Maximizing Lightweighting
In Steel Automotive Bodies And Frames With

The Steel Tube Air Forming (STAF) Process

Ryuichi Funada,
Technical Marketing, STAF Project,
Sumitomo Heavy Industries

Contents

1. Company profile

- Head Office: Sumitomo Heavy Industries, Ltd.
  ThinkPark Tower, 1-1,
  Osaki 2-chome, Shinagawa-ku,
  Tokyo 141-6025, Japan
  Tel. 03-6737-2000
  Fax. 03-6866-5104
  URL http://www.shi.co.jp
- President: Shunsuke Betsukawa
- Founded: November 20, 1888
- Incorporated: November 1, 1934
- Capital: 30,872 million yen (As of March 31, 2017)
- Employees: Consolidated : 18,491 (As of March 31, 2017)
- Net sales: Consolidated : 700,838 million yen (FY 2017)

Sumitomo Heavy Industries, Ltd.

Business Segments & Major Products

Sumitomo Heavy Industries, Ltd.

World Network

Contents

Sumitomo Heavy Industries, Ltd.

We propose STAF (Steel Tube Air Forming) process, which

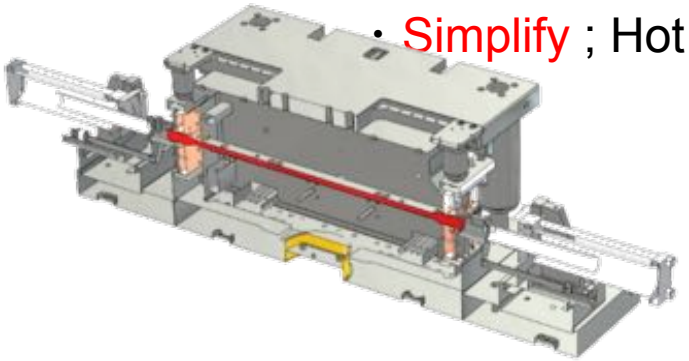
is a type of hot metal gas forming.

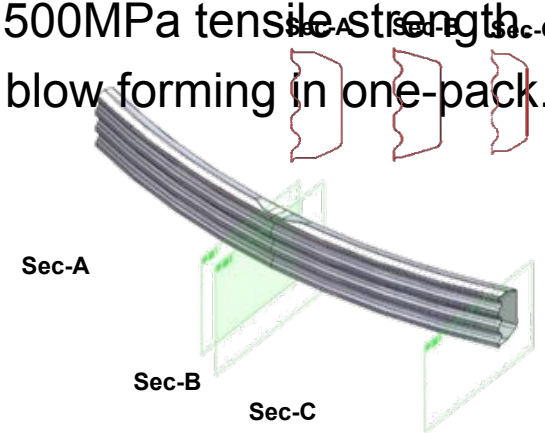
Feature

- Lighten ; Flanged tube structure.

  Continuously varying the closed cross-section.

- Strengthen ; 1,500MPa tensile strength.
- Simplify ; Hot blow forming in one-pack.

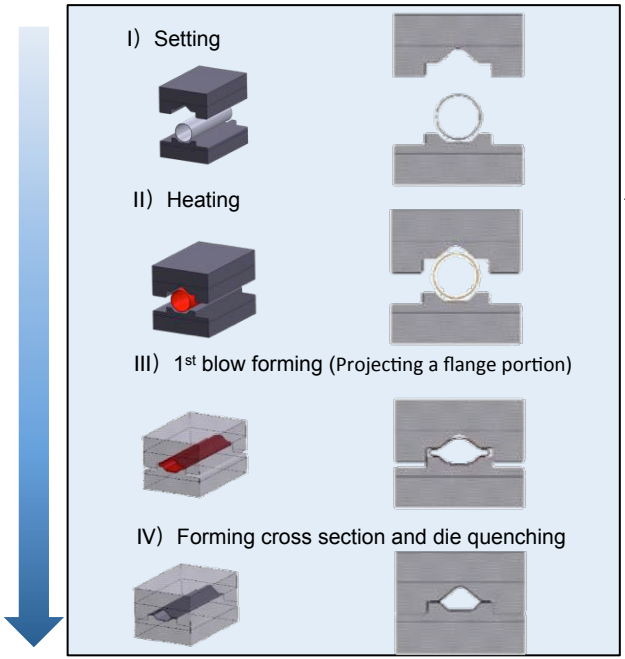


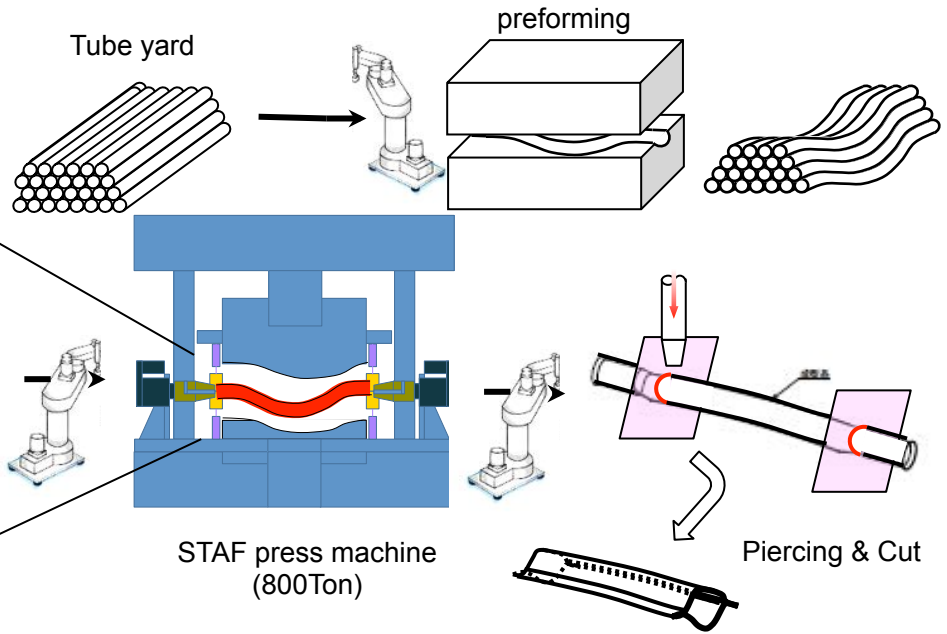


2. Introduction and Concept

- Form high strength and high rigidity auto parts in one-pack.
- Form flanges, drastically the assembly processes are reduced.

Forming Process



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2. Introduction and Concept

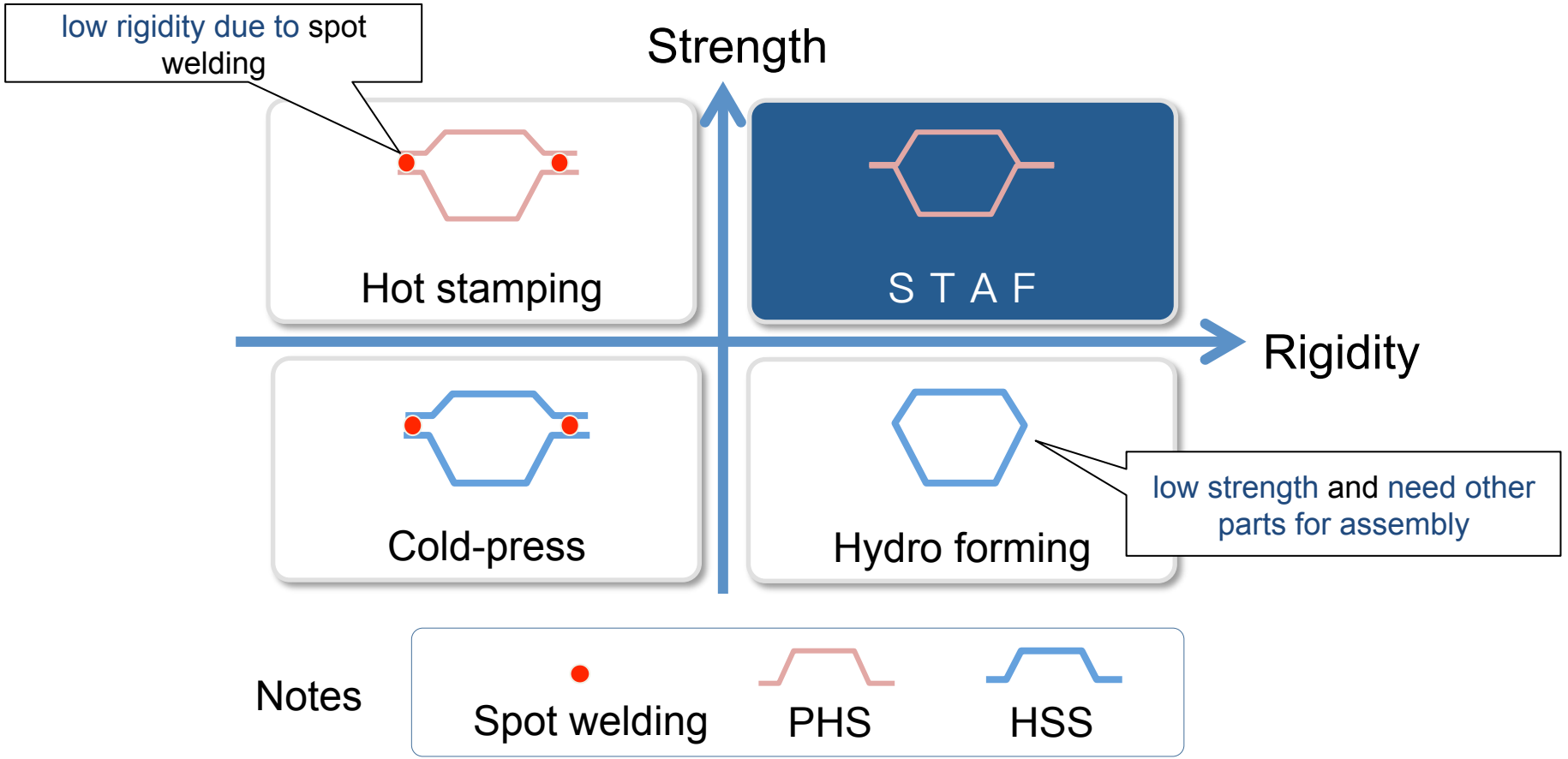

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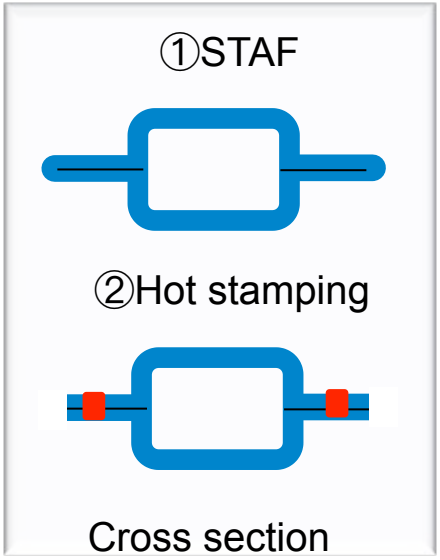
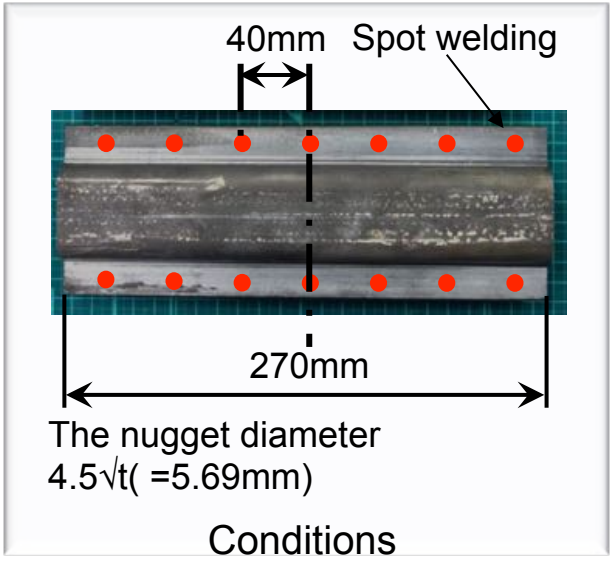
Table1 material

Steels	Chemical components (%)						Carbon equivalent (C_{eq})	HV after die quenching
	C	Cr	Mn	Si	Ti	B		
Mn-B鋼	0.21	0.29	1.29	0.16	0.027	0.0018	0.48	440 (measured value)

Table2 forming conditions





3. STAF parts evaluation methods

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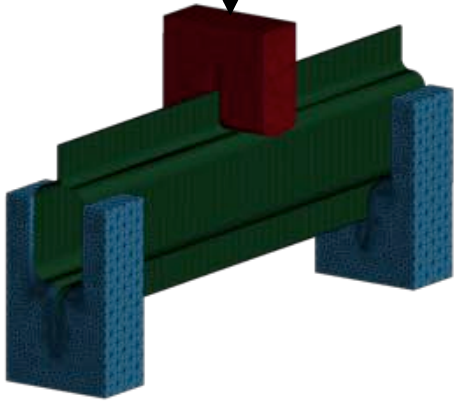
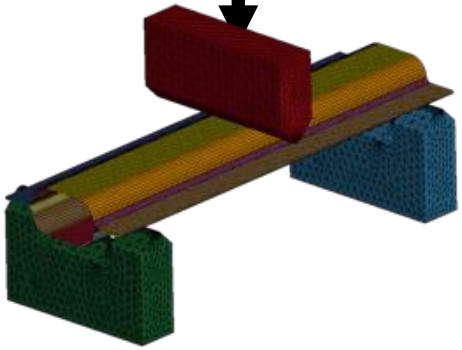
Forced displacement



【Longitudinal bending】

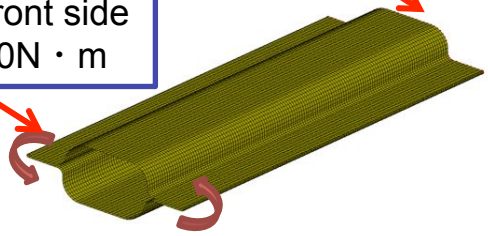
Forced displacement



【Lateral bending】

Complete restraint of the rear side

Rotate the front side
Torque： 300N・m



【Torsion】

3. STAF parts evaluation test results

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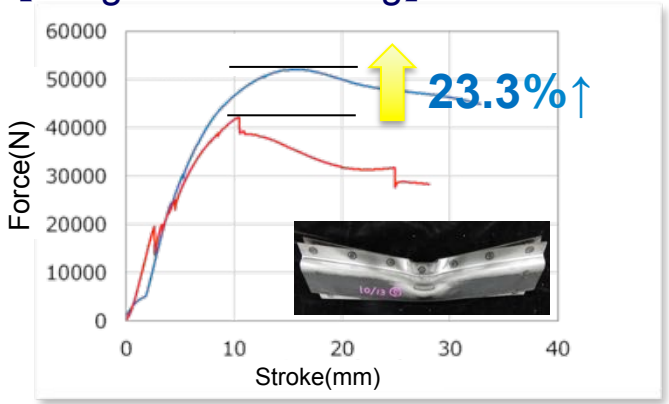
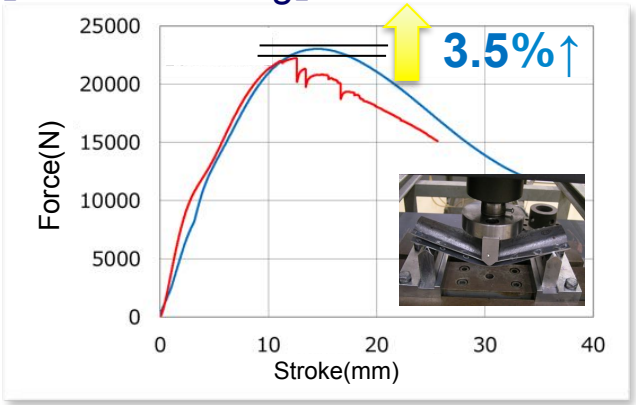
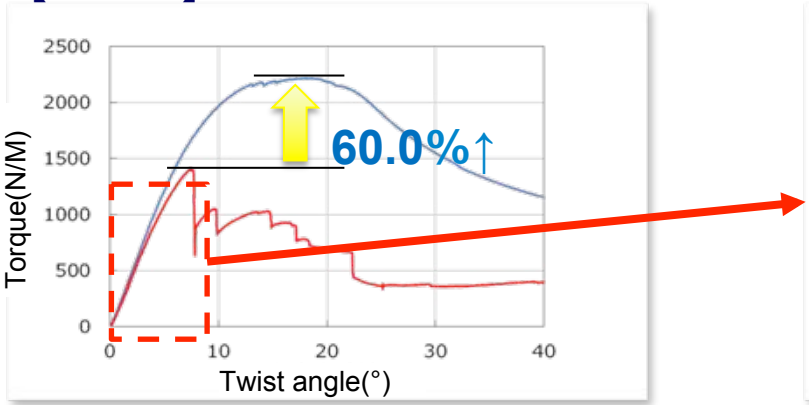
【Longitudinal bending】

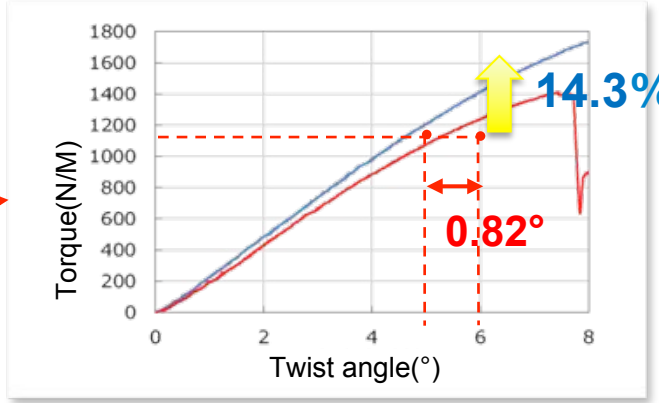


【Lateral bending】



【Torsion】





graph legend

STAF

Hot-stamping

4. Lightweight effect

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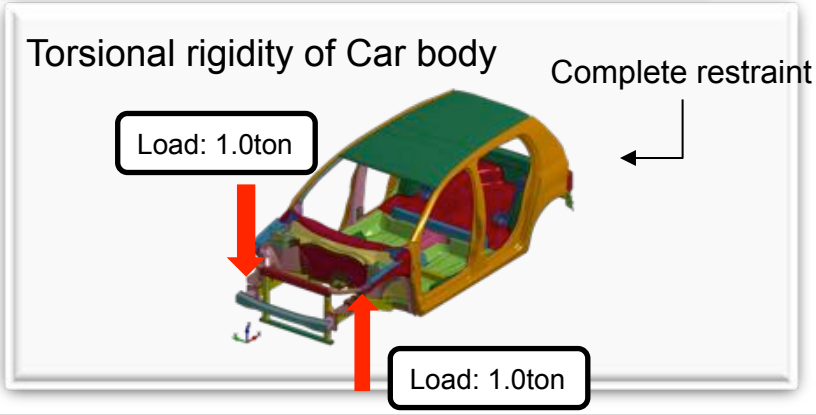
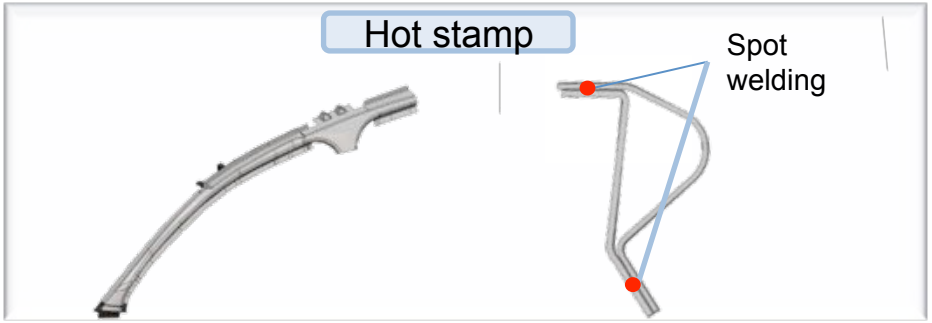
- Weight 30% reduction with keeping assembly-rigidity equal
- Reduce the number of components and spot welding

	Hot stamp	STAF
Thickness	1.8mm/1.5mm	1.2mm(φ58)
Weight	4.311kg	2.825kg

Reducing weight by 1.486kg
(About 30%)





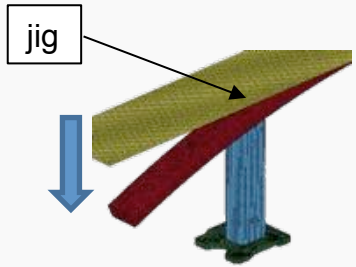
4. Lightweight effect

- Higher strength and Lighter weight than aluminum extrusion
- Reduce the production cost by

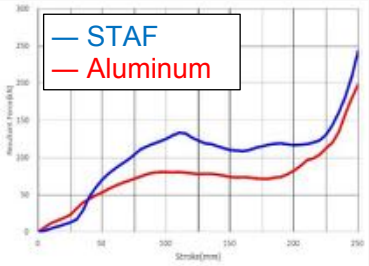
	Aluminum extrusion	STAF
Thickness	2.6mm	1.0mm
material	A6061-T5	MnB5(1.5GPa)
Weight	2.407kg	2.164kg

＊Same conditions

Offset crash analysis

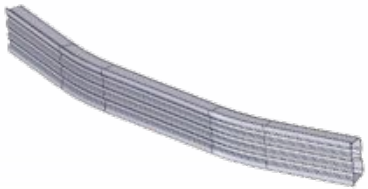


Test result



Alminum extrusion

STAF



5. Dropping weight test

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Height : 6.3m
Collision speed : 40km/h

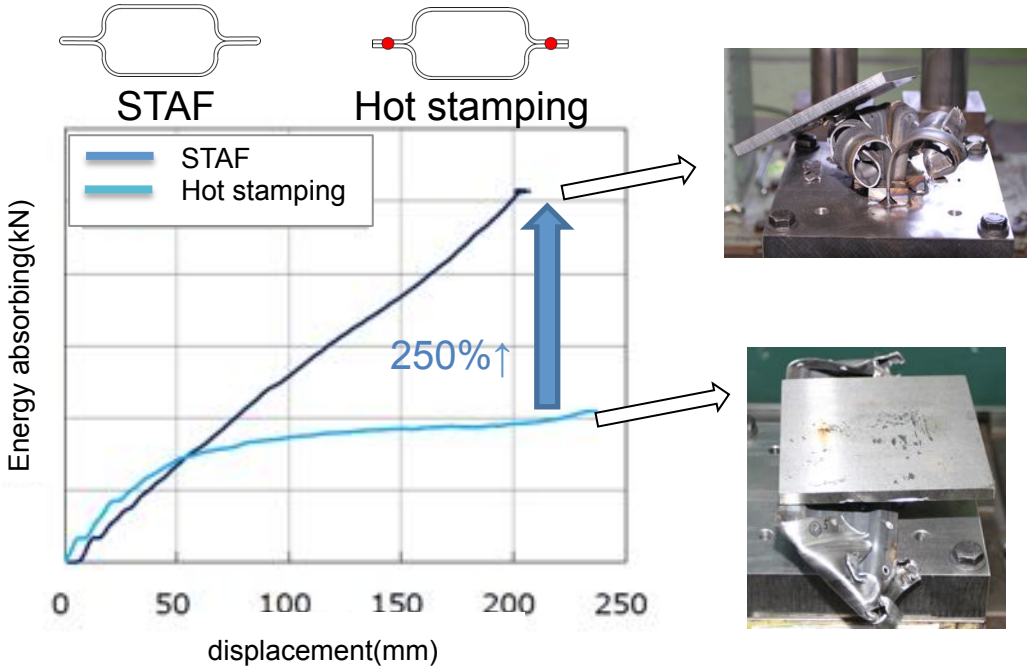
Weight : 500kg
Collision energy : 31kJ

Hot stamping

STAF

5. Dropping weight test

- STAF parts ; High energy absorption.
- Hot stamping parts ; Broken in two.



6. Feature

6. Feature

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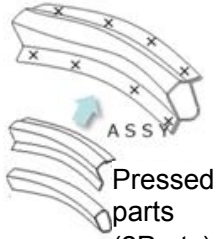
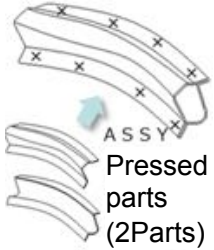
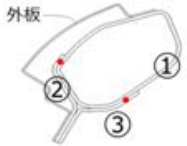
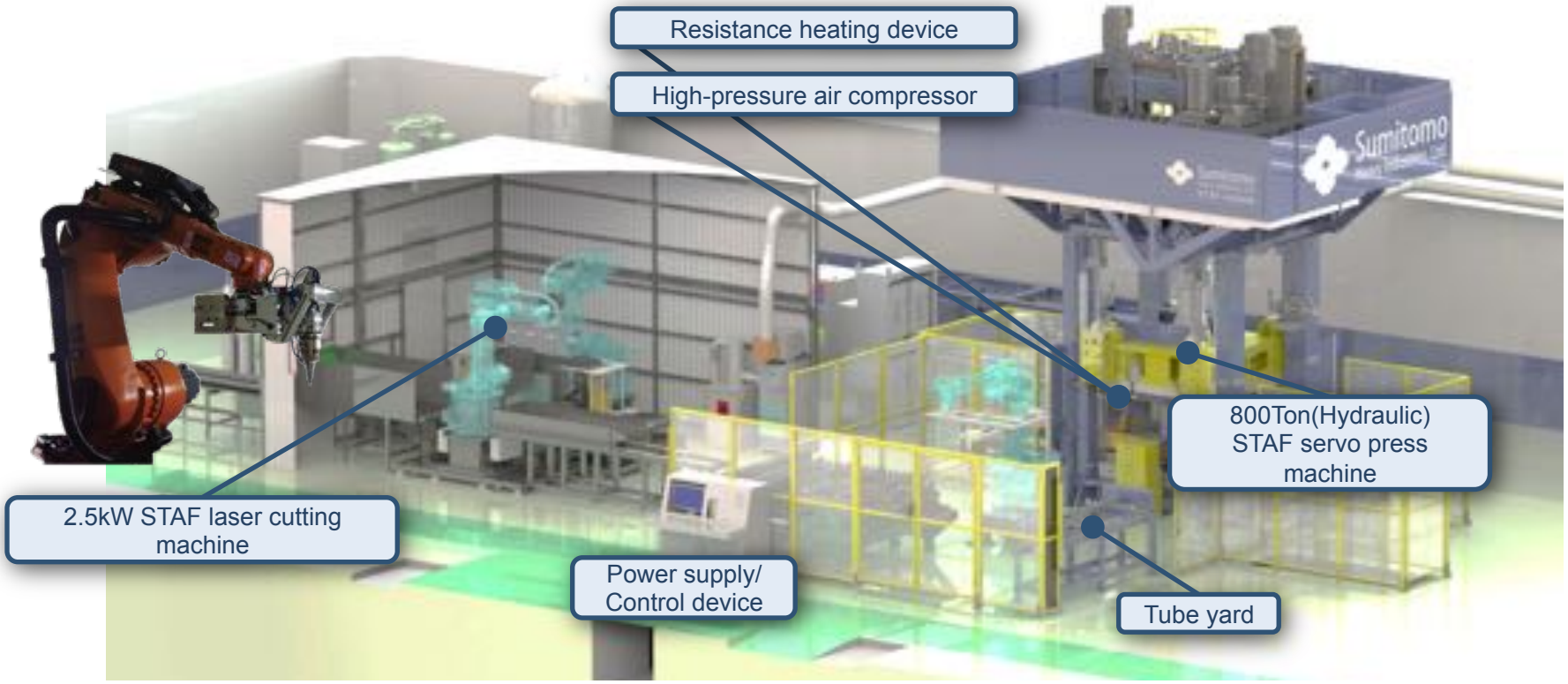
	Hydroforming	Hot stamping	STAF
Strength	～980MPa	**1,500MPa**	**1,500MPa**
Parts construction	 Pressed parts (2Parts)	 Pressed parts (2Parts)	 STAF part (1 part)
Cross section image	 2~3 parts	 2 parts	 1 parts
Process	5 processes ➢ Preforming ➢ Hydroforming ➢ Laser cutting ➢ Press forming ➢ Welding(ass'y)	4 processes ➢ Heating furnace ➢ Hot stamping (2 sheets) ➢ Laser cutting ➢ Welding(ass'y)	2 processes ➢ STAF (one-pack process) ➢ Laser cutting

7. STAF product machines

- The main equipment are STAF press machine and laser cutting machine.
- STAF prototype machine has been in operation since September, 2017



8. STAF prototype machine

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Trial manufacture of auto parts is available.
The conditions of trial manufacture are as fallowing.

- products' length(~1600mm)
- diameter of a tube(φ50~φ150)
- products' thickness 1.0mm~2.3mm

Formable products shape	
Maximum tube diameter(φ)	150mm
Minimum tube diameter(φ)	50mm
Full length(mm)	～1600
Material length(mm)	750～1930
Thickness(mm)	t1.0～2.3
Minimum allowable bending radius(R)	500
Minimum allowable bending angle(°)	120°～180°
Material	Mn-B

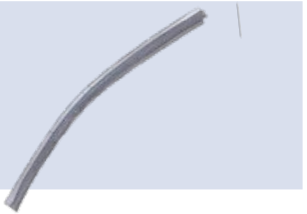
Prototype forming video

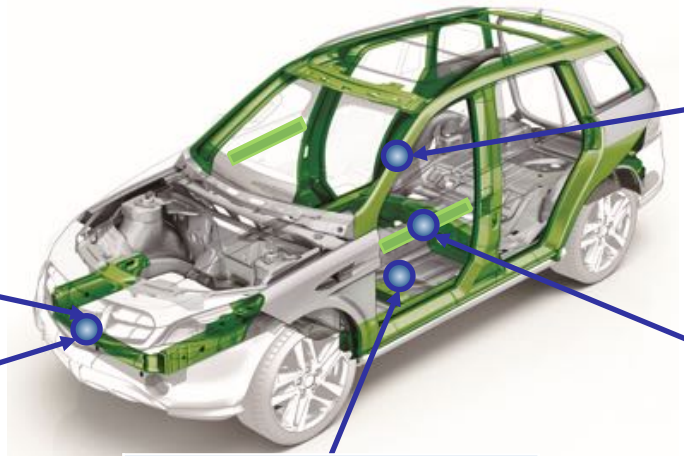
Records of consideration with OEM

- Particularly, we're considering in the development period that's why it takes a long time for becoming commercial.

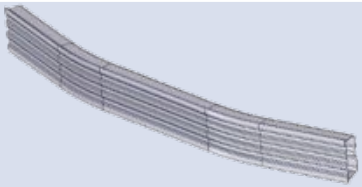
①Bumper beam

②Front roof rail side

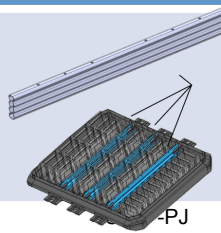




③Pedestrian beam

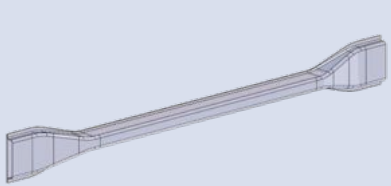


④Battery frame



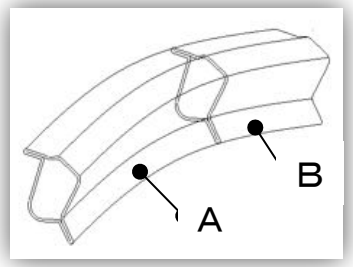
-PJ

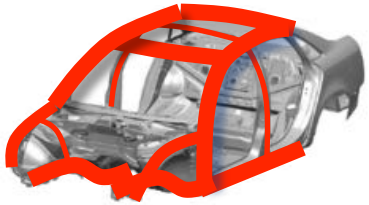
⑤Door collision beam

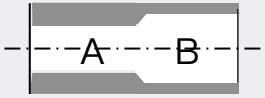
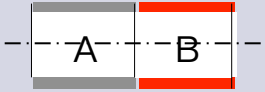
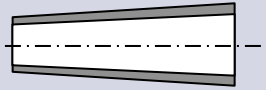


9. Future technology prospects

1) Application to various automotive parts.
2) Tube forming with thickness distribution.
3) Strength distribution by tailored tempering.
4) Tube forming with diameter distribution.





Technology	Example
Thickness distribution	 1.4t 1.0t
Tailored tempering	 1,180MPa 1,500MPa
Different diameter	 φ50mm φ70mm

Thank you all for listening

APPENDIX

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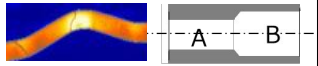
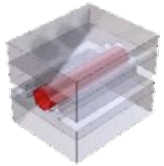
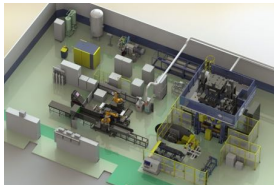
- ~FY'15: Systemizing the forming process and acquiring the basements of know-how
- FY'16~: Promotion for the practical application

	FY'13	FY'14		FY'15	FY'16	FY'17~18
	Establishing STAF process			Product development		
				Component Technology	Prototype machine	Commoditizing
Item	➢ Material	➢ Formability		➢ Forming process	➢ Complicated shape	➢ Proposal for practical use
Shape	Sheet material 	Tube expanding 	Flanged structure 	Flange shape control 		Tailored tempering Thickness distribution 
Achieved Technology	➢ Hardenability	➢ Plunger Sealing ➢ High pressure air controlling ➢ Tube expanding	➢ Heating ➢ Flange forming	➢ Forming process ➢ Component design ➢ Component evaluation 	➢ Press machine design (Laser cutting) ➢ Oxidized scale evaluation ➢ Weldability evaluation 	➢ Quality stability ・Complicated component ・Long curved component ➢ Applicability investigation of the Al-Si plating material and Al material ➢ Tailored tempering ➢ Thickness distribution