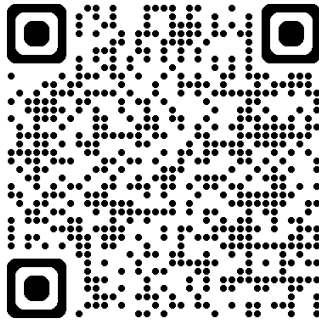


Hot Local Compression and Die Quench Ausforming of Quenchable Steel Sheet and its Application for Corner Strengthening

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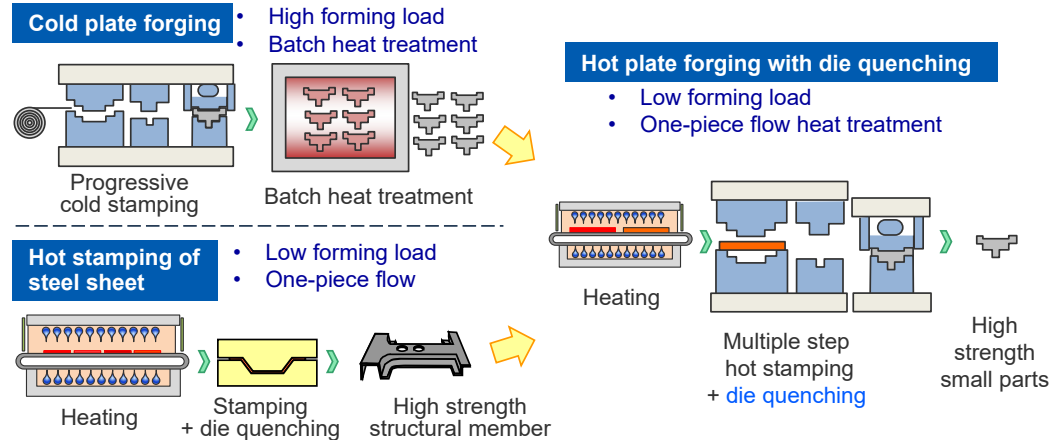


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Hot Local Compression and Die Quench Ausforming of Quenchable Steel Sheet and its Application for Corner Strengthening

YNU YOKOHAMA National University

T. MAENO, Y. IKEDA, A. HANADA (YOKOHAMA National University)
K. MORI (Toyoashi University of Technology)



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2/ 32

Difference of deformation between sheet metal-forming and plate forging

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Sheet metal-forming

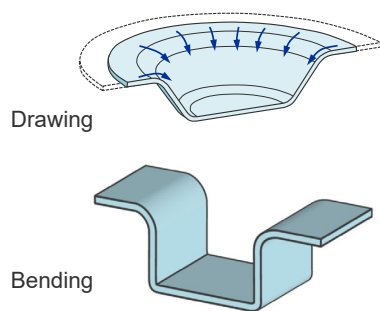
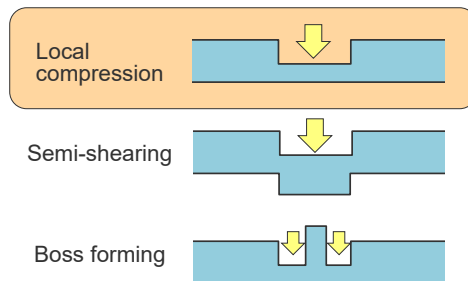


Plate forging



Purpose

The effect of a forming temperature on reduction ratio and hardness was examined.

3/ 32

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Hot Local Compression and Die Quench Ausforming of Quenchable Steel Sheet and its Application for Corner Strengthening

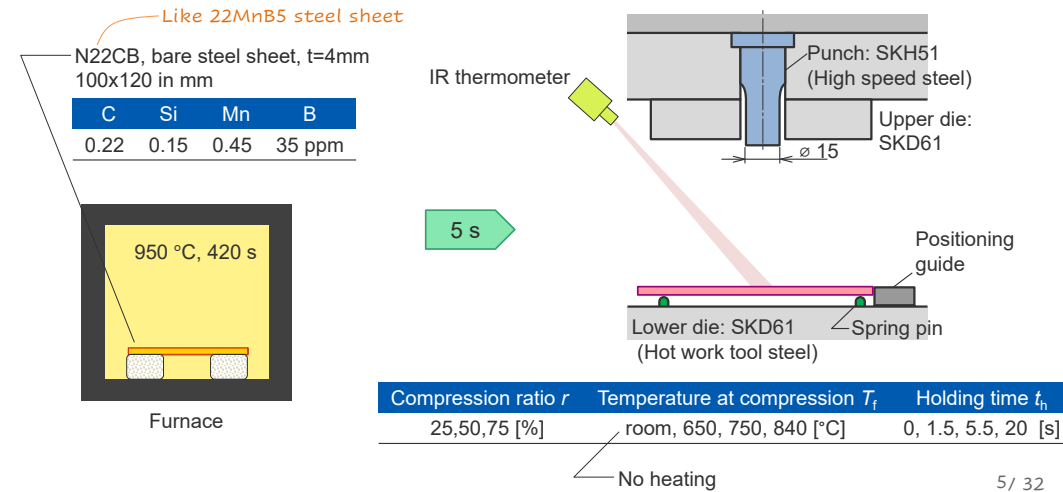
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- Hot local compression of quenchable thick steel sheet
- Results of hot local compression in thickness direction of quenchable thick steel sheet
- Mechanism of increasing in compression ratio by holding at bottom dead centre
- Improvement in hardness by die quench Ausforming
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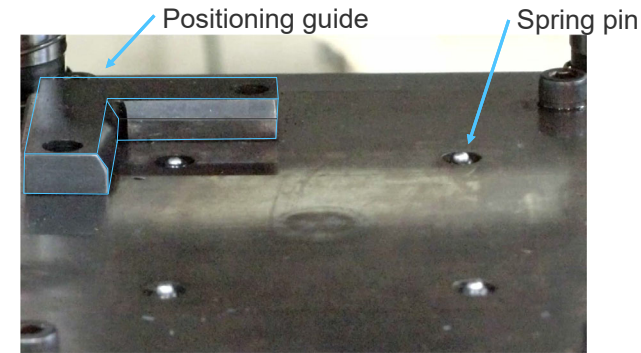
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4/ 32

Hot local compression and die-quenching of quenchable thick steel sheet



Video of hot local compression and die quench



$$r = 50\%, T_f = 840\text{ °C}, T_h = 20\text{ s}$$

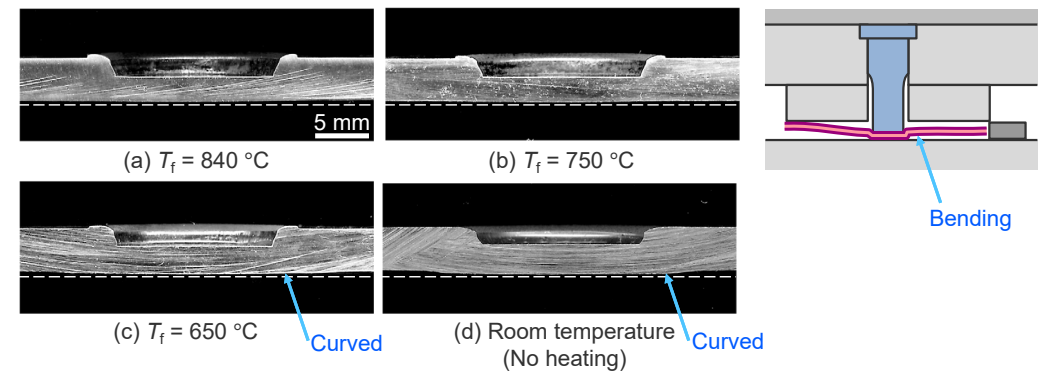


Locally compressed and quenched sheet

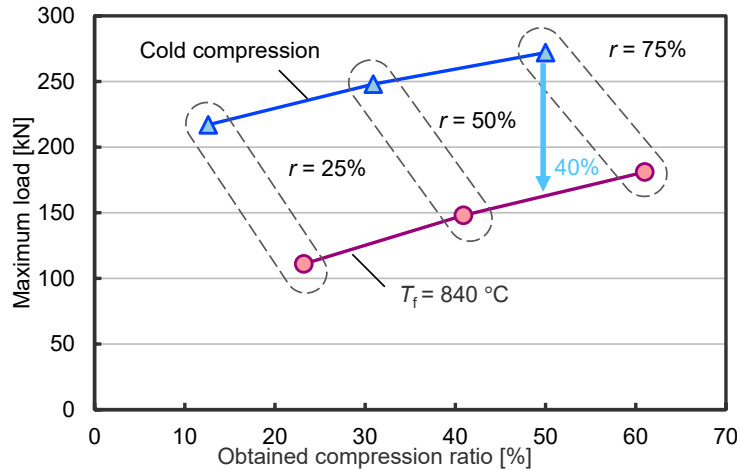
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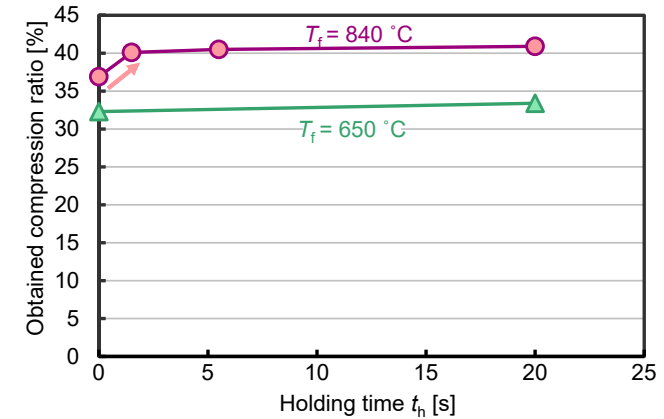
Cross sections of compressed portion obtained at different compression temperature for $r = 50\%$, $t_h = 20\text{s}$



Relationship between maximum load and compression ratio for $T_f = 840^\circ\text{C}$ and room temperature without sheet holder



Effect of holding time on obtained compression ratio for hot local compression for $T_f = 650^\circ\text{C}$ and 840°C

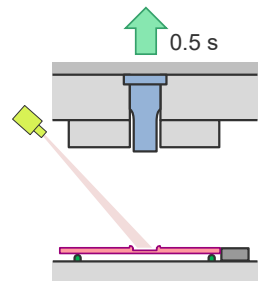
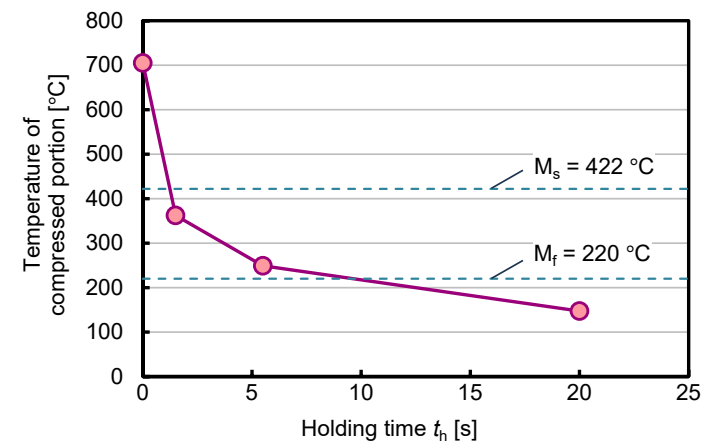


The holding is effective to increase the compression ratio

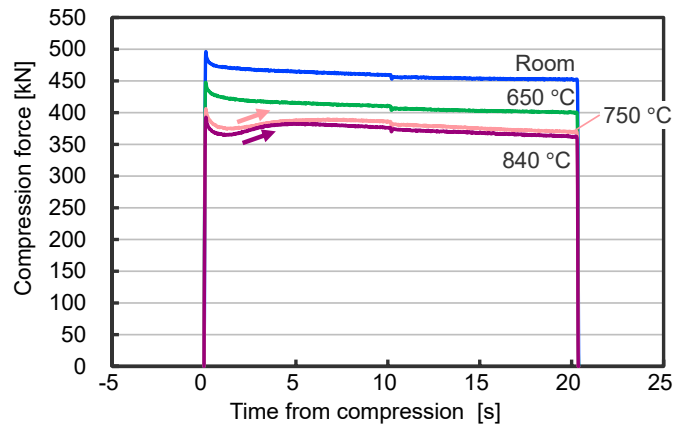
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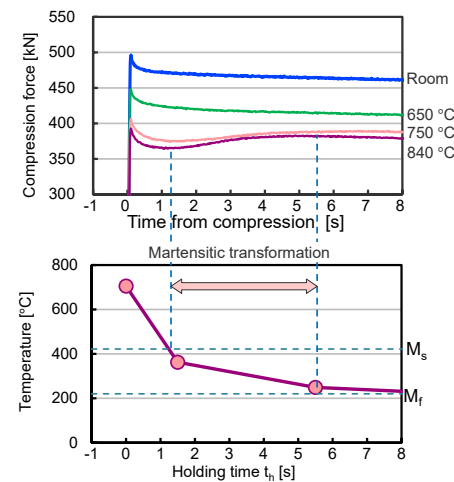
Relationship between temperature at compressed portion just after compression and holding time for $T_f = 840^\circ\text{C}$, $r = 50\%$



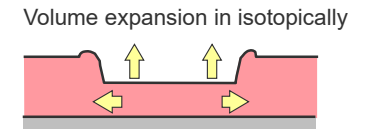
Compression load behaviour during holding at bottom dead centre for $r = 50\%$



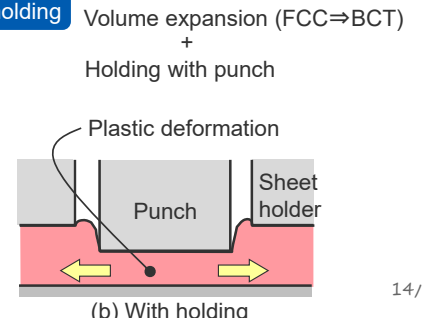
Mechanism of improvement of compression ratio by holding at bottom dead centre in local hot compression



Without holding



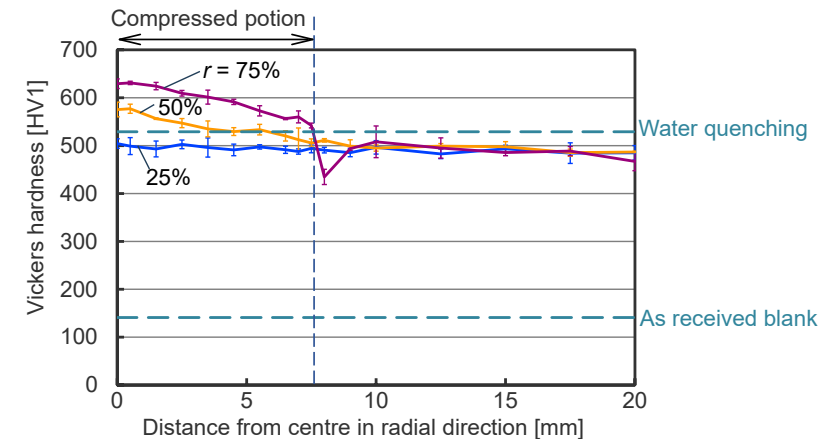
With holding



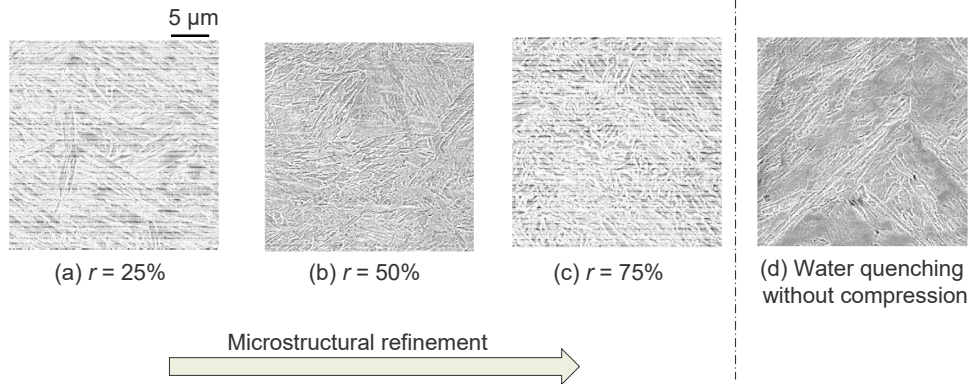
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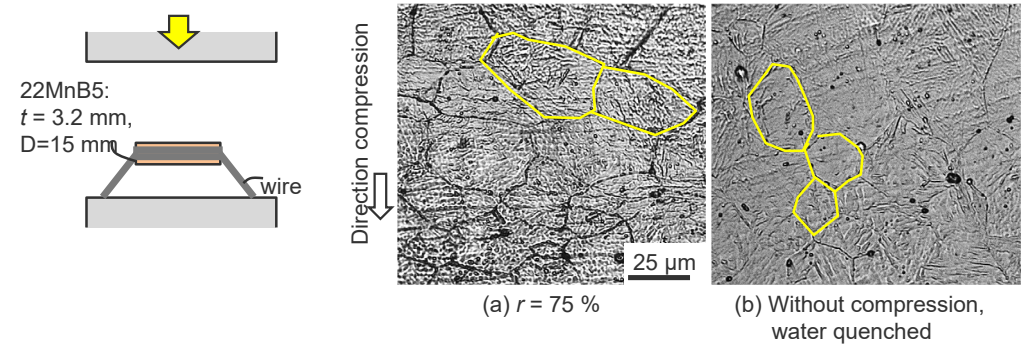
Hardness distributions of compressed portion for $T_f = 840^\circ \text{C}$.



Microstructure of cross-section at centre of hot local compressed portion after die quenching for $T_f = 840^\circ\text{C}$ and $t_h = 20$ s

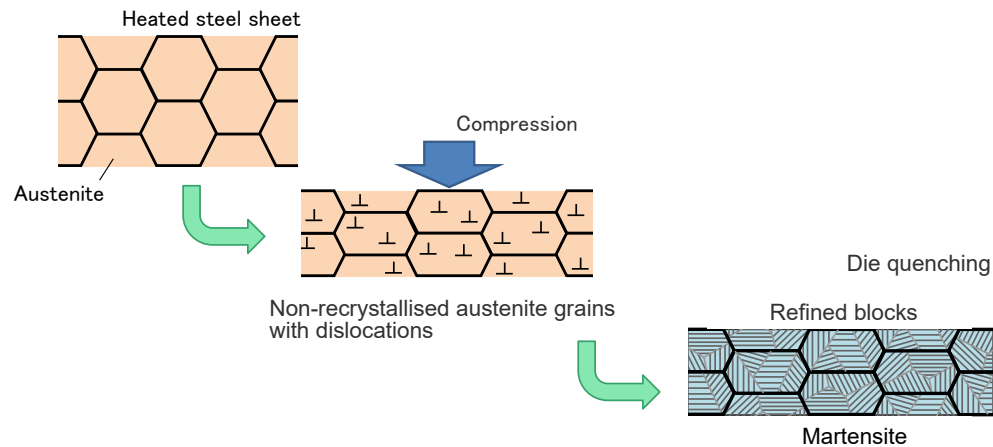


Prior austenite grain boundaries of 22MnB5 disc after compression and die quenching ($r = 75\%$)

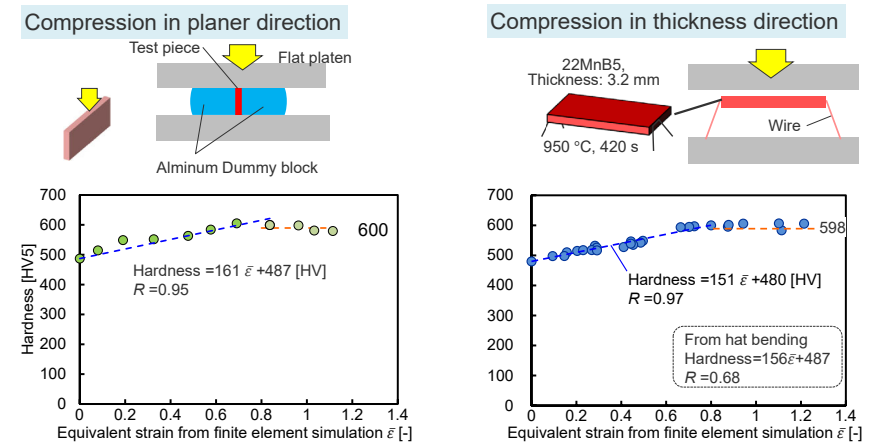


Grains were slightly flattened by compression and No recrystallized grains were observed

Mechanism of hardness improvement through ausforming induced by local compression and die quenching



Relationship between hardness and pre-strain of die quenching for 22MnB5

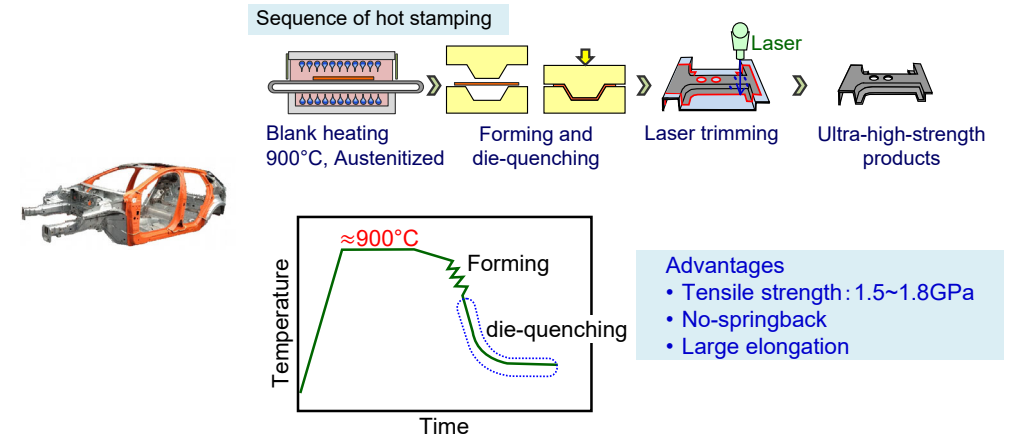


The hardness increased linearly below 0.8 in equivalent strain, and it reached 600 HV

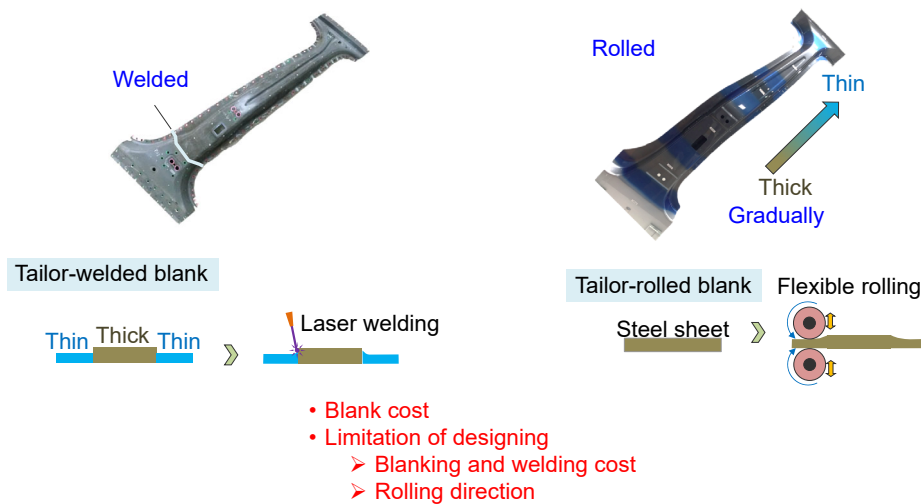
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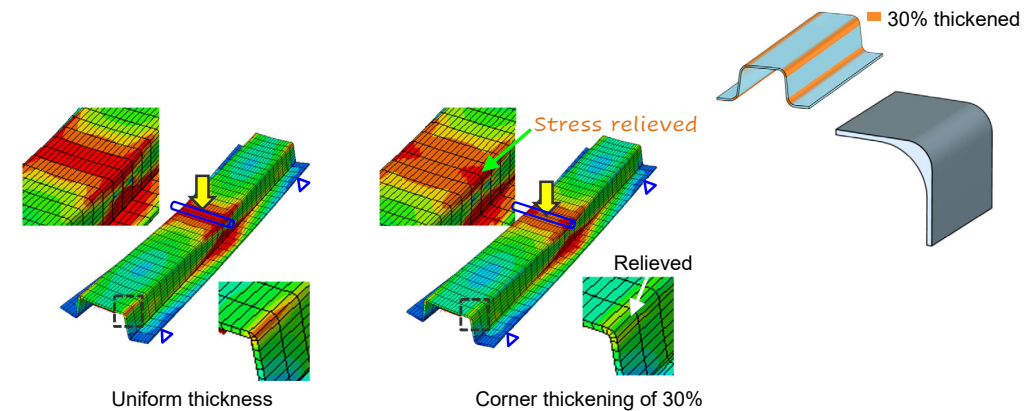
Hot stamping of quenchable steel sheet



Tailoring of product strength in hot stamping

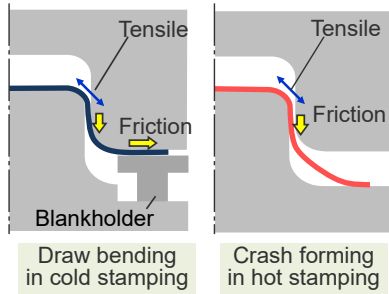


Improvement of member strength that can be expected by thickening corners

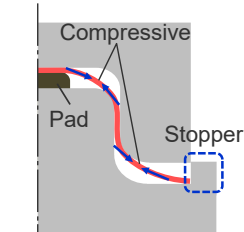


Thickening around corner is effective for improvement of the bending strength

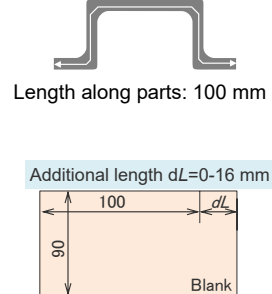
Corner thickening by planer compression in hot stamping



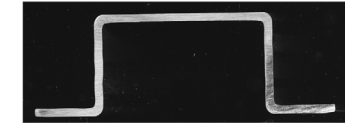
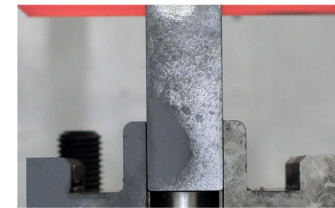
Tensile stress
↓
Thickness decrease



Compressive stress
↓
Thickness increase



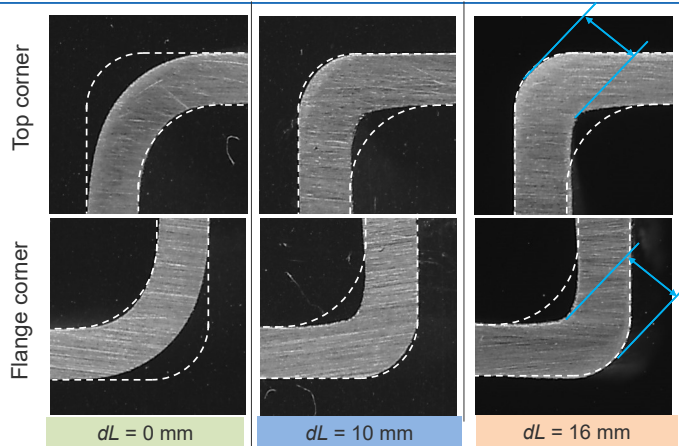
Video of hot hat-shaped bending using planer compression and Cross-sections of hot hat-shaped bent parts for $dL = 0-16$ mm



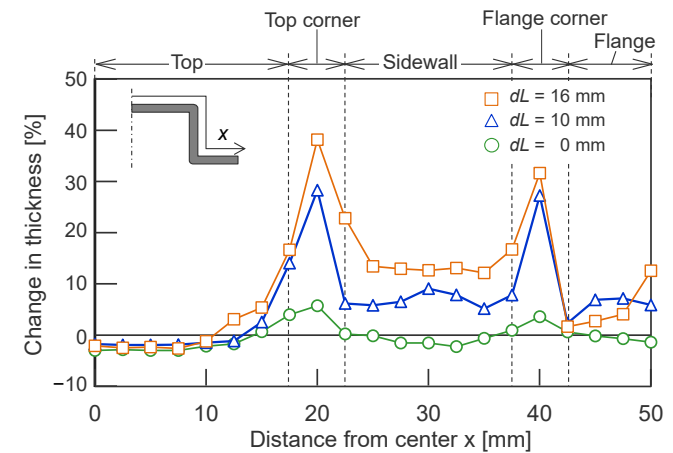
Sharp corners



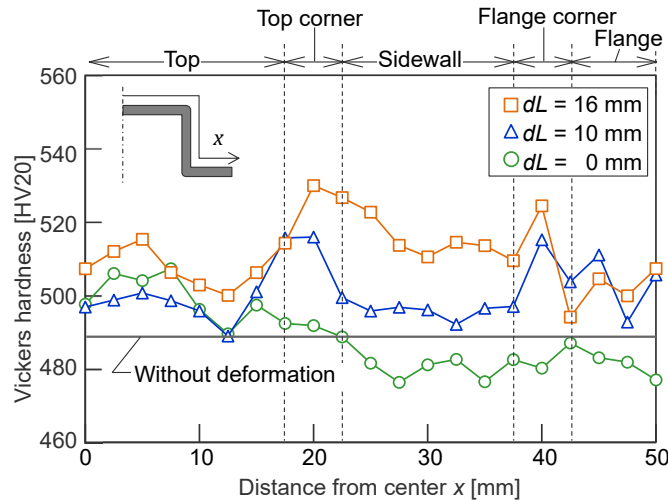
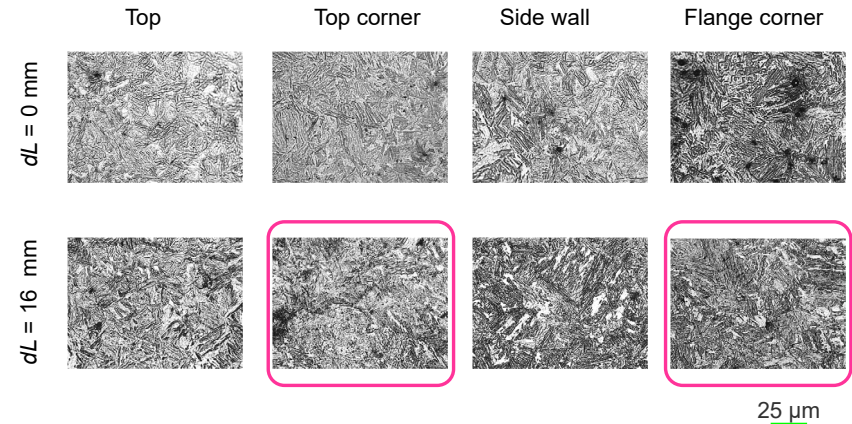
Cross-sections around top and flange corners of hot hat-shaped bent parts



Distributions of change in thickness in hot hat-shaped bent parts

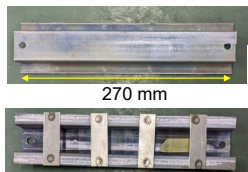


Distributions of Vickers hardness in hot hat-shaped bent parts

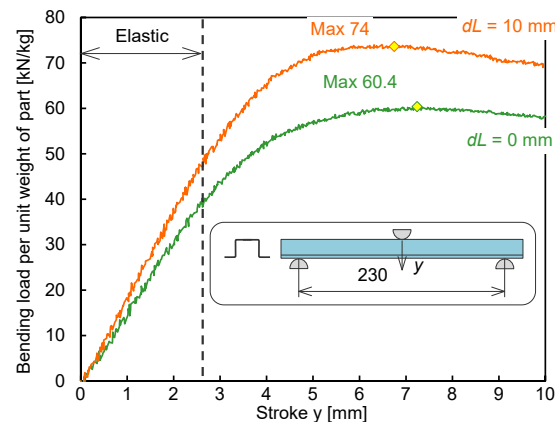
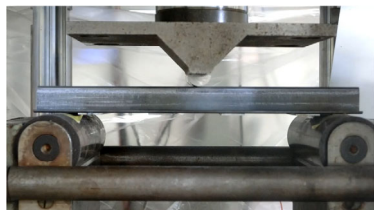
Microstructures of hot hat-shaped bent parts for $dL = 0$ and 16 mm

Microstructure of martensite is refined by corner thickening

3 point bending test of hat bent beam with and without corner thickening



Bridge plate was added to prevent opening of flanges

Rigidity in bending : 25% UP
Strength of bending : 22% UP

Conclusions

- Holding at the bottom dead centre by die quenching is effective not only for hardening but also for increasing the compression ratio.
- By applying a relatively large plastic deformation before die quenching, the hardness after die quenching increases. This has the same effect as ausforming. The hardness increased linearly below $\bar{\epsilon} = 0.8$, and it reached 600 HV by modified ausforming under die quenching.
- When compression is applied in the planar direction during normal hot stamping, strength can be increased by increasing in thickness and die quench ausforming. The strength of the formed components was heightened by the increase in not only thickness but also hardness.

Thank you for kind attention