-GRADEABLE PRODUCTION TOOL

PROTOTYPING INSERTS ARE USED FOR PART DEVELOPMENT AND RE-CUTTING



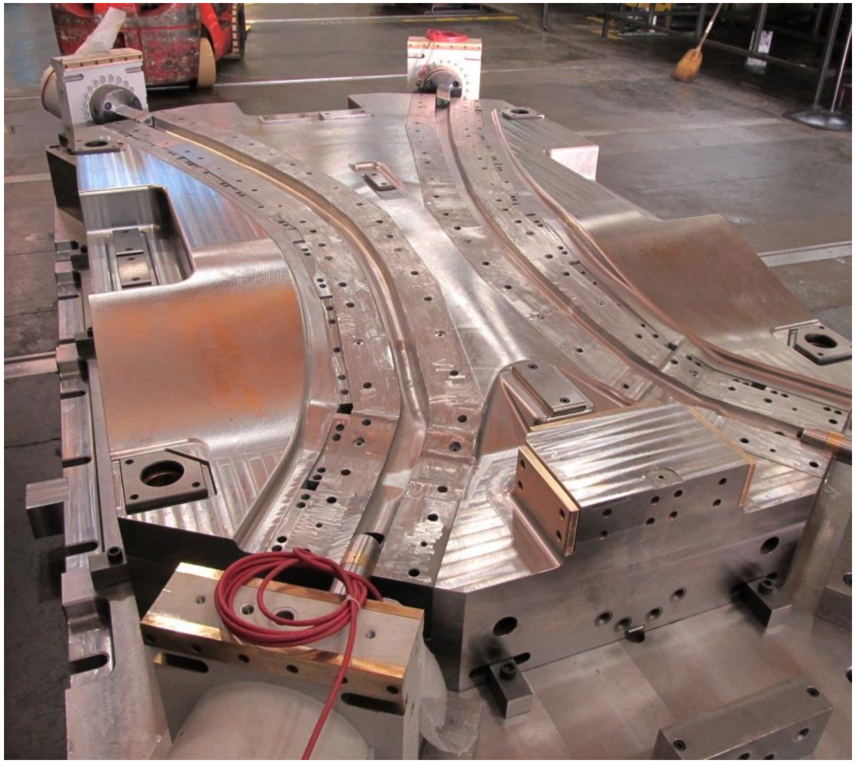
Prototyping inserts for re-cutting

Upgradeable production Tool

There is no separate prototyping tool used!

TYPICAL ROOFRAIL PRODUCTION TOOL BUILD BY SCHULER

PROTOTYPING INSERTS ARE USED FOR PART DEVELOPMENT AND RE-CUTTING



Global hydroform tool standard

Schuler has build:

16 roofrail dies for 9 suppliers on 3 continents

"Same process"

EXAMPLE FOR GLOBAL PLATFORM: FORD CD4.2

ALL HYDROFORM ROOF RAILS DEVELOPED BY SCHULER

Ford Edge North America (top right) – Supplier A

Ford Edge Asia (top left) – Supplier B

Ford Smax (lower left) – Supplier C

Not shown: Galaxy Europe and Lincoln MKX

Images courtesy of Ford, Carmagazine, Paultan

VARIOUS ROOFRAIL PROJECT WITH ADVANCED HIGH-STRENGTH STEEL

Prototyping parts at Schuler

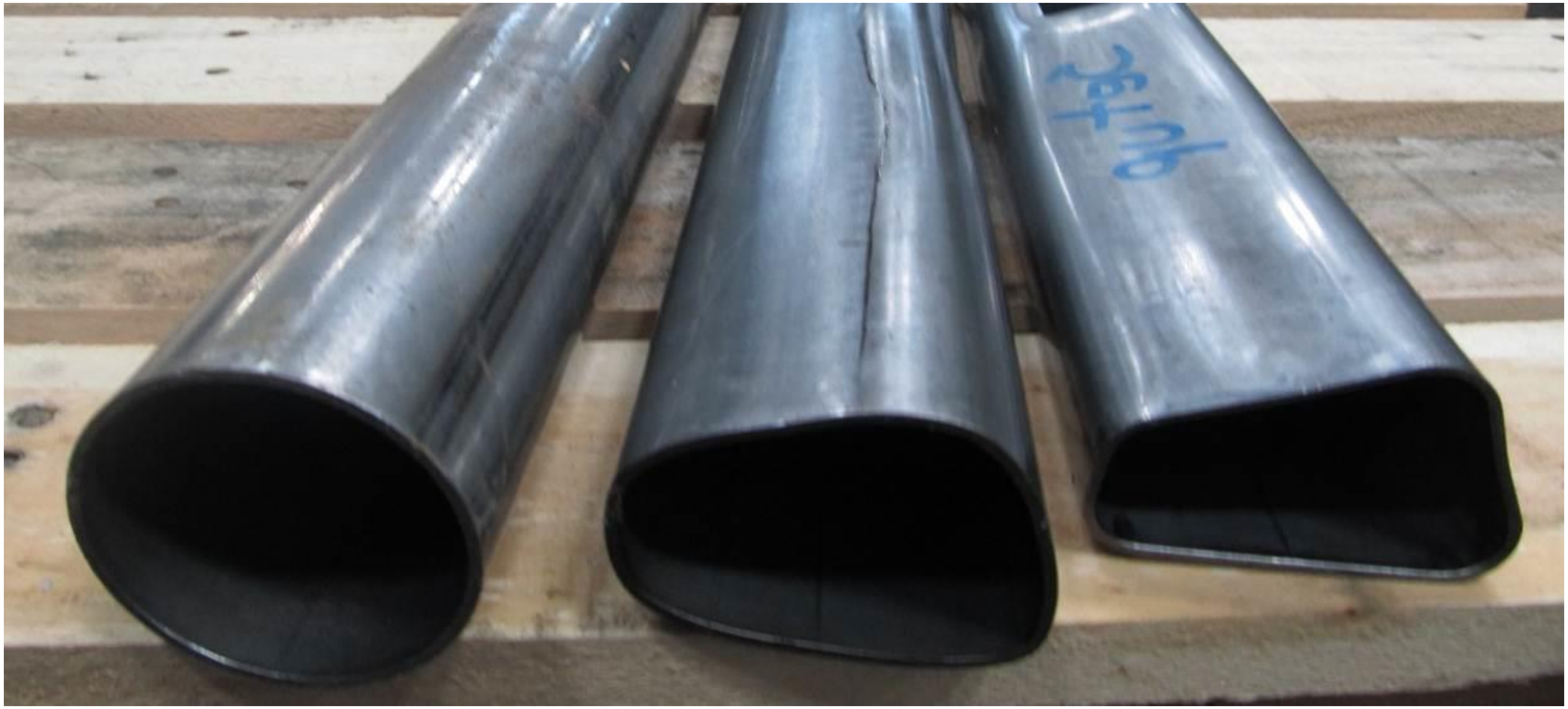
Selection of various DP 1000 roofrails

HYDROFORMING DP1000 MATERIAL

EXPERIENCE, SPRINGBACK, LESSONS LEARNED

PROCESS STEPS: BENDING – PREFORM – HYDROFORM

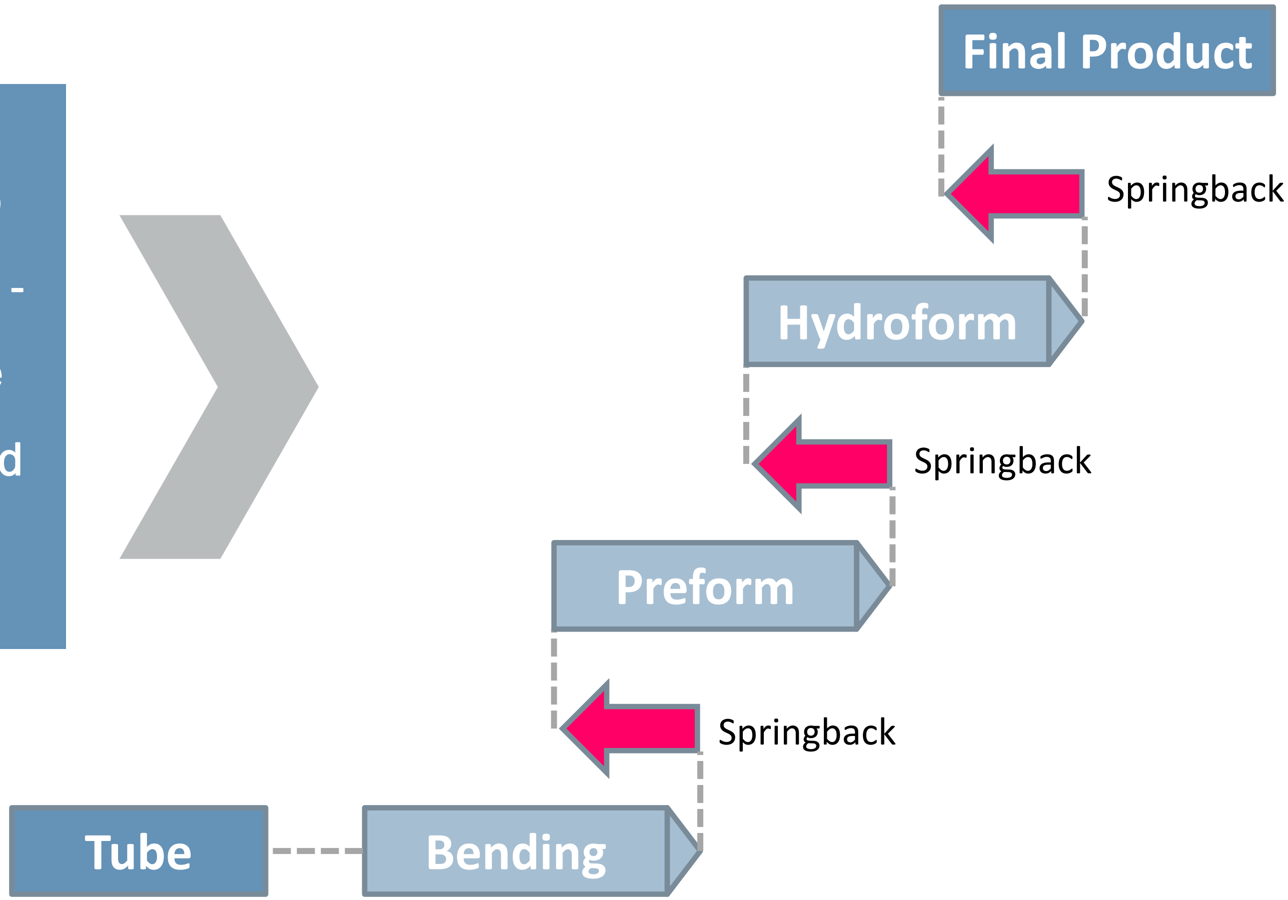
PROCESS STEPS TO CREATE A HYDROFORMED ROOFRAIL



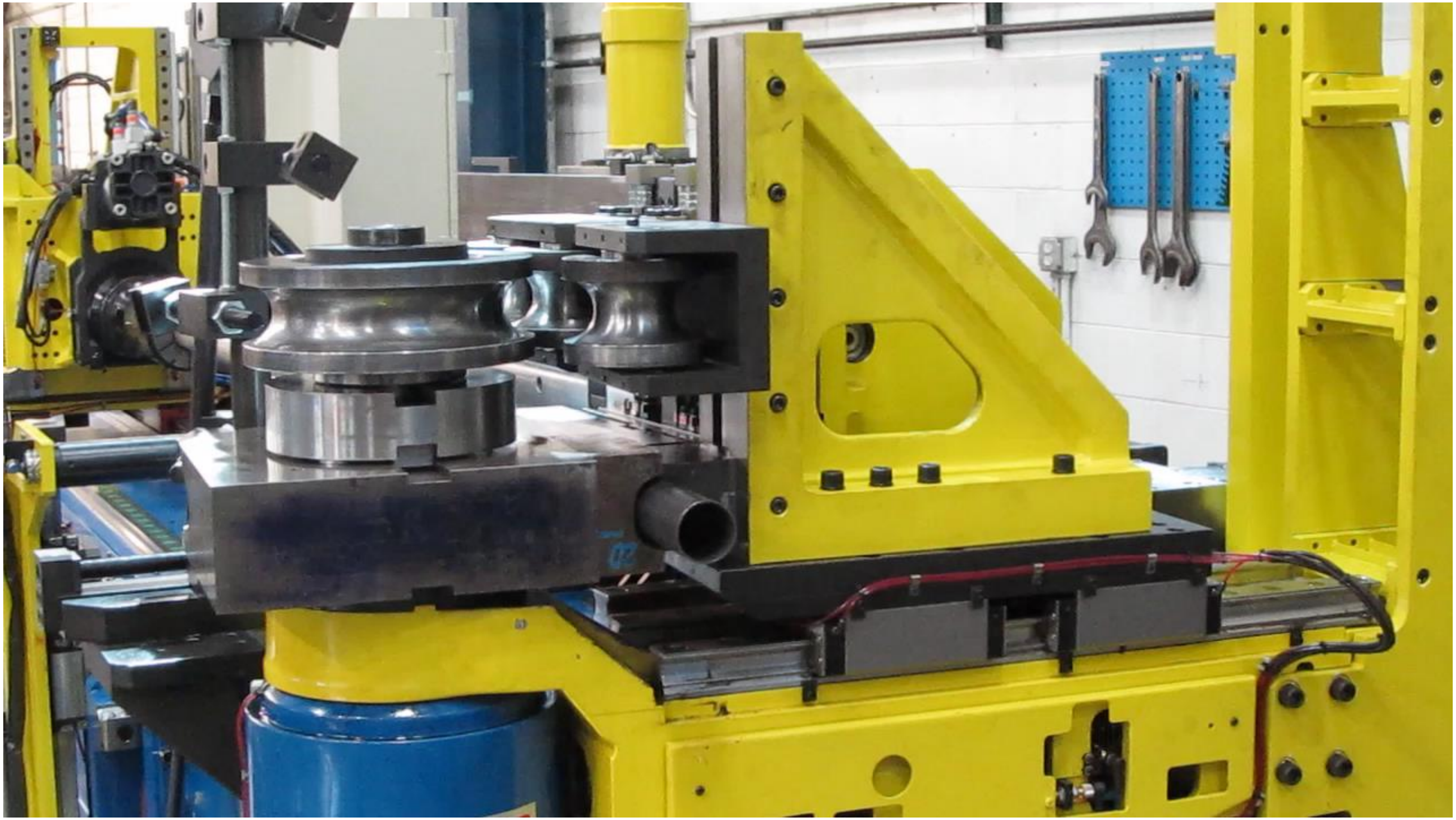
CNC bending Preform Hydroform

SPRINGBACK OF DP1000 MATERIAL AFTER EACH FORMING OPERATION

Each forming step creates springback - which needs to be carefully considered and compensated

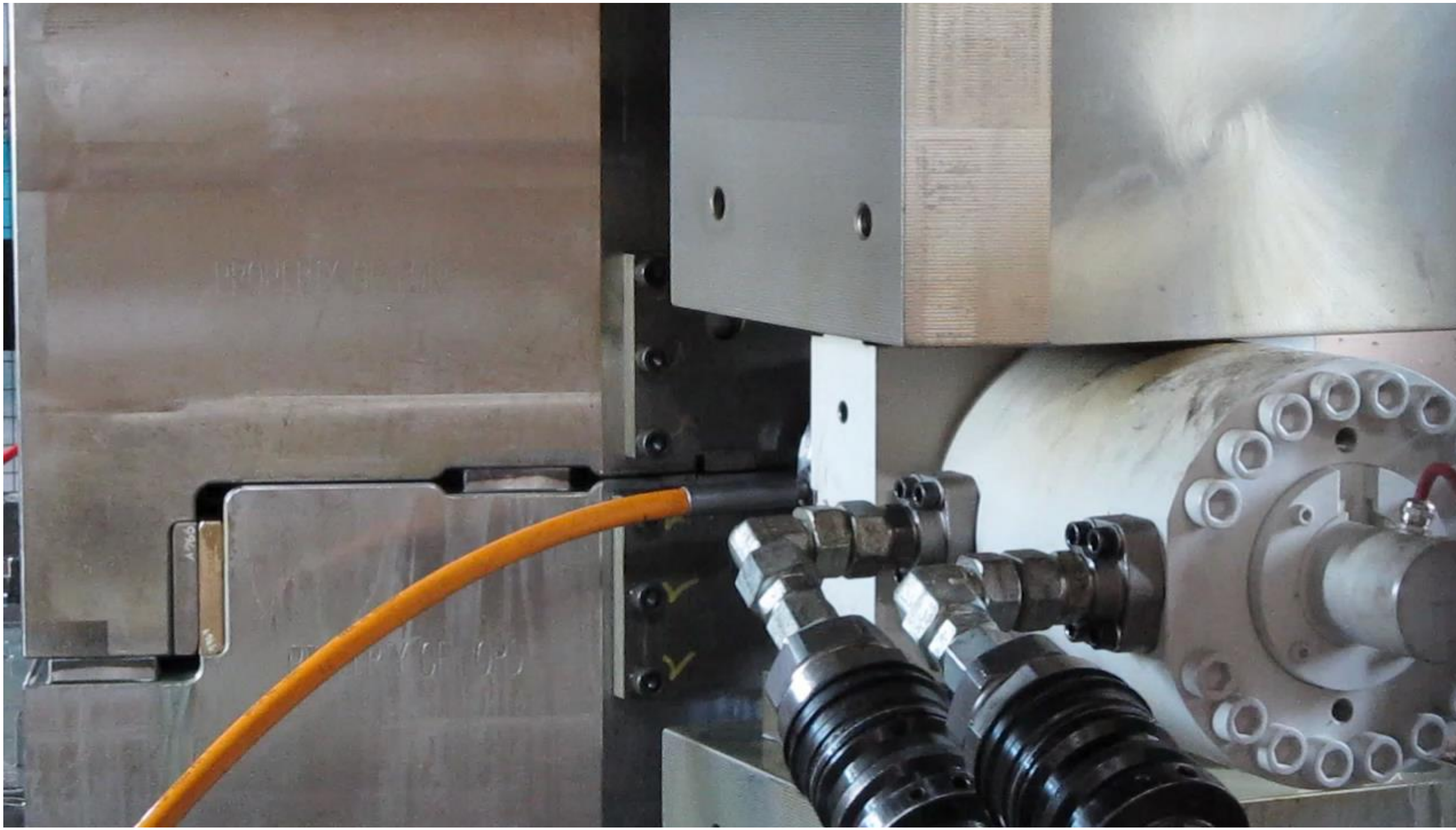


BENDING OPERATION ROOFRAIL (PROTOTYPING)



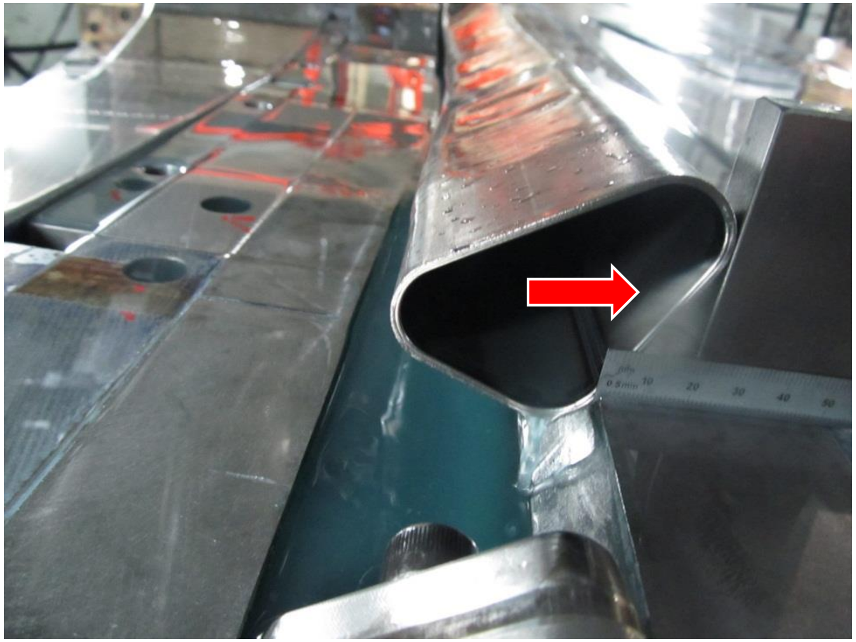
PREFORM OPERATION ROOFRAIL (PROTOTYPING)

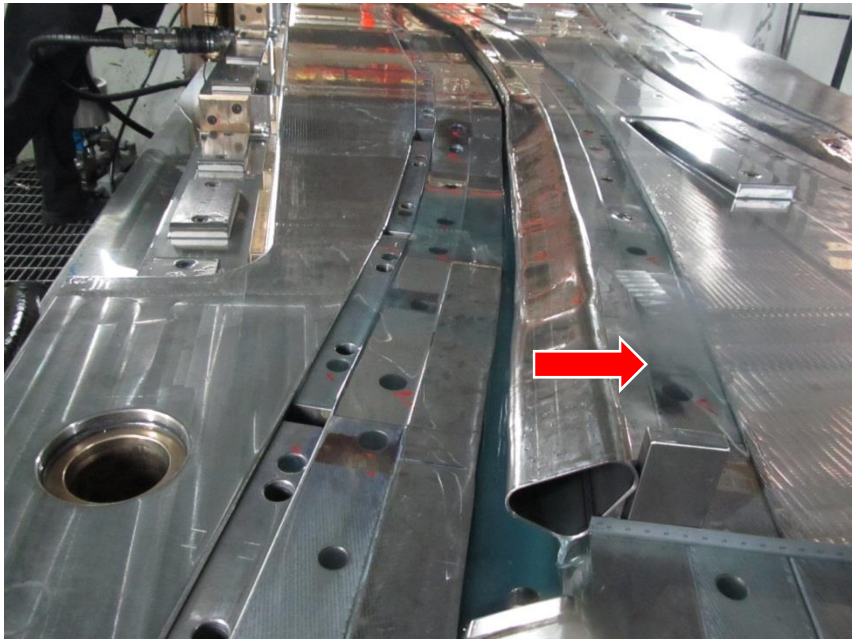
HYDROFORM OPERATION ROOFRAIL (PROTOTYPING)



EXAMPLE FOR SPRINGBACK AFTER HYDROFORMING

DP1000 TUBES AFTER HYDROFORMING SHOW SIGNIFICANT SPRINGBACK





20 mm springback after hydroforming

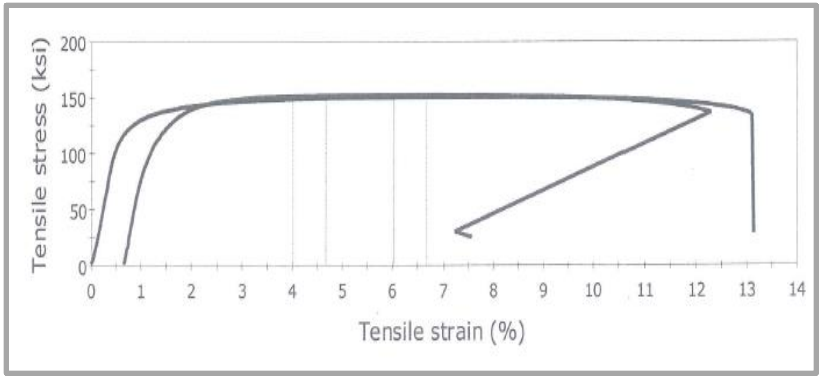
(Measured on one leg only)

MECHANICAL PROPERTIES OF ADVANCED HIGH STRENGTH STEEL

COMPARISON OF MILD STEEL VS ADVANCED HIGH STRENGTH STEEL

Advanced High-Strength Steel: DP 1000
Yield: 800 N/mm^2
Tensile: 1000 N/mm^2
Total Elongation: 10%

Mild Steel:
Yield: 280 N/mm^2
Tensile: 330 N/mm^2
Total Elongation: 25%



Reason for springback

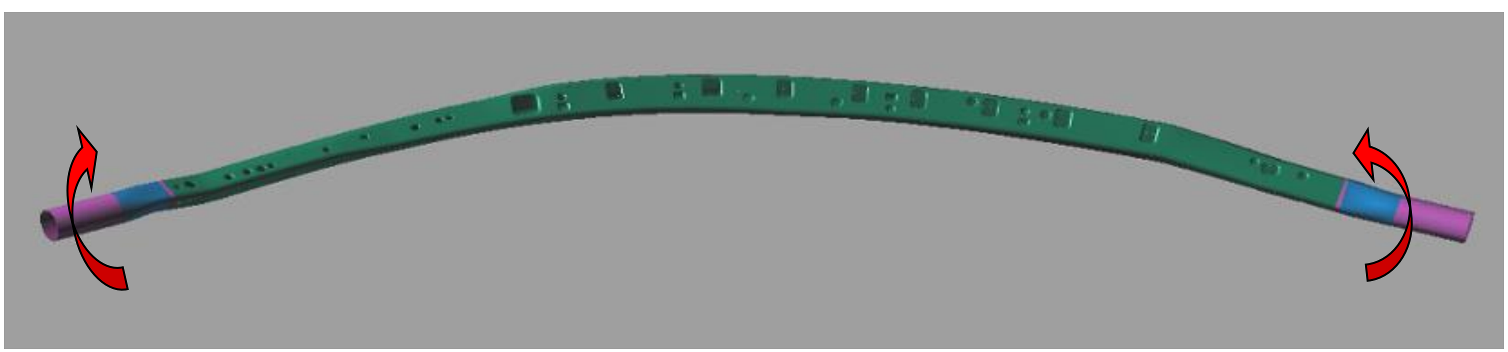
"The reason for springback is the high yield and tensile strength in the raw material"

USAGE OF ADVANCED HIGH-STRENGTH STEEL IN HYDROFORMING

SPRINGBACK COMPENSATION IS FAIRLY NEW TO HYDROFORMING

	< 2005:	2007:	2009:	2013:	2016:
Material grade:	HSLA	DP600	DP800	DP1000	???
Springback:	None	Small	Medium	Major	

Example: DP1000 roofrail, 10 mm springback per leg after hydroforming



IMPROVING OF PART QUALITY THROUGH RECUTS

COMPENSATION SEQUENCE FOR RE-CUTS

Step 1:

- Springback prediction with FEA
- Initial morphing in CAD
- First prototyping

Step 2:

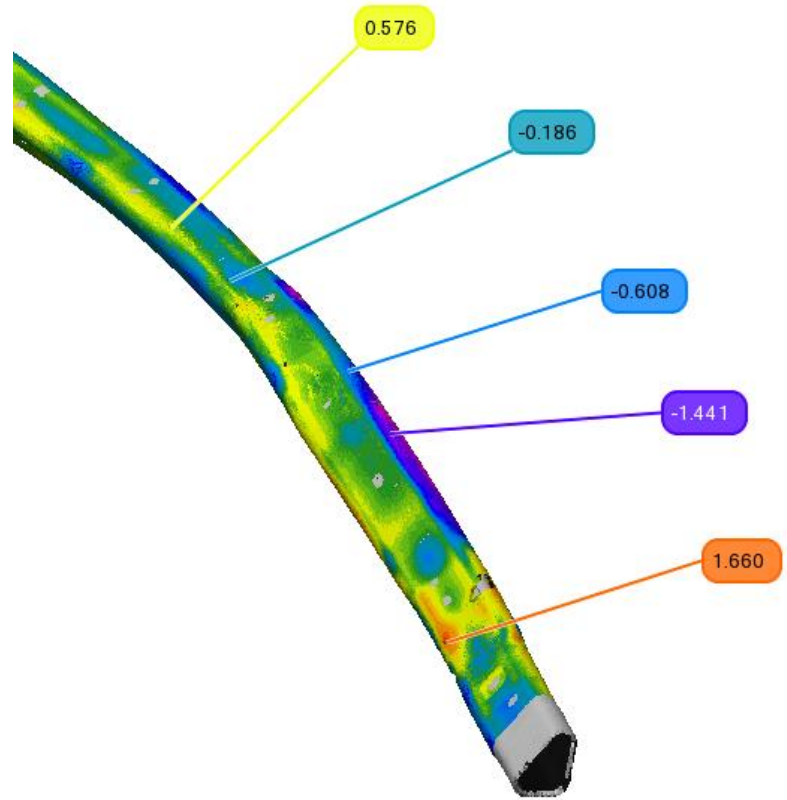
- Laser-scanning / reverse engineering
- Update morphing in CAD
- 1st recut and tryout

Step 3:

- 2nd recut

SCANNING AND REVERSE ENGINEERING OF ACTUAL PARTS

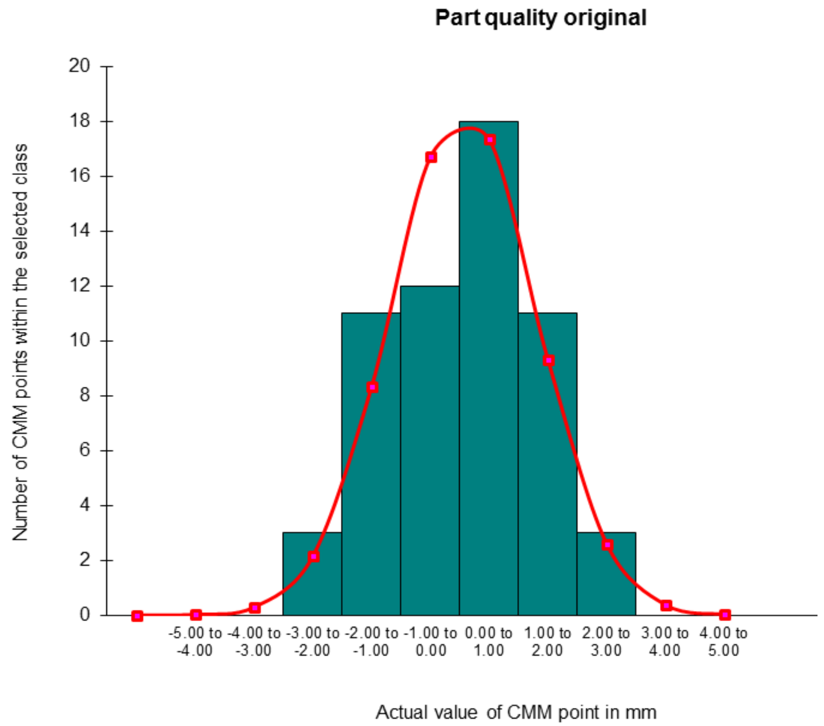
SCANNING IS THE ESSENTIAL TOOL FOR SPRINGBACK COMPENSATION



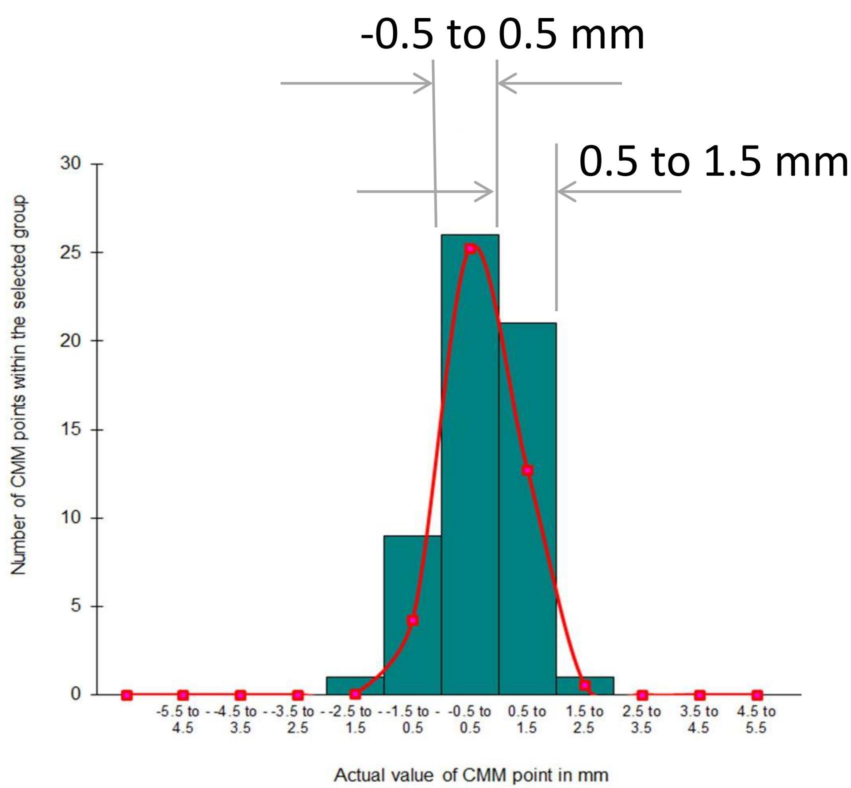
Actual parts are measured on a CMM fixture
3D laser-scanning and reverse engineering
Loading actual part surfaces back into CATIA

IMPROVING OF PART ACCURACY THROUGH RECUTS

WITH EACH RECUT THE PART IS GETTING CLOSER TO PRINT



Part accuracy at original prototyping



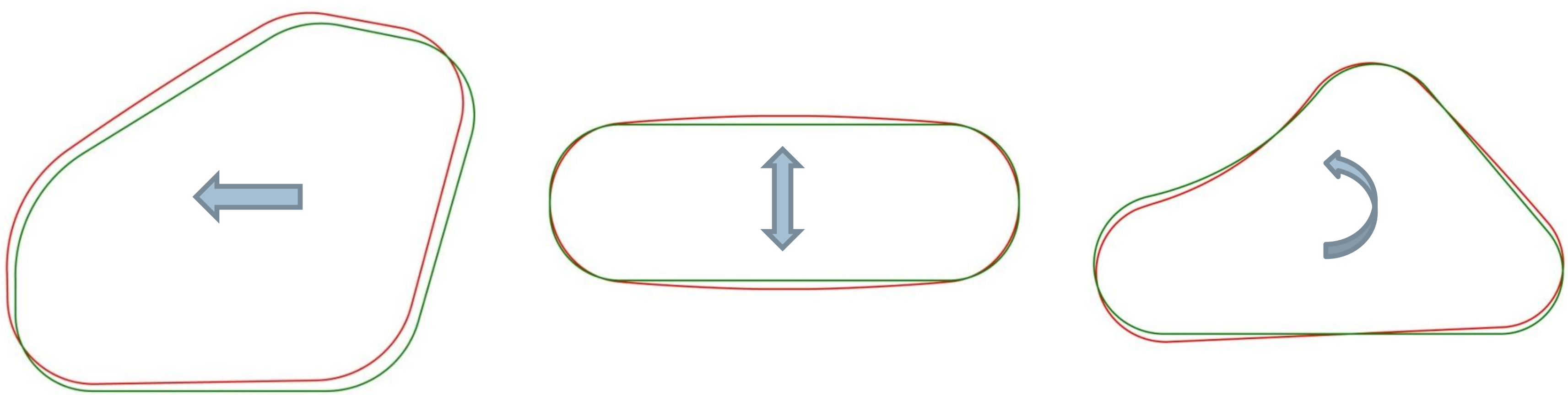
Part accuracy after 2nd recut

SPRINGBACK EFFECTS IN HYDROFORMING

3 DIFFERENT TYPES OF SPRINGBACK: GLOBAL – CROWNING - TWISTING

Green: Target cross section

Red: Actual cross-section after forming

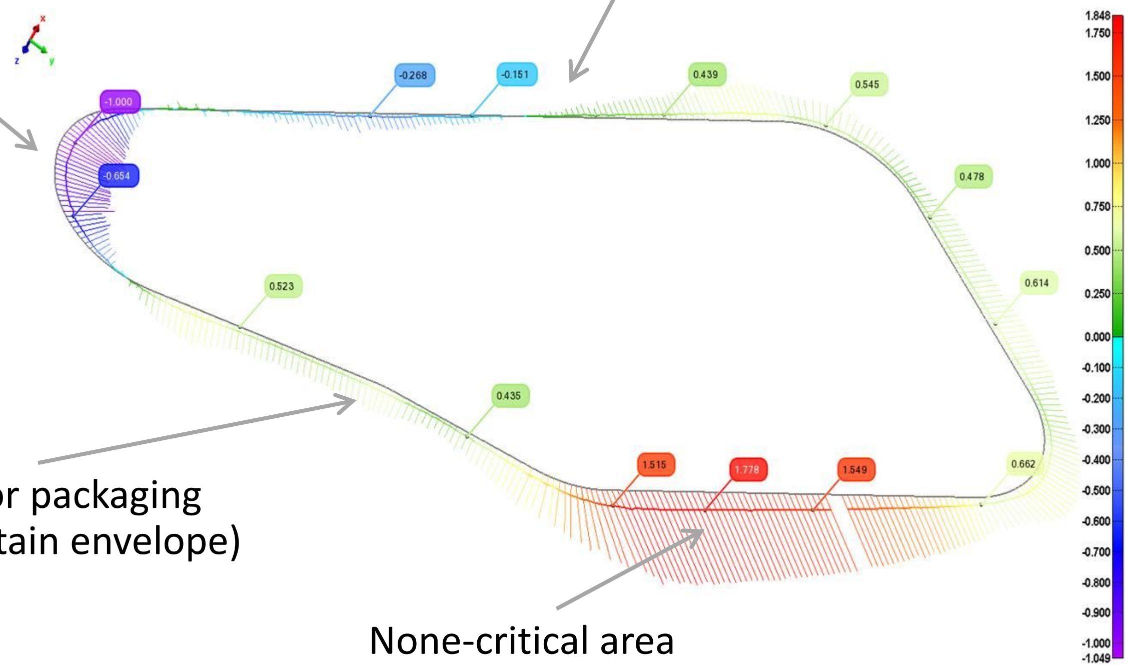


Global Springback | Crowning | Twisting

TYPICAL EFFECTS OFF SPRINGBACK ON AN ACTUAL CROSS SECTION

Critical surface for laser welding
(needs to be accurate and flat)

Corner radius not filled
(acceptable)

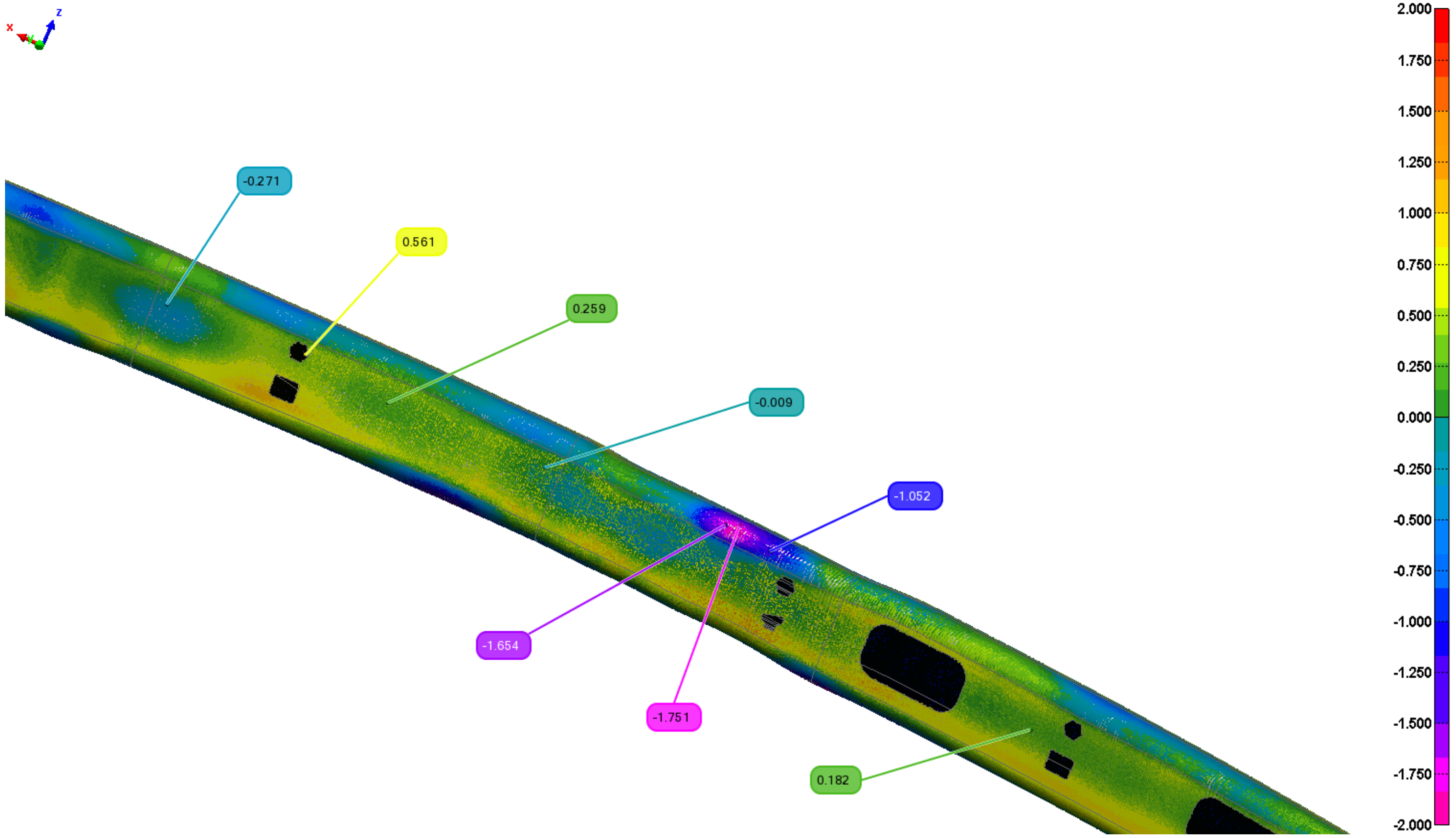


Critical surface for packaging
(cannot exceed certain envelope)

None-critical area
(relaxed surface tolerance)

SPRINGBACK PART ACCURACY ON A 3-DIMENSIONAL PART

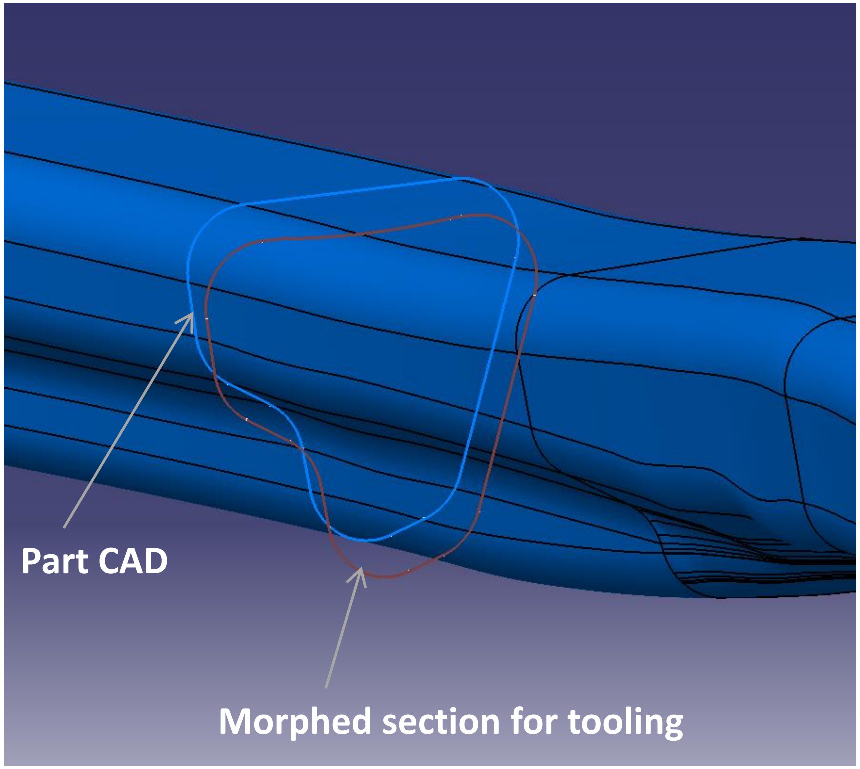
GLOBAL SPRINGBACK – CROWNING – TWISTING – ALL IN ONE PART



COMPENSATION OF SPRINGBACK THROUGH TOOL DESIGN

SPRINGBACK GETS COMPENSATED IN THE HYDROFORM TOOL

Part surface and compensated section

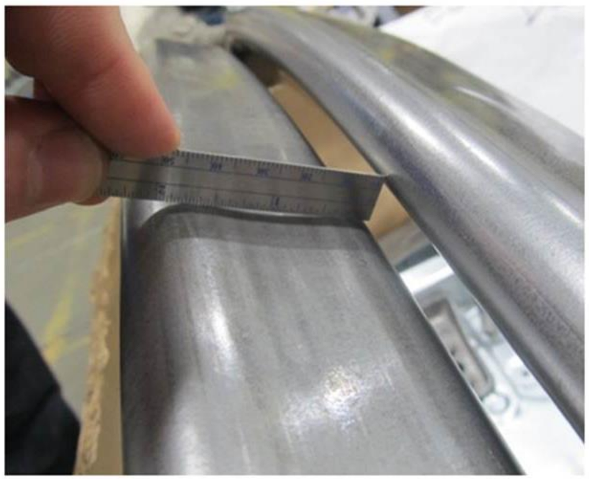


Morphing means: Compensation for springback

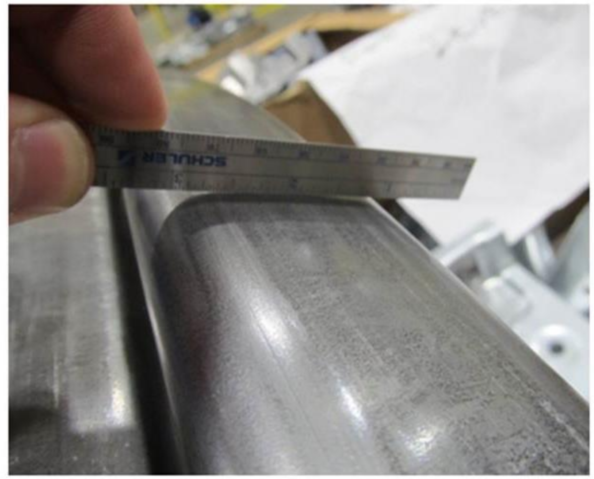
"The entire part needs to be re-designed to create tool surfaces"

CROWN COMPENSATION IN THE TOOL DESIGN

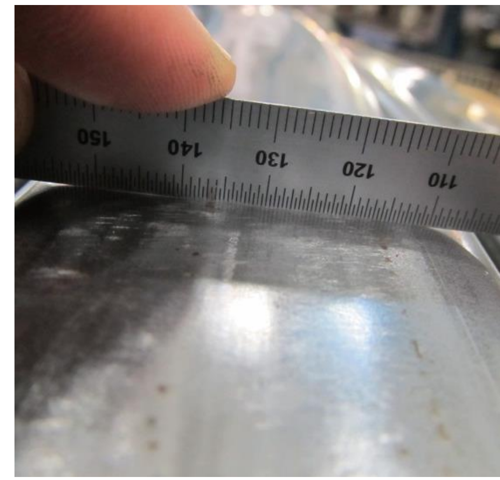
THE DIFFICULTY TO GET FLAT SURFACES WITH DP1000



Too much compensation
(Concave part surface)



Too little compensation
(Convex part surface)



Correct compensation
(Straight surface)

SPRINGBACK PREDICTION IN THE FEA SIMULATION

RESULTS FROM AUTOFORM SIMULATION AT SCHULER

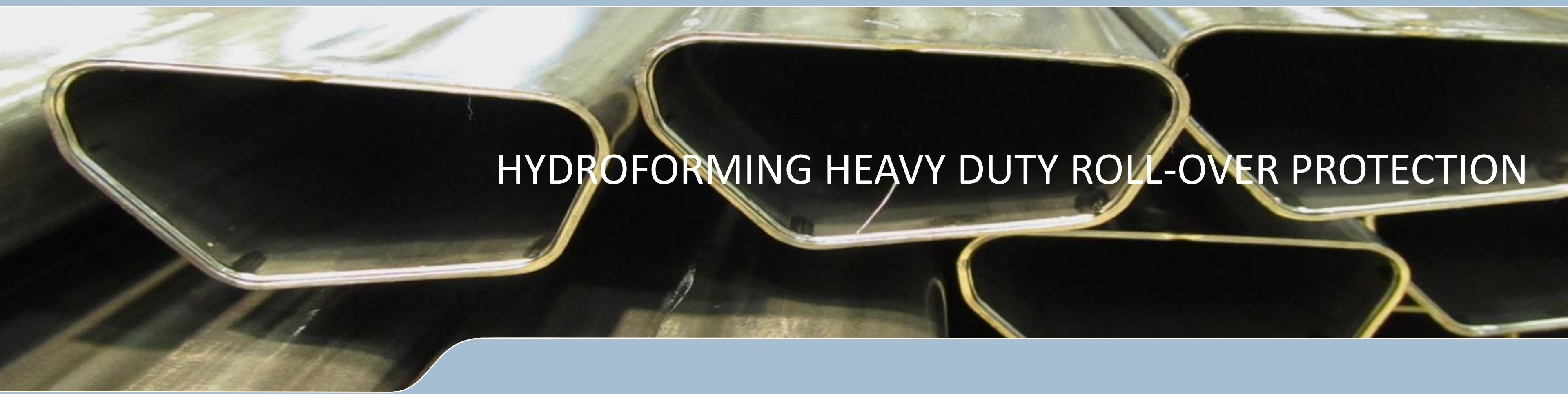
		Raw tube dimensions (mm)			Springback (mm)	
	Material	Diamter	Wall thickness	Part length	Max predicted FEA	Max observed actual
Project 1	DP 1000	60	1.8	2450	11.3	10.0
Project 2	DP 1000	60	1.8	2325	11.7	10.3
Project 3	DP 1000	63	1.4	2200	8.8	7.5
Project 4	DP 1000	60	2	1850	2.6	3.2
Project 5	Alu 6082	51	2.8	2615	2.7	2.3
Project 6	Alu 6161	101	3.1	1525	1.7	2.0

Predicted vs. actual springback on 6 different projects.
Using Autoform for the FEA simulation

VARIABLES CAUSING VARIATION IN SPRINGBACK

SELECTION OF FACTORS CAUSING SPRINGBACK ARE SHOWN BELOW

Factor	Effect on Springback
Length of part	The longer the part – the more springback
Thickness of the tube	A thicker tube is stiffer and has less springback
Diameter / Thickness	Tube diameter / wall thickness ratio plays a role in springback
Bending radius	The larger the bending radius - the smaller is the springback
Cross section / Geometry	The shape of the cross section
Forming process	Bending, preforming method, hydroform parameters etc.


HYDROFORMING HEAVY DUTY ROLL-OVER PROTECTION

HYDROFORMED ROLL OVER PROTECTION

Hydroformed roofrail

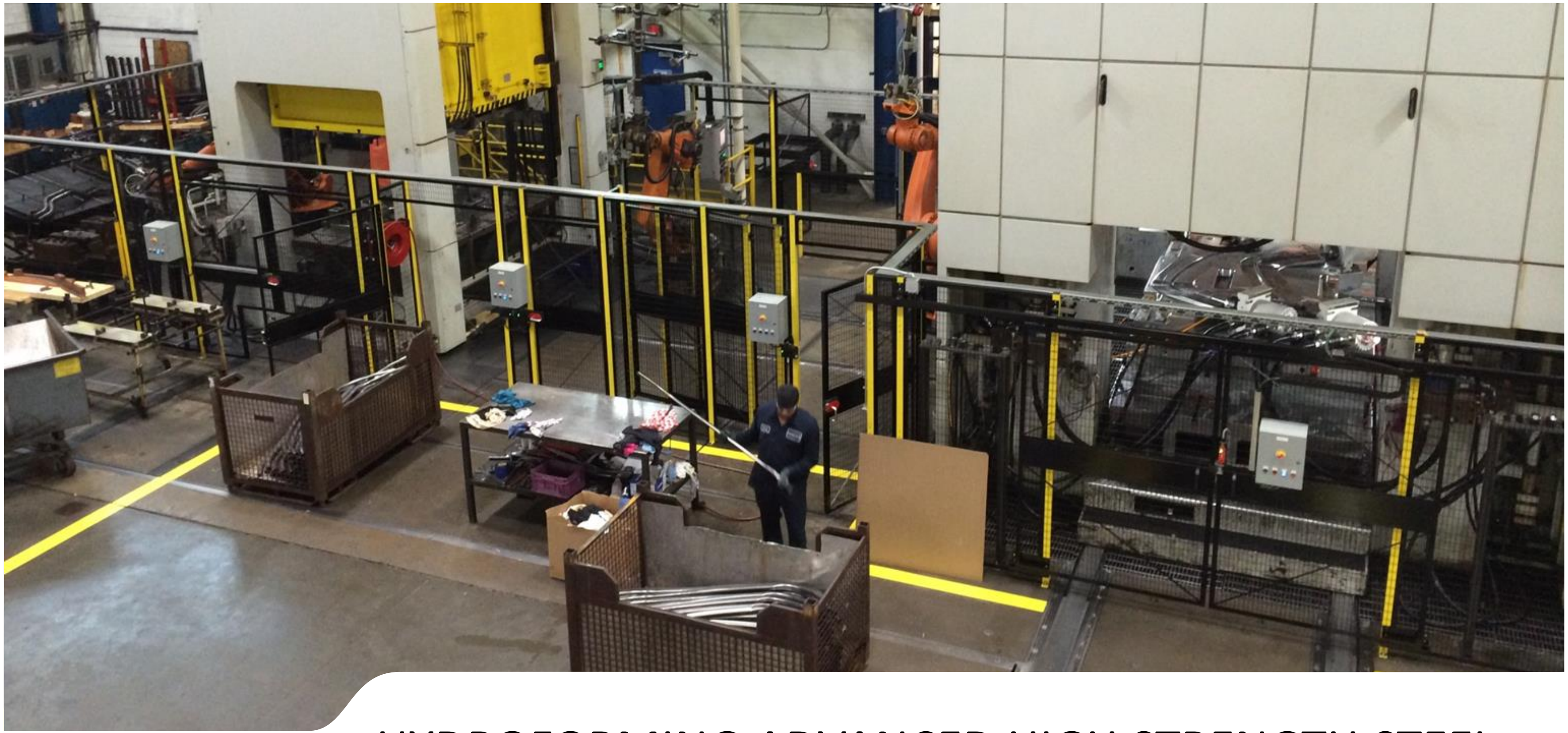
Hydroformed Roll-Over Protection:

“Not just in Automotive”

HYDROFORMED ROLL OVER PROTECTION

Example for a
heavy duty part application
in hydroforming

Tube thickness: 8 mm
Tube diameter: 150 mm
Part weight: 270 lbs
Material tensile: 500 N/mm2



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