Optimization of an adaptive control system for spot welding within Vinnova PROFS

Felix Lindblom

Agenda

- Background
- Resistance spot welding
- Purpose and goals
- Delimitations
- Test setup
- Results
- Conclusions

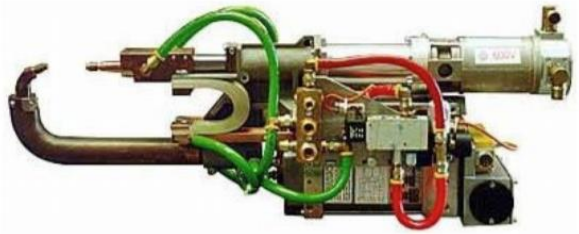
Background

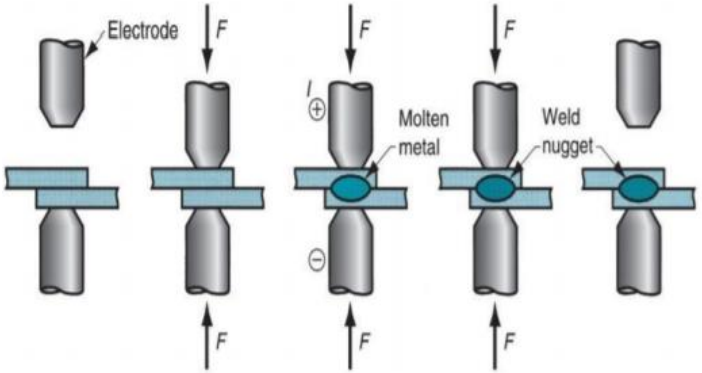
- Scania Oskarshamn
- Body in white
- Resistance spot welding
- Heat Capacity Control (HCC)
- Optimization of adaptive control

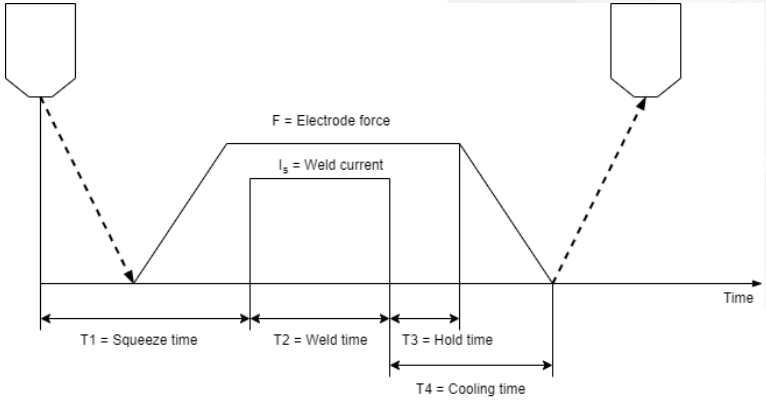
Resistance spot welding (RSW)

- Method to join thin sheets of metal together
- Force
- Current
- Time
- Resistance

$$Q = RI^2t$$

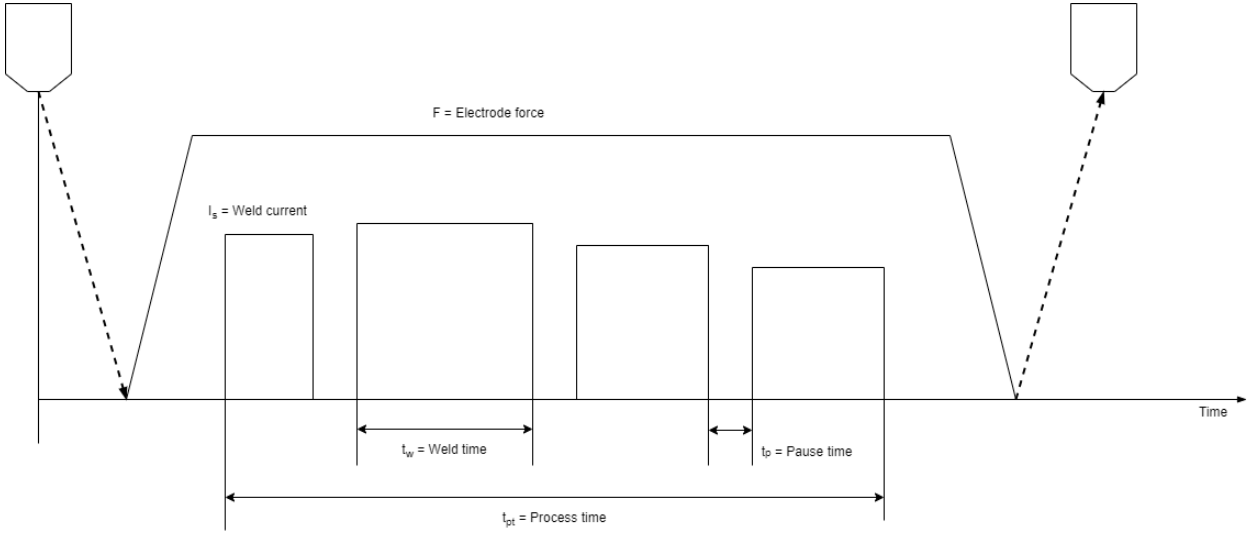






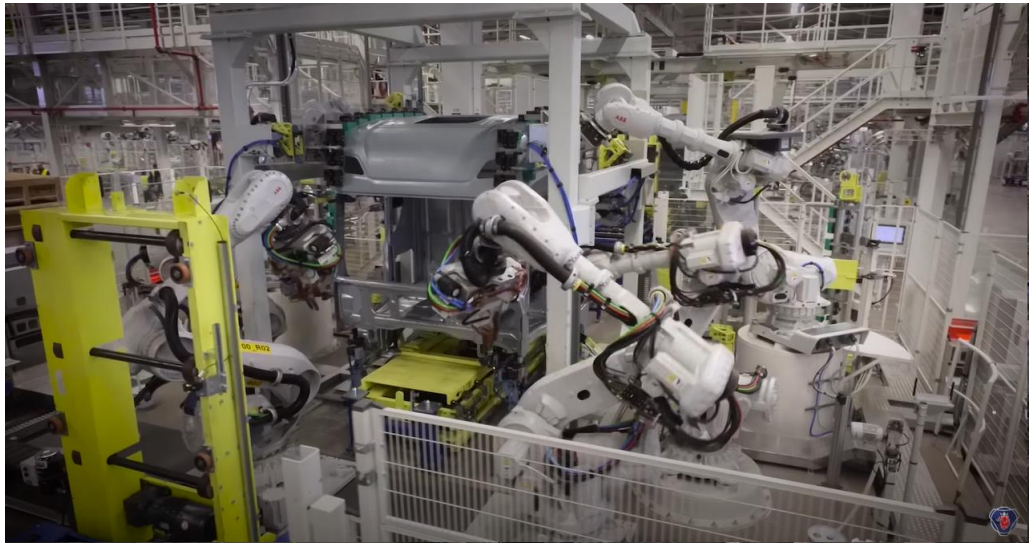
HCC

- Heat Capacity Control (HCC)
- Adaptive control
- Expulsion



Purpose and goals

- Investigate how different pause times and weld times affect process time
- Lower the process times with maintained quality



Delimitations

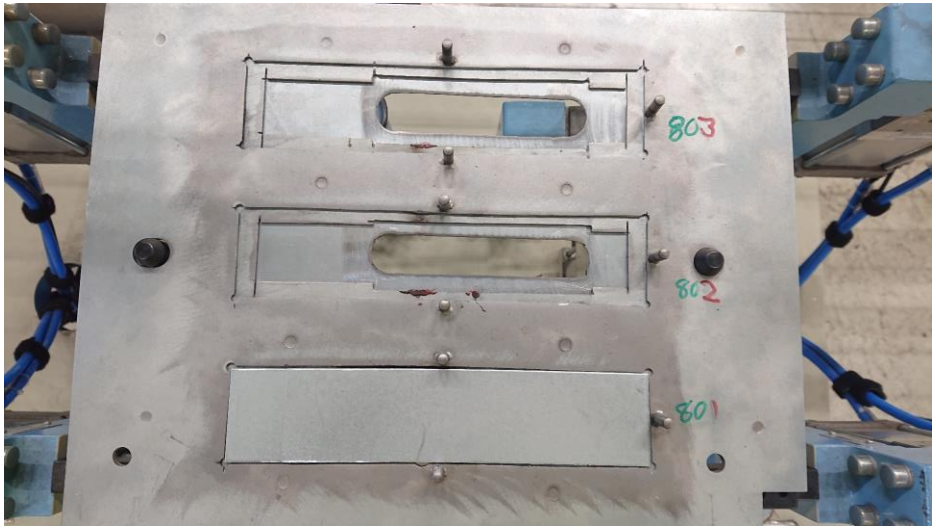
Combination	Sheet 1	Sheet 2	Sheet 3
1	0,8	0,8	
2	1,2	1,2	
3	1,2	0,8	0,8
4	0,8	0,8	0,8

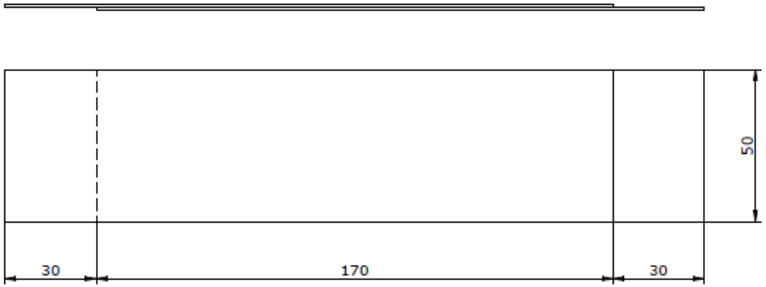
- HCC
- Program 1000
- Mildsteel *t*<3mm
- Two sheet stack-ups and three sheet stack-ups
- Pause times and weld times
- HC220Y+ZE75/75B
- HX220YD+Z100MB

	Pulse 1	Pulse 2	Pulse 3	Pulse 4	Pulse 5	Pulse 6	Pulse 7	Pulse 8	Pulse 9	Pulse 10
WT [ms]	65	85	70	70	70	70	70	70	70	70
PT [ms]	5	5	5	5	5	5	5	5	5	-

Test setup

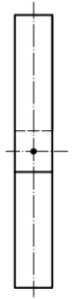
- Basic Skills Scania Oskarshamn
- STD4429

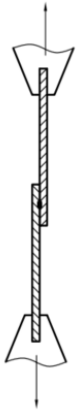


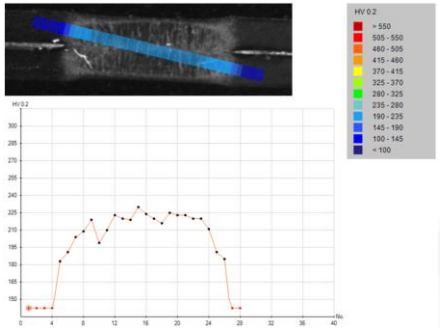


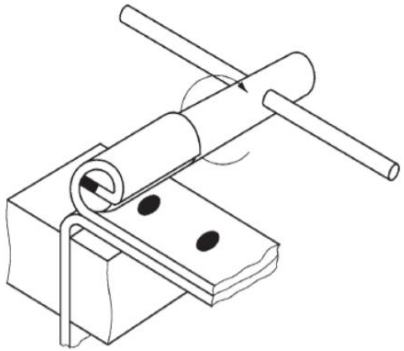
Test setup

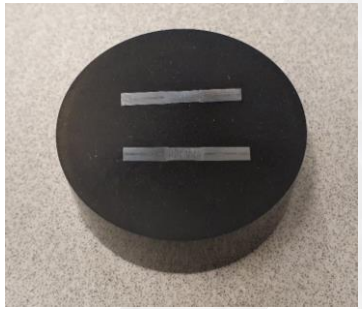
- Three test phases
- OFAT
- DOE
- Peel test
- Shear test
- Metallography
- Hardness test











Test parameters – test phase 1

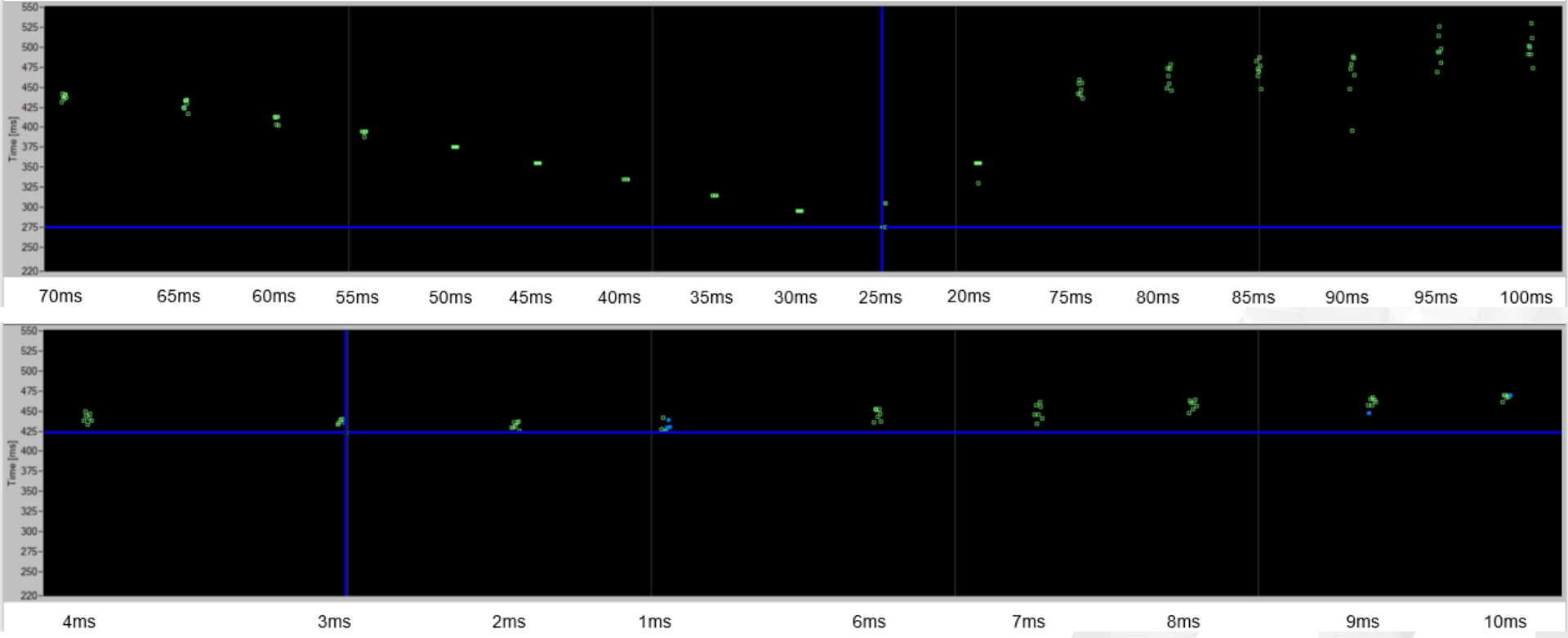
- Testing different weld times with 5ms change between each test

Test	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
WT	100	95	90	85	80	75	70	65	60	55	50	45	40	35	30	25	20
PT	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5

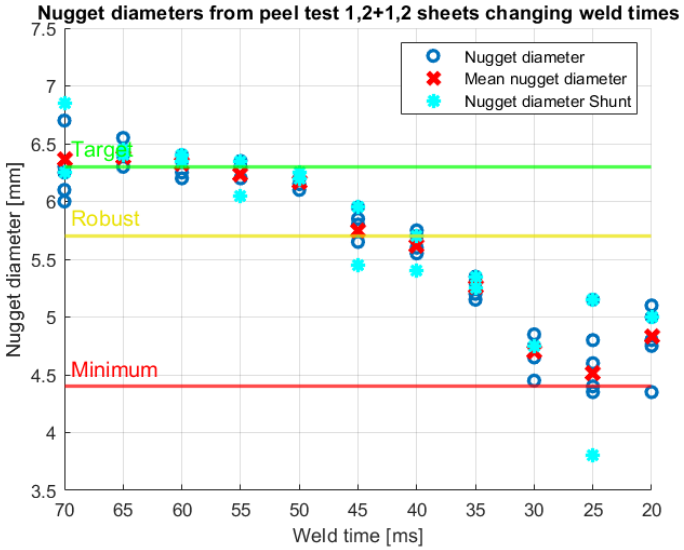
- Testing different pause times with 1ms change between each test

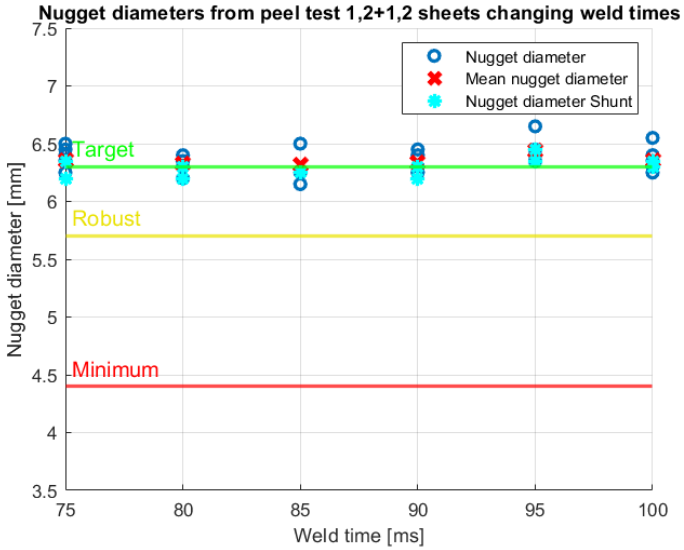
Test	18	19	20	21	22	23	24	25	26	27
WT	70	70	70	70	70	70	70	70	70	70
PT	1	2	3	4	5	6	7	8	9	10

Results test phase 1 – 1,2 sheets
Weld time and pause time



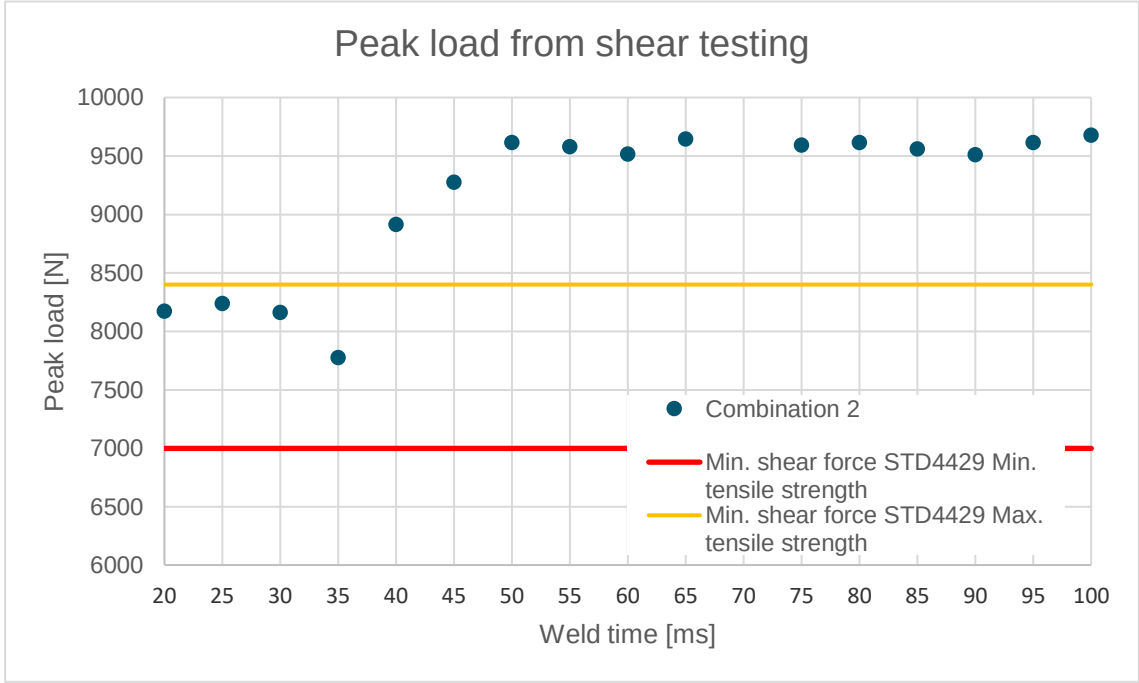
Results test phase 1 – 1,2 sheets Weld time





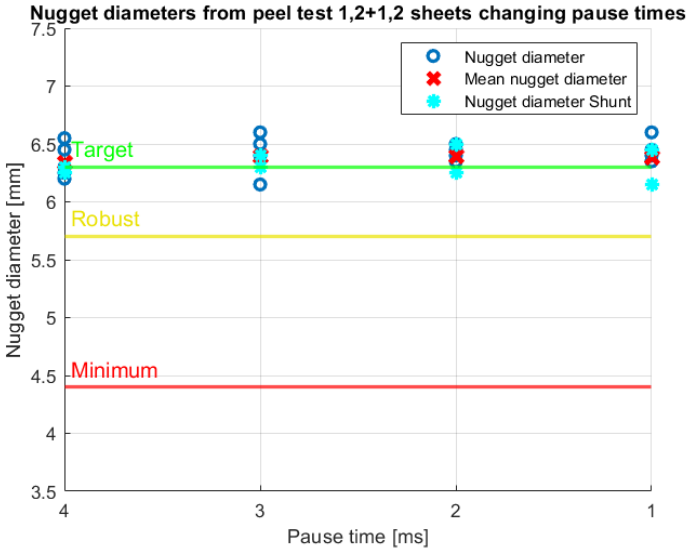
- Target nugget diameter STD4429: 6,3mm
- Robustness nugget diameter STD4429: 5,7mm

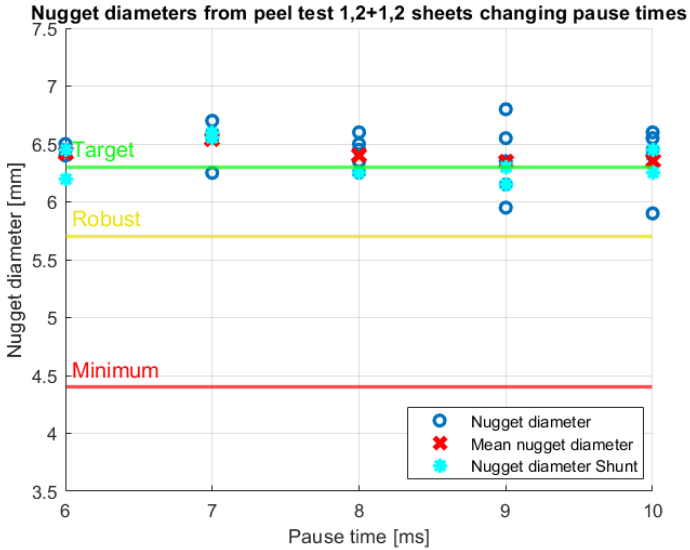
Results test phase 1 – 1,2 sheets
Weld time



Test No 65-20ms	Force @ Peak (N)	Test No 75-100ms	Force @ Peak (N)
1	9646,500	1	9593,500
2	9515,400	2	9616,300
3	9580,300	3	9561,300
4	9614,000	4	9511,100
5	9275,200	5	9613,800
6	8914,400	6	9678,700
7	7775,900		
8	8161,900		
9	8238,000		
10	8172,300		

Results test phase 1 – 1,2 sheets Pause time





- Target nugget diameter STD4429: 6,3mm
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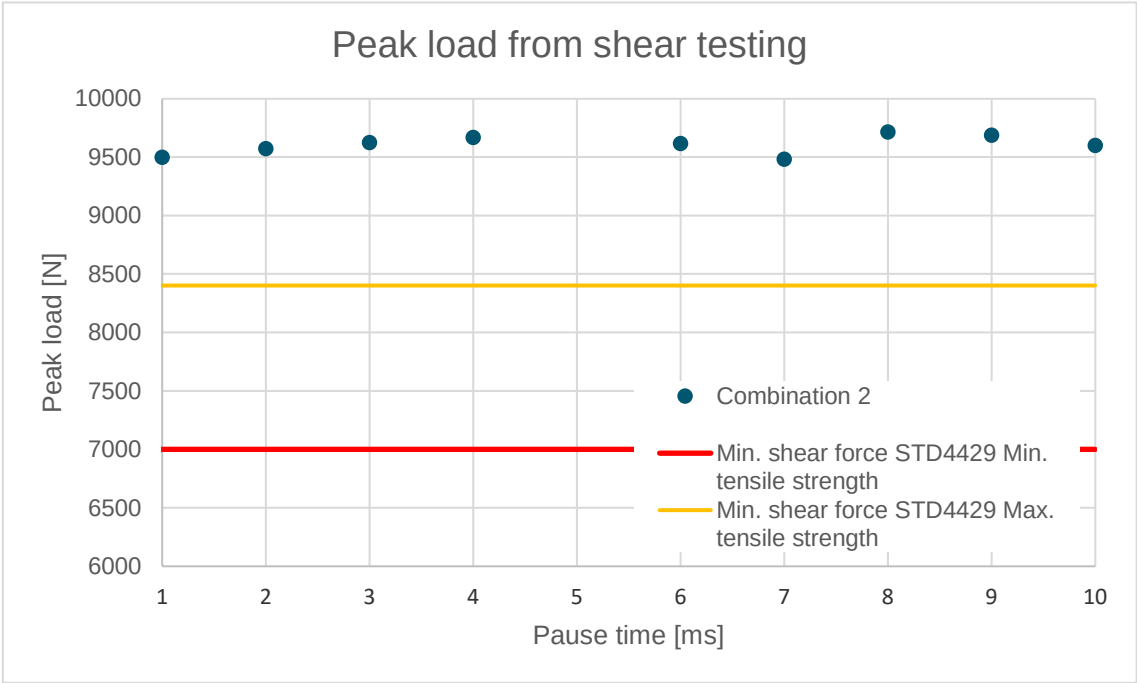
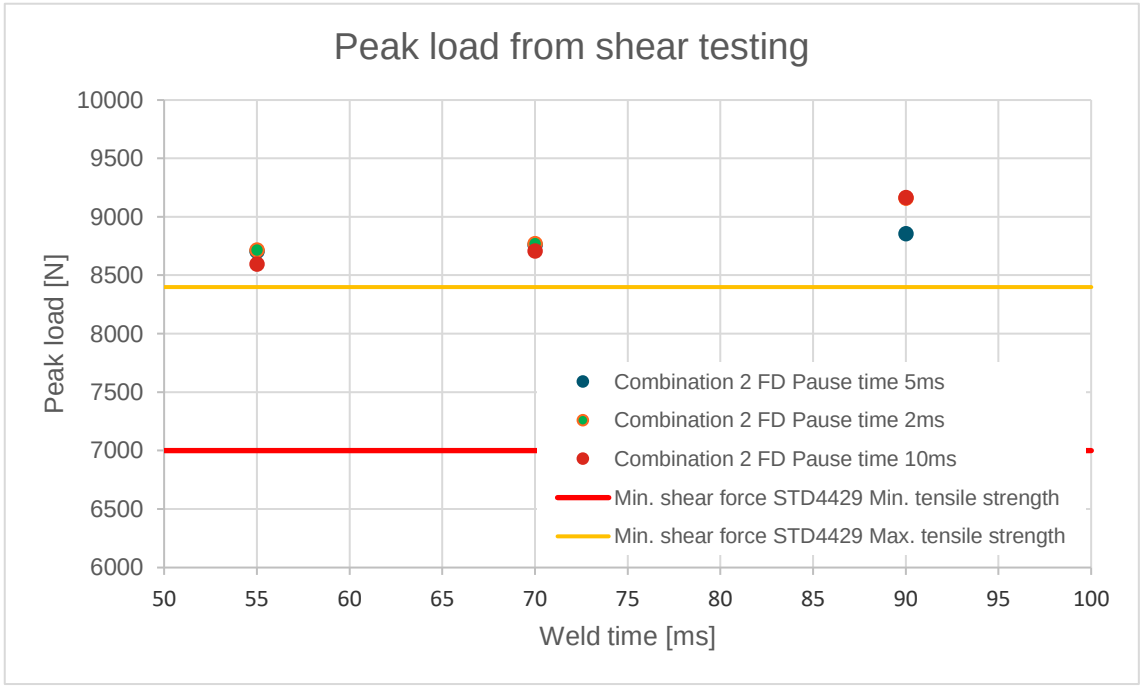
Results test phase 1 – 1,2 sheets
Pause time

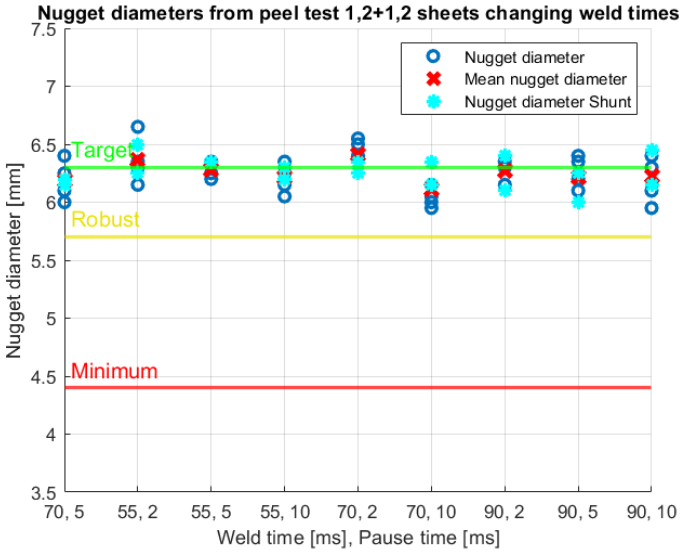


Test No 4-1ms	Force @ Peak (N)	Test No 6-10ms	Force @ Peak (N)
1	9668,300	1	9615,400
2	9622,500	2	9482,100
3	9571,100	3	9713,300
4	9499,000	4	9687,800
		5	9598,000

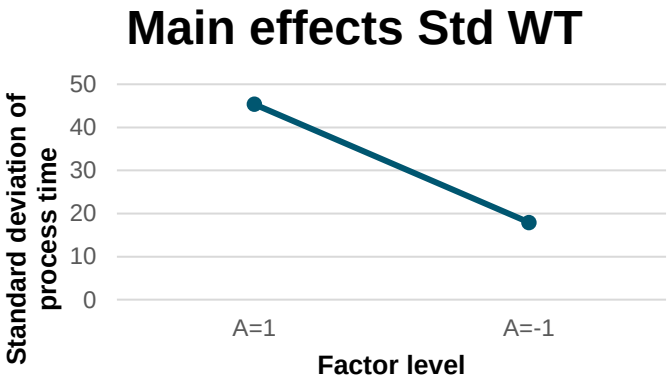
Results test phase 2 – 1,2 sheets Factorial Design

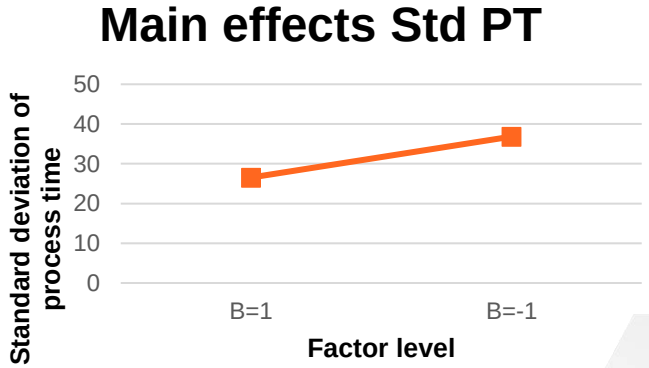
		Level	
Factor		-1	1
A: Weld time		55	90
B: Pause time		2	10

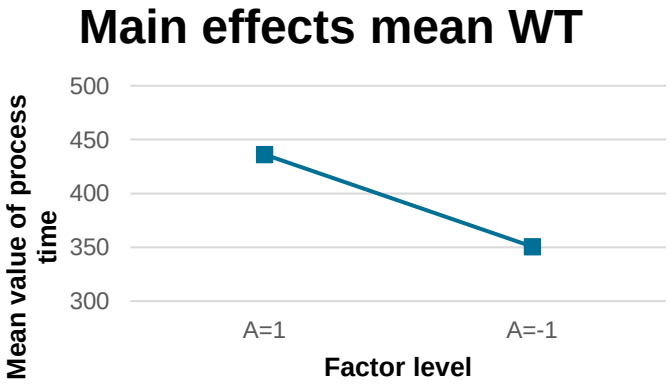


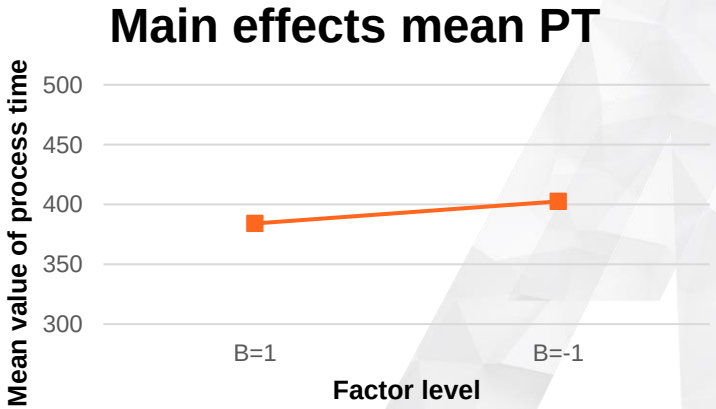


Results test phase 2 – 1,2 sheets Factorial Design



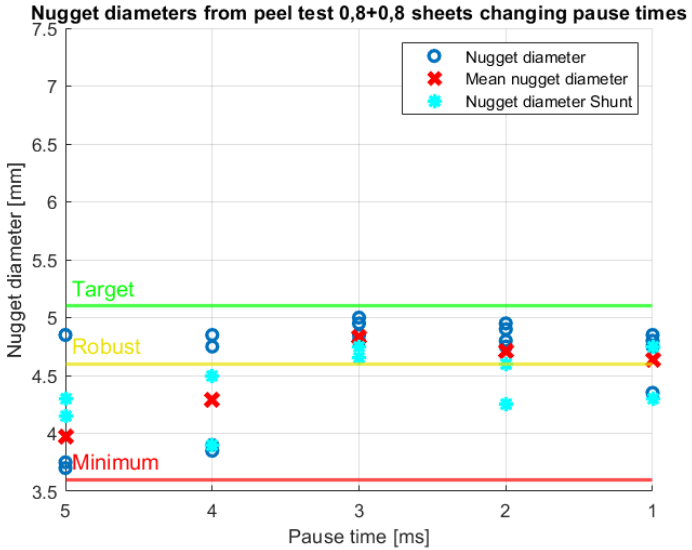


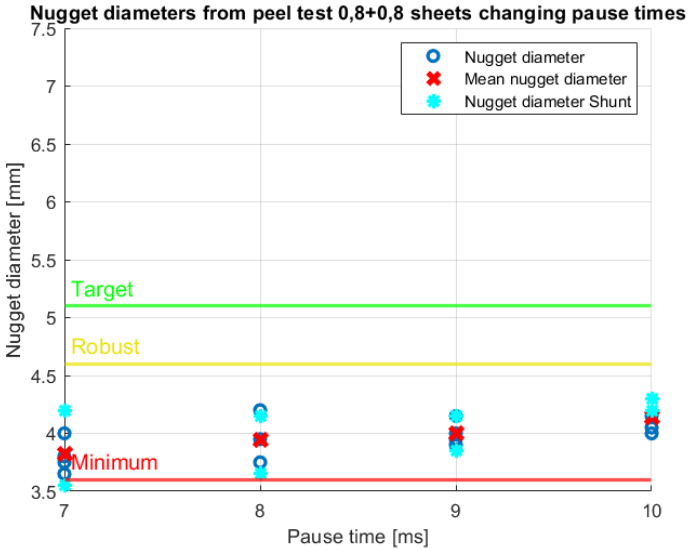




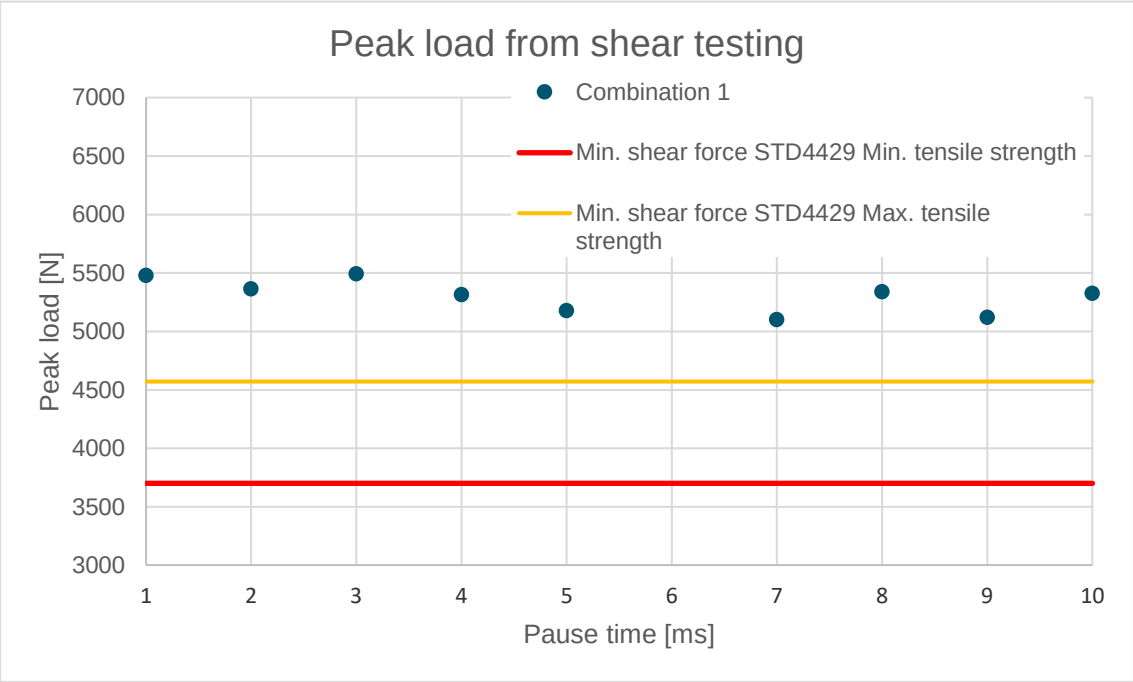
Results test phase 3 – 0,8 sheets Pause time

- Weld time set to 30ms, changing pause times



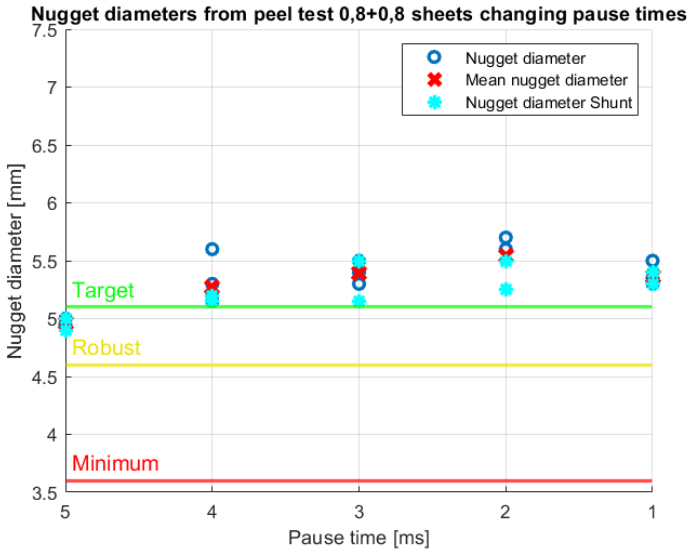


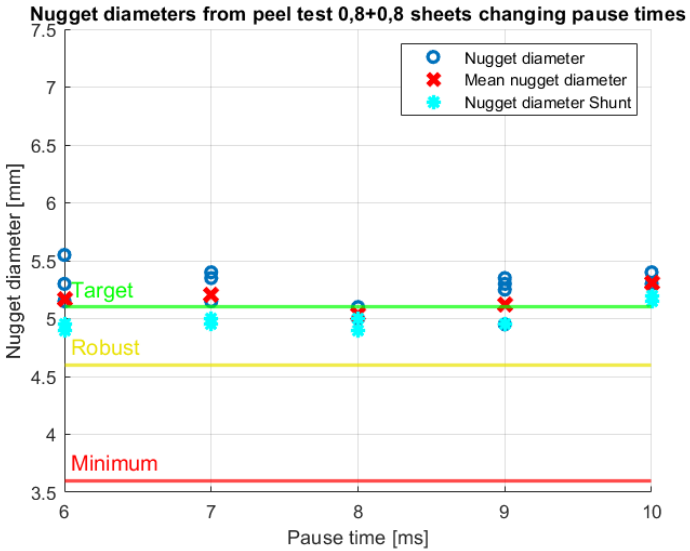
Results test phase 3 – 0,8 sheets Pause time



Results test phase 3 – 0,8 sheets Pause time

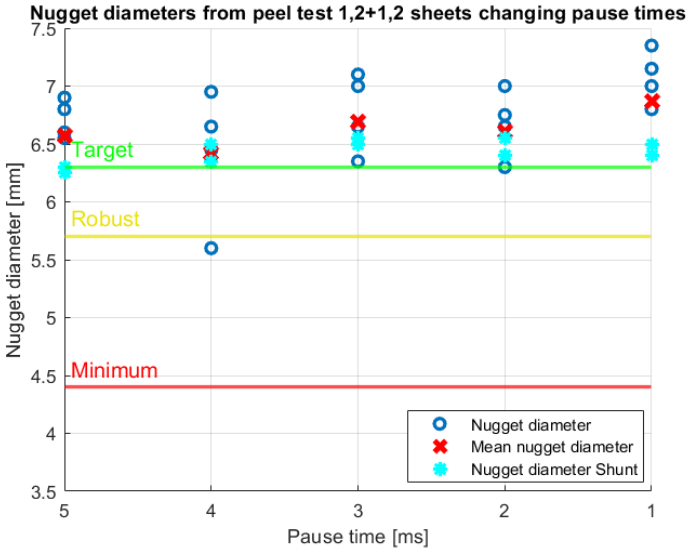
- Weld time set to 45ms

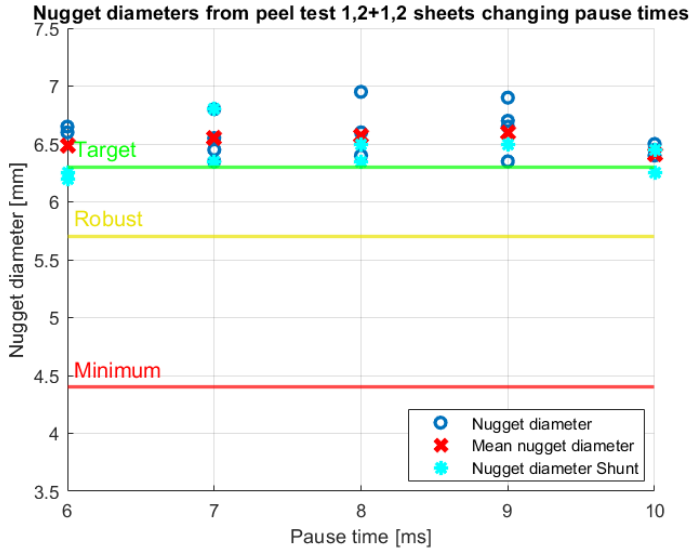




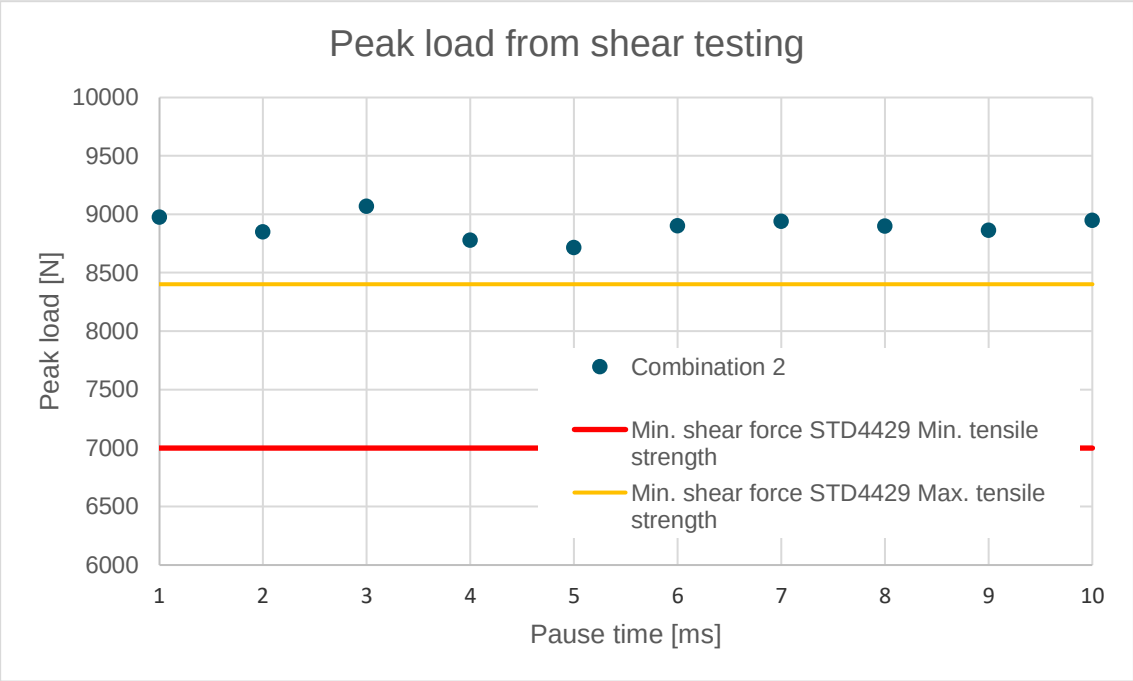
Results test phase 3 – 1,2 sheets Pause time

- Weld time set to 55ms



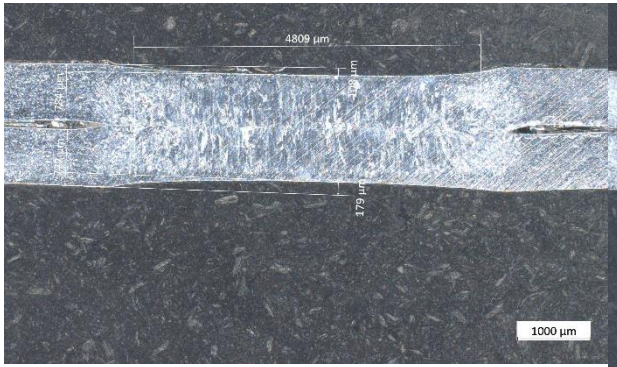


Results test phase 3 – 1,2 sheets Pause time

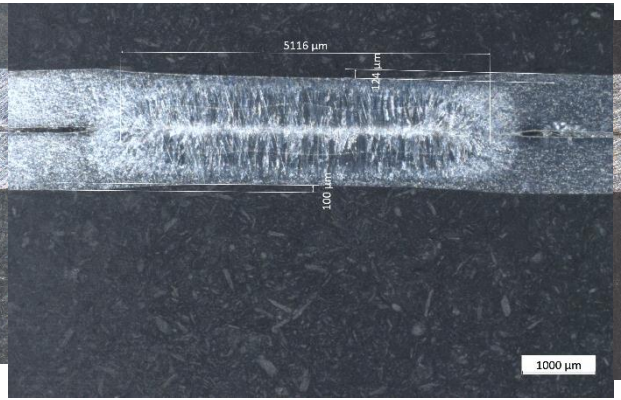


Metallography – 0,8 sheets

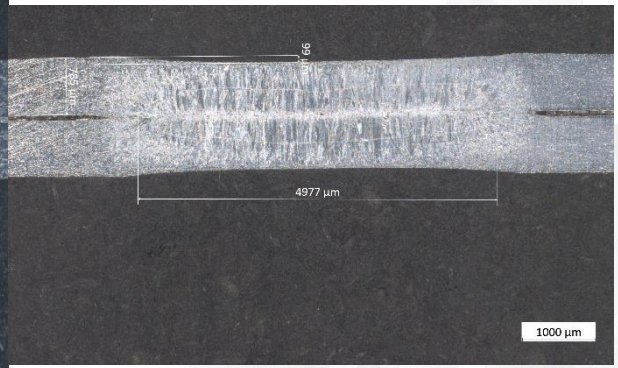
70ms WT and 5ms PT



45ms WT and 10ms PT



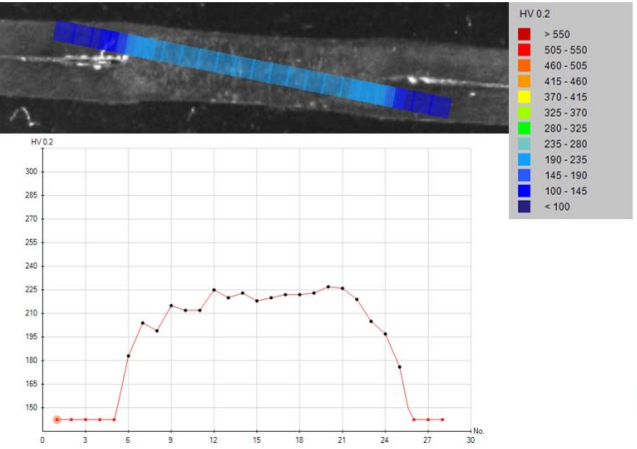
45ms WT and 2ms PT



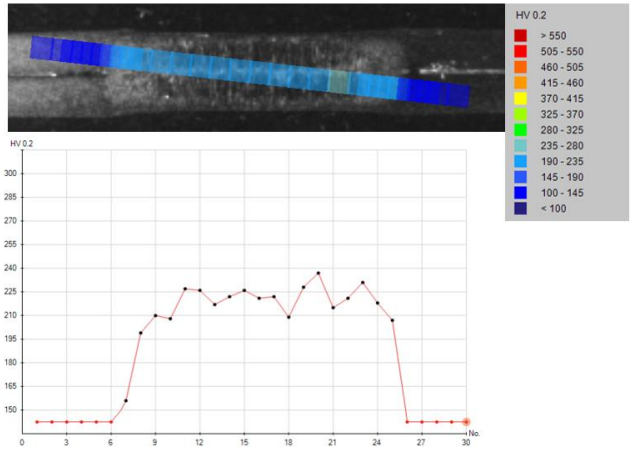
Target nugget diameter 4,5mm

Hardness testing – 0,8 sheets

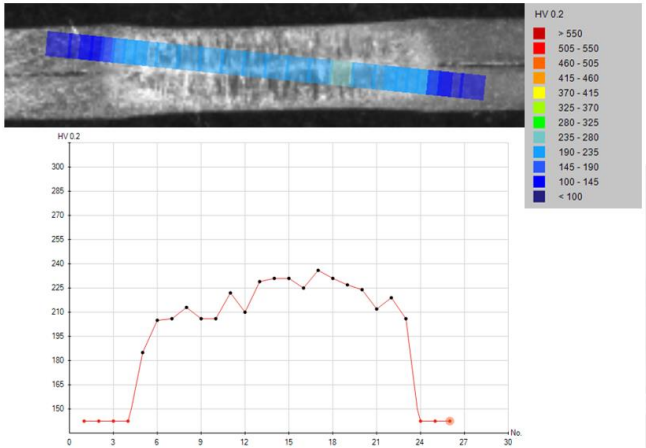
70ms WT and 5ms PT



45ms WT and 10ms PT



70ms WT and 2ms PT



Maximum hardness must not exceed 550 HV0.2
in the weld nugget and the HAZ

Results – Potential time savings

- 63-67ms in potential time savings depending on material combination
- Body in white using program 1000 for 1500 spot welds
- If 60ms would be possible to save for all material combinations that program 1000 uses it would save 90 seconds for each body in white

Conclusions

- Shorter weld times than used today in program 1000 can be used to lower process times and still generating spot welds with sufficient strength
- Pause time affects the stability of the process, higher pause times tend to generate welds produced with fewer pulses than when using lower pause times
- Approximately 17% shorter process times could be achieved with maintained strength in the welds


SWERIM
SCANIA