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Advanced Forming Technologies for Lightweighting BIW

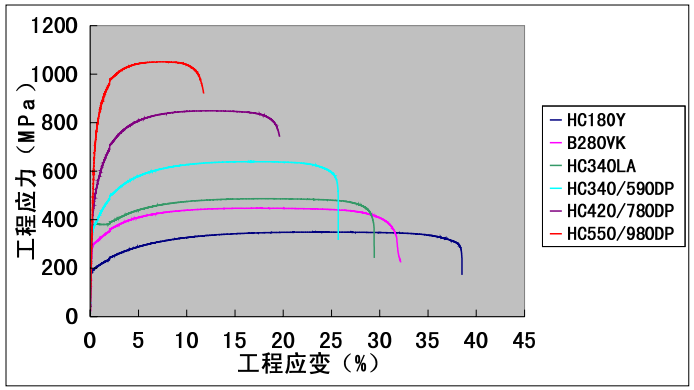
Research Institute
Baoshan Iron & Steel Co.,Ltd

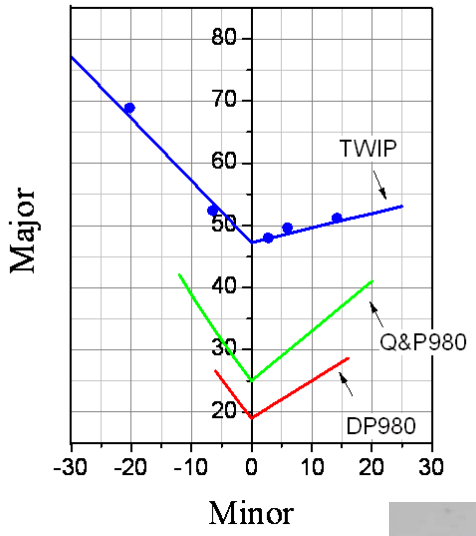
June. 2014

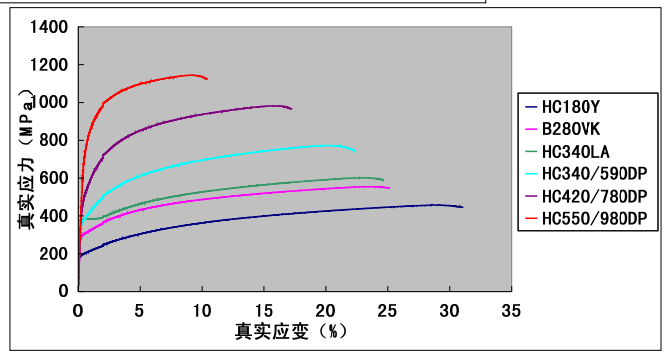
Contents

Generic AHSS Property Study

- Database
- FLD
- Formability







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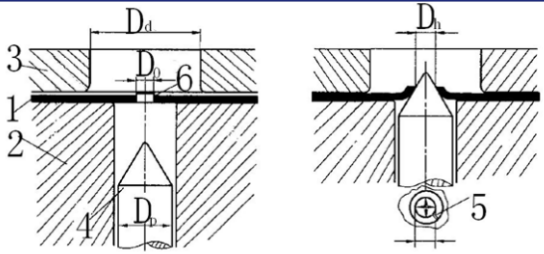
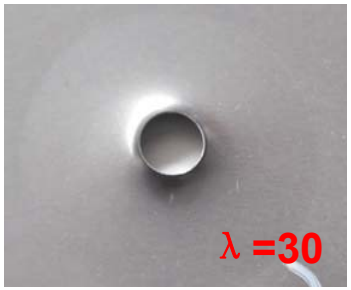
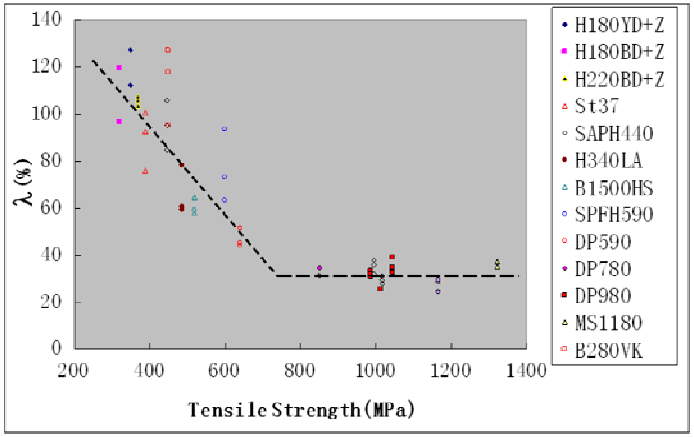
Generic AHSS Property Study

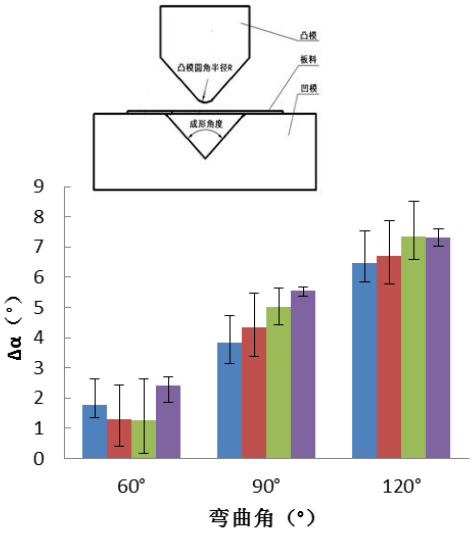
- Hole Expansion

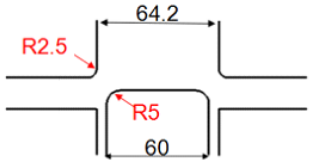






- Springback





- TWIP950
- QP980
- DP980
- DP780
- TRIP780

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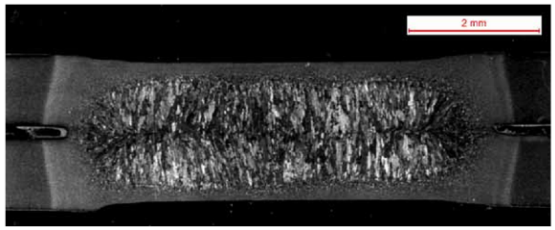
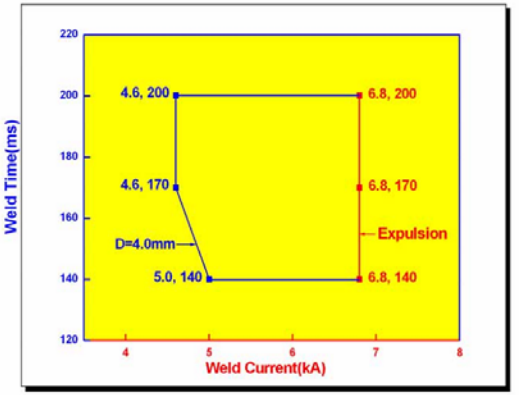
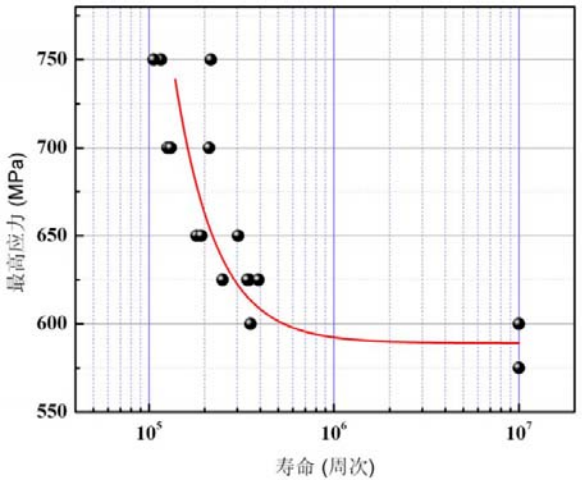
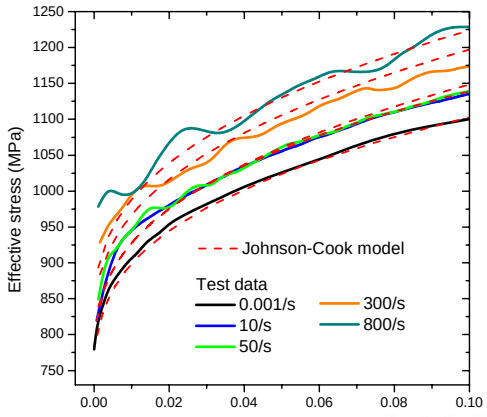
Generic AHSS Property Study

- Bendabilty
- Weldability
- Fatigue
- High Strain









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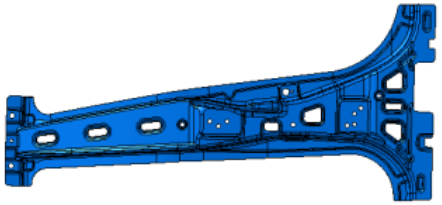
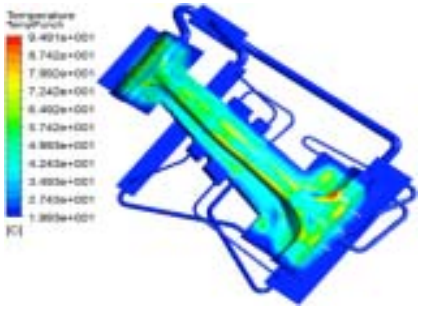
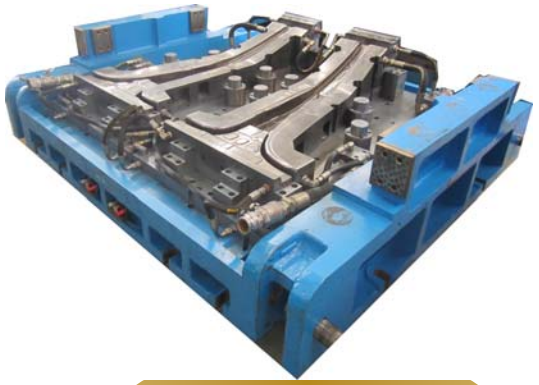
Hot Forming



Part design



Quenching Simulation



Tooling design and Making

HF tech solution package

TWB HF

Patch Work HF

Variable Strength HF

Prototype

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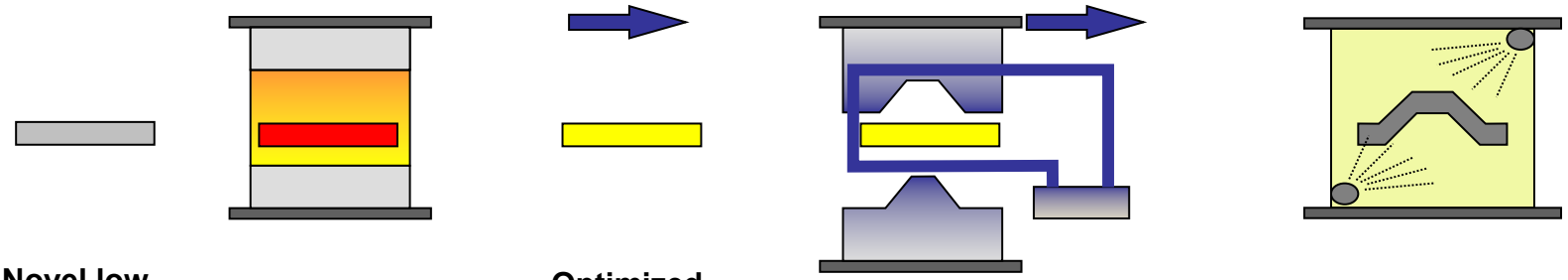
Latest HF Techs in BaoSteel

1. Low-cost short-cycling HF process

- Novel low-temp HF steel (Forming temp ↓ drops down 100-200C)
- High-conductible antiwearing die steel (Die life ↑ > 40%, die cost ↓ 10%)
- Optimized lightweight grabber (device weight ↓ >50%)
- Optimized adapted tooling and process unit



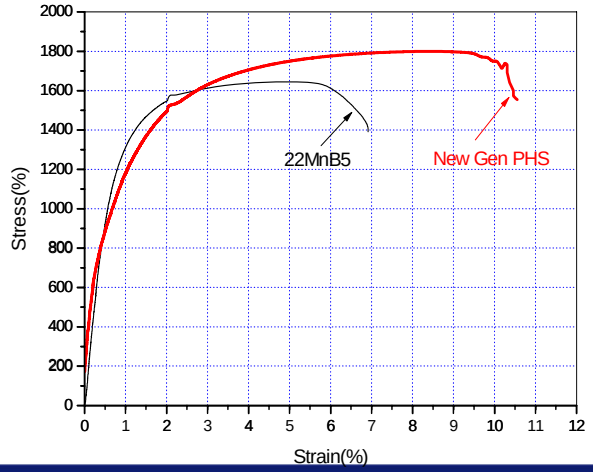
Novel low-temp HF steel

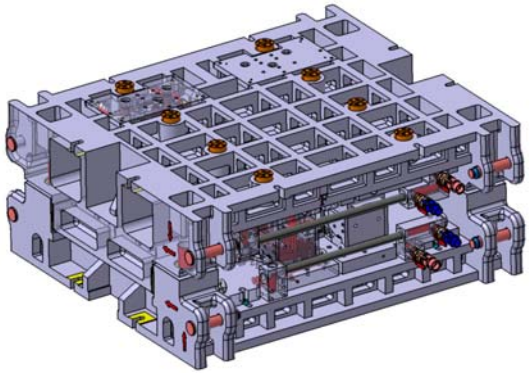
Low-temp heating

Optimized lightweight grabber

High-conductible antiwearing die steel set & process

Shot blasting





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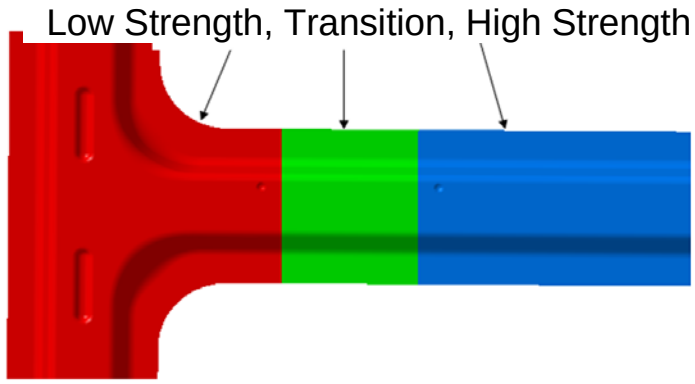
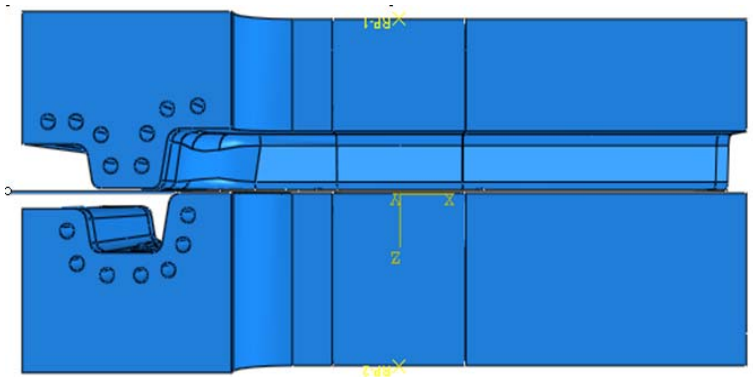
Latest HF Techs in BaoSteel

2. Variable Strength HF process

- Forming die design and optimization
- Process varification and improvement
- Prototype quality analysis



Prototype design



Tooling design

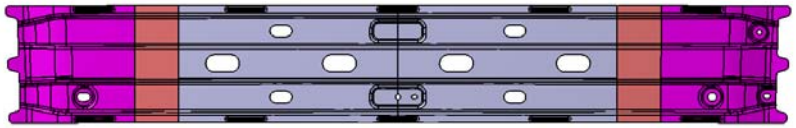
Process study

Prototype

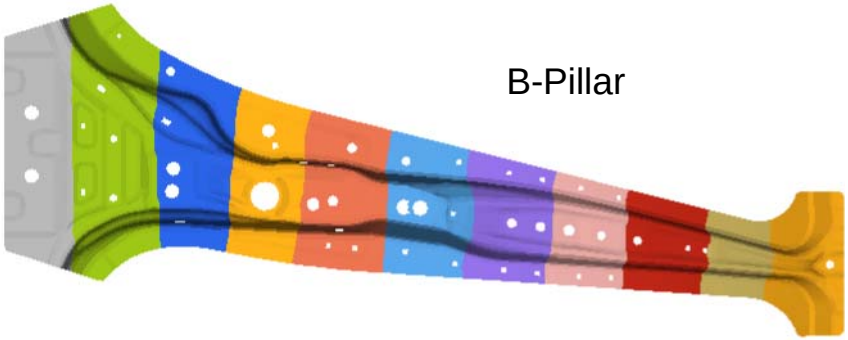
Latest HF Techs in BaoSteel

3. HF process for variable thinkcess blanks

- **Forming die design and optimization; Process varification and improvement, and Prototype quality analysis**



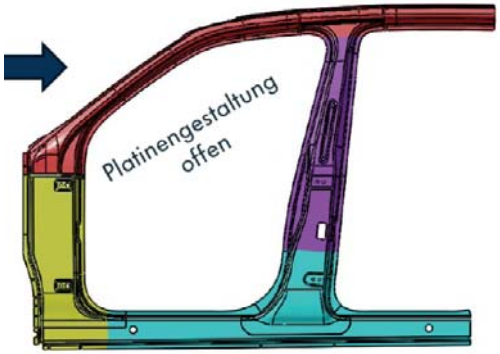
Roof Cross Member



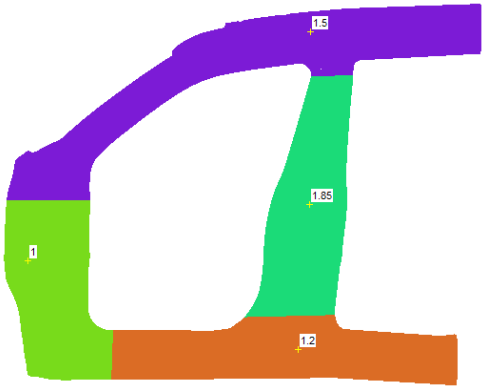
B-Pillar

4. Door Ring HF process

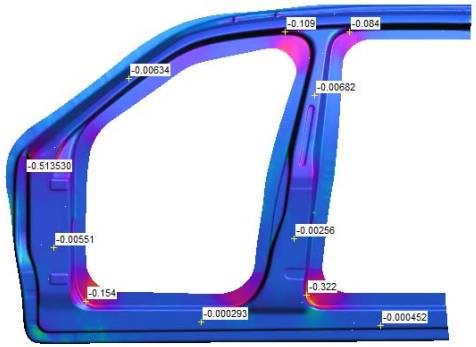
- **Door ring structure analysis and optimization**
- **Forming Process varification and improvement**



Structural analysis



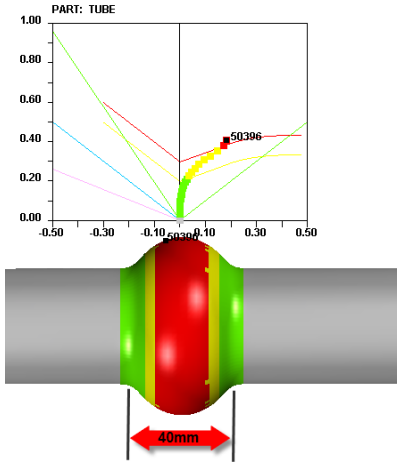
Process study



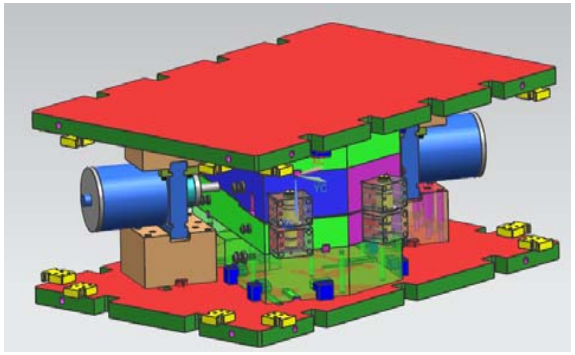
Forming simulation

Hydro Forming

Formability



Tooling Techs



Pre-forming + Hydroforming

Prototypes

Process Study

Cylinder Force

$$F = P_i.\pi.\left[\left(1-\frac{\alpha.2\rho_2}{2\rho_2+\alpha.(d_0-t_0)e^{\varepsilon_1}}\right).\frac{(d_0-t_0)^2e^{2\varepsilon_1}}{2}\right.$$
$$\left.-t_0.(2d_0-3t_0)/4+\mu.d_0.(l_0-s)\right]$$

Inner Pressure

$$P_i = K.t_0\left(\frac{2}{2-\alpha}\right)^n.\left(\sqrt{1-\alpha+\alpha^2}\right)^{n-1}.e^{-(1+\beta)\varepsilon_1}$$
$$.\varepsilon_1^{\,n}.\left(\frac{2}{(d_0-t_0)e^{\varepsilon_1}}+\frac{\alpha}{\rho_2}\right)$$

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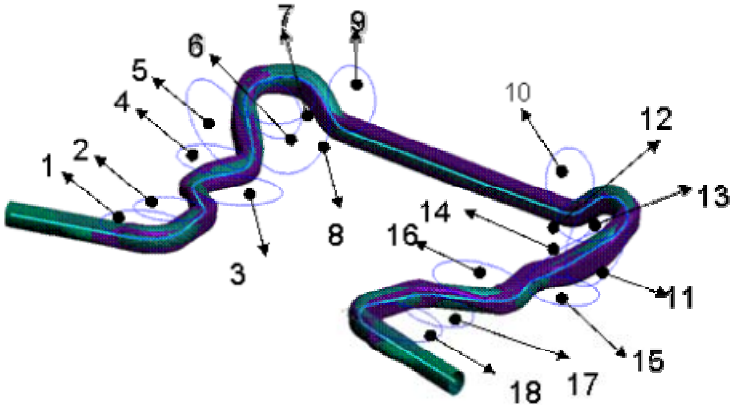
Hydro Forming

Having the capability to provide steel solution for car cradle, complex Torsion Beam, and body members as well

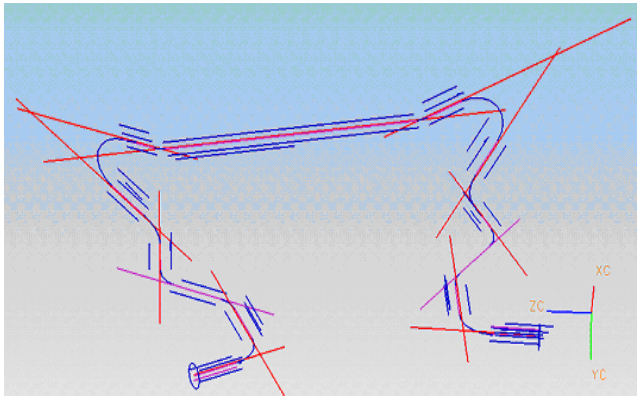
- ✓ Wrote hydroformed steel and process standards:
  1. Hot Rolled Steels for Automotive Hydro Forming Application
  2. Testing Mothed for FLD of Metal Tube Forming

- ✓ Product simultaneous engineering
- ✓ Steel selection
- ✓ Bending process design
- ✓ Forming process design
- ✓ Tooling design
- ✓ Quality control

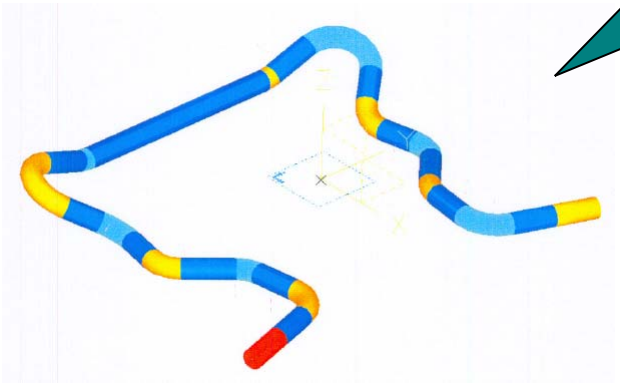
Case Study: Front Cradle



Original Design:
18 Bending with 5 Radii

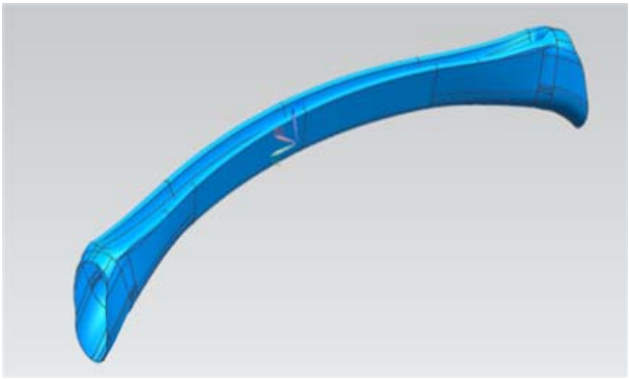


Structure redesign and optimization



Optimized Design:
12 Bending with 1 Radius

Case Study: Torsion Beam



Structure:

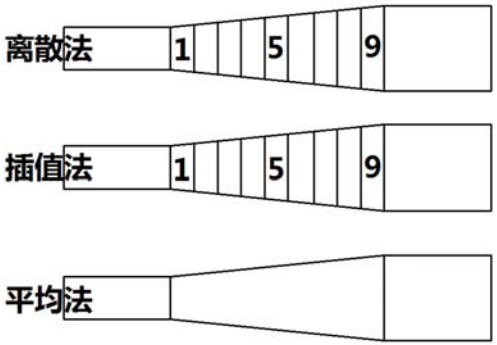
- ✓Thickness：3.5mm
- ✓Length：1250mm
- ✓Min circumference：
  358.03mm (Φ114.31)
  Max circumference：
  372.52mm (Φ119.02)
- ✓Weight：11.832kg
- ✓Steel：BR1500HS

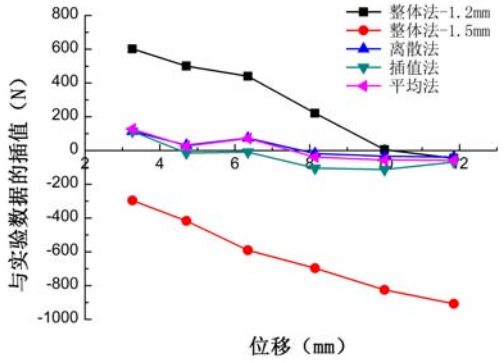
1. Large curvature profile: Max radian of 1258mm，Horizontal length 1600mm，and max arc depth 227mm

2. Heat treated after forming to achieve required Martinsitic microstructure and relative mechincal propertity.

3. Advanced springback compensation techniques for this big curvature, high strength and hydroforming process.

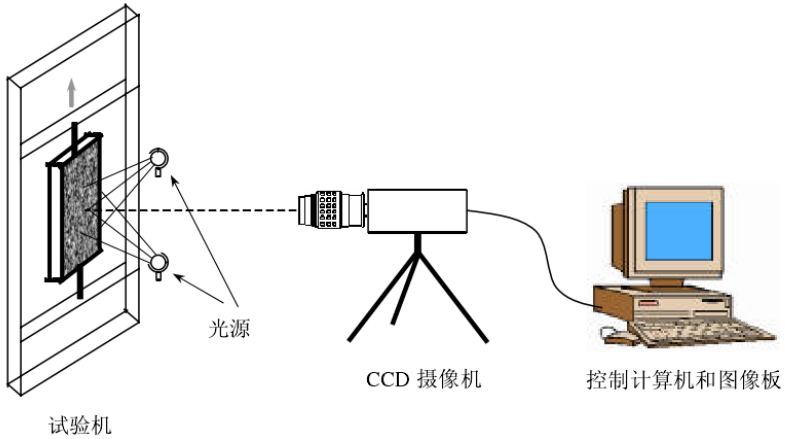
VRB (Variable-thickness Rolled Blank)





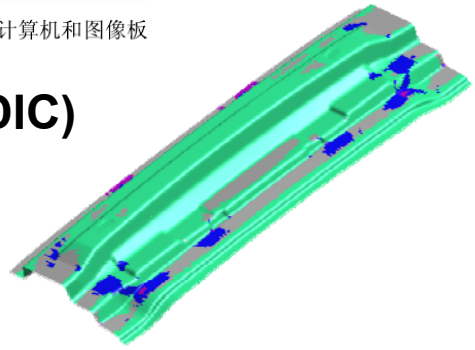
Thickness transition disperse

Front rail inner to replace TWB 1.2/1.5/1.8



Digital Image Correlation (DIC) Tensile test

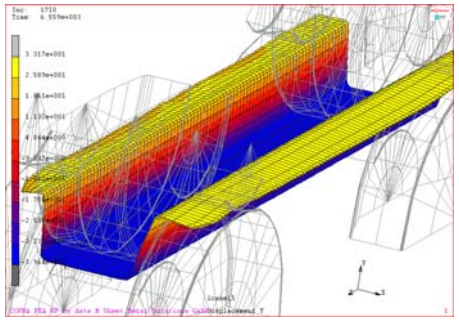
Cockpit cross member 1.0/2.0



Rear Roof Cross Member 0.9/1.8/0.9/1.8/0.9

Roll Forming

- ✓AHSS performance evaluation & material recommendation;
- ✓The formability analysis;
- ✓Design & optimization of roll flower process and die;
- ✓Prediction & optimization of roll forming defects;
- ✓Prototype trial manufacturing;
- ✓Steel grade: >1500 MPa

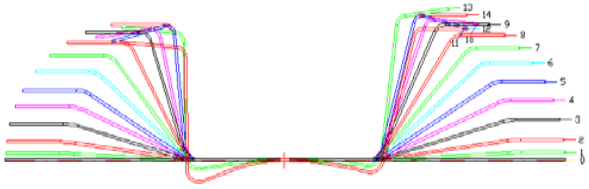


Process Simulation

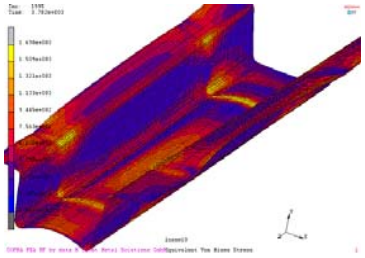
Die Set

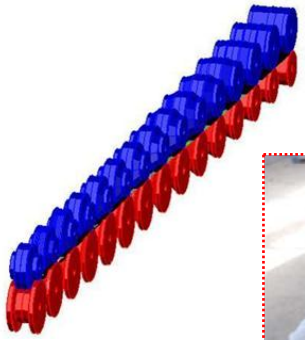
Experiment Facility

Case Study: Rocker Reinforcement



Process/roll profile design





Forming simulation

Tooling Adjustment

- ✓Original: 2.0 mm, B410LA, 6.8kg
- ✓Final: 1.4mm, 1180MS, 4.76 kg
- ✓Weight: ↓ 30%(per part)
- ✓Cost: ↓ 23.2% (per part)

Final Assembly

Part Prototype

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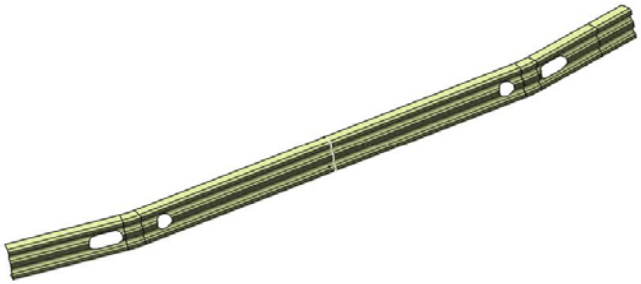
Roll Forming

Rocker reinforcement,1180MS

Front Bumper, 1180MS



Front Bumper, 1180MS

Grade	Thickness recommendation via empirical equation (mm)	Individual part weight (kg)	Weight loss per part	Sheet weight per part (kg)	Material utilization	Material cost per part (¥)	Cost reduction per part
B410LA	2.0	6.80	2.04kg	7.82	87%	54.10	12.55¥
1180MS	1.4	4.76	30%	5.10	93.3%	41.55	23.2%

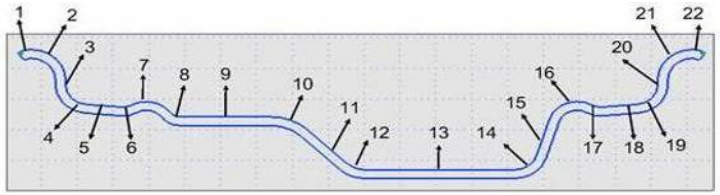
Flow Forming for Rim

Traditional Process

ROUND BENDING, WELDING → FLARING → ROLL FORMING → EXPANSION → VALVE HOLE PUNCHING

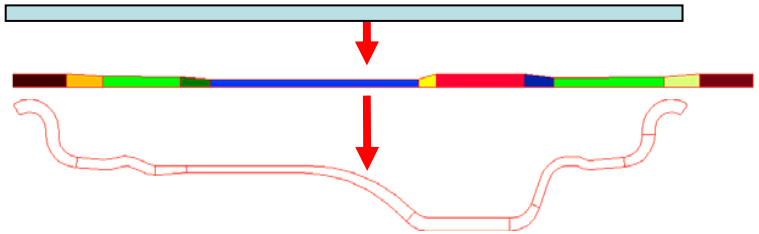
FLOWFORMING

Traditional Rim Section (Constant thickness)



- Add one flowforming step to trasitional process
- 16 inch lightweight steelwheel rim
- with weight reduction 12%

New Rim Section

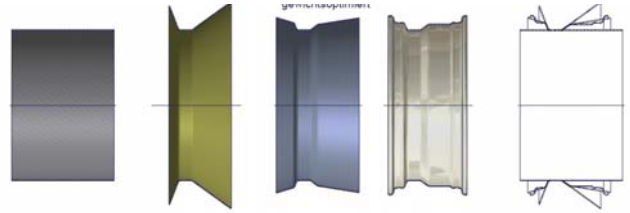


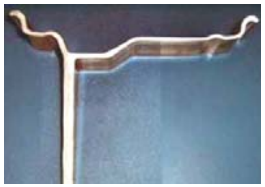
Flowfoming Flaring Roll-Forming Expansion

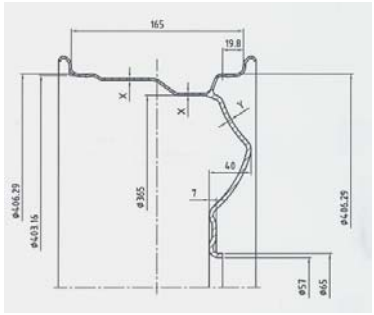
Samples and Testing

Process Optimization for Flow Forming

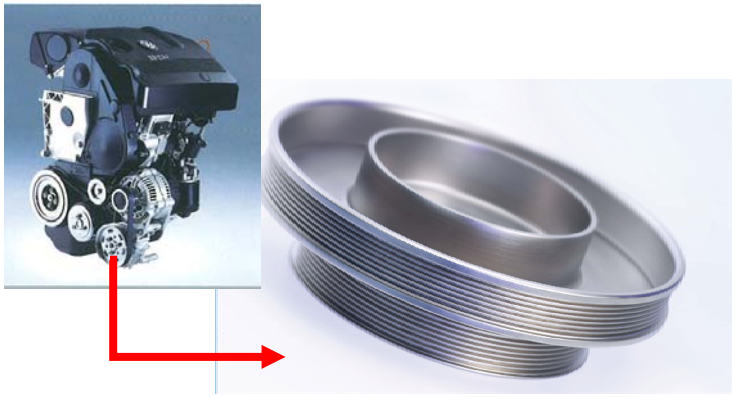
- Market promotion of lightweight steelwheel rim
- Research on flowfoming performance of AHSS
- Developing fullspinning wheel rim and one-piece wheel







- Flowforming process developing on Engine and Gear-box parts, such as pulley, dicc carrier, clutch housing.



Laser Welding

Variable thickness Laser Welding
3.75 kg → 2.80 kg (↓ 25.3%)

LW for all steels in BaoSteel, i.e.
S600MC、B1500HS, HC700/980DP、
HC550/980DPD+Z,etc

Weldability Study(TWIP1000, Thick 1.4mm)

Rp0.2 (MPa)	Rm (MPa)	Ag (%)	A_{80} (%)	$n_{20\text{-}30\%}$
511.98	1000.9	45.79	51.19	0.488

LW B Pillar
DP800

Contents

1. Metal Forming Techs
2. Lab Facilities

Facilities

- **Metal Forming Technological and Experiment units**

Hot Stamping Press
Capacity: 800 MT

Hydro Forming Press
Capacity: 5000 MT
Max Pressure: 400 MPa

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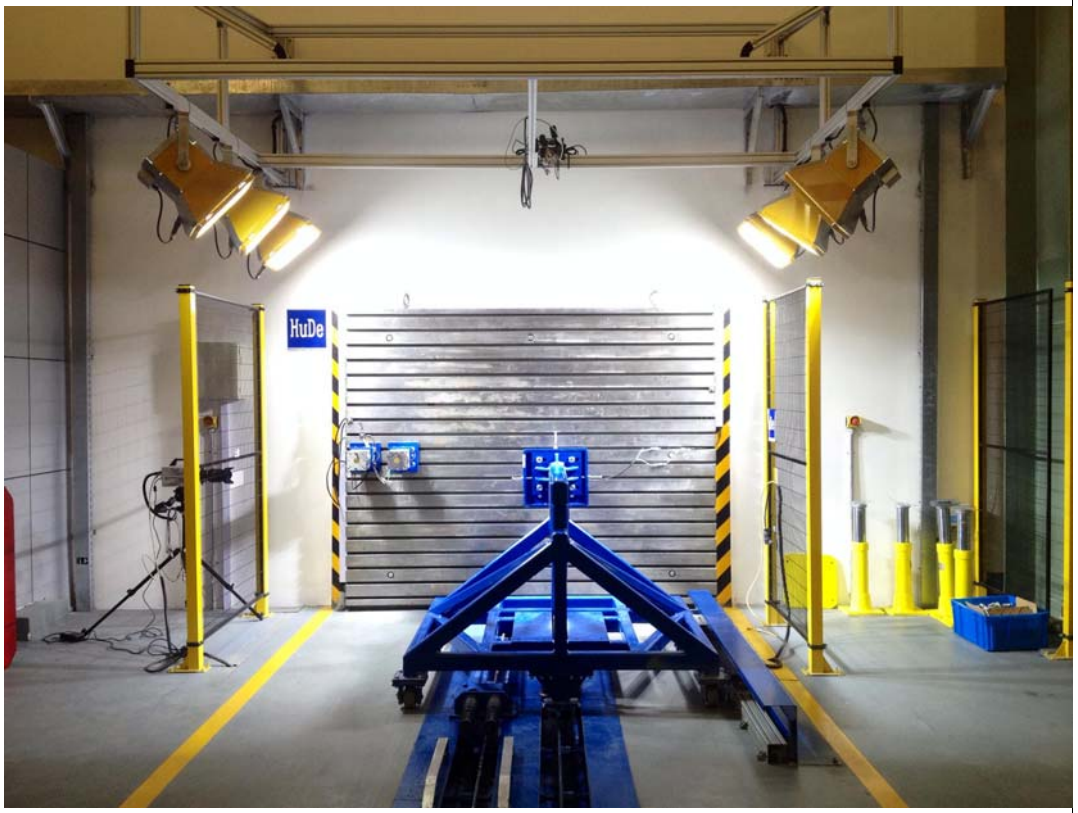
Facilities (cont'd)

Roll Forming Line

Flow Forming Press
Dia: 14-24.5 in
Strength: <800 MPa
Thickness: 2.0-18.0 mm

Facilities (cont'd)

AHSS Forming Press
Capacity: 600 MT



Impact Testing Machine
Max speed: 64 km/h

Facilities (cont'd)

High-speed continous annealing machine
sheet: (250-550) x (0.2-5.0)
cooling speed: 1000K/s

Resistence Welding Tester

Facilities (cont'd)

High-frequence Fatigure Tester
Frequence: 35 - 300 Hz
Amplitude: <6.0 mm

AHSS Bending Tester

Facilities (cont'd)

Hydrogen Analysis Instrument

Hot dip galvanizing simulator

Facilities (cont'd)

- **Mechanical Property Testers**

Tensile tester

High strain rate machine

Facilities (cont'd)

- **Physical Simulators**

Gleeble 3800

Thermecmaster-Z

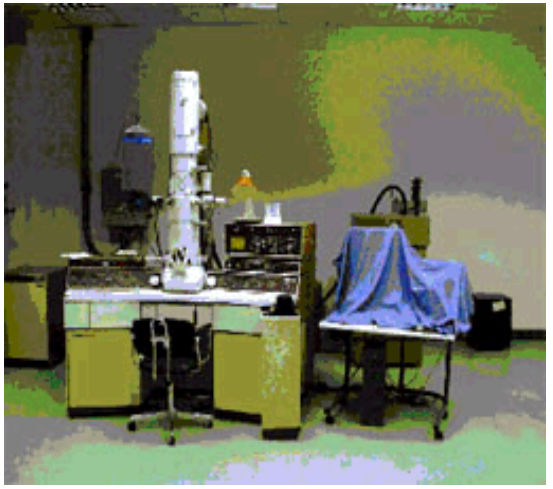
Facilities (cont'd)

SEM

EPMA

X-ray EDX Diffractor

TEM



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Thanks