DUAL PHASE STEEL APPLICATIONS IN TAILOR-WELDED BLANK TECHNOLGY

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Overview

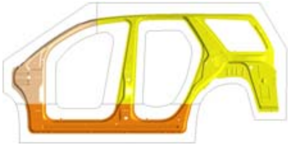
- Introduction
  - Material Properties
  - Opportunities & Challenges
- DP Steel (Dual Phase) TWB (Tailor Welded Blanks)
  - Quality
  - Micrographs
  - Fatigue Performance
- Dual Phase Steel TWB Rails
- DP Steel LW (Laser Welded) Tubular Blanks
- Conclusions

- Small heat input in laser welding
  - Due to small heat input, LW is a favorable joining technology for fabrication of DP steel TWB
- Industrial applications/advanced trials:
  - TWBs composed with DP600, DP800, DP1000

Rails

A & B-pillars

Body side inner, etc.



DP LW hydroformed engine cradles, etc.

Opportunities

- *Range of gauge and grade combinations (DQ, DP600, DP800, DP1000, etc.)*
- *Unique opportunities to reduce cost and improve performance:*
  - *Optimize strength and mass distribution over the vehicle body*
  - *Optimize vehicle crash and structural performance*
  - *Reduce part count and overall assembly cost*

- Challenges:
  - Need to optimize laser welding processes
  - Need to optimize part geometry and stamping process for springback control
  - Higher press tonnage/pressure requirements
  - Impact on tool's durability
  - Differences in material strength, work hardening rate, and resulting heat generation in stamping

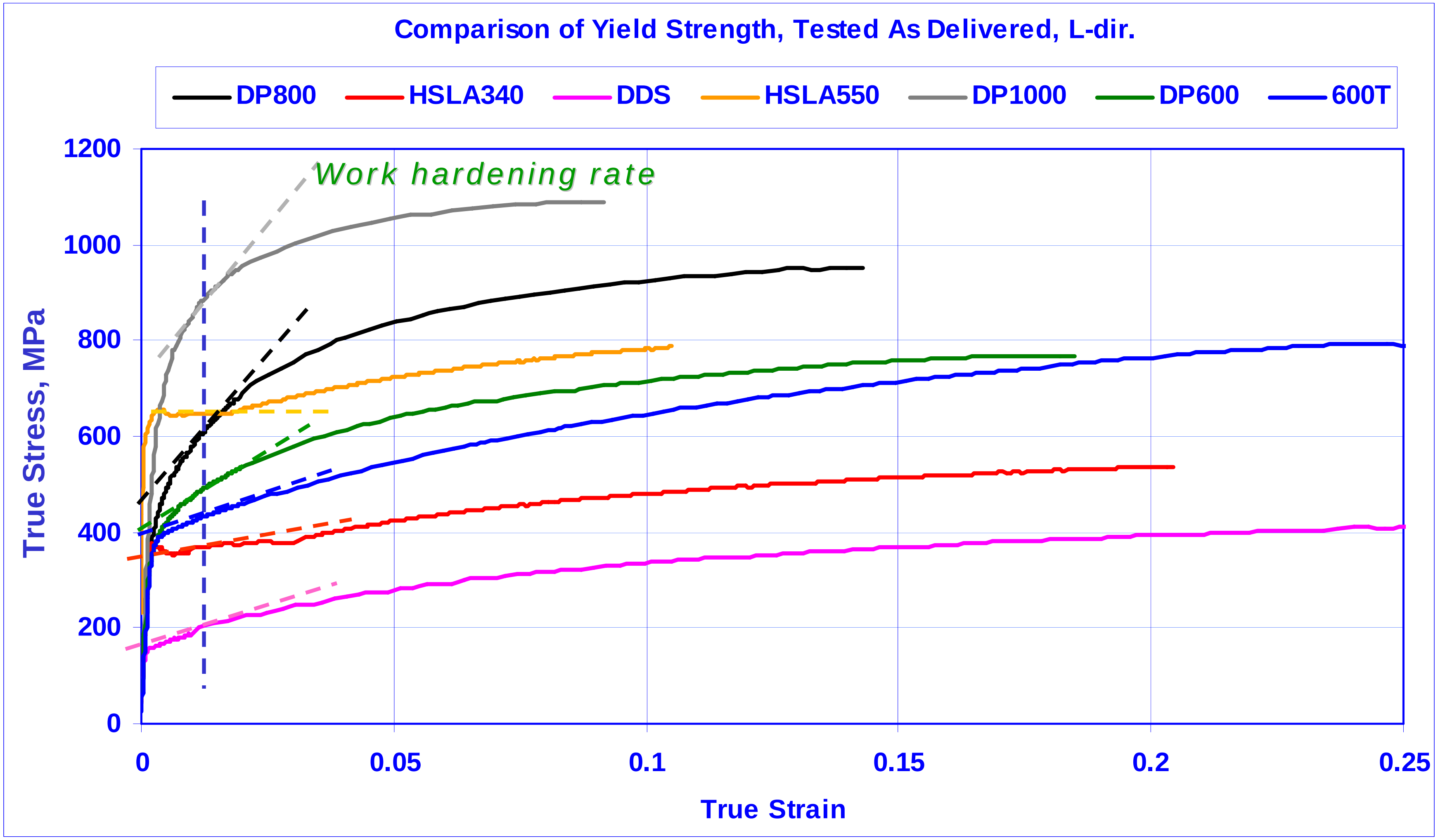
Tested Materials

Example of Typical Mechanical Properties

GRADE	YS (MPa)	UTS (MPa)	El (%)	t (mm)	n-value (10%-UE)	n-value (4-6%)
IF	163	282	49.0	-	0.240	-
DDQ	183	314	42.9	1.6	0.230	-
DQ	*214*	*323*	*37.5*	*2.8*	*0.192*	-
HSLA340	*387*	*438*	*30.8*	*1.6*	*0.170*	-
C-Mn440	375	484	16.0	2.8	0.180	-
HSLA480	487	604	28.0	2.2	0.128	-
HSLA550	641	672	13.5	2.0	0.040*	-
DP600	*386*	*607*	*25.5*	*1.2&1.6*	*0.168*	*0.208*
T600	390	618	35.1	1.6	0.230	-
DP800	*459*	*838*	*17.2*	*1.2&1.6*	*0.115**	*0.168*
T800	475	822	28.0	1.6	0.240	-
DP1000	726	1003	10.8	1.2	0.060*	0.08

Tested Materials, Cont'd

True Stress – True Strain Curves

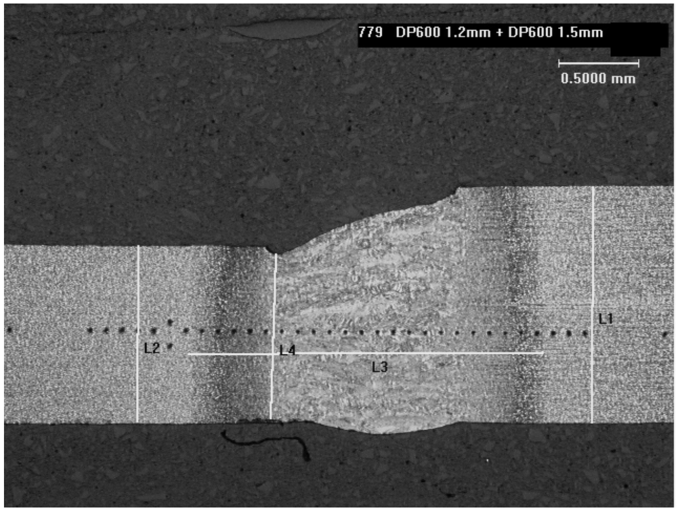


Dual Phase Steel Tailor Welded Blanks

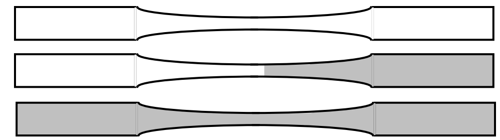
TWB Welding Process Parameters

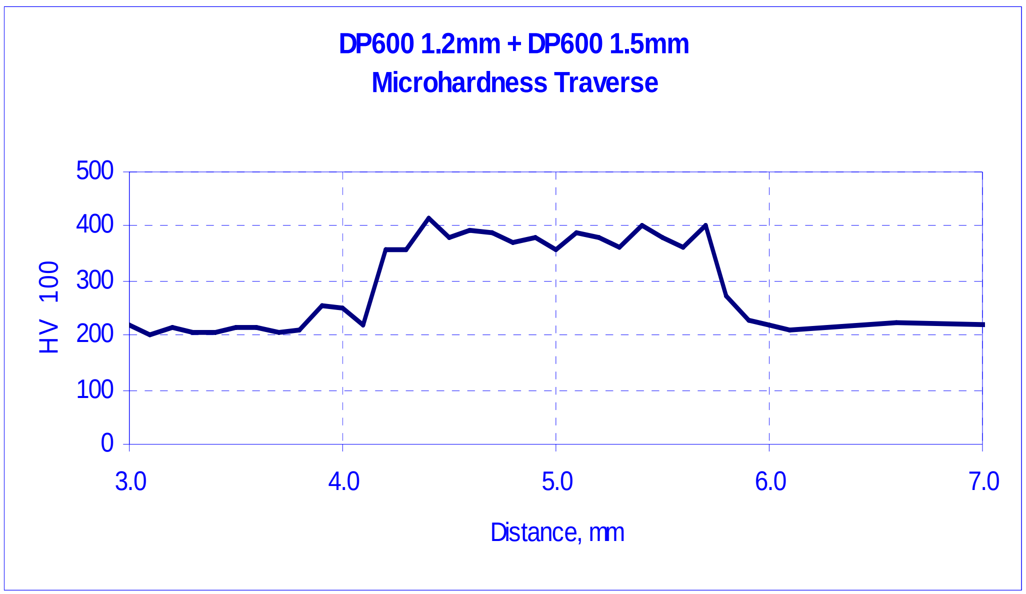
	Laser Welding	Mash Seam Welding
Batch 1	Laser: YAG Power: 4kW, 2 beams Speed: 6.1 – 7.1 m/min Focus: Part surface	Current: 18kA Force: 12kN DP600 Overlap: 2.5 mm Speed: 4m/min
Batch 2	Laser: YAG Power: 3kW Speed: 5.25m/min Focus: 0.5mm from bottom of part	-

Weld Seam Quality and Hardness



	YS, MPa	TS, MPa
1.2mm DP600	427	638
Welded	429	646
1.5mm DP600	432	683
Quality	93.6%	

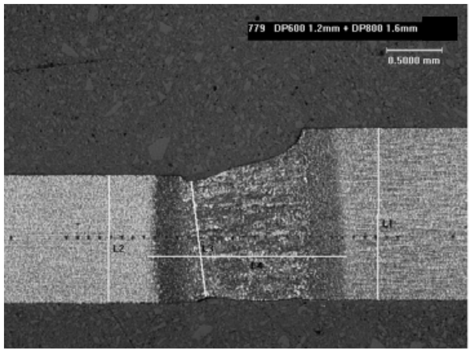




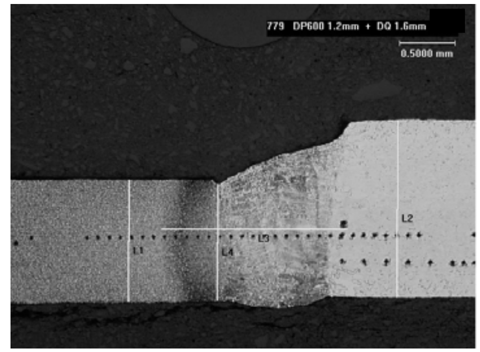
Performed test:
- Tension test
- Olsen test
- Geometry evaluation
- Microhardness

High quality laser weld seam geometry for dissimilar gages of TWB is not an issue.
Acceptance criterion: Minimum 85% of theoretical cross-section.

Weld Seam Quality and Hardness, Cont'd



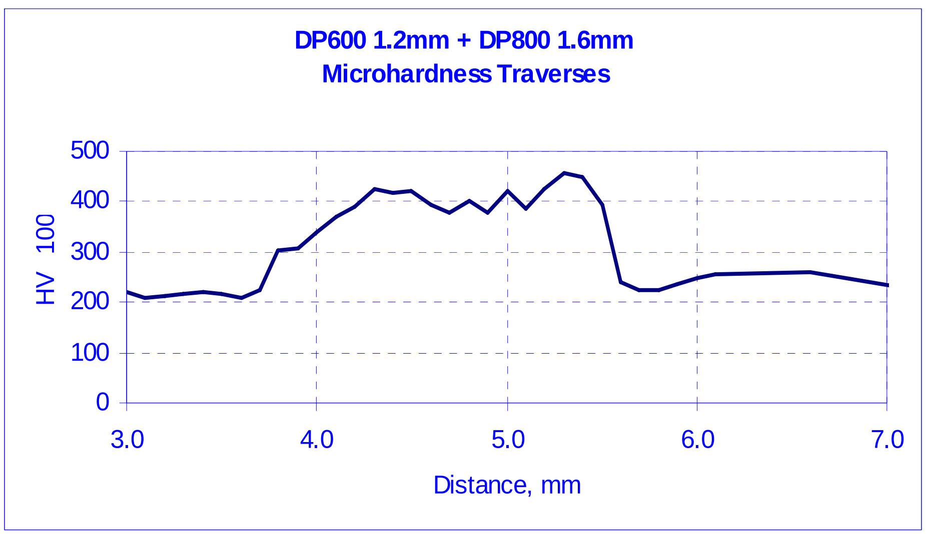
	YS, MPa	TS, MPa
1.2mm DP600	408	647
Welded	433	648
1.6mm DP800	407	786
Weld Quality	93.0%	

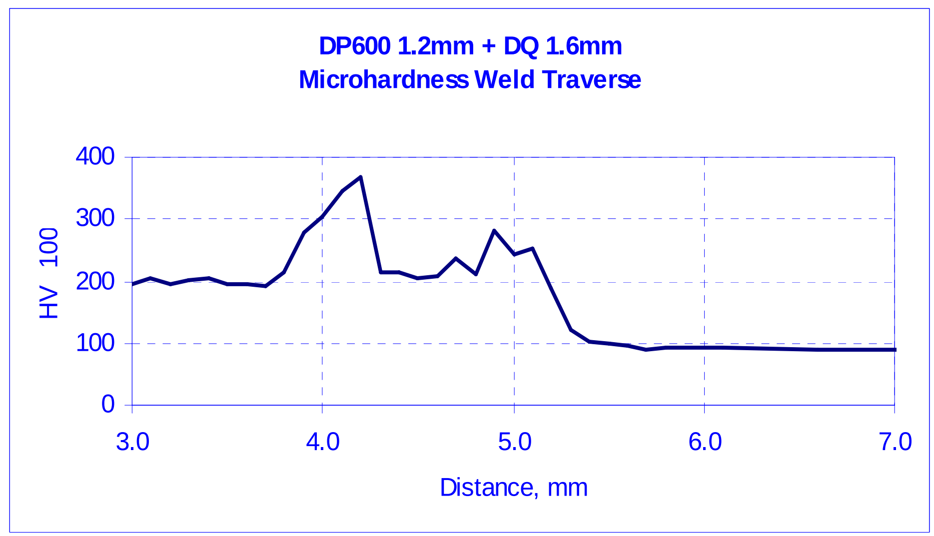


	YS, MPa	TS, MPa
1.2mm DP600	404	639
Welded	170	307
1.6mm DQ	168	298
Weld Quality	95.5%	

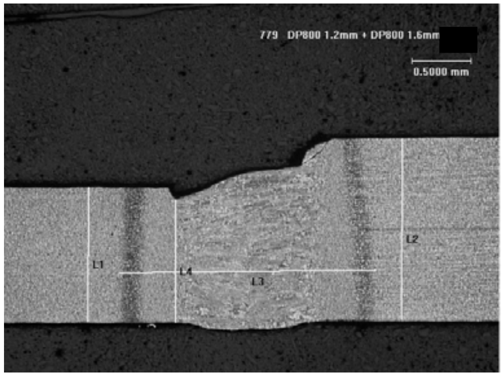
DP600 1.2mm + DP800 1.6mm

DP600 1.2mm + DQ 1.6mm



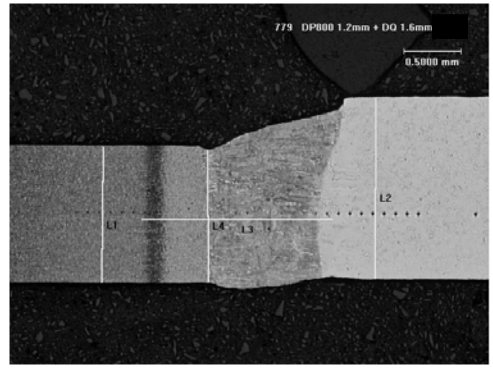


Weld Seam Quality and Hardness, Cont'd



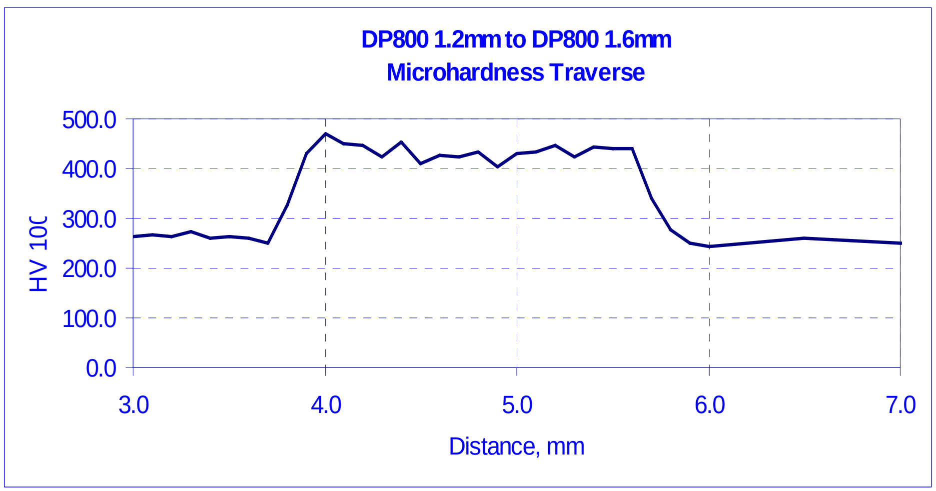
	YS, MPa	TS, MPa
1.2mm DP800	492	866
Welded	502	870
1.6mm DP800	418	795
Weld Quality	92.4%	

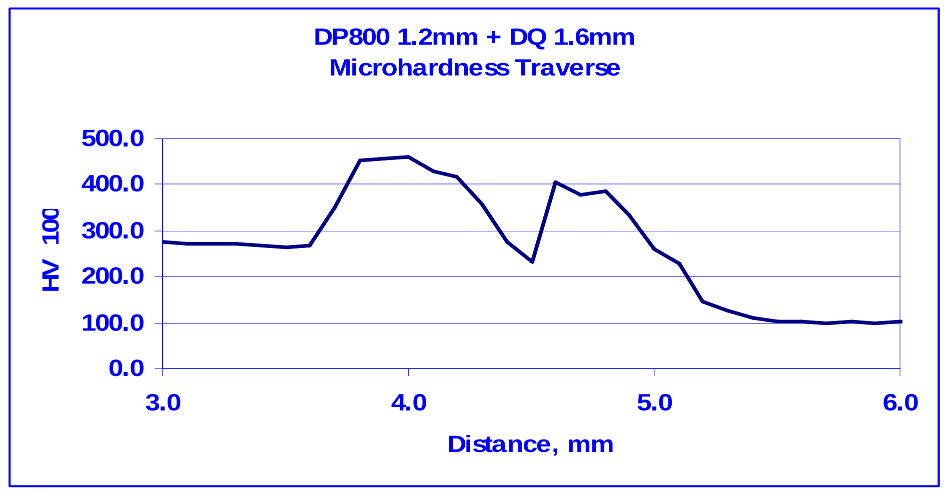
DP800 1.2mm + DP800 1.6mm



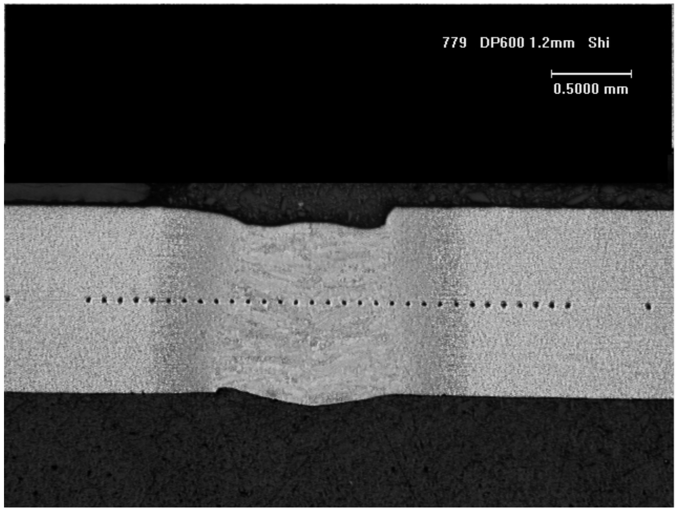
	YS, MPa	TS, MPa
1.2mm DP800	470	851
Welded	168	306
1.6mm DQ	160	300
Weld Quality	97.4%	

DP800 1.2mm + DQ 1.6mm



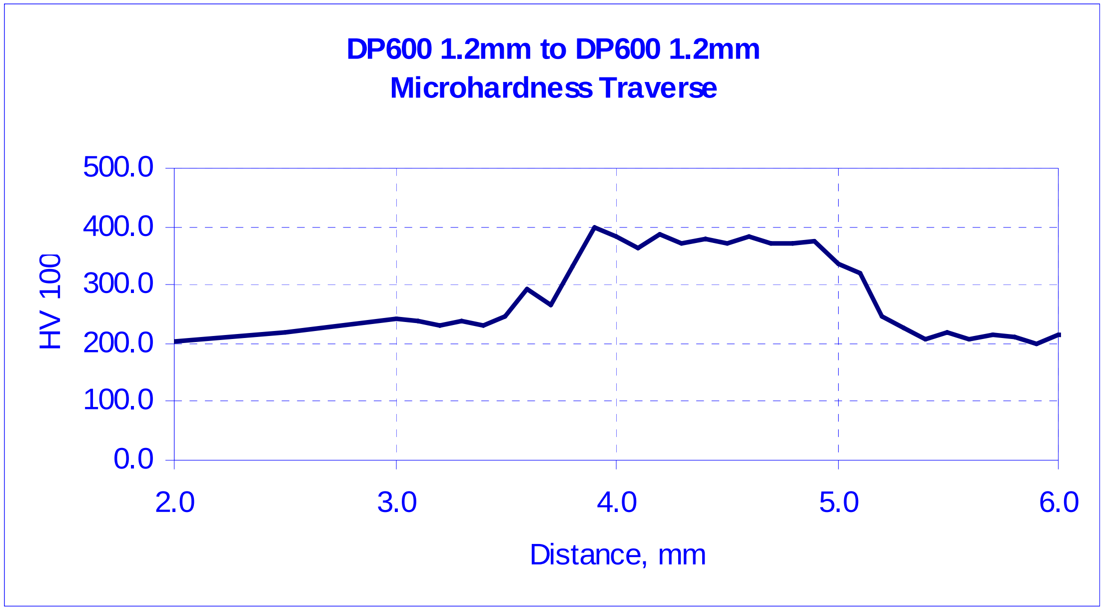


Weld Seam Quality and Hardness, Cont'd



	YS, MPa	TS, MPa
Left Bar	407	640
Welded	408	635
Right Bar	401	632
Weld Quality	91.8%	

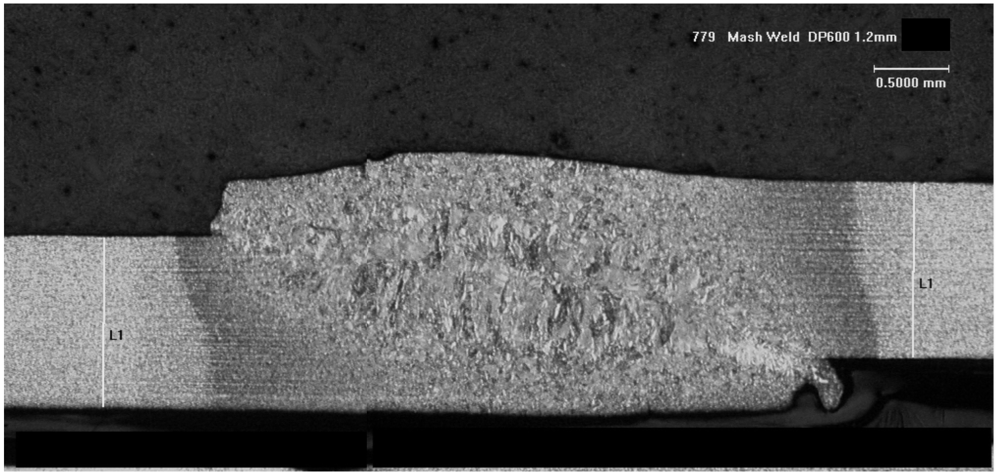
DP600 1.2mm + DP600 1.2mm



Laser welding is <u>more</u> difficult for similar gages

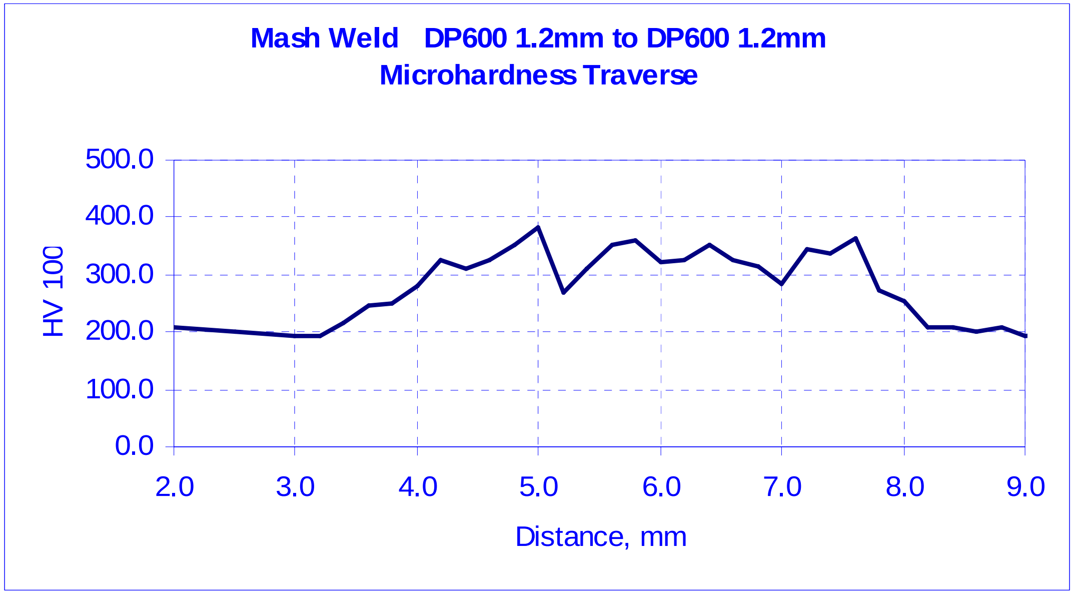
Fatigue testing results for this case are presented later

Weld Seam Quality and Hardness, Cont'd



	YS, MPa	TS, MPa
Left Bar	398	632
Welded	412	634
Right Bar	398	633
Weld Quality	n/a	

DP600 1.2mm + DP600 1.2mm

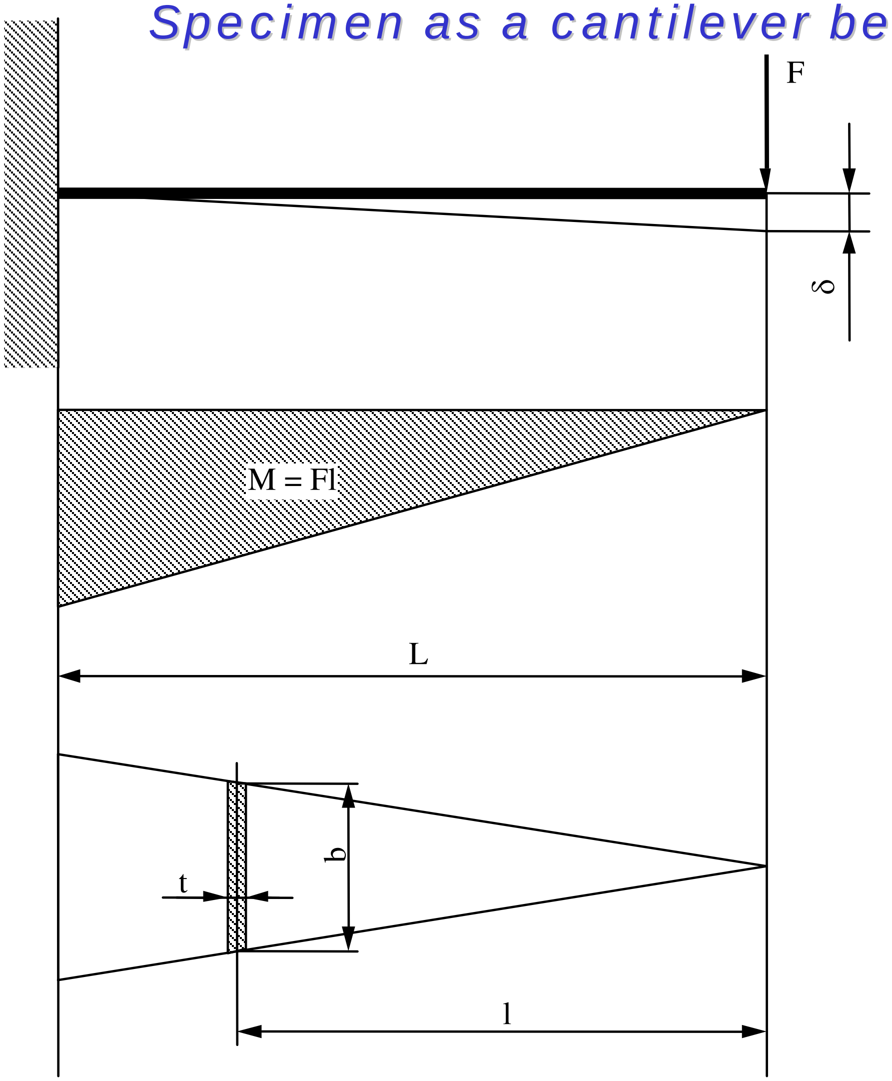


Mash welding results in "added material"

Fatigue testing results for this case are presented later

DP 600 TWB Fatigue Test

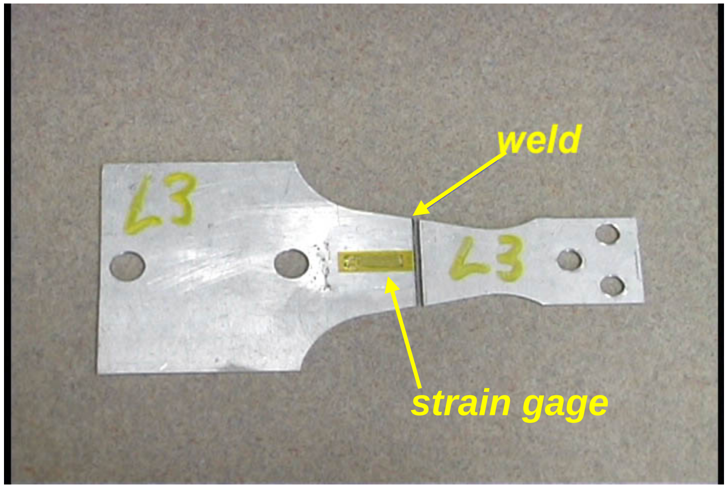
Specimen as a cantilever beam with constant controlled stress



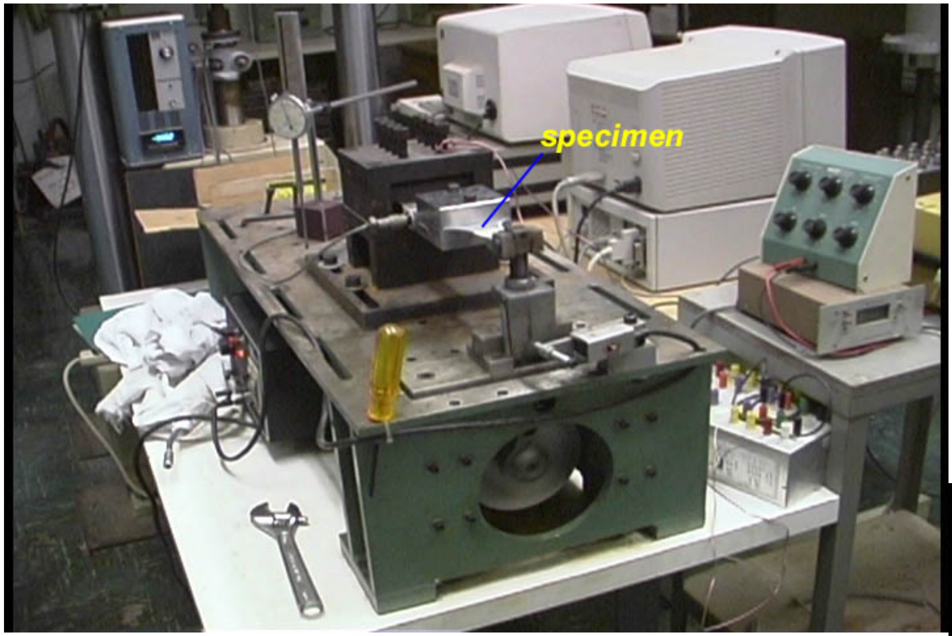
$$\delta = \frac{Fl^3}{2EI}$$

$$I = \frac{bt^3}{12}$$

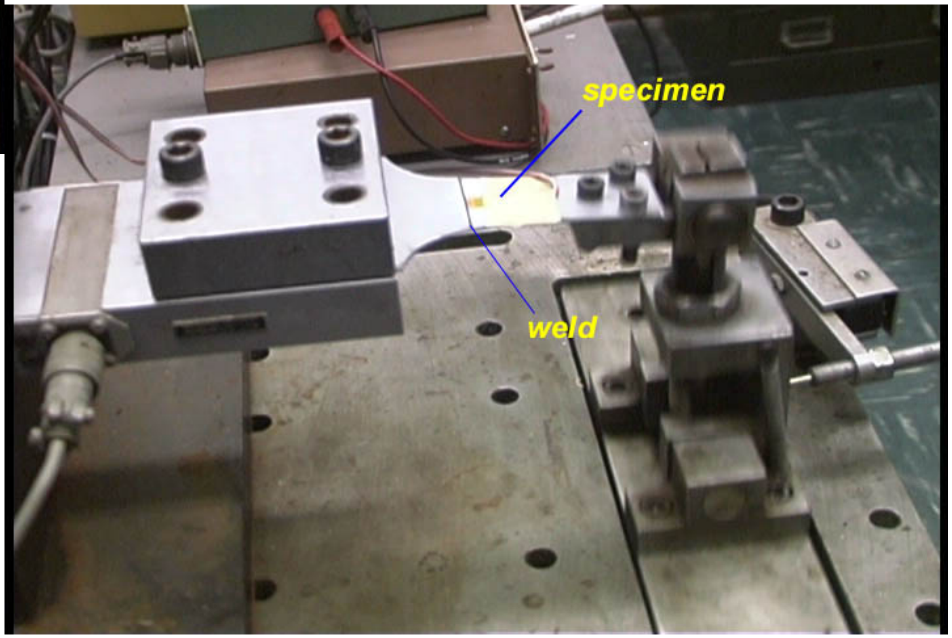
$$l = \frac{Sbt^2}{6F}$$



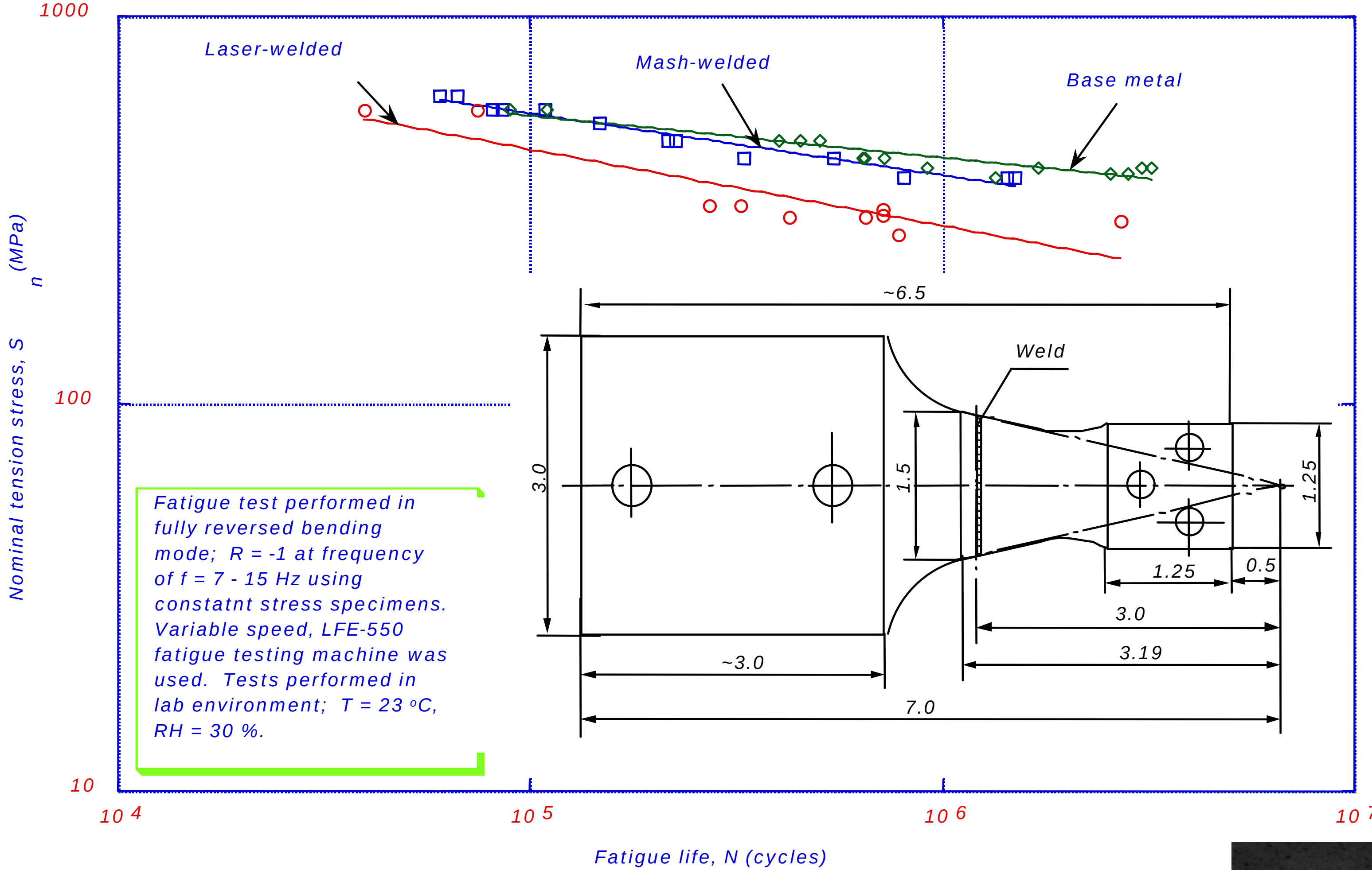
DP 600 TWB Fatigue Test, Cont'd

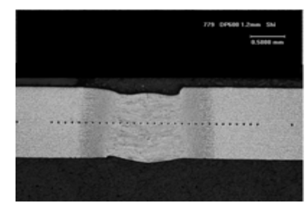


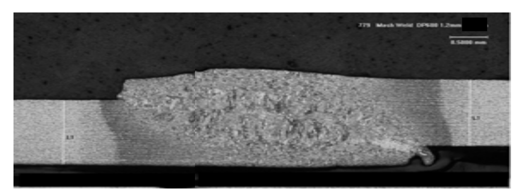
Experimental setup for constant stress bending fatigue test



DP 600 TWB Fatigue Test, Cont'd

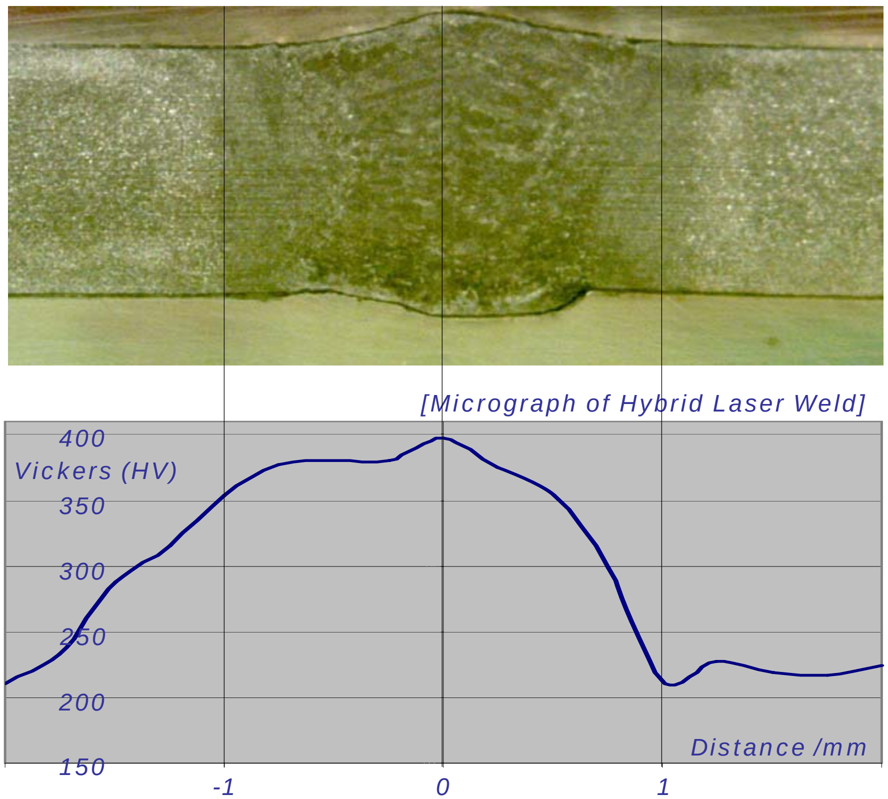






Summary plot for laser-welded, mash-welded, and base metal sheet steel

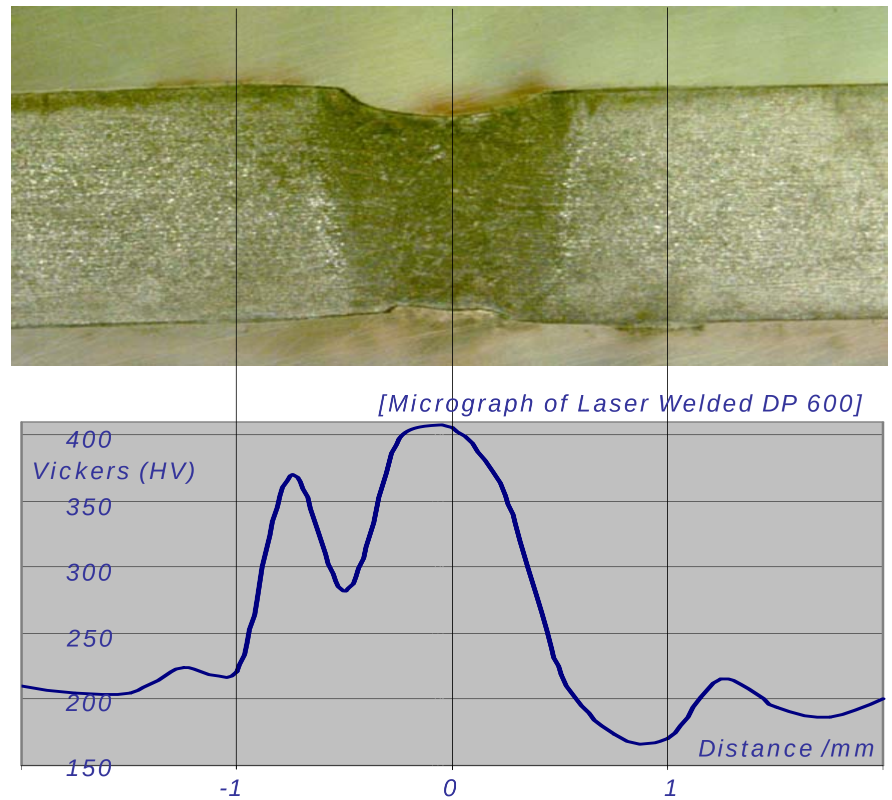
Hybrid Laser/MAG Welding



[Micrograph of Hybrid Laser Weld]

[Vickers-Micro Hardness Traverse]

Sample N°: AS 33
Material: DP 600
Process: Laser/MAG Hybrid
Focus: Twin Spot
Traces Speed: 4.5 m/min



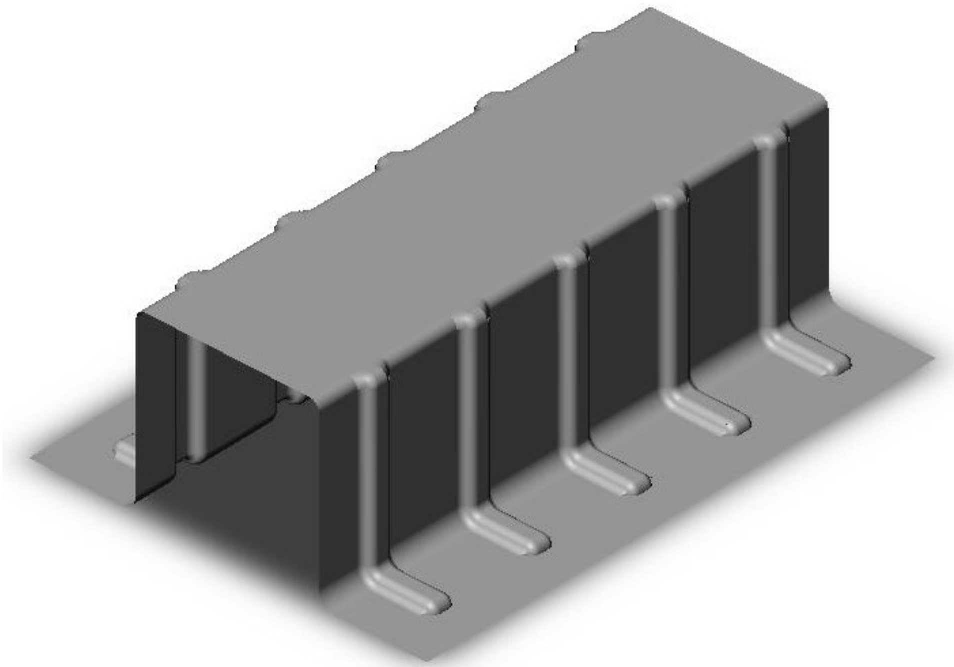
[Micrograph of Laser Welded DP 600]

[Vickers-Micro Hardness Traverse]

Sample N°: AS 40B
Material: DP 600
Process: Laser only
Focus: Mono Spot
Traces Speed: 4.5 m/min

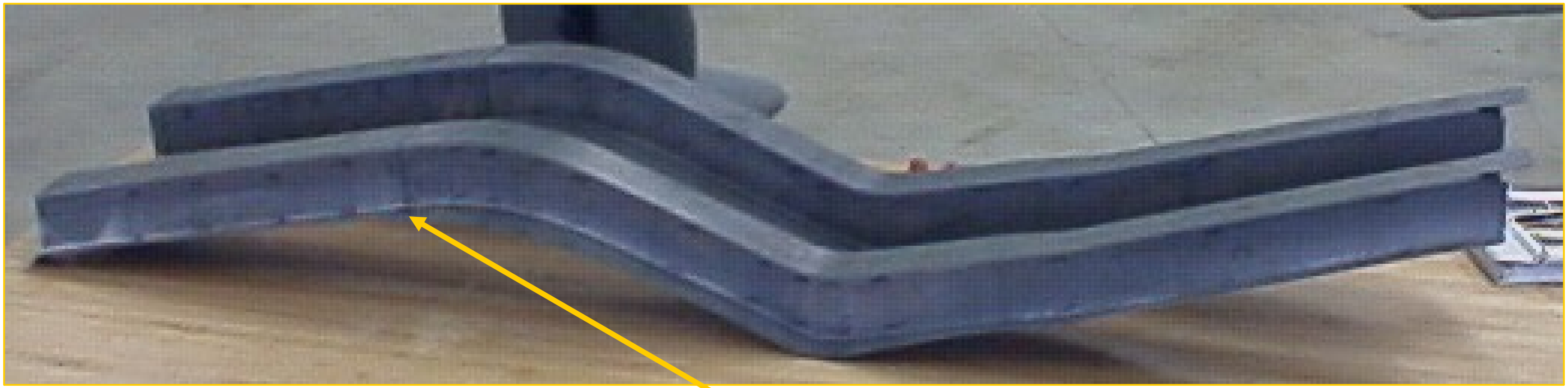
Hybrid Laser Welding for TWB production: Tolerates gaps up to 1.00mm

Dual Phase Steel Tailor Welded Blank Rails



Stamping of DP TWB Rails

Example of DP600 TWB Front Rail



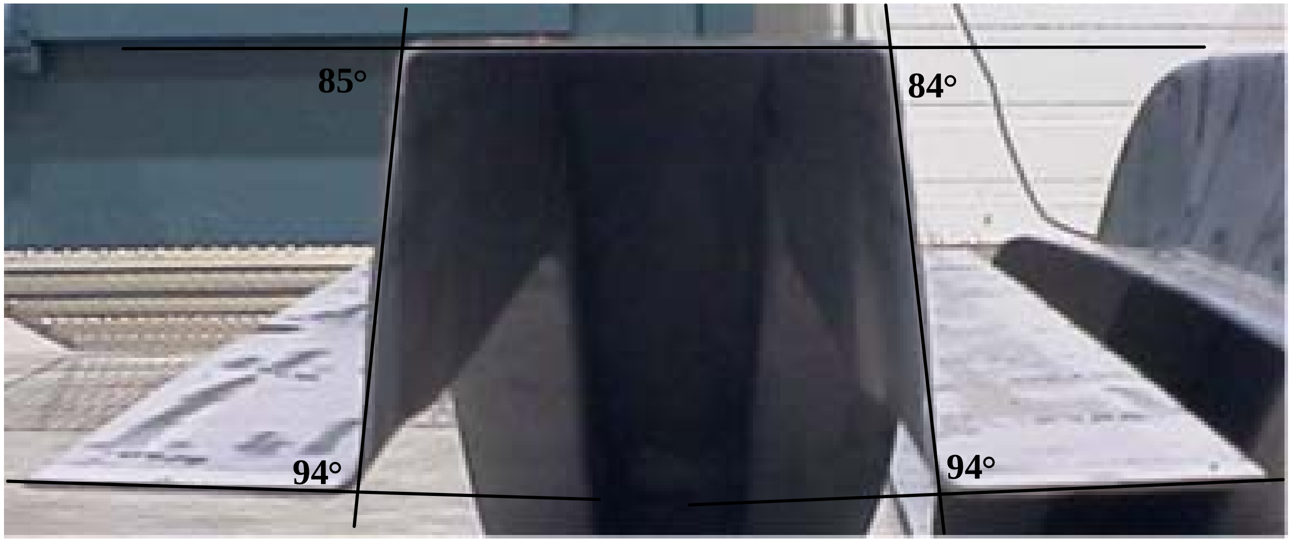
Heavy gauge side

Laser Weld Seam Location

Heavy gauge side

Stamping of DP TWB Rails, Cont'd

Springback for DP600 and HSLA280 TWB rails

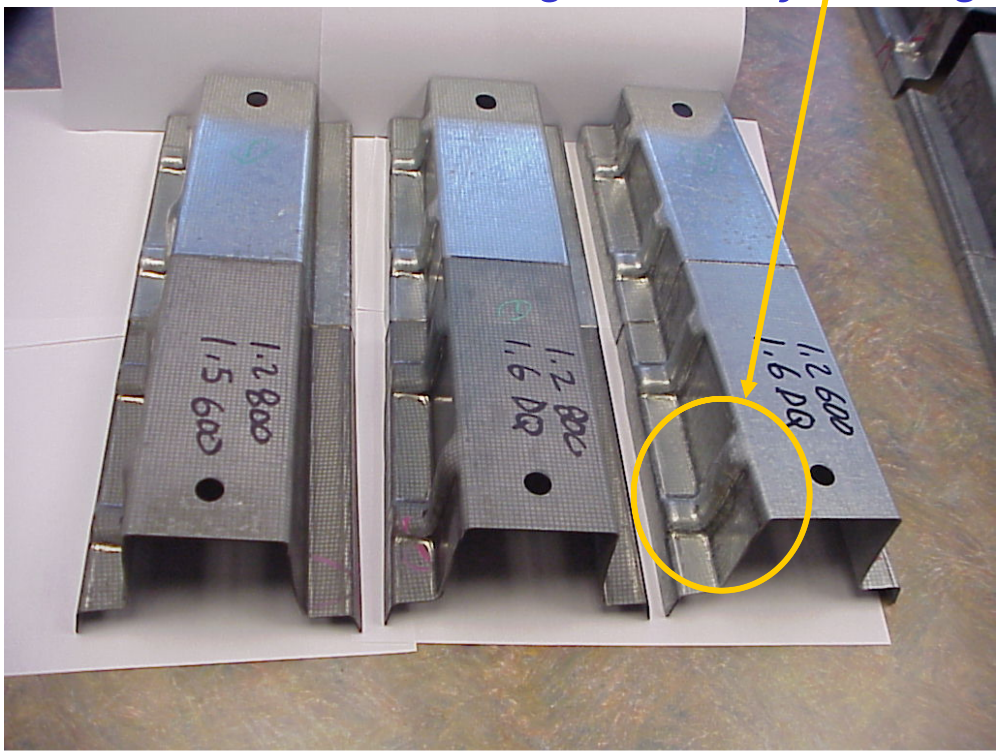


HSLA280, 2mm
Original Design

DP600, 2mm
Direct Substitution

Stamping of DP TWB Rails, Cont'd

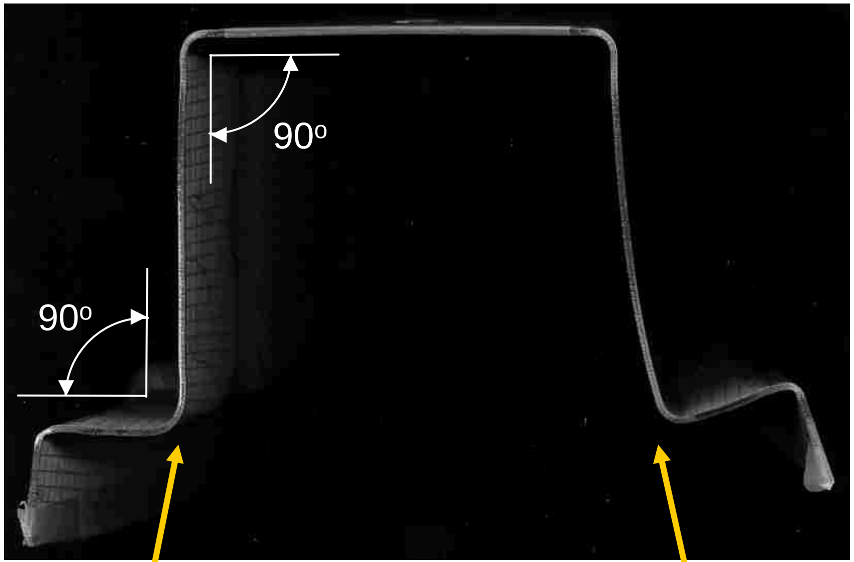
AHSS – TWB: Part geometry designed for springback control



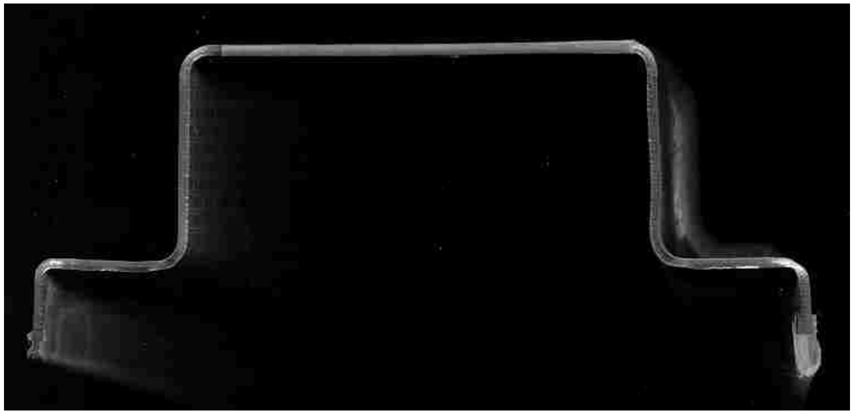
- *Various grades combinations: from DQ to DP800, and gages from 1.2mm to 1.6mm*
- *5% stretch across weld seam*
- *All combinations stamped without failure in industrial conditions*
- *No springback related issues even though UTS varied by 500MPa within the part*

Stamping of DP TWB Rails, Cont'd

Dimensional Accuracy/Springback Control Solution for DP TWB



Product Geometry Designed for Springback Control



Designed for springback

Conventional approach

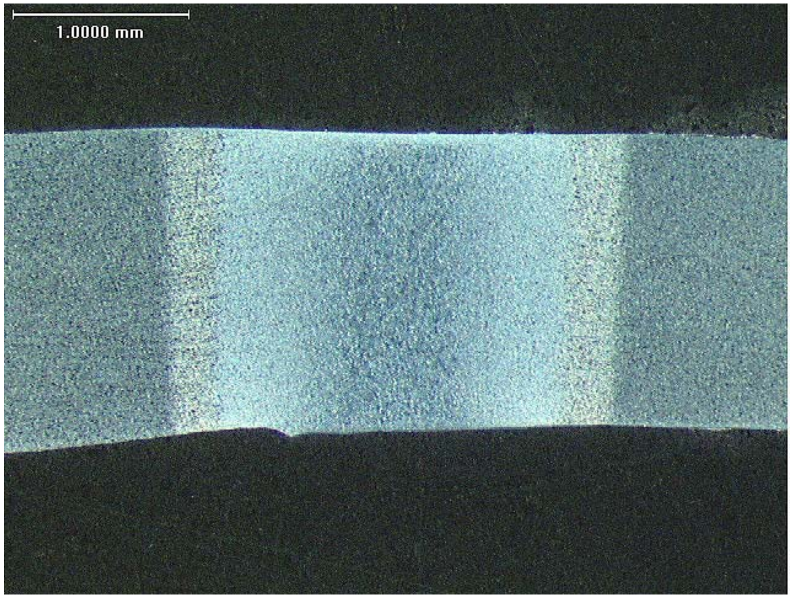
View from the end of DP800,1.2mm

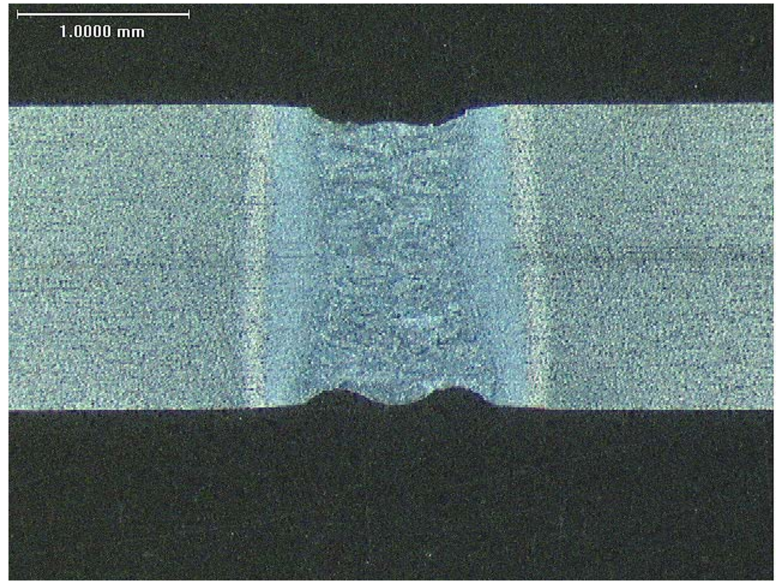
View from the end of DQ,1.6mm

500 MPa difference in UTS

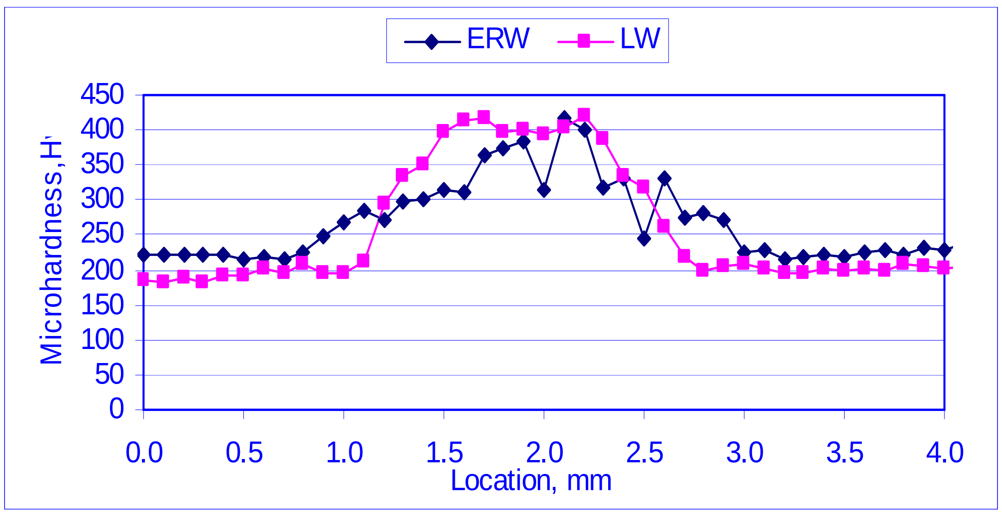
Dual Phase Steel Laser Welded Tubular Blanks

Microhardness & Micrograph



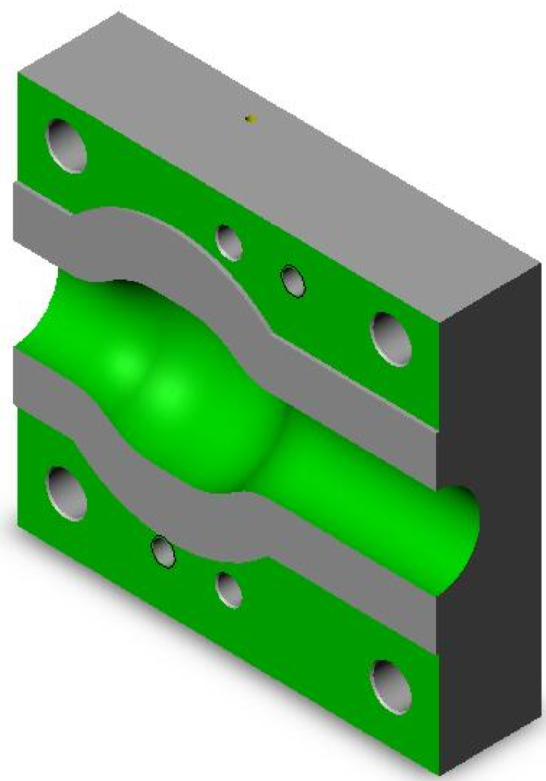


DP600 ERW (Electric Resistance Welded) Tube



DP600 LW (Laser Welded) Tube

Tubular Laser Welded DP600 Blanks



Die for hydroforming expansion

- Free expanded LW DP 600 tubes
- Various end feed rate
- No failure up to 65% expansion

Conclusions

- DP Steels are excellent candidates for TWB component applications
- As demonstrated, springback in stamping of DP TWB can be controlled even though UTS varies up to 500MPa
- DP TWB display good fatigue performance
- Similar to other welded joints, fatigue performance for LW joints is geometry driven. Note: Weld seam area in TWB components are located by the designer in the "protected zones"
- DP600 LW tubular blanks are suitable for hydroforming applications with expansion up to 65%

Conclusions, Cont'd

- *Laser welding is the only recommended process for manufacture of DP 800 and DP1000 TWB (after M. Uchihara & K. Fukui)*
- *Industrial laser welding processes allow for good quality production DP TWBs*
- *Adding material in welding process (e.g. mash welding) results in improved fatigue performance of TWB (almost as good as of substrate material)*
- *In case of welding similar or heavy gauges of DP steels, other blank welding technologies could be applied, e.g. hybrid laser welding*
- *Further study is needed to optimize TWB technologies for AHSS*

Acknowledgments

Presented in cooperation with:

Tailor Welded Blank Technologies Committee of Auto-Steel Partnership

References

- M. Uchihara, K. Kiyoyuki, Tailored Blanks of High Strength Steels – Comparison of Welding Processes, SAE 2003-01
- A. Konieczny, X.M. Chen, D.A. Witmer, M.F. Shi, Y. Hayashida and Y. Omiya, Hydroforming Performance of Laser Welded and Electric Resistance Welded High Strength Steel Tubes, SAE 2004-01-0830

DUAL PHASE STEEL APPLICATIONS IN TAILOR-WELDED BLANK TECHNOLGY

Q & A

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