

GREAT DESIGNS IN **STEEL**

MAXIMIZING LIGHT WEIGHTING IN STEEL AUTOMOTIVE BODIES AND FRAMES WITH STEEL TUBE AIR FORMING (STAF) PROCESS

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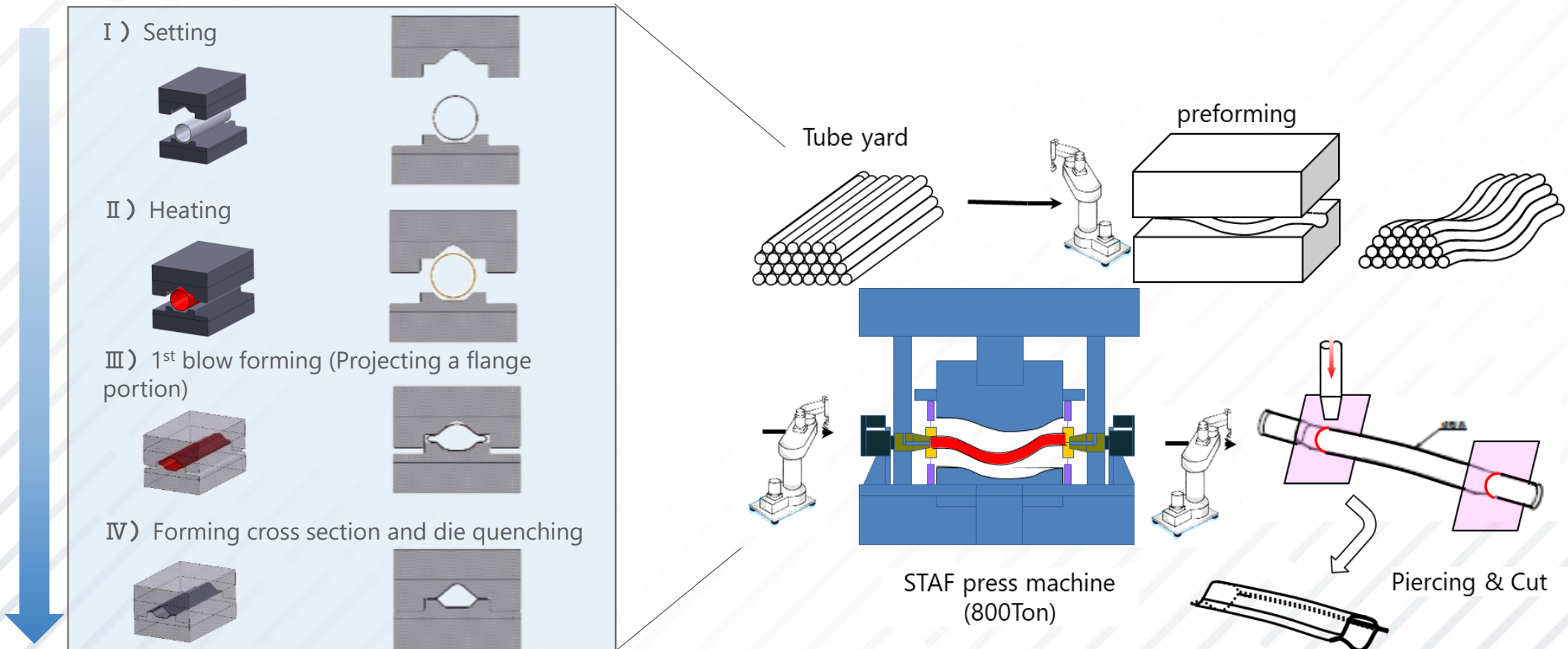
AGENDA

1. Introduction of STAF
2. STAF's benefit
3. Case Study for verification of STAF's benefit
4. What SHI can support to the new produced items

1. INTRODUCTION OF STAF

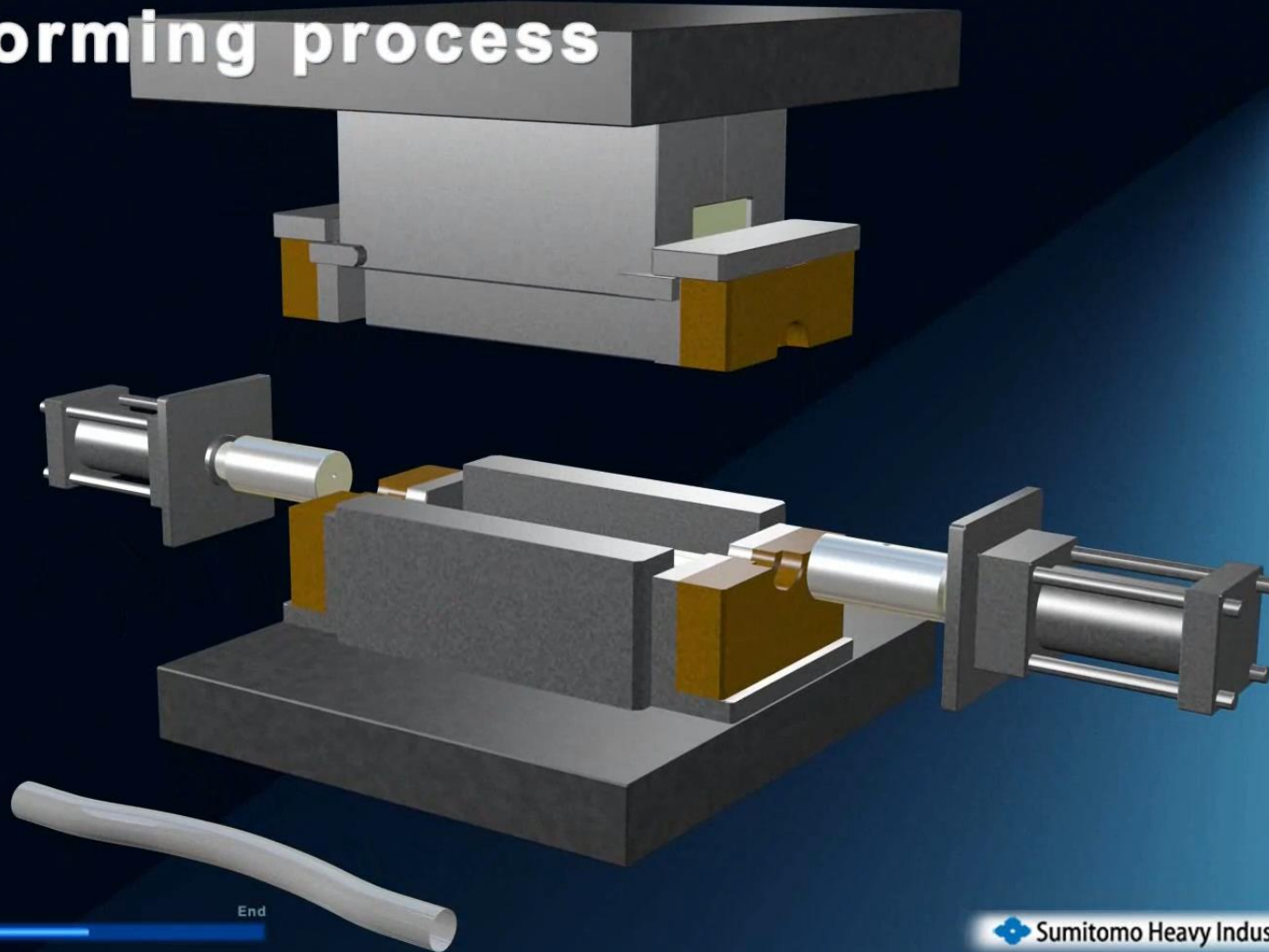
- Form **high strength and high rigidity** auto parts in one-pack.
- Form flanges, **drastically the assembly processes are reduced**.

Forming Process



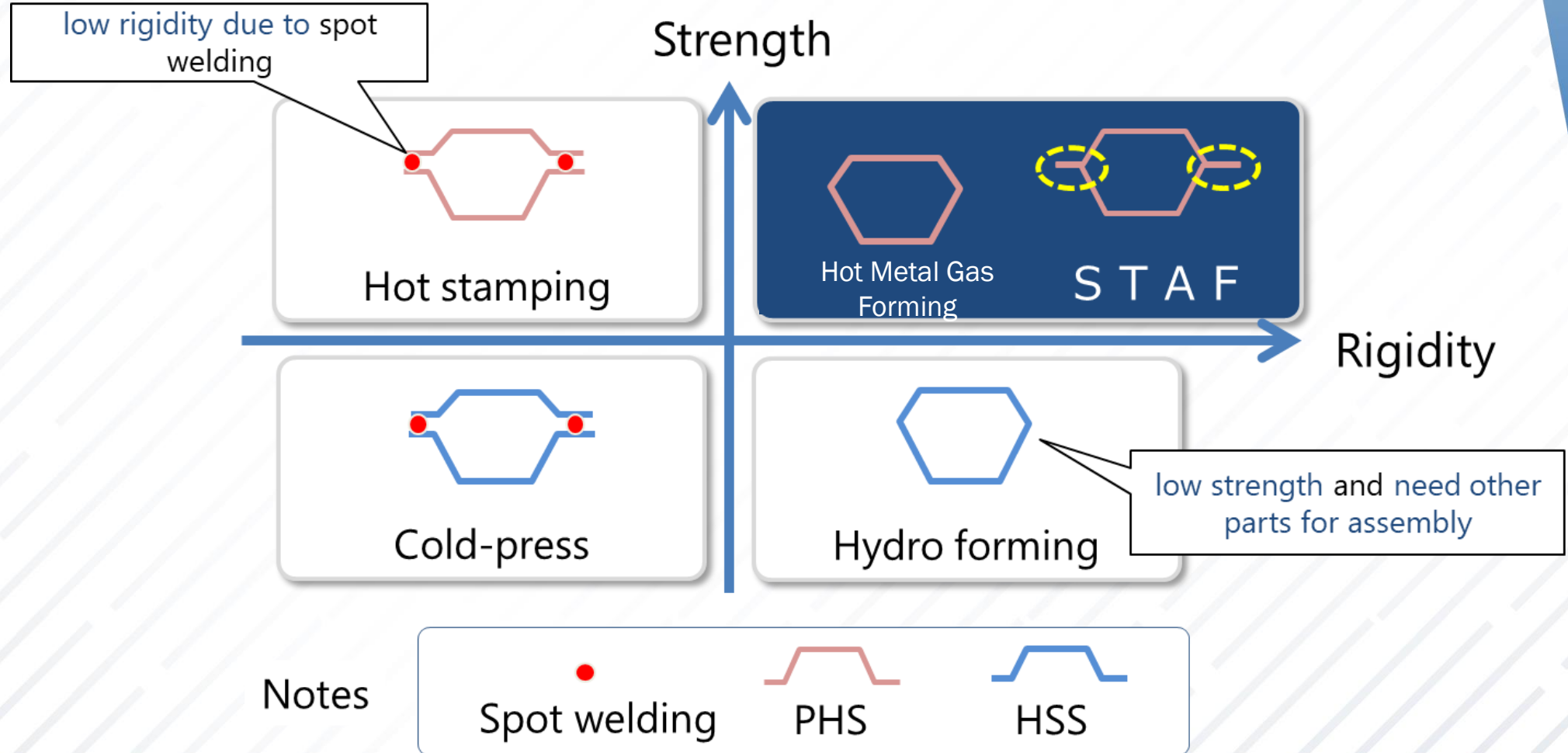
1. INTRODUCTION OF STAF

STAF forming process



1. INTRODUCTION OF STAF

Position of STAF technology



2. STAF'S BENEFITS

STAF

◆ Flanged closed section

①. Drastically weight reduction

②. Performance can be controlled by flanges

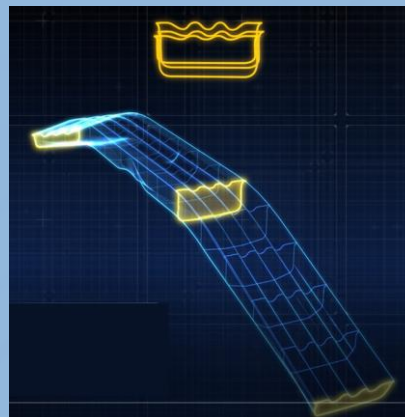
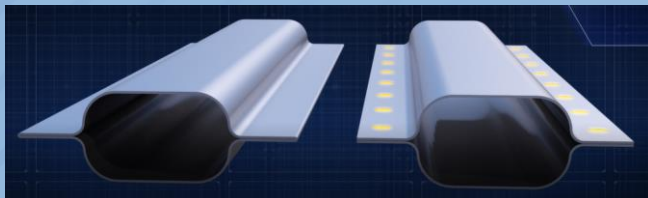
③. Simplification (Reduction of num of parts, simplified process=compact equipment)

+ High versatility of spot welding connection

①. Drastically weight reduction

②. Performance controlled by flanges

③. Simplification

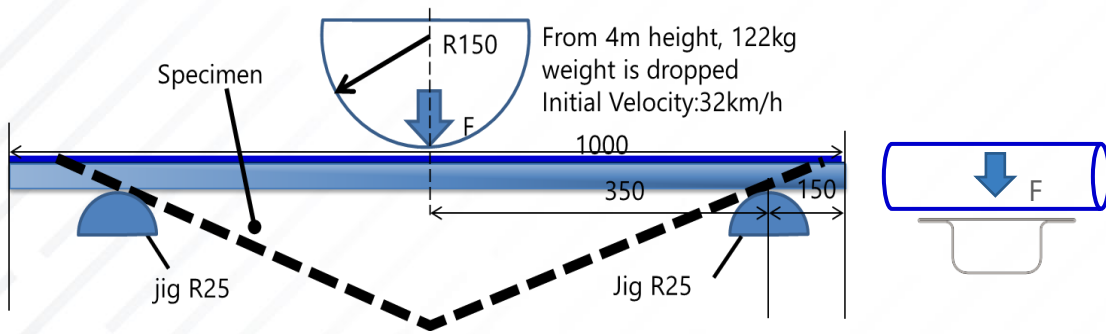


2. STAF'S BENEFITS

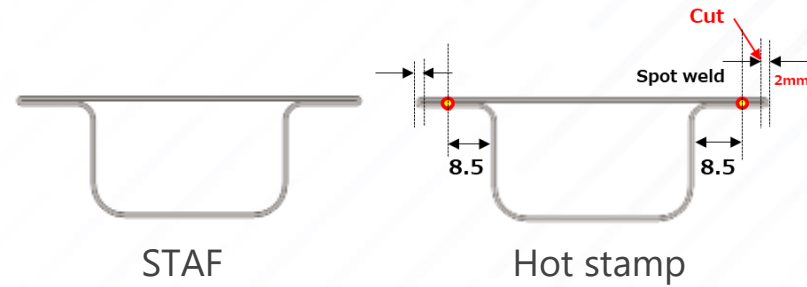
① **Drastically weight reduction; Improved basic performance**

The basic performance can be improved by eliminating the peeling of spot welds.(24.3%↑)

【Drop Weight Test I】

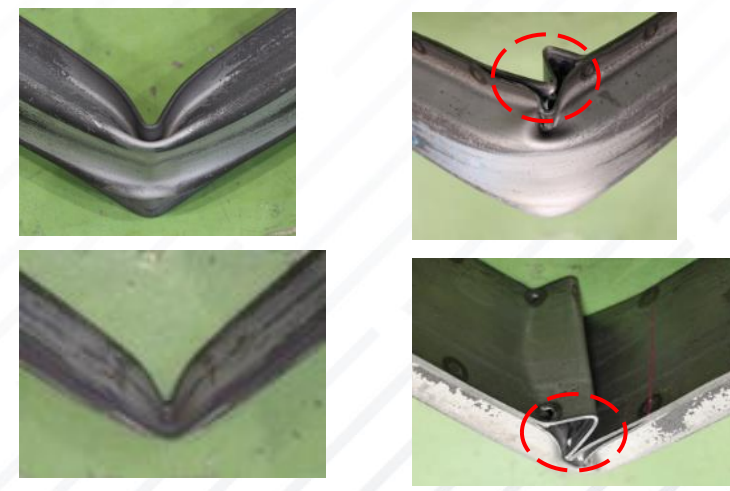


Specimen's Cross section(t1.6&t1.2)



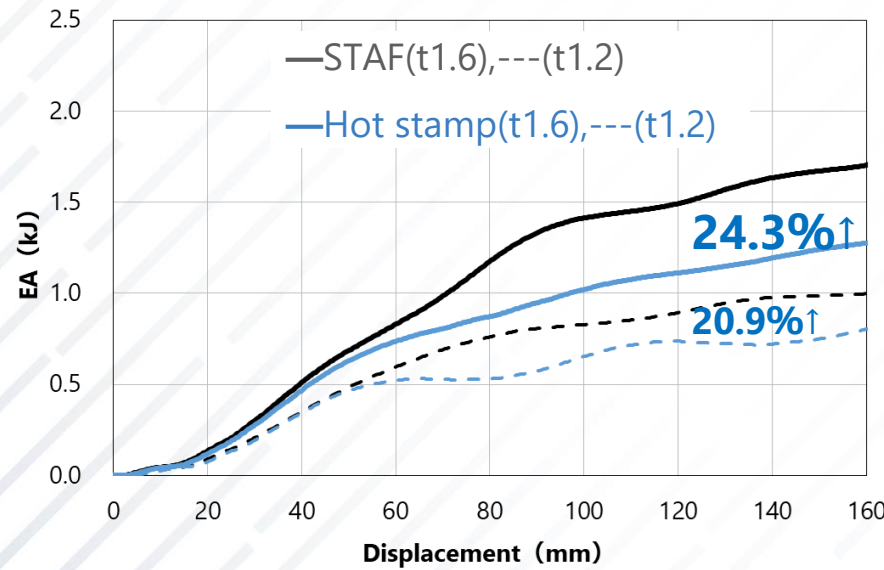
After collision

Side view



STAF(t1.6)

Hot stamp(t1.6)



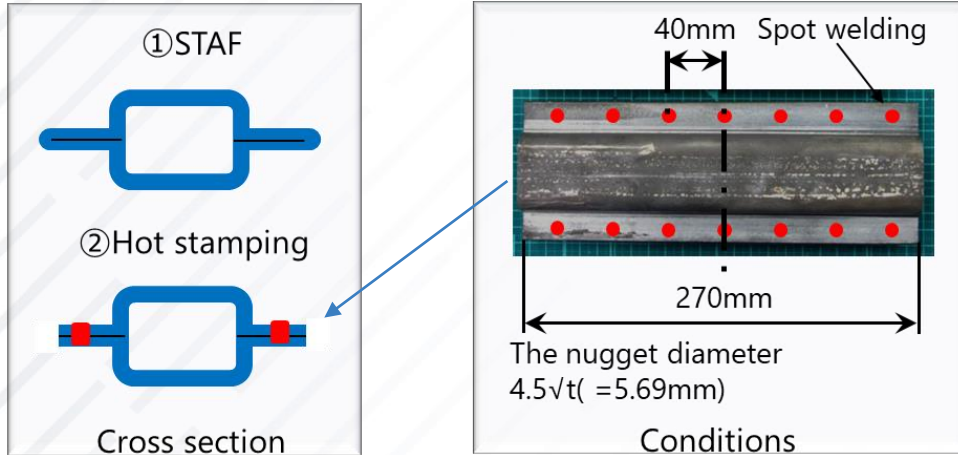
2. STAF'S BENEFITS

① Drastically weight reduction; Improved basic performance

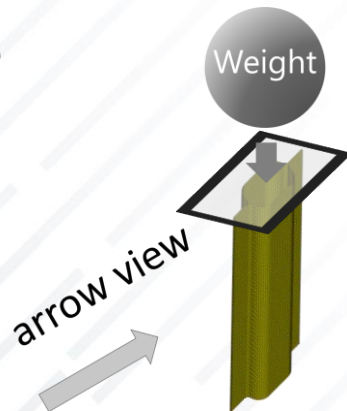
The basic performance is improved by eliminating the peeling of spot welds.

【Drop Weight Test II】

Specimen's Information (t1.6mm,22MnB5)



Test image

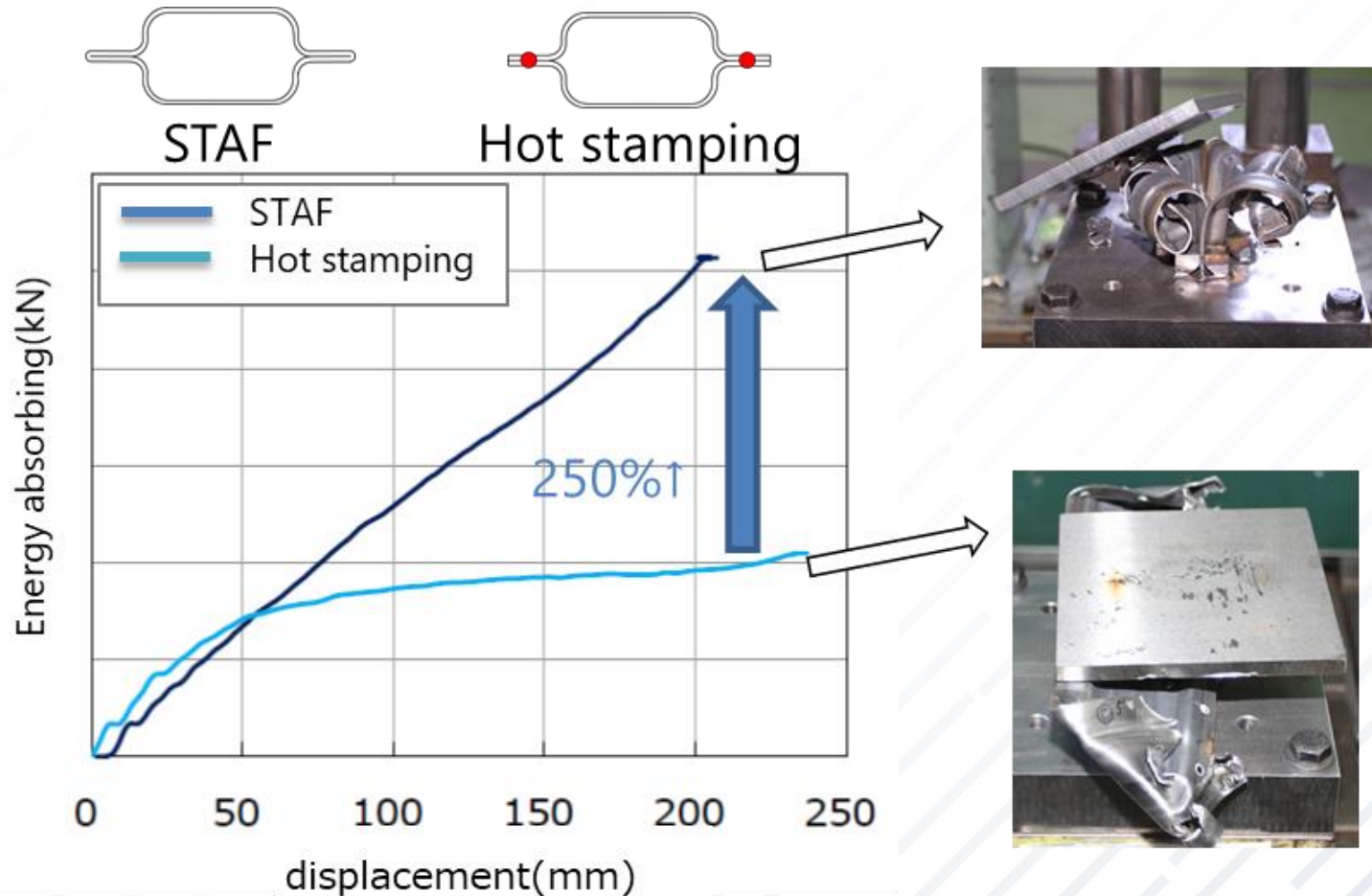


<p>Height : 6.3m</p> <p>Collision speed : 40km/h</p>	<p>Weight : 500kg</p> <p>Collision energy : 31kJ</p>
<p>Hot stamping</p>	<p>STAF</p>

2. STAF'S BENEFITS

① **Drastically weight reduction; Improved basic performance**
 The basic performance is improved by eliminating the peeling of spot welds.(250%↑)

【Drop Weight Test II】



2. STAF'S BENEFITS

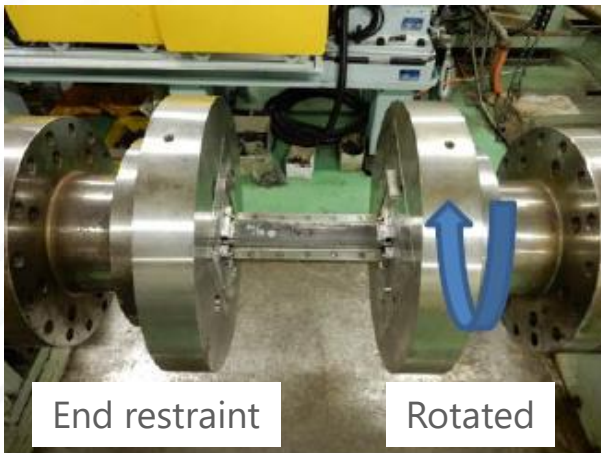
① **Drastically weight reduction; Improved basic performance**

The basic performance is improved by eliminating the peeling of spot welds.(60.0%↑)

【Torsion】

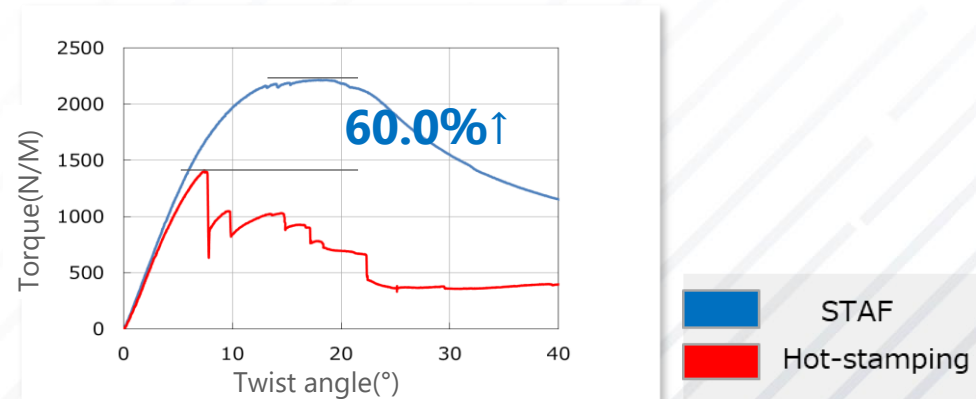
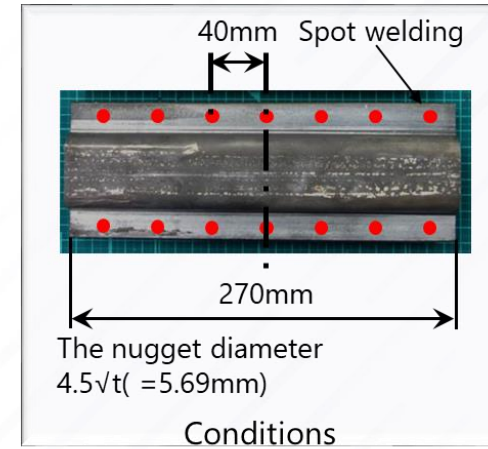
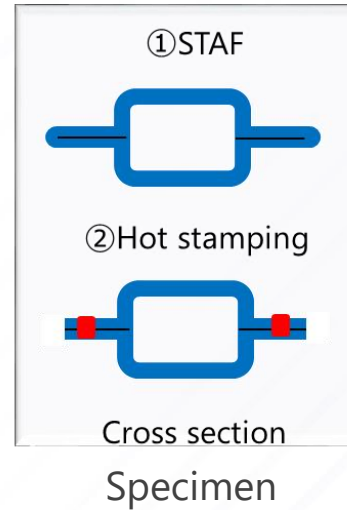


Forming video clip



End restraint

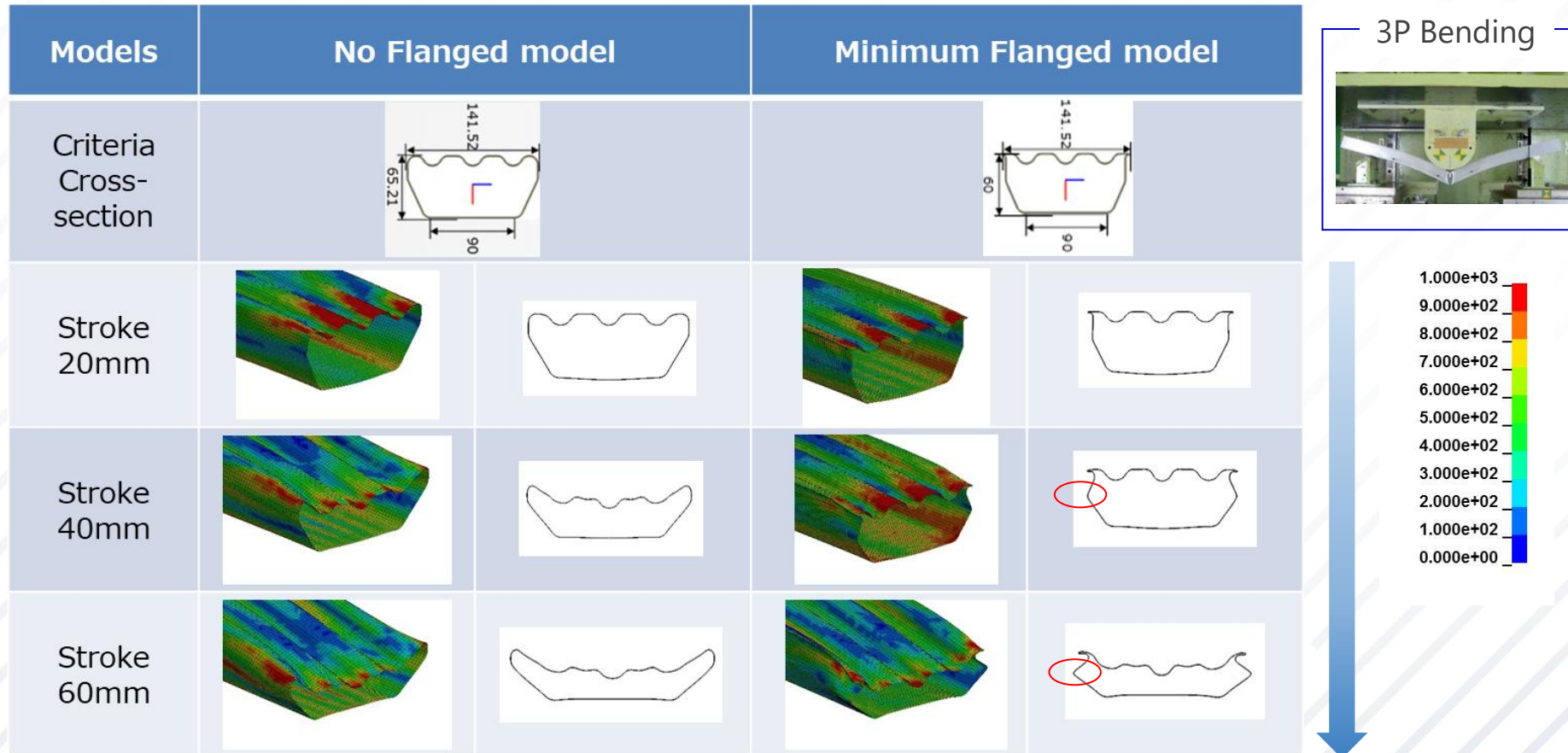
Rotated



2. STAF'S BENEFITS

② Performance can be controlled by flanges

The flange that enables spot joining with other parts can also control the deformation mode of the cross section. The following is the difference in cross-sectional deformation due to the placement of the minimum flange in the three-point bending test for the beam.



2. STAF'S BENEFITS

③Simplification

Efficient and compact process due to the reduced number of parts and dies, the simplification of the heating process and the welding subassembly process.

	Hydroforming	Hot stamping	STAF	Hot gas forming
Strength	~980MPa	1,500MPa~	1,500MPa~	1,500MPa~
Parts construction	<p>Pressed & Hydro parts</p>	<p>Pressed parts (2Parts)</p>	<p>STAF part (1 part)</p>	<p>Pressed & Tube parts</p>
Cross section image	2~3 Parts	2 Parts	1 Part	2~3 Parts
	<p>Outer</p> <p>2~3 parts</p>	<p>Outer</p> <p>2 parts</p>	<p>Outer</p> <p>1 part</p>	<p>Outer</p> <p>2~3 parts</p>
Process	5 processes	5 processes	3 processes	6 process
	<ul style="list-style-type: none"> ➤ Preforming ➤ Hydroforming (3000Ton~) ➤ Laser cutting ➤ Press forming ➤ Welding(ass'y) 	<ul style="list-style-type: none"> ➤ Blanking ➤ Heating furnace ➤ Hot stamping (2 Sheets &2 Dies) ➤ Laser cutting ➤ Welding(ass'y) 	<ul style="list-style-type: none"> ➤ Preforming ➤ STAF form (800Ton~) ➤ Laser cutting 	<ul style="list-style-type: none"> ➤ Preforming ➤ Heating furnace ➤ Gas forming ➤ Laser cutting ➤ Press forming ➤ Welding(ass'y)

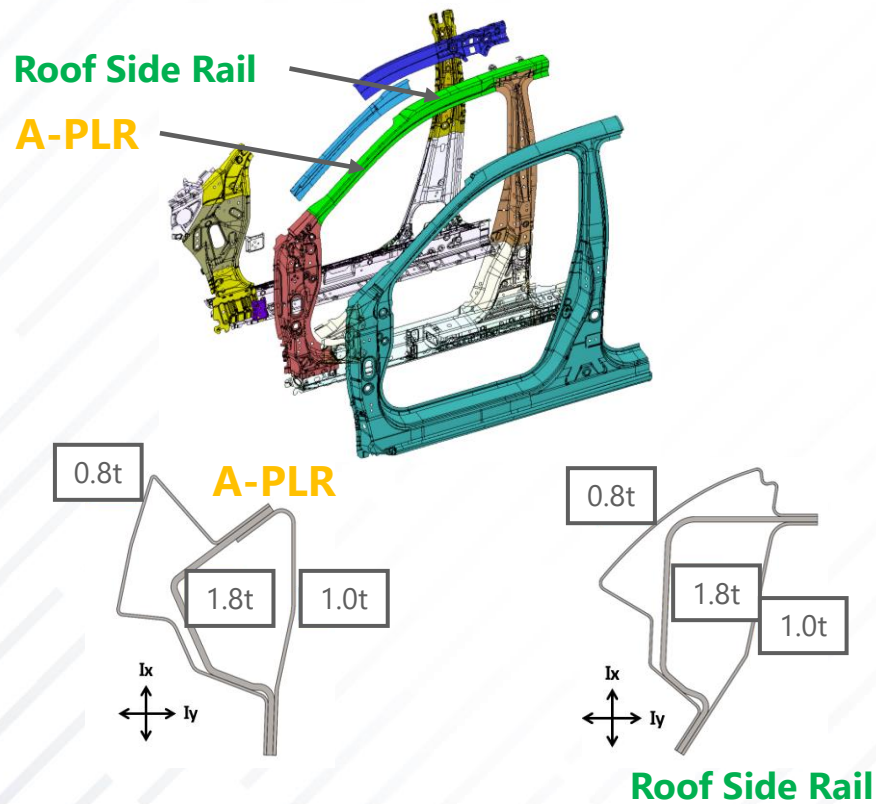
CASE STUDY FOR A PILLAR VERIFICATION OF STAF'S BENEFITS

3. CASE STUDY

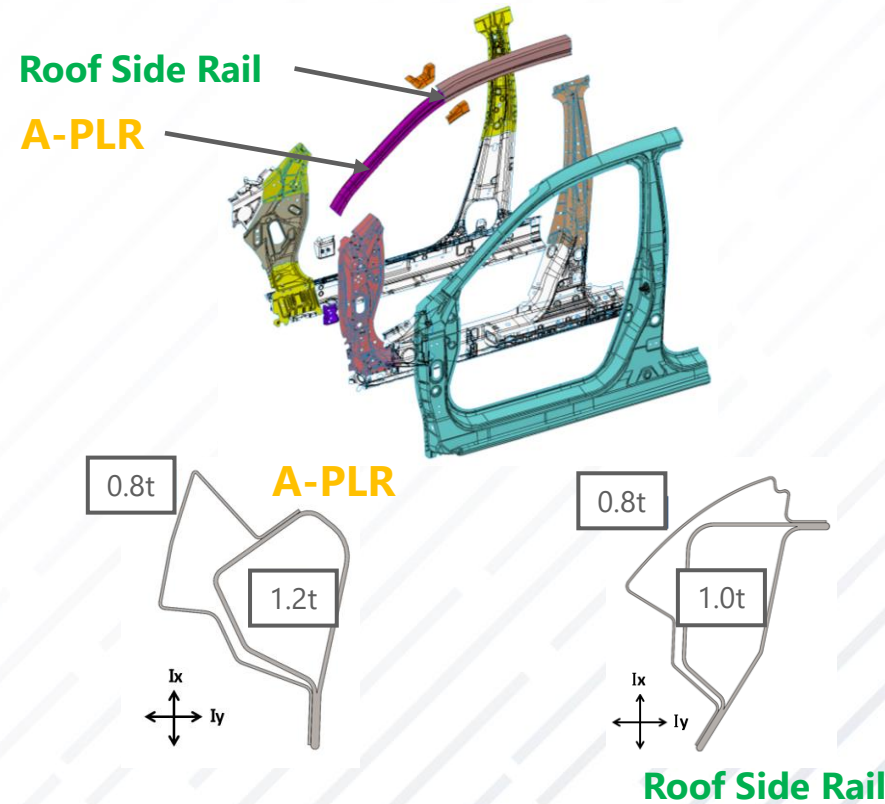
Model description

Replaced A-pillars and roof side rails section with STAF for the market vehicles that consist of hot stamped parts. For STAF, A pillar and roof side rail is welded and connected with brackets.

Market model



STAF



3. CASE STUDY

Evaluation conditions

We selected a market car and replaced the A-pillar and roof rail parts with the STAF design. The cross section shape is slightly changed, depending on the formability.(Same layout) Also, plate thickness was reduced. Then Full-wrap collision was performed.

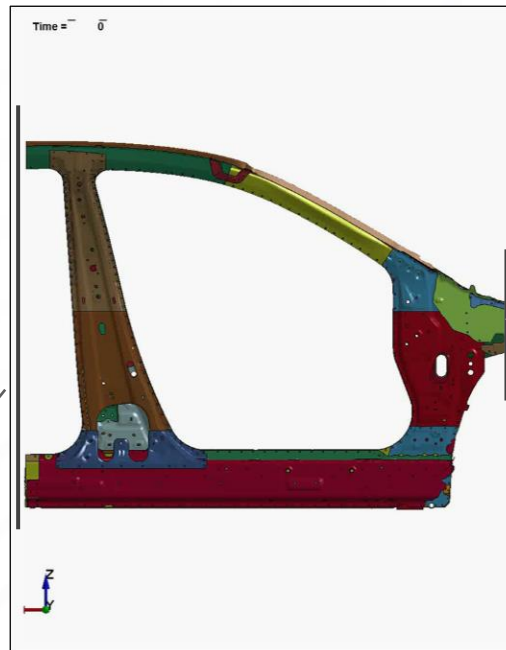
◇ Static press test (CAE)

Solver : LS-DYNA

Methods : Forcibly the contact area is moved at 0.5 mm / sec to evaluate the load and energy absorption.

*The contact area is set as the rigid.

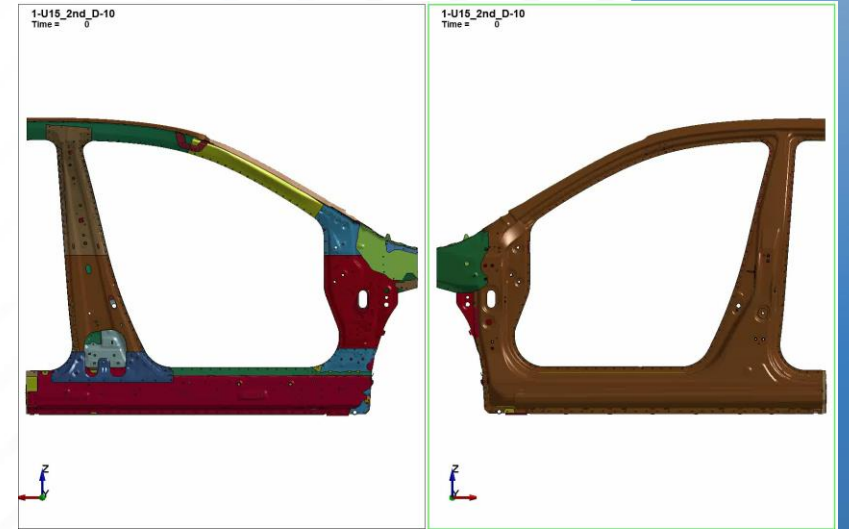
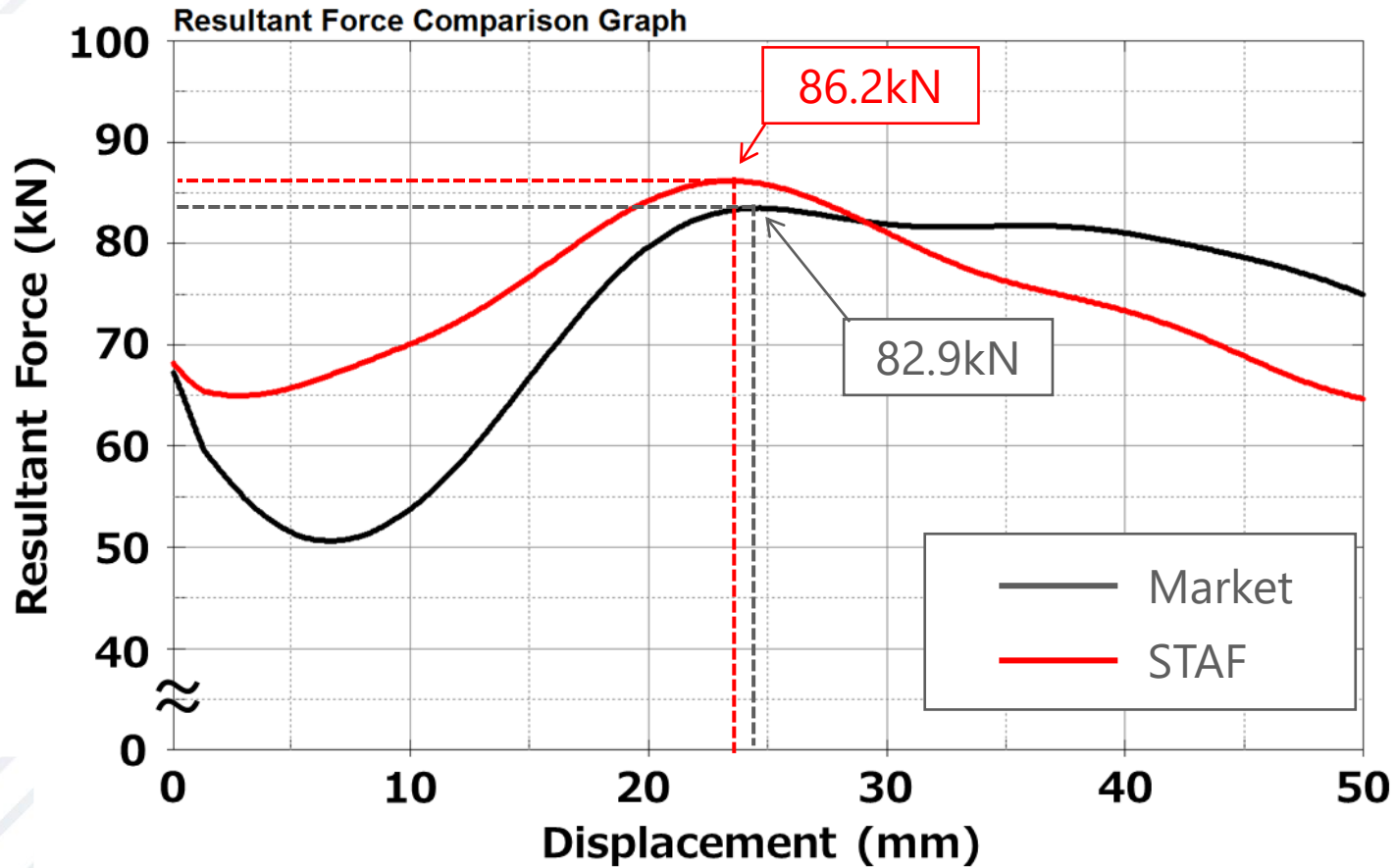
Constrained from all directions



Press speed : 0.5mm/sec

The contact area

3. CASE STUDY



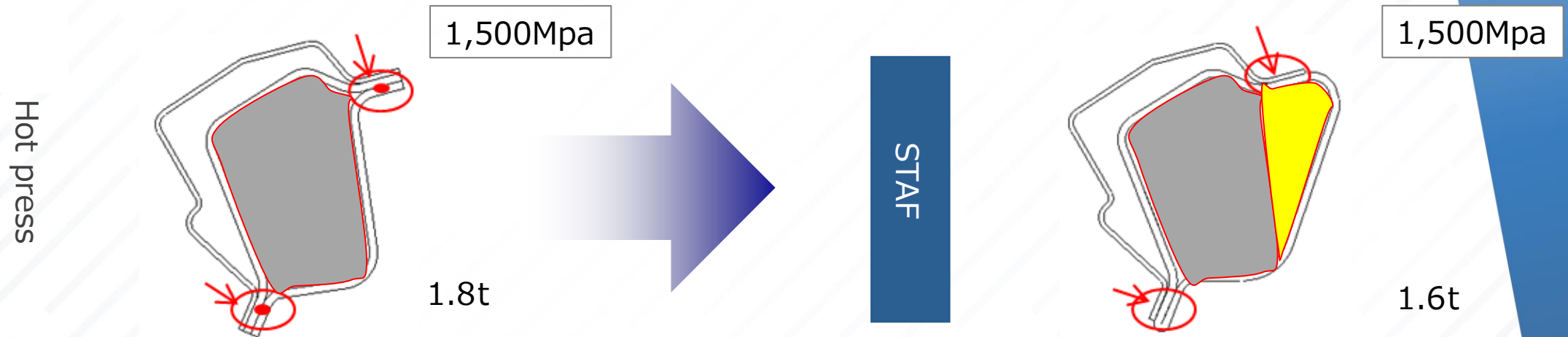
Inner side

Outer side

	A-PLR Thickness	Roof Side Rail Thickness	Weight (kg)	Light weight ratio (%)	Max reaction force(kN)
Market	1.8mm/1.0mm	1.8mm/1.0mm	8.387	-	82.9
STAF	1.0mm	1.0mm	6.532	22.1	86.2

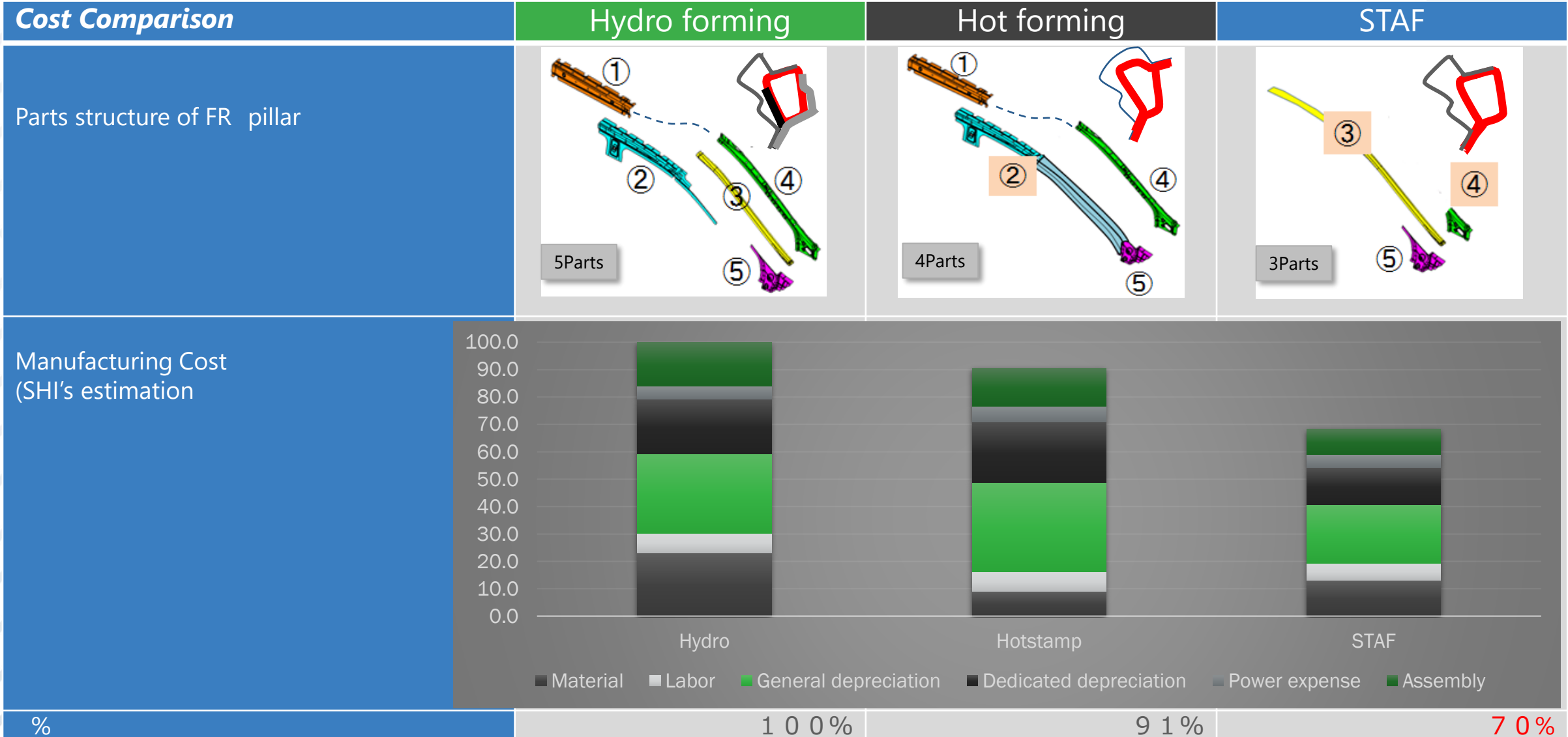
3. CASE STUDY

In the case study of strength evaluation, we could confirm a high weight reduction effect even with the same shape. This page introduces the characteristic cross sections **that can be achieved with only STAF**. (Single flanged model)



- ① High strength and high rigidity because spot welding is not required for the body frame
- ② By changing the flange on one side to a flat shape, the shape can only be achieved with STAF. And since the plate used for the flange can be brought to the cross section, the weight can be further reduced.

3. CASE STUDY



These cost numbers are calculated based on SHI's standard, not guaranteed for actual mass production.

3. CASE STUDY

Summary

STAF applicability to A-pillar test

1. In this test condition(Front crush test), it is possible to reduce **the weight by 22%**, compared with conventional A pillar of hot stamped.(Apple to Apple same profile comparison)
2. By reducing the number of parts, production efficiency and the number of dies, manufacturing cost will be reduced **by 21.4%**.
3. Structure that cannot be manufactured by other forming process

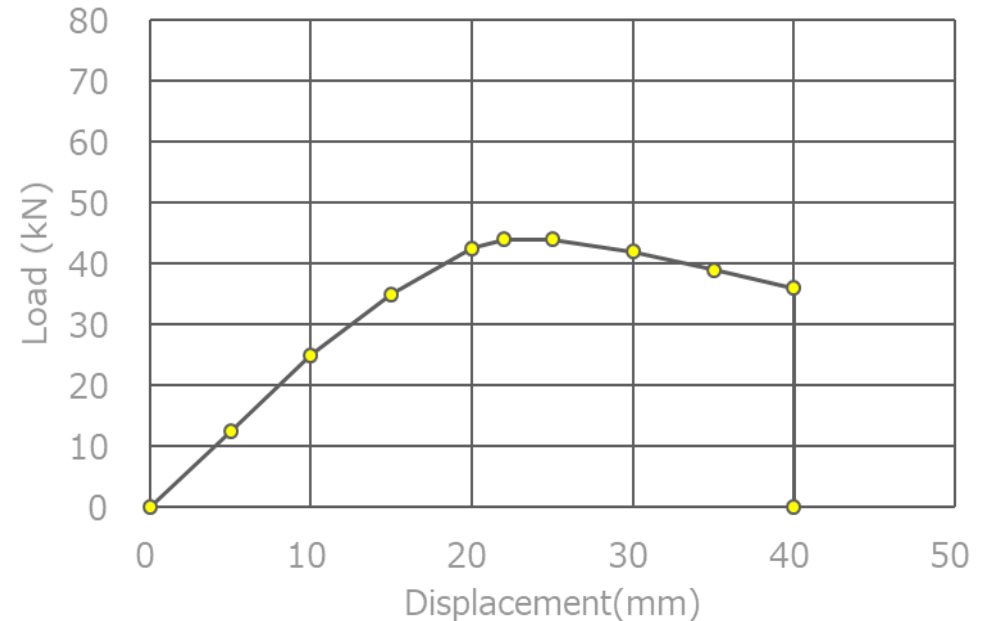
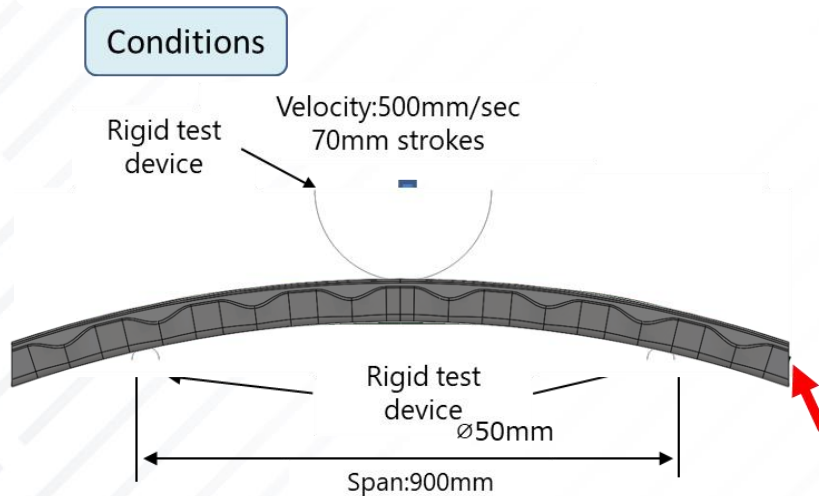
CASE STUDY FOR BUMPER VERIFICATION OF STAF'S BENEFITS

3. CASE STUDY

Evaluation conditions

We selected a market car and replaced a conventional bumper beam with STAF design. Section shape is designed under the same layout. We tested this evaluation with several strength evaluation, for this page introduce the basic beam performance improvement.

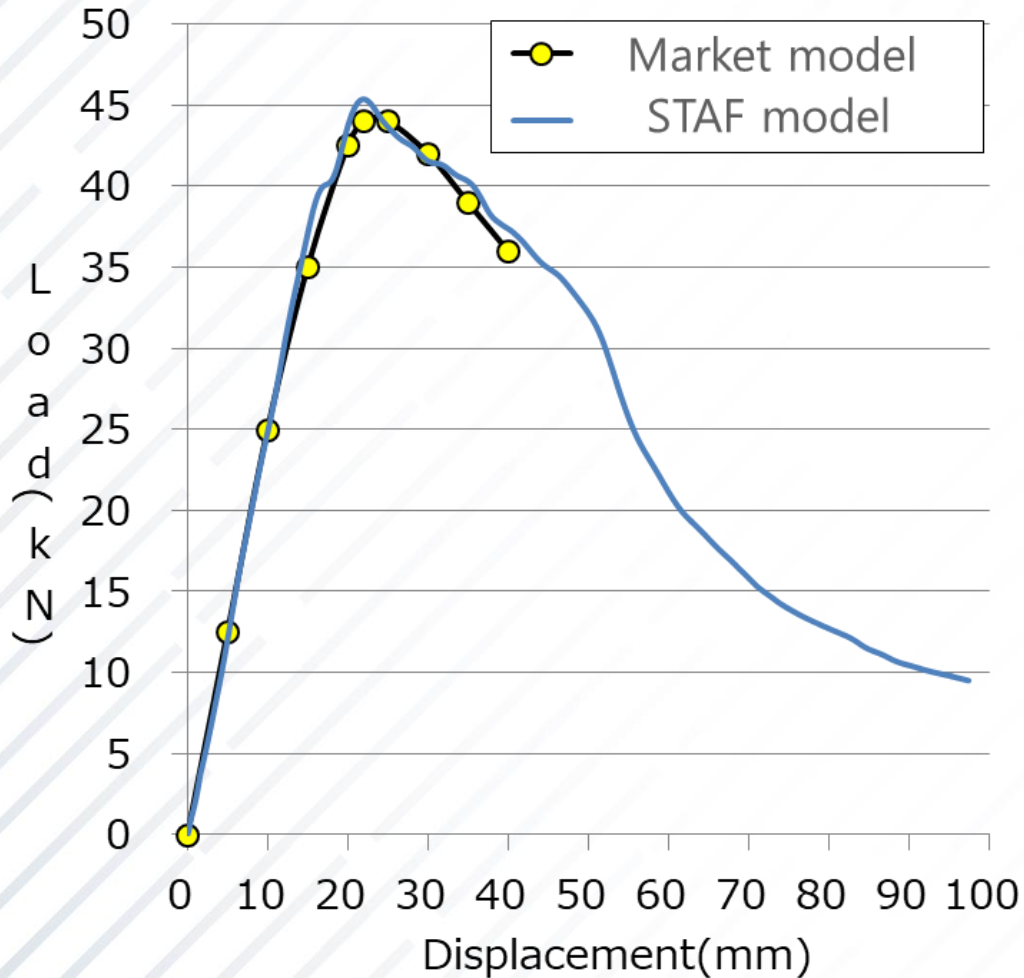
◇ 3 point bending test (CAE evaluation) Solver : LS-DYNA

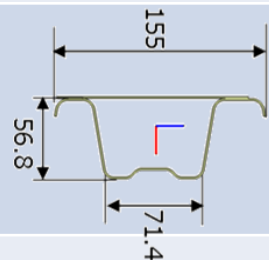
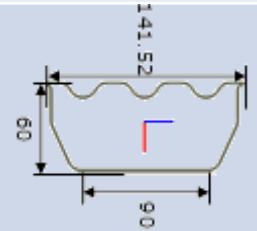


◇ Criteria for performance of STAF applied part
Achieve the target load as shown on right and lighter weight than Market model with keeping the same beam cross section area.

3. CASE STUDY

Test results



Model	Market model	STAF model
Pipe diameter (mm)	-	φ114.3
Thickness (mm)	①Camber surface 590MPa,t1.25 ②Beam 1800MPa,t1.6	t1.2
Cross section		
Weight(kg)	5.15	3.72 (⊙-27.7%)

Achieve target reaction force of Market model (1.8G material) with 1.5G material.

3. CASE STUDY

Cost Comparison	Hot forming	STAF																				
Parts structure of FR pillar																						
Manufacturing Cost (SHI's estimation)	<table border="1"> <caption>Manufacturing Cost Breakdown (%)</caption> <thead> <tr> <th>Part</th> <th>Material</th> <th>Press</th> <th>Weld</th> <th>Total</th> </tr> </thead> <tbody> <tr> <td>CLOSING PLATE</td> <td>13</td> <td>19</td> <td>11</td> <td>43</td> </tr> <tr> <td>BUMPER</td> <td>32</td> <td>23</td> <td>0</td> <td>55</td> </tr> <tr> <td>STAF-BEAM</td> <td>43</td> <td>37</td> <td>0</td> <td>80</td> </tr> </tbody> </table>		Part	Material	Press	Weld	Total	CLOSING PLATE	13	19	11	43	BUMPER	32	23	0	55	STAF-BEAM	43	37	0	80
Part	Material	Press	Weld	Total																		
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BUMPER	32	23	0	55																		
STAF-BEAM	43	37	0	80																		
%	<p>100% 80.3%</p>																					

These cost numbers are calculated based on SHI's standard, not guaranteed for actual mass production.

3. CASE STUDY

Summary

STAF applicability to Bumper beam

1. In this test condition(3point bending), it is possible to reduce **the weight by 27.7%**, compared with conventional bumper of hot stamped.(Apple to Apple same layout design comparison)
2. By reducing the number of parts, production efficiency and the number of dies, manufacturing cost will be reduced **by 19.65%**.
3. Structure that cannot be manufactured by other forming process

4. WHAT SHI CAN SUPPORT TO THE NEW DEVELOPMENTS

Currently, several projects are underway with Tier1s and OEMs to adopt STAF.

We Sumitomo, an equipment manufacturer, not only provides equipment, but also supports the technology required for adoption of STAF.

The parts below are just an example of the prototype parts that we are studying with our customers.

Green: Body frame parts to which STAF is applicable.

FR Pillar Prototype sample



Bumper Beam Prototype sample



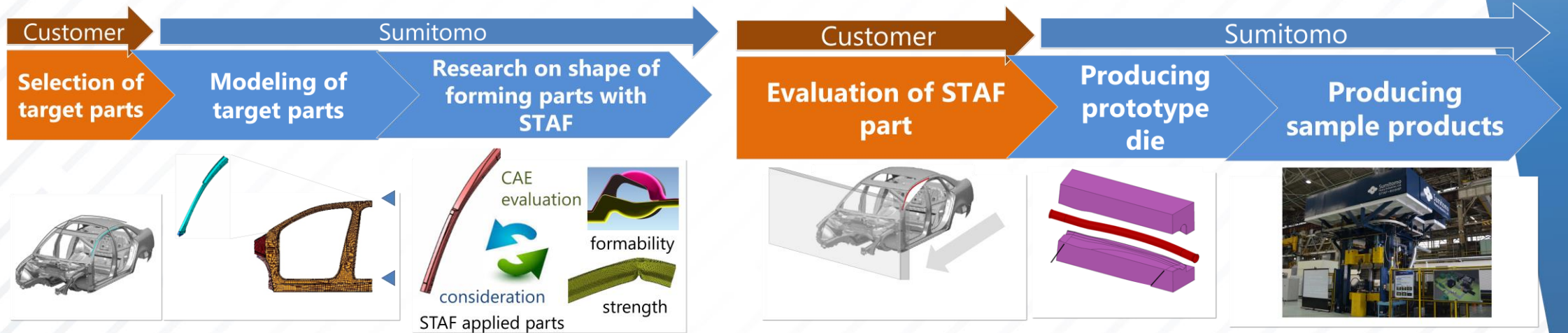
Studied application

- Side sill
- B PLR
- Battery's cross mem
- Roof rail

4. WHAT SHI CAN SUPPORT TO THE NEW DEVELOPMENTS

This is a summary that we can support for customer's development. STAF is a newly developed forming process, so just installing equipment is not the best solution for OEMs or Tier1 suppliers. We can support customer's adoption of STAF in design and provide technical support for solving the problems for introducing STAF.

● CAE × Design support & Engineering support



● Technical support

Through these activities, Sumitomo can provide the technical know-how in the feasibility and strength confirmation CAE that have already been verified, and the confirmation results such as the weldability, formability and corrosion protection of STAF product, etc., The adoption of STAF by OEMs and Tier1 suppliers can be strongly promoted.

THANK YOU

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