Optimum spot-weld locations for multi-material components

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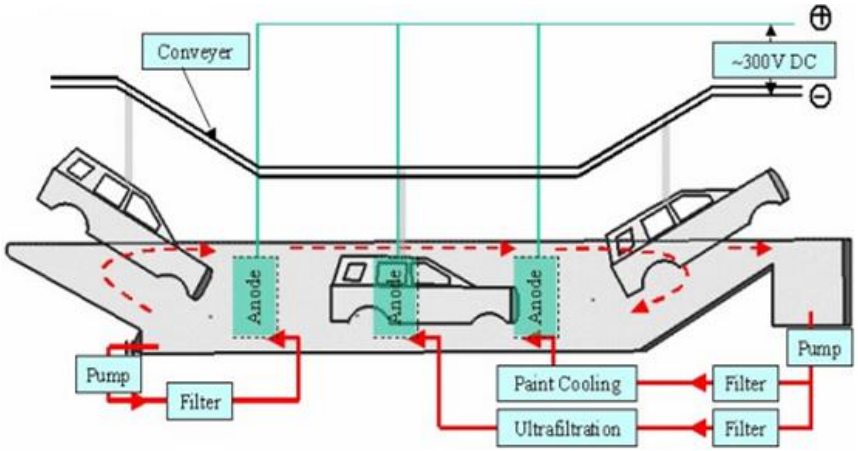
Agenda

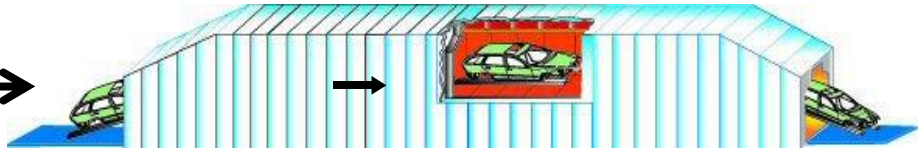
1. Motivation
2. Problem Overview
3. Optimization Methodology
4. Results

BiW E-coating –Process Flow

Automotive E-coating is the anti-corrosion layer on a vehicle body

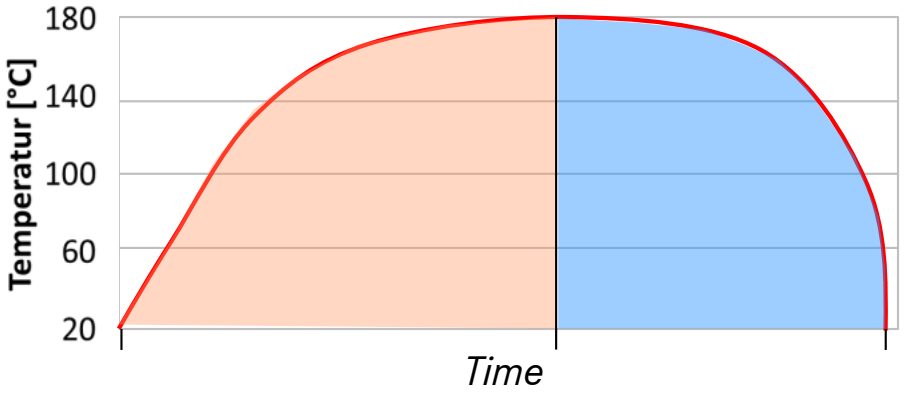


KTL (spraying/immersion)
*(**K**athodische **T**auch**L**ackierung -or cataphoretic painting*
Coating
the car body for corrosion resistance)



KTL-IMC-Drier

Motivation



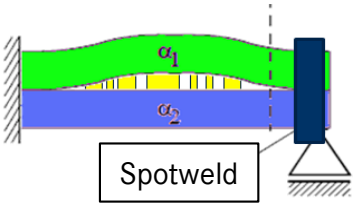
Effect of temperature on Multi Material parts

Phenomenon:

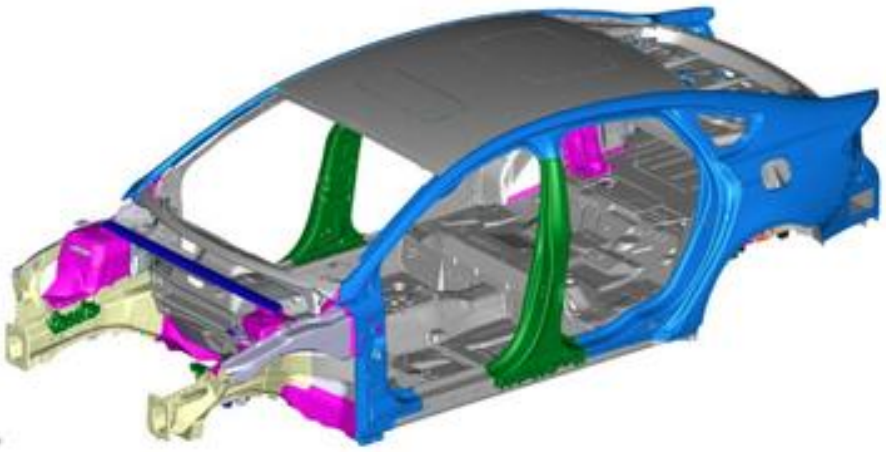
- Flange opening at Max temperature T_{max}
- Detachement of adhesive

Risk:

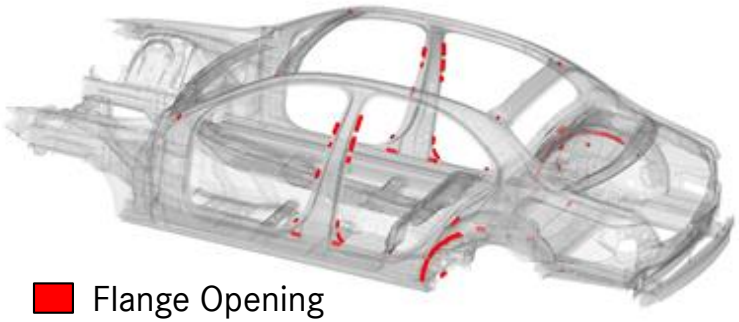
- Stifness reduction in the flange
- Dimensional tolerance (locally)



Multi Material BIW



Flange opening due to mismatch in thermal expansion coefficients



Flange Opening

Problem Overview

Objective

Optimize Number and Position of Spotwelds along two spot lines

Constraints

- Flange Opening < 0.4 mm
- Distance of spotwelds from each other ≥ 35 mm

Pre-processor

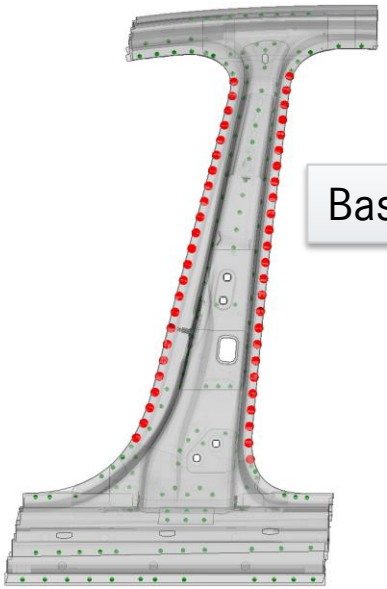
Ansa

Solver

Abaqus

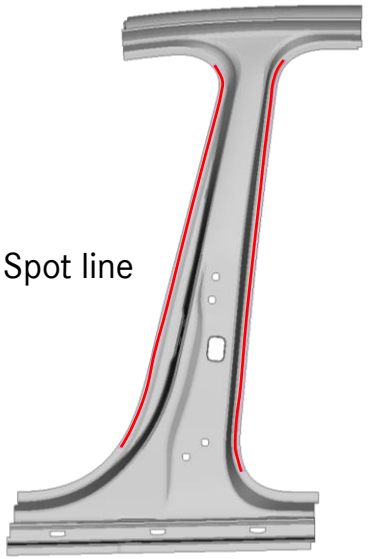
Optimzation Tool

Optislang



Base Model

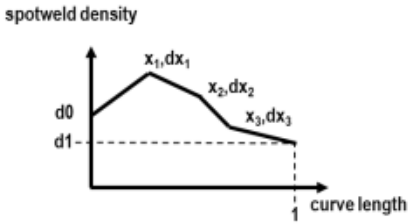
Number of spotweld : 49
Max Flange opening - 0.29 mm
Pitch uniform distribution -35 mm

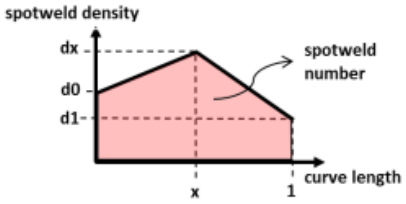


Spot line

Optimization methodology

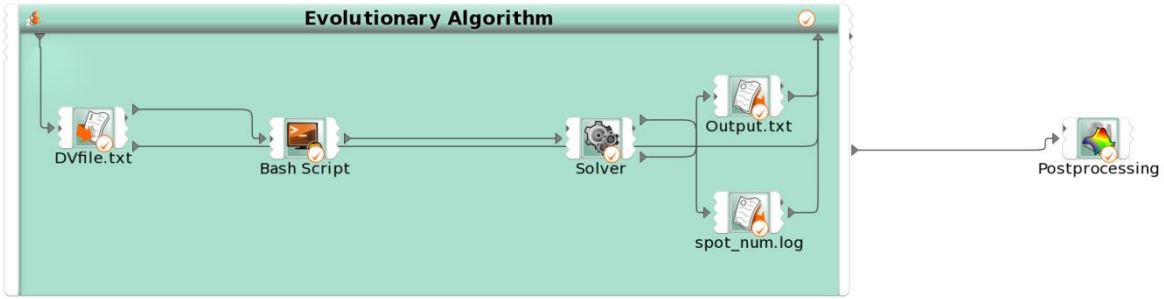
Parametrize the spotline using Bezier curve (parametric curve) concept



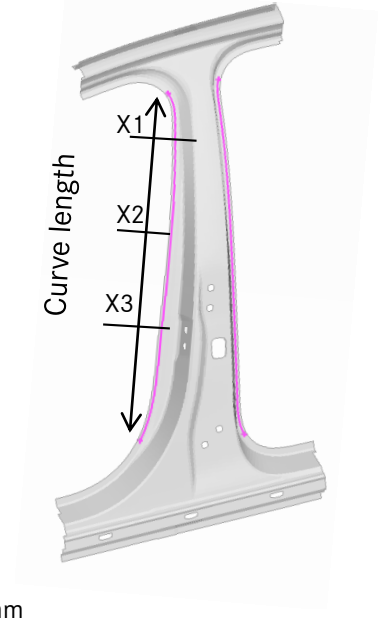


Animation of a cubic Bézier curve

The X-axis corresponds to the connection line length normalized form 0 to 1. The Y-axis represents the spotweld density [number of points per unit length].



Evolutionary algorithm is used as Optimization algorithm



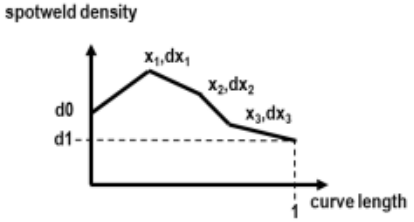
Curve Length 800mm
X1 - 240 mm, X2 - 480 mm, X3 -640 mm
Normalized values : X1- 0.3 , X2 -0.6, X3 -0.8

Design variables

Evolutionary Algorithm

Parameter | Start designs | Criteria | Initialization | Selection | Crossover | Mutation | Other | Result designs

	Name	Parameter type	Reference value	Constant	Value type	Resolution	Range		Range plot
1	Curve_1_d0	Det+Stoch	0.028	☐	REAL	Continuous	0.01	0.028	
2	Curve_1_d1	Det+Stoch	0.028	☐	REAL	Continuous	0.01	0.028	
3	Curve_1_dx1	Det+Stoch	0.028	☐	REAL	Continuous	0.01	0.028	
4	Curve_1_dx2	Det+Stoch	0.028	☐	REAL	Continuous	0.01	0.028	
5	Curve_1_dx3	Det+Stoch	0.028	☐	REAL	Continuous	0.01	0.028	
6	Curve_1_x1	Det+Stoch	0.3	☐	REAL	Continuous	0	1	
7	Curve_1_x2	Det+Stoch	0.6	☐	REAL	Continuous	0	1	
8	Curve_1_x3	Det+Stoch	0.8	☐	REAL	Continuous	0	1	
9	Curve_2_d0	Det+Stoch	0.028	☐	REAL	Continuous	0.01	0.028	
10	Curve_2_d1	Det+Stoch	0.028	☐	REAL	Continuous	0.01	0.028	
11	Curve_2_dx1	Det+Stoch	0.028	☐	REAL	Continuous	0.01	0.028	
12	Curve_2_dx2	Det+Stoch	0.028	☐	REAL	Continuous	0.01	0.028	
13	Curve_2_dx3	Det+Stoch	0.028	☐	REAL	Continuous	0.01	0.028	
14	Curve_2_x1	Det+Stoch	0.3	☐	REAL	Continuous	0	1	
15	Curve_2_x2	Det+Stoch	0.6	☐	REAL	Continuous	0	1	
16	Curve_2_x3	Det+Stoch	0.8	☐	REAL	Continuous	0	1	

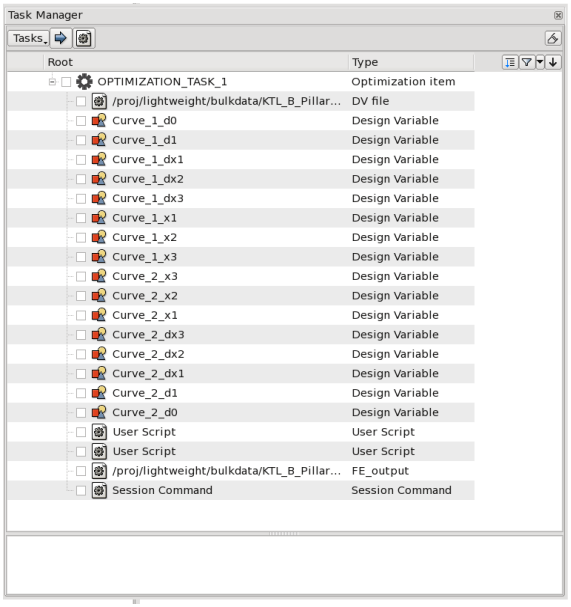


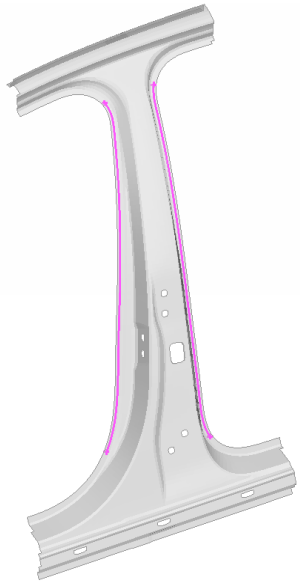
d0,d1,dx1,dx2,dx3 –Spotweld density - Pitch 35mm to 100 mm ([1/100] ***0.01*** to [1/35] ***0.028***)

x1,x2,x3 –Normalized length of spotline –0 to 1

Optislang –ANSA interface using script

ANSA optimization Task module

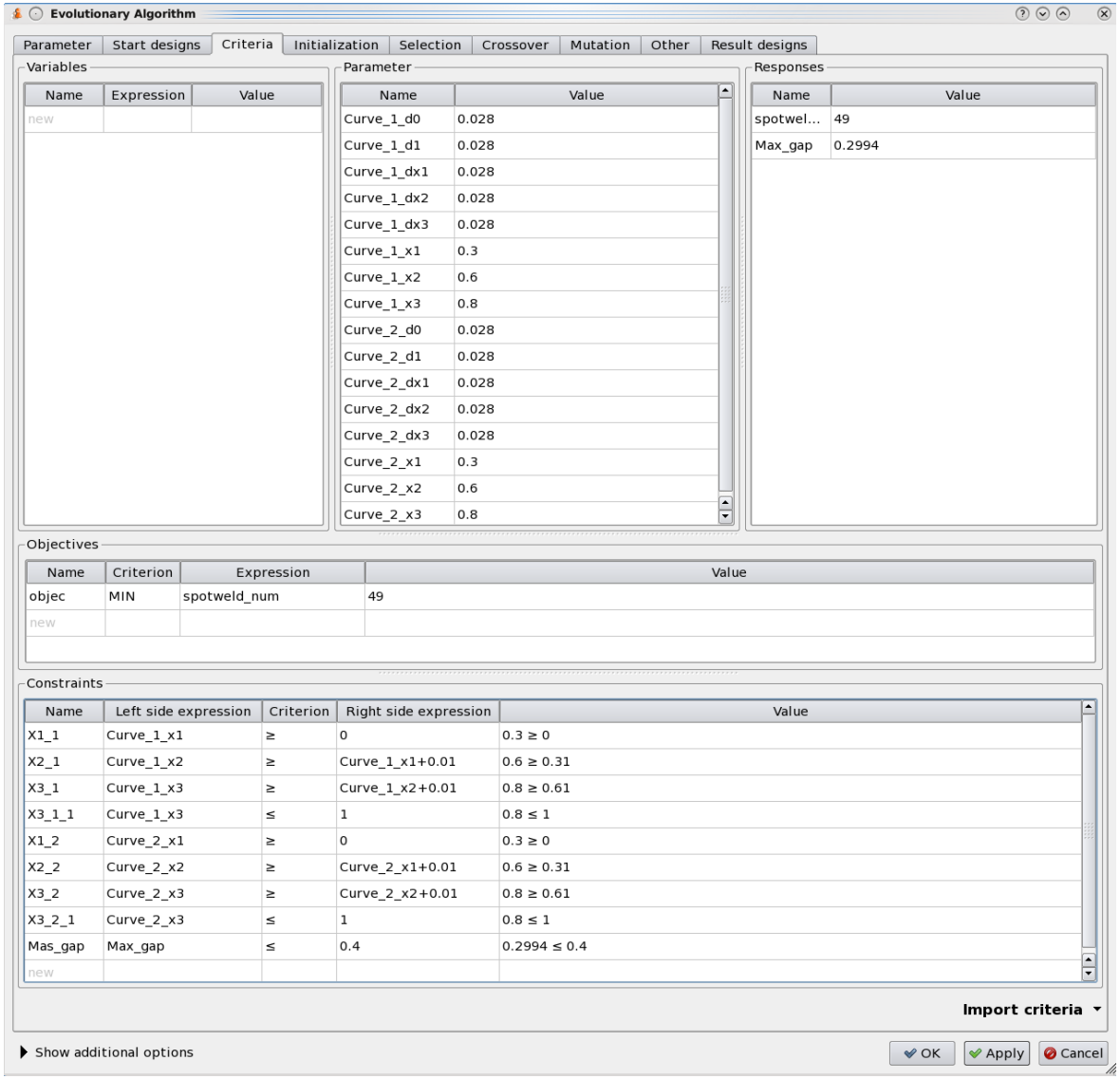


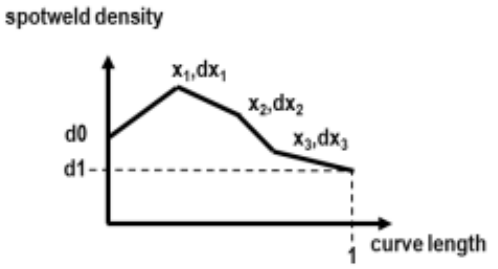


Optislang –ANSA interface using script

```
ansa_15.2.0 -nogui -lm_retry 20 -foregr -i
/proj/lightweight/bulkdata/KTL_B_Pillar_Optimization/OPTISLANG/Basemodel/base_35mm_NSET_Conn_optimizatio.ansa -exec
'InputDV("DVfile.txt");FEOutputName("base_KTL_optimization.inp"); RunAllTasks ( ) ; '

cp /proj/lightweight/bulkdata/KTL_B_Pillar_Optimization/OPTISLANG/Basemodel/BR213_BPillar_HeatUp_OptModell.inp .
sleep 3

scjobsubmit_abaqus base_KTL_optimization.inp -v 6.14-1 -c 16  -r . -f



startzeit=`getseconds`
while [ ! -s *.dat ]; do
  neuezeit=`getseconds`
  bisherige_dauer=`expr $neuezeit - $startzeit`
if [ $bisherige_dauer -gt 24800 ]; then
    exit
  fi
  sleep 3
done
#sleep 120

#Extraktion

sleep 5

echo "Extraktion"
#gzip *.pch
#gzip *.slang
grep MAXIMUM base_KTL_optimization.dat > Output.txt
rm -rf *.odb
rm -rf BR213_BPillar_HeatUp_OptModell.inp
rm -rf *.jo*
rm -rf *.f04
```

Optimization setup in optislang

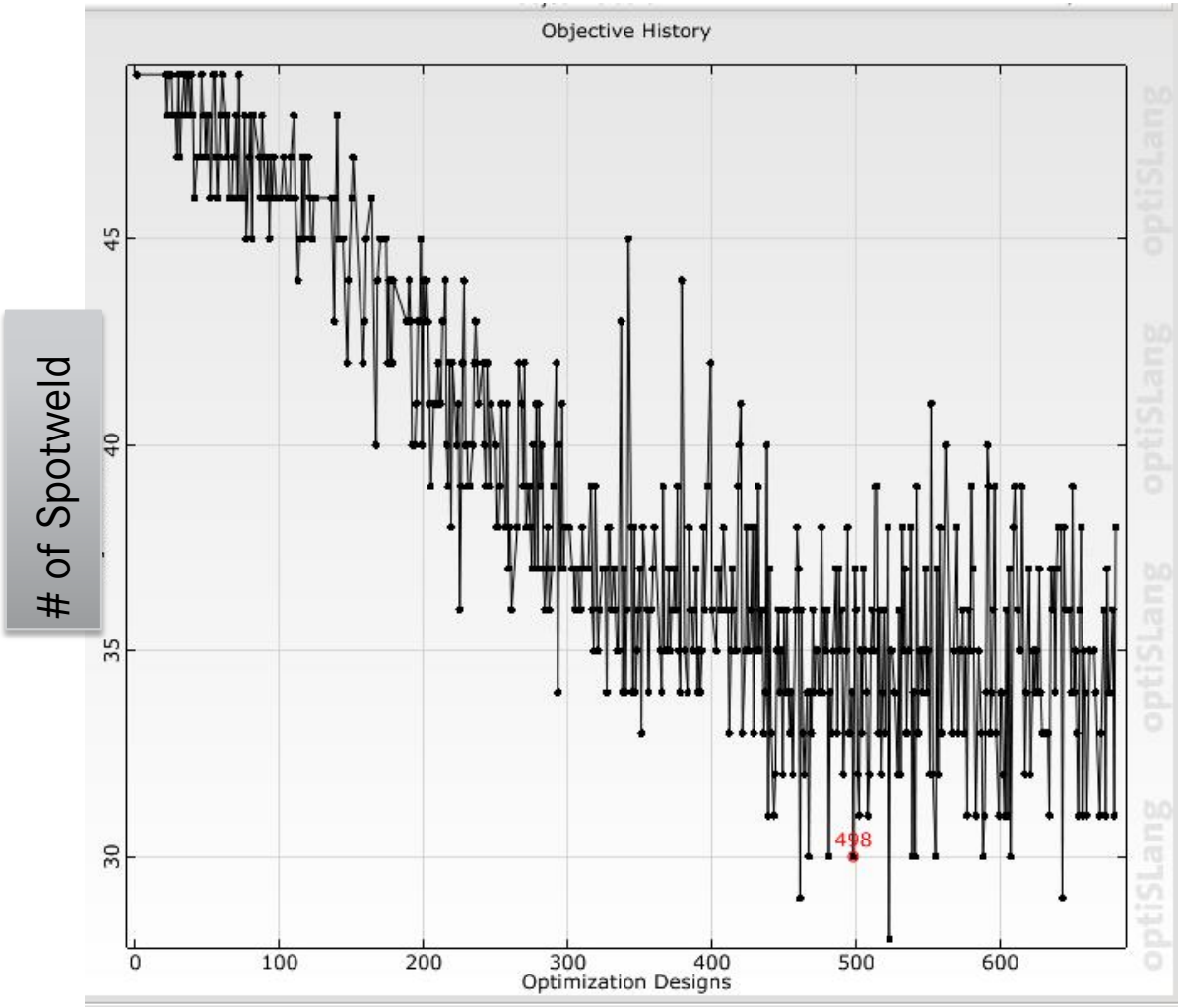


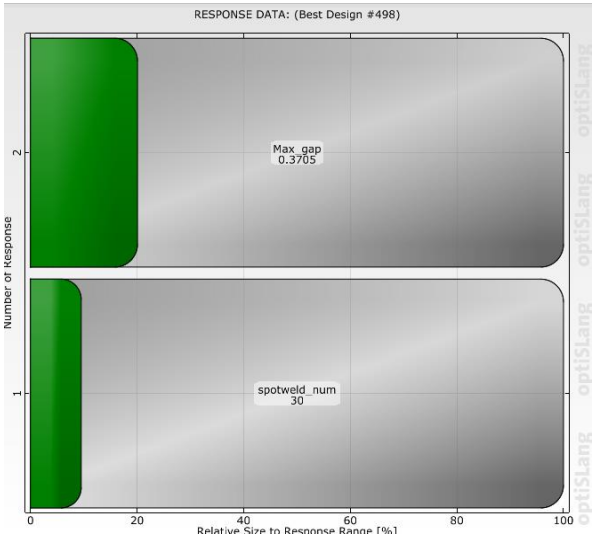


d0,d1,dx1,dx2,dx3 –Spotweld density - Pitch 35mm to 100 mm ([1/100] ***0.01*** to [1/35] ***0.028***)

x1,x2,x3 –Normalized length of spotline –0 to 1

Optimization results





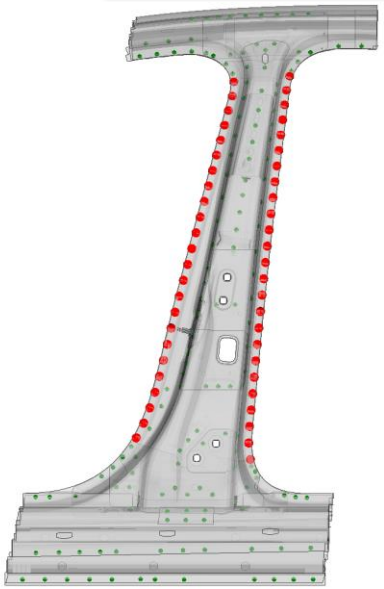
Spotweld Optimization B-Pillar -Overview

Objective : Minimize number of spotwelds

Design Variable : Spotweld pitch - 35 mm to 100 mm

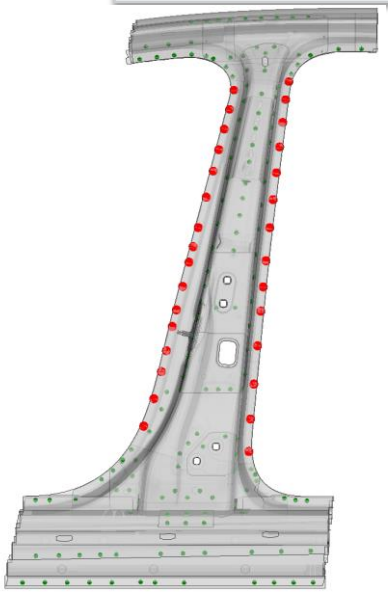
Constraints : Max gap < 0.4, spotweld pitch > 35 mm

Base Model

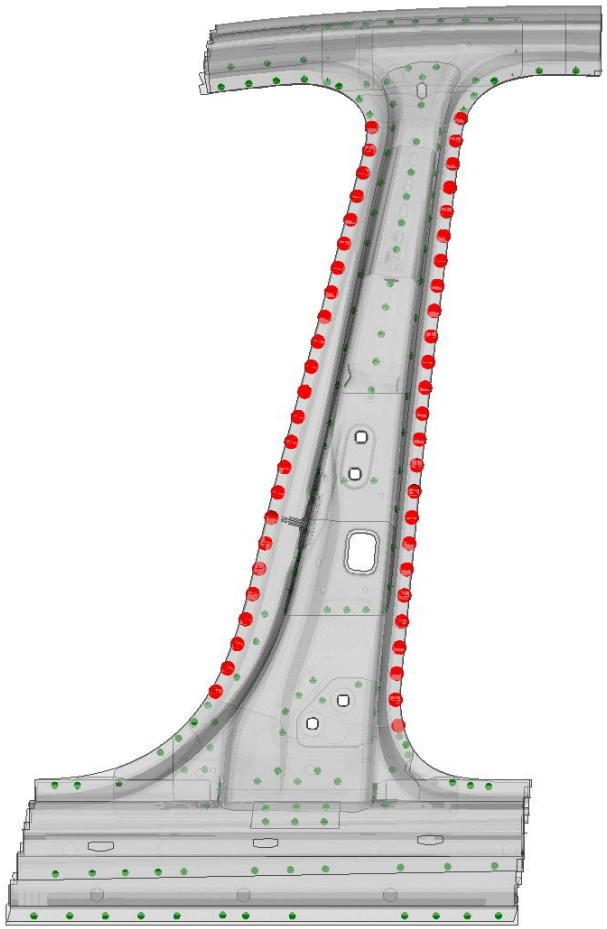


Number of spotweld : 49
Max gap - 0.29
Pitch uniform distribution -35 mm

Opti Model



Number of spotweld : 30
Max gap – 0.38
Pitch non uniform distribution - 35 to 83 mm



Thank you for the attention.