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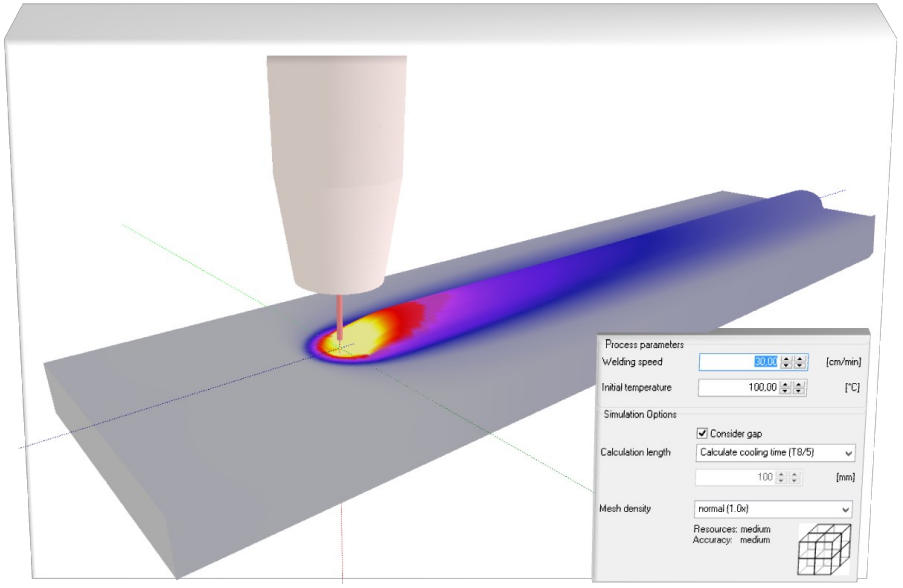
Can we predict weld geometry by simulation



Tobias Loose

28.03.2019

Studienamiddag 3 AUTOLAS:
Lasmallen, vervorming en lasparameters

SimWeld®
from IS+F e.V Aachen

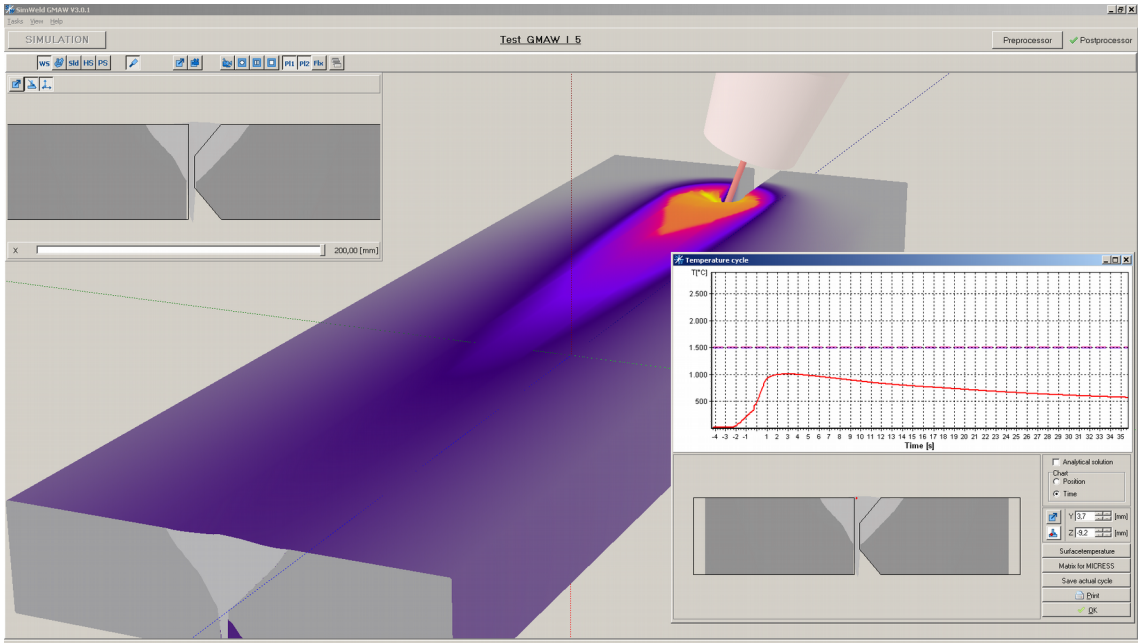
Expo Brussel

Welding Process simulation is the prediction of:

- Melt pool evolution
- Penetrations
- Real time history of current and voltage
- Local temperature field
- Imposed energy
- Droplet

By given process parameter:

- Currency
- Voltage
- Puls design
- Wire and wire feed speed
- Travel speed
- Shielding gas
- Weld position and torch angel



Option 1 - general purpose CFD Code

- free in modeling
- long time for model set up of one Simulation
- simultion expert needed

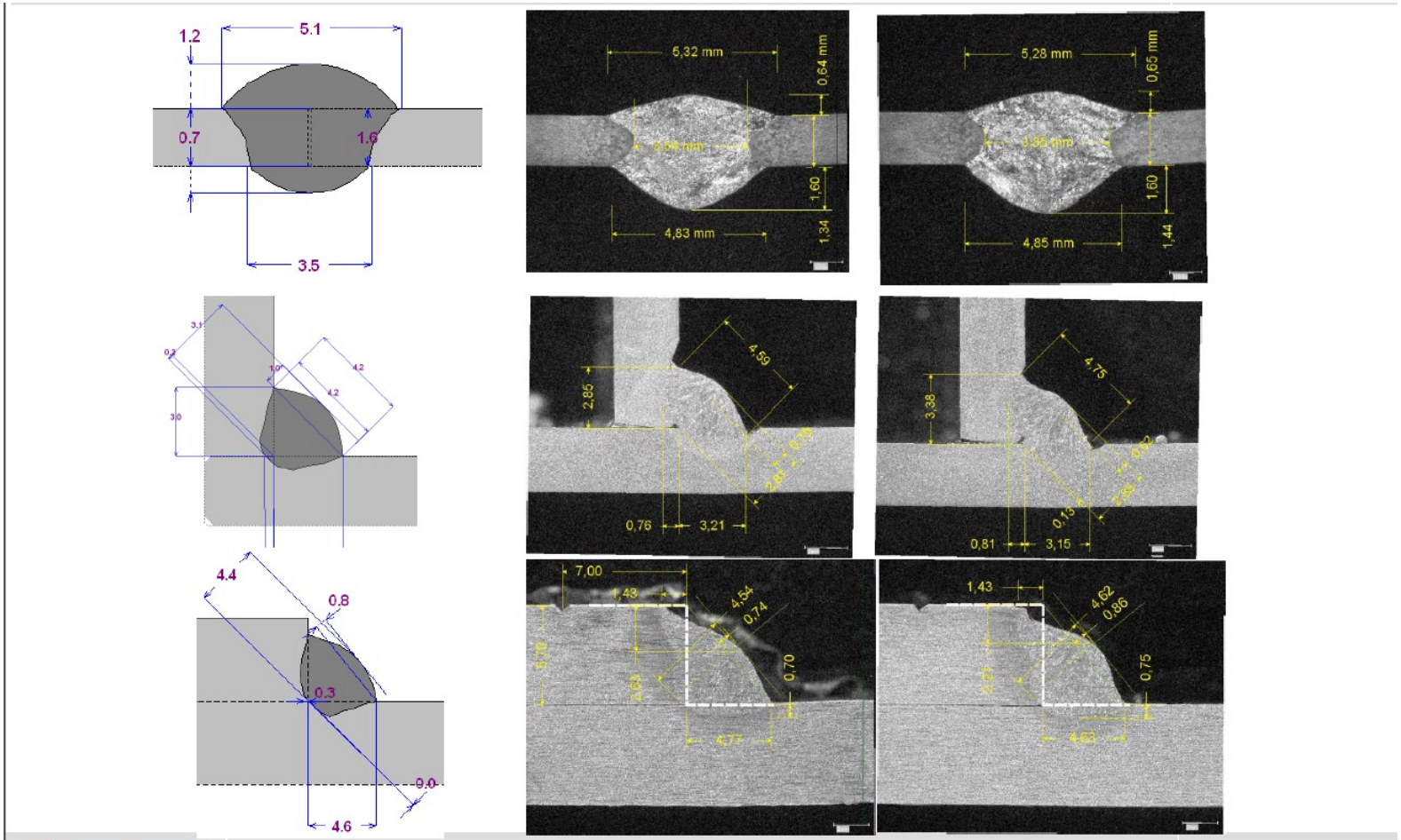
Option 2 - tailored software tool for industrial application

- specialised on discrete processes
- Self explaining GUI
- Input based on speach of applicant
- Enables welders to use the software no expert needed

Example:

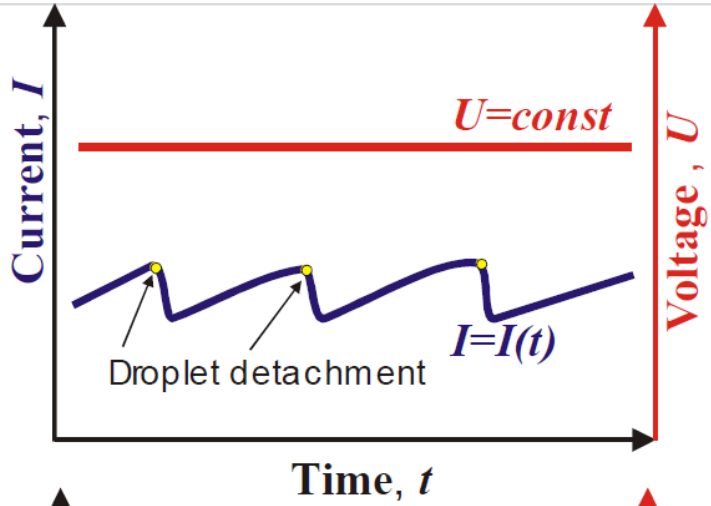
→ SimWeld Process simulation for Gas Metal Arc Welding

Validation of Results



SimWeld Verifikation. T-Stoß Experiment

(1)



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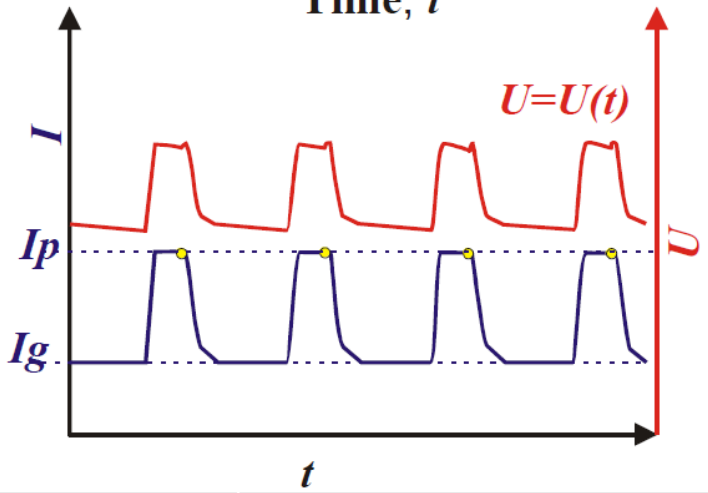
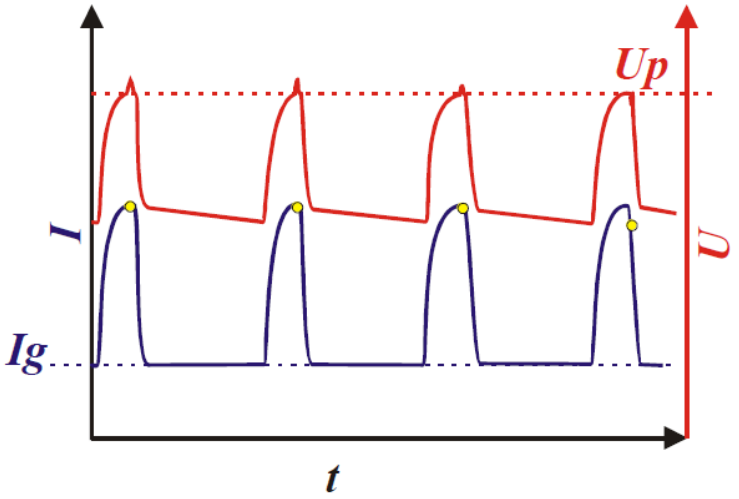


(3)



SimWeld enables

- (1) normal process
- (2) puls process with I-I modulation
- (3) puls process with U-I modulation

Material and Material Data

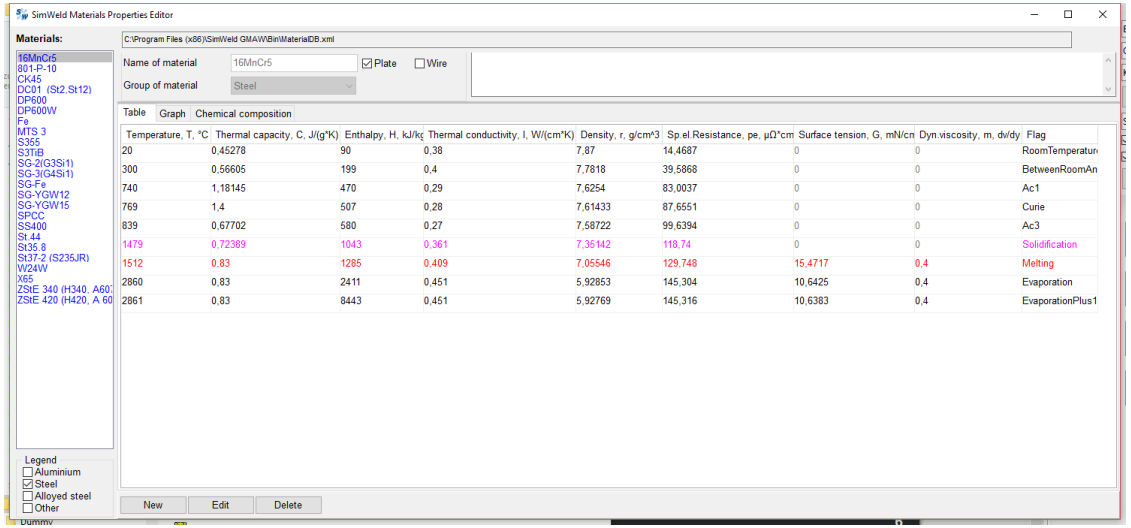
SimWeld simulations are aplicable for low alloyed steels.

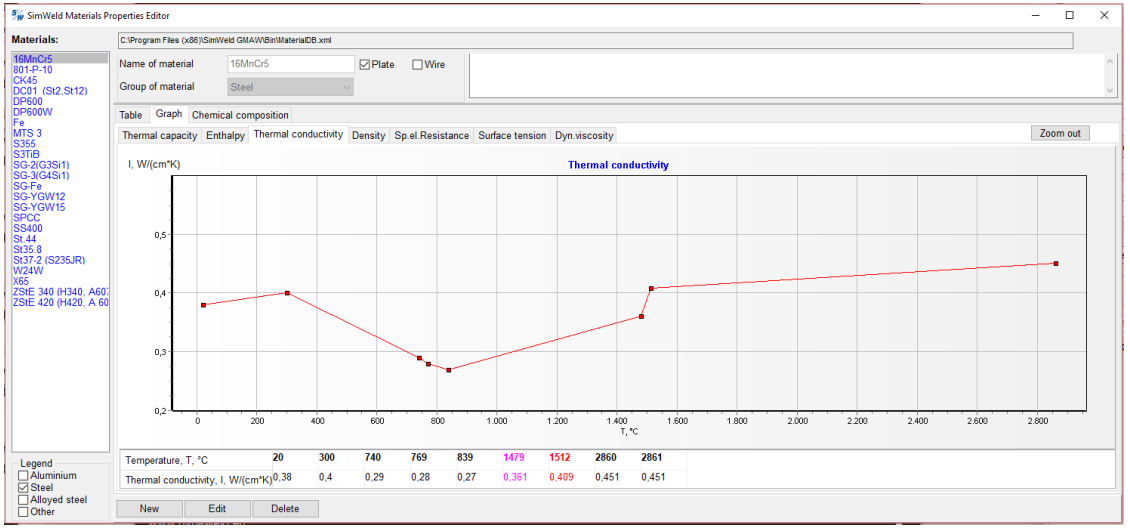
A material database exists for most used steel grades.

The database can be extended or updated by user defined data.

Requested data are:

- Enthalpy
- Thermal conductivity
- Density
- Specific electric resistivity
- Surface tension
- Dynamic viscosity

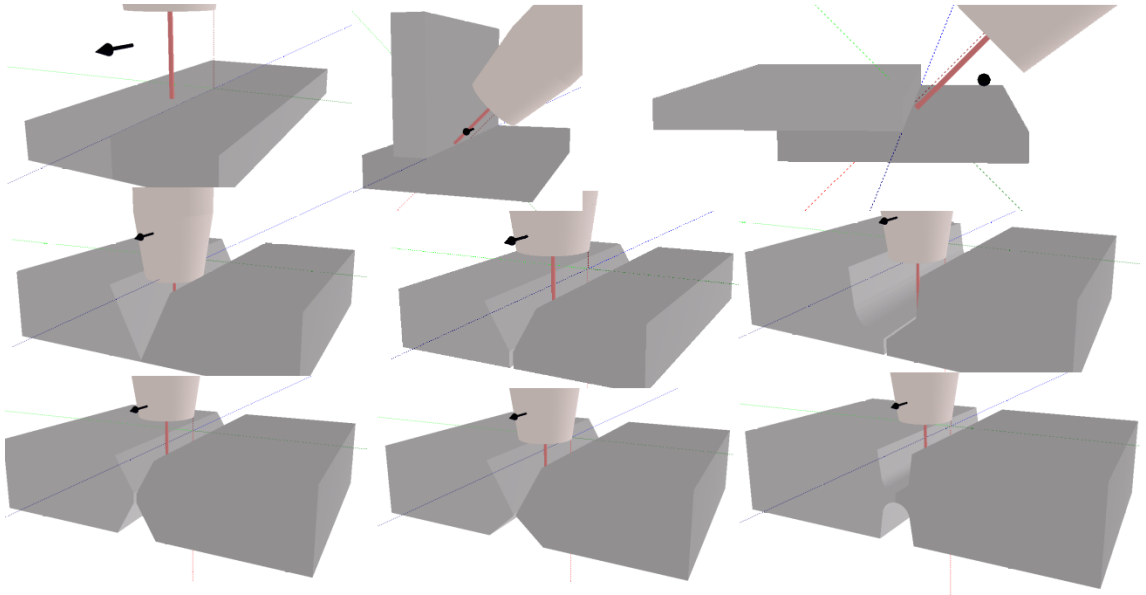




Geometry and Weld Position

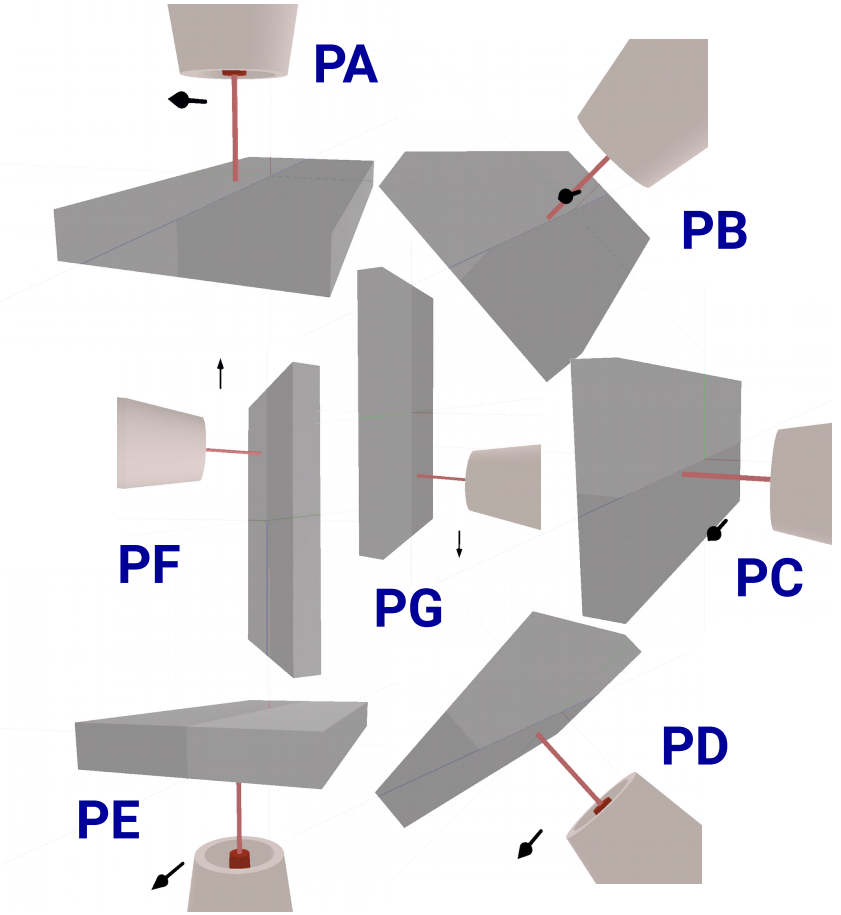
Weld preparations according ISO 9692-1

minimum plate thickness: 2 mm



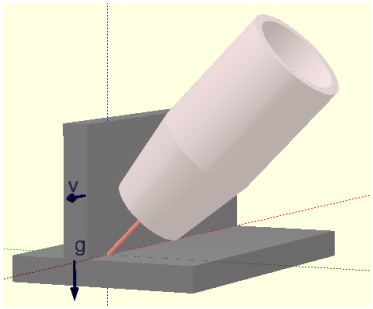
Applicable for root pass simulation.

All work positions are aplicable



as well as individual position angles

Example: Fillet Weld - PB
Definition

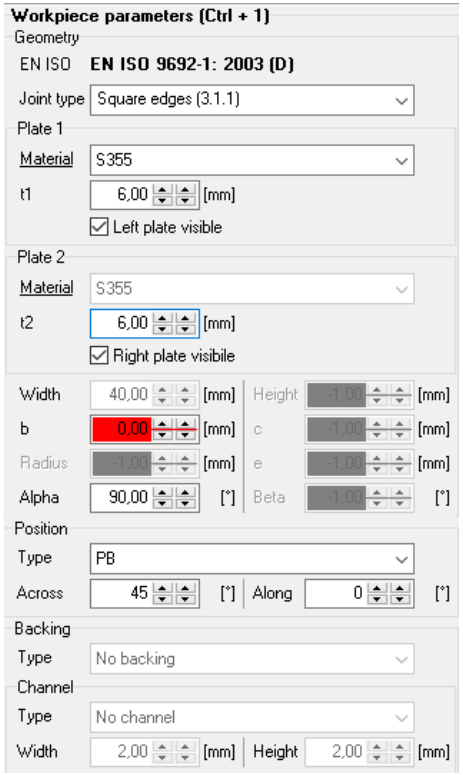


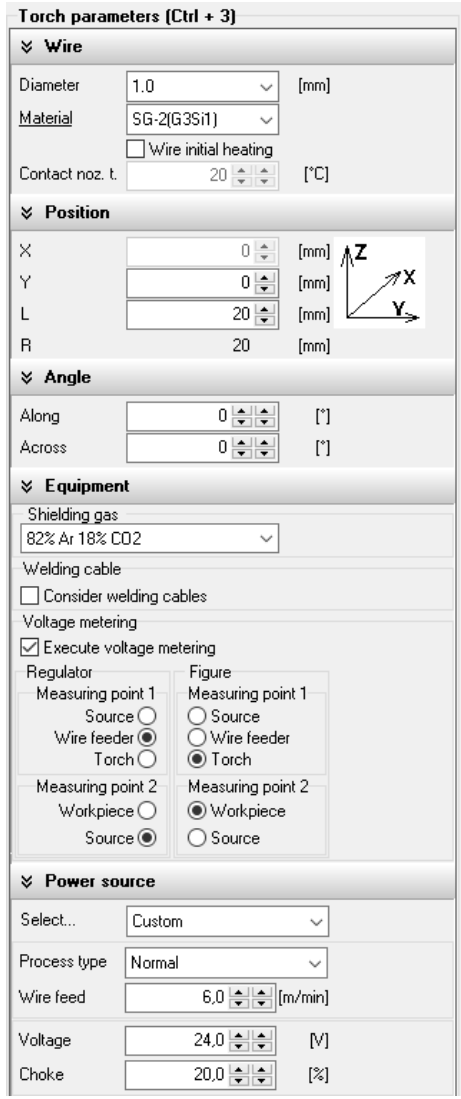
Process Parameter

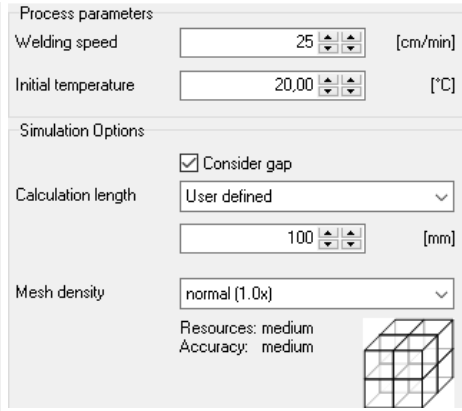
Travel speed	25 cm/min
Wire diameter	1 mm
Wire speed	6 m/min
Voltage	24,0 V

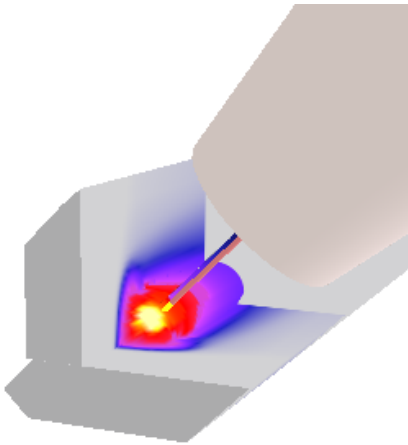
Geometry Parameter

Plate 1 S355	6 mm
Plate 2 S355	6 mm
Postition	PB

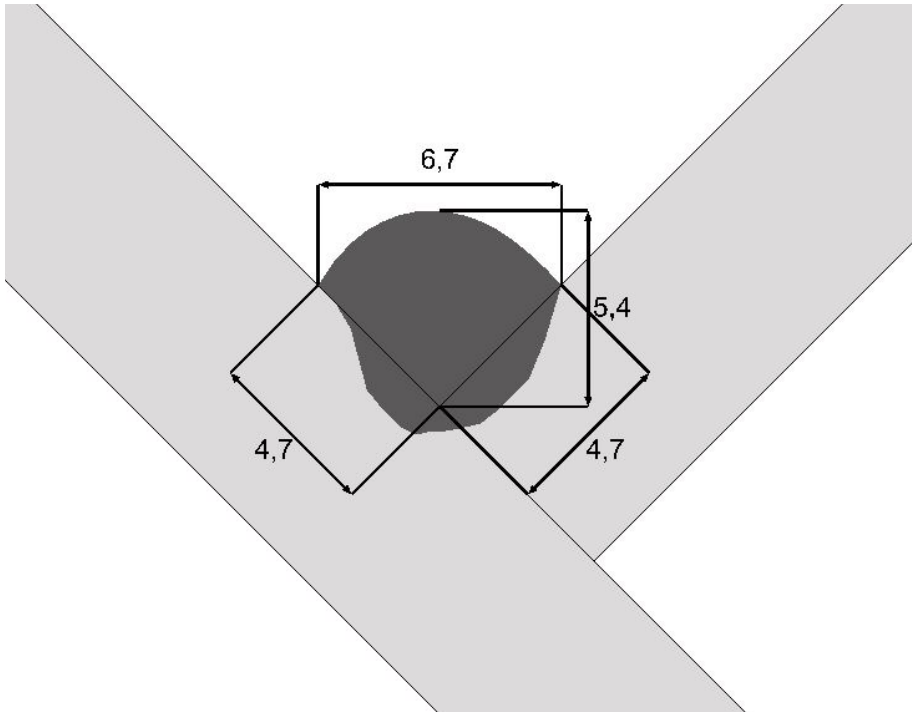




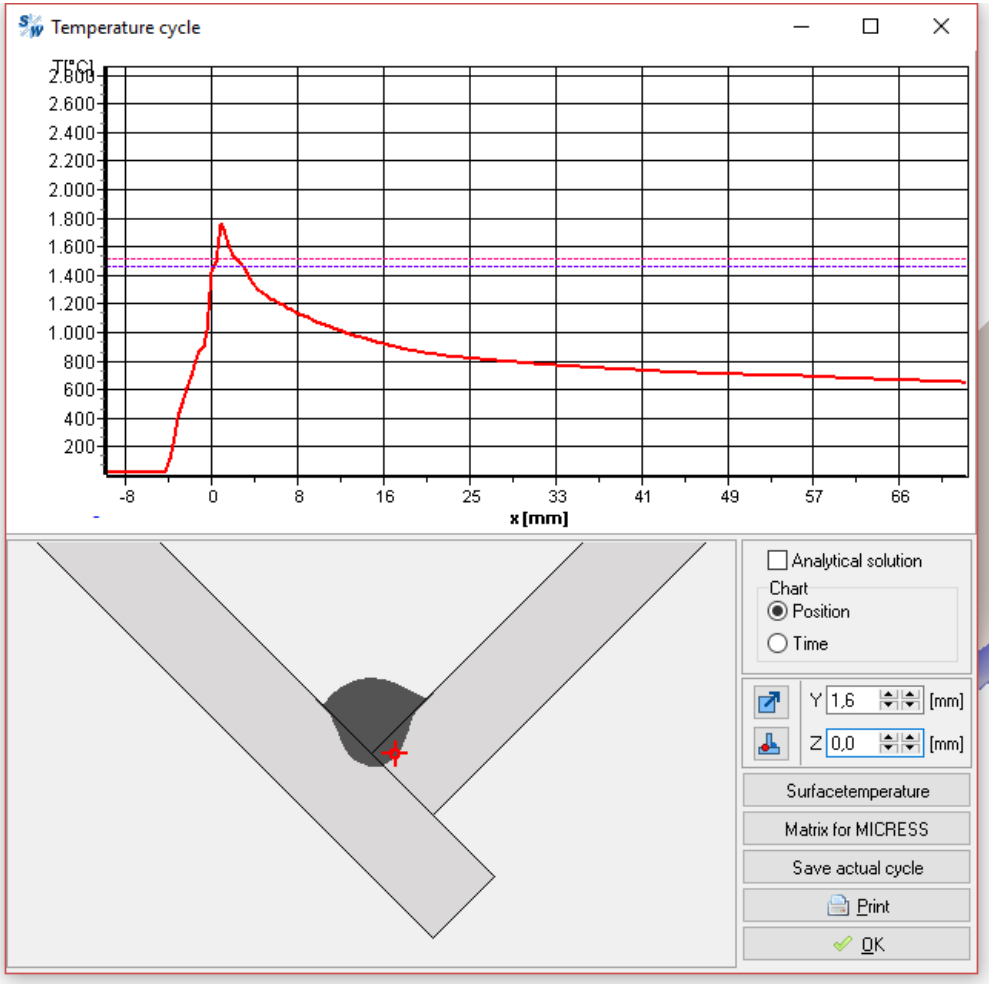




Weld pool geometry



Temperature - Time at arbitrary points



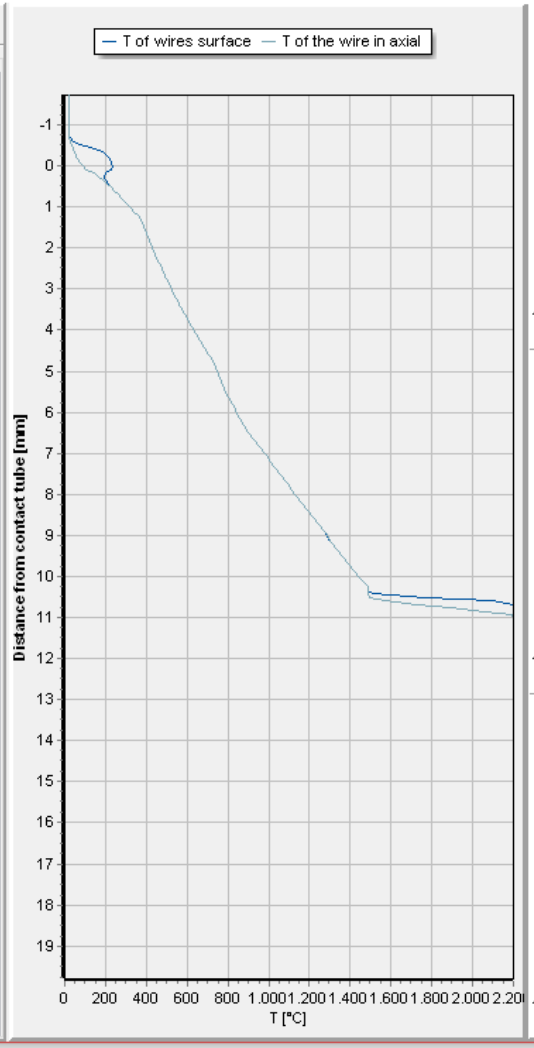
Example: Fillet Weld - PB

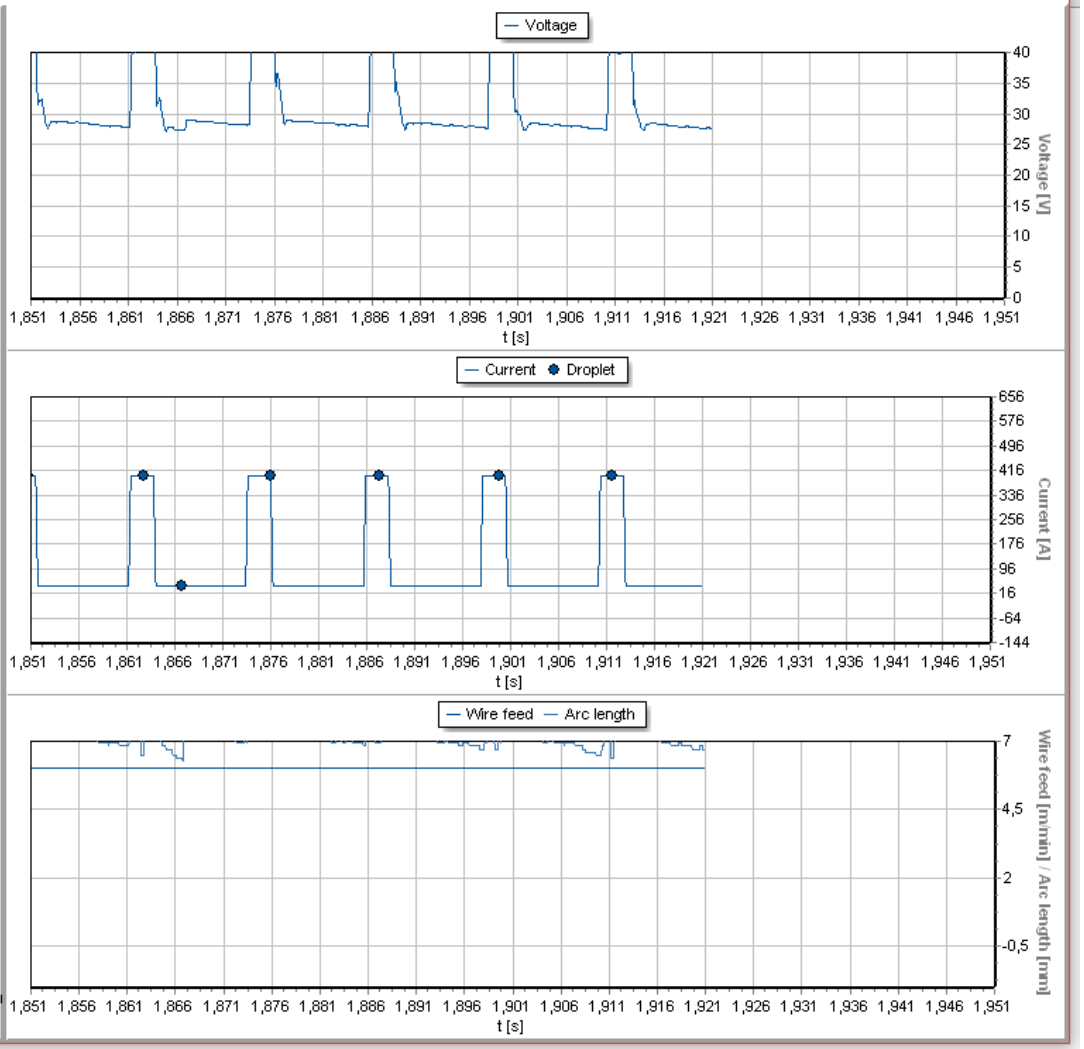
Results Wire Temperature, Energy, Voltage, Current, Droplet

SimWeld GMAW V3.3.0 Beta Signals of wire and arc

Average result values

	Results
Wire voltage drop, [V]	2,7
Anode volt. eqv., [V]	5,1
Volt.drop column, [V]	12,7
Volt.drop cathode, [V]	10,3
Voltage at arc, [V]	31,2
Cable losses, [V]	0,6
Average current, [A]	116,4
RMS current, [A]	185,7
WireFeed, [m/min]	6,0
Anode+wire power, [W]	1389,7
Droplets power, [W]	1314,3
Cathode power, [W]	1550,7
Total electric power, [W]	4270,6
Efficiency factor, [%]	68,9
Evap.loss abs., [W]	210,8
Evap.loss rel., [%]	15,2
Droplet Temp., [°C]	2581,3
Droplet diameter, [mm]	-
Droplet detachm. freq., [Hz]	-
Pulse freq., [Hz]	0,0
Short circuit freq., [Hz]	5,2





Experiment is documented in extended WPS

SimWeld GMAW V3.3.0 Beta 25.03.2019 10:45:25

Experiment: K1

Workpiece parameters			
DIN	EN ISO 9692-1: 2003 (D)	C	- [mm]
Type	Square edges (3.1.1)	Radius	- [mm]
Material	S355	E	- [mm]
Width	40,00 [mm]	B	0,00 [mm]
Height	- [mm]	Alpha	90,00 [°]
		Beta	- [°]

Plate parameters			
Plate 1		**Plate 2**	
Material	S355	Material	S355
Thickness	6,00 [mm]	Thickness	6,00 [mm]

Welding Process	GMAW
Description	

Welding speed	25,00 [cm/mi
Backing Type	None

Calculation	User defined
Length	75,00 [mm]

SimWeld GMAW V3.3.0 Beta 25.03.2019

Experiment: K1

Torch			
Shielding gas	82% Ar 18% CO2	**Power source**	
Position		Source type	Custom
X	0,00 [mm]	Process type	Normal
Y	0,00 [mm]	Wire feed speed	6,00 [m/min]
Contact t. dist.	20,00 [mm]	Voltage	24,00 [V]
Angle along	0,00 [°]	Choke	20,00 [ms]
Angle across	0,00 [°]		
Wire			
Material	SG-2(G3Si1)		
Diameter	1,00 [mm]		
Initial heating	☐		
☐ **Consider Welding Cables**			
☑ **Consider Regulator**			
Regulator			
Start	Wire feeder		
End	Source		
Figure			
Start	Torch		
End	Workpiece		

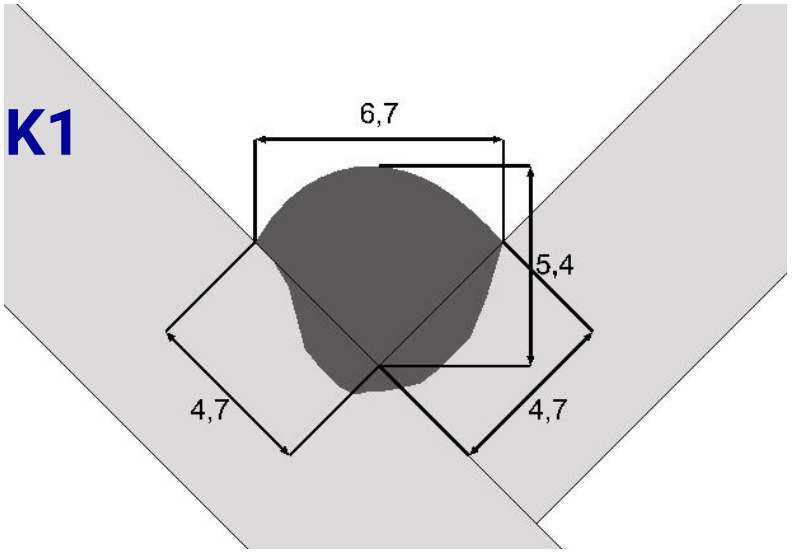
SimWeld GMAW V3.3.0 Beta 25.03.2019 10:45:25

Experiment: K1

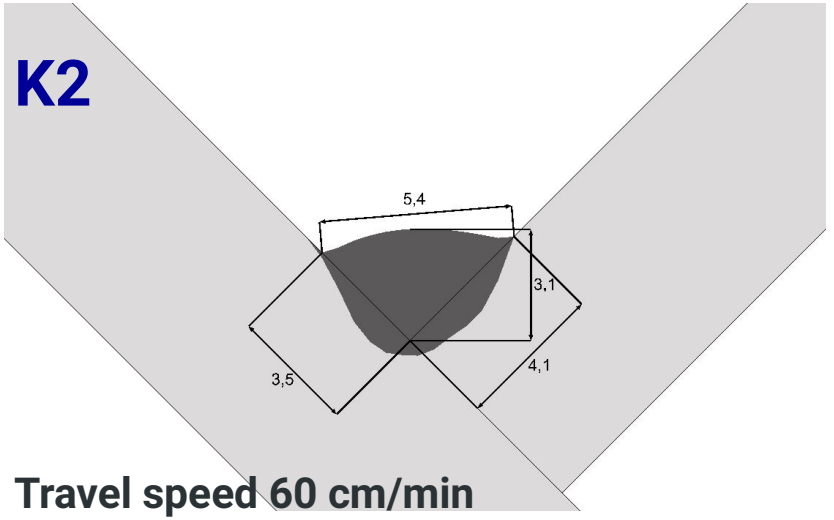
☑ **Simulation results**			
Date	25.03.2019	**Geometrical results**	
Energy input	8,41 [kJ/cm]	Seam area	20,50 [mm²]
E.i./plate thickn.	- [kJ/cm²]	Seam width	6,70 [mm]
T 850/500°C	- [s]	Leg length 1	111,00 [mm]
T 800/500°C	- [s]	Leg length 2	111,00 [mm]
Workp. dil. level	8,00 [%]	Overthickness	111,00 [mm]
		Root penetration	111,00 [mm]
		Undercut 1	- [mm]
		Undercut 2	- [mm]
		Fusion penet.	- [mm]
		Throat thickness	- [mm]

Heat and mass input results			
Wire feed	6,00 [m/min]	**Voltage**	
Electric power	4270,63 [W]	Wire volt. drop	2,68 [V]
Deposition rate	2,00 [kg/h]	Andone equival.	5,11 [V]
Dilution level	92,00 [%]	Column	12,71 [V]
Current		Cathode	10,32 [V]
Average current	116,36 [A]	Voltage at arc	31,25 [V]
RMS current	185,73 [A]	Cable losses	0,64 [V]
Generated thermal power		**Process characteristics (average values)**	
Anode + wire	1389,73 [W]	T droplet	2581,29 [°C]
Droplets heat	1314,27 [W]	Droplet diam. eq.	0,11 [mm]
Cathode	1550,73 [W]	Droplet det. freq.	- [Hz]
Heat input	2865,00 [W]	Pulse frequency	- [Hz]
Efficiency factor	67,09 [%]	SC frequency	5,20 [Hz]
Evaporation losses			
Droplet loss abs.	210,82 [W]		
Droplet loss rel.	15,17 [%]		

K1

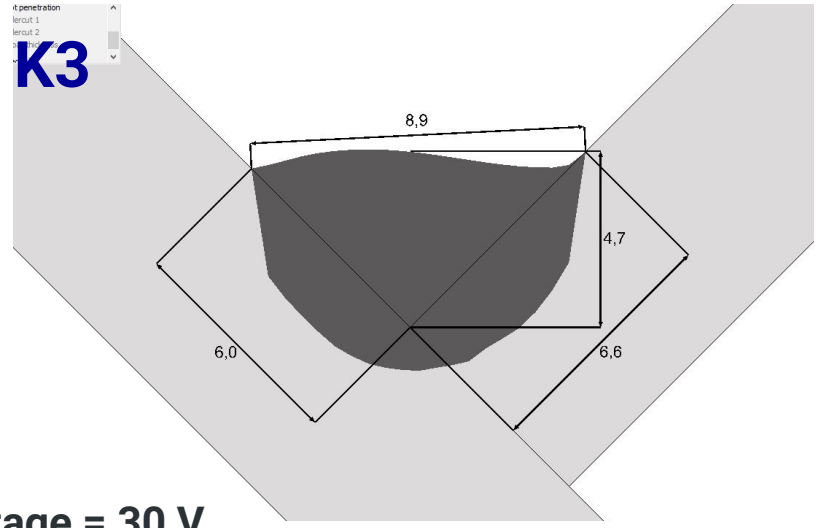


K2



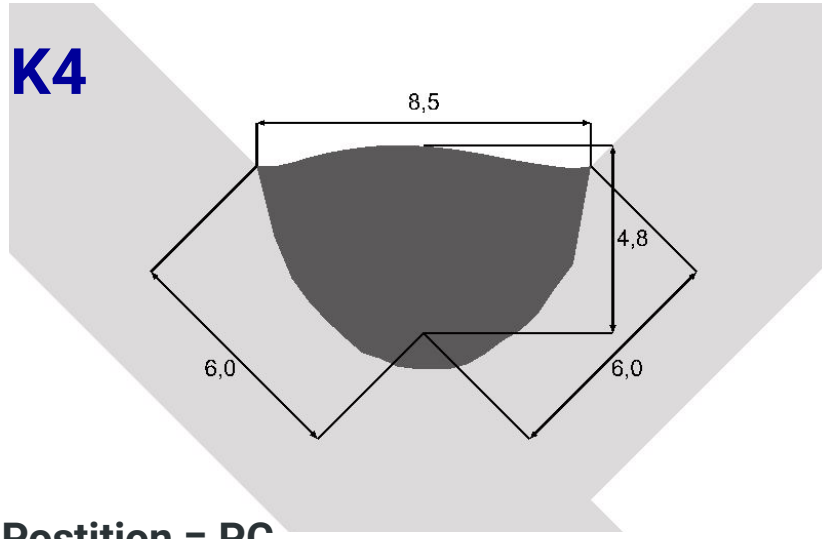
Travel speed 60 cm/min

K3



Voltage = 30 V

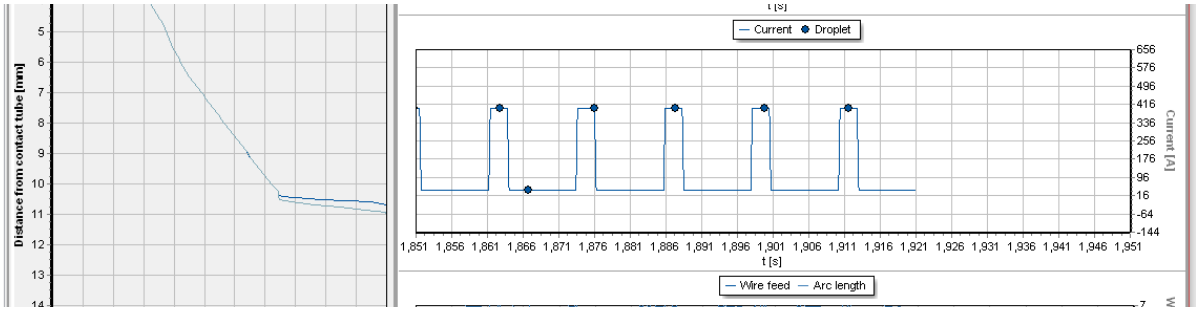
K4



Postition = PC

K1

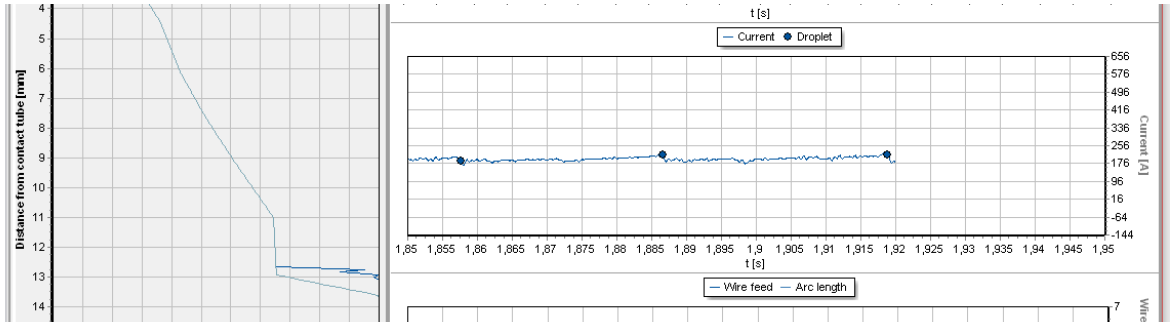
RMS current, [A]	185,7
WireFeed, [m/min]	6,0
Anode+wire power, [W]	1389,7
Droplets power, [W]	1314,3
Cathode power, [W]	1550,7
Total electric power, [W]	4270,6
Efficiency factor, [%]	68,9
Evap.loss abs., [W]	210,8
Evap.loss rel., [%]	15,2
Droplet Temp., [°C]	2581,3
Droplet diameter, [mm]	-
Droplet detachm. freq., [Hz]	-



Arc with short cirquit droplet (25 V)

K3

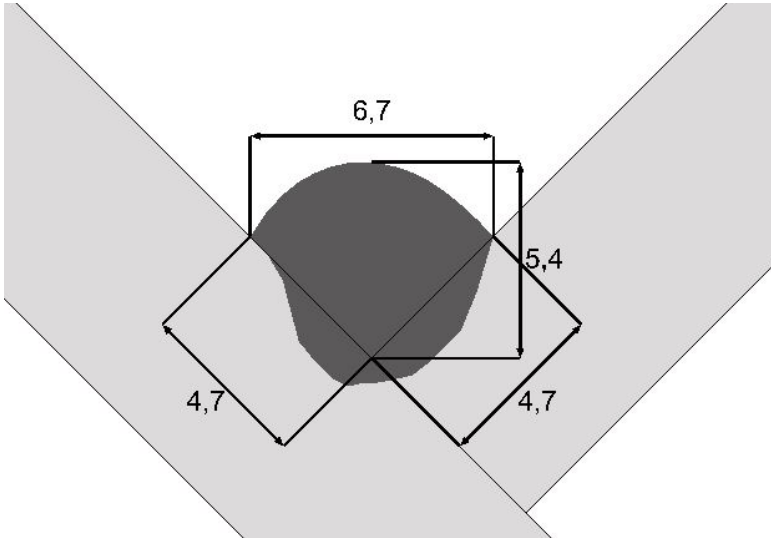
RMS current, [A]	181,6
WireFeed, [m/min]	6,0
Anode+wire power, [W]	1694,0
Droplets power, [W]	1677,5
Cathode power, [W]	2333,5
Total electric power, [W]	5325,5
Efficiency factor, [%]	75,6
Evap.loss abs., [W]	16,5
Evap.loss rel., [%]	1,0
Droplet Temp., [°C]	2681,4
Droplet diameter, [mm]	-
Droplet detachm. freq., [Hz]	-
Pulse freq., [Hz]	-



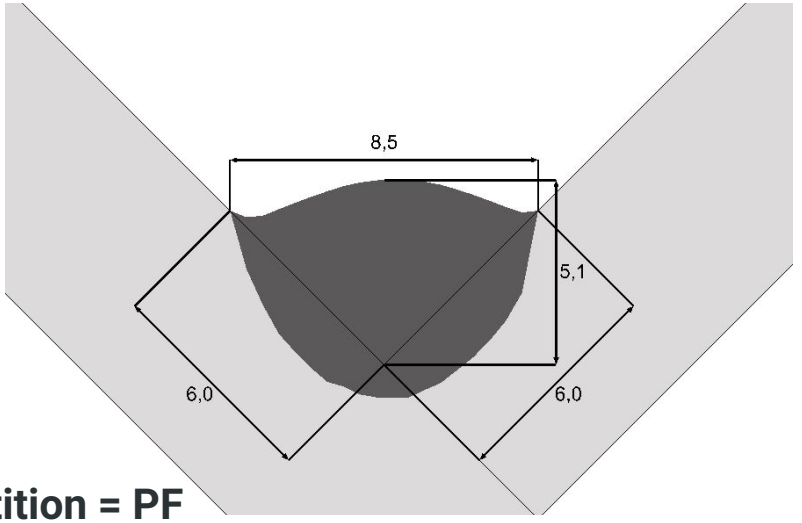
Spray-Arc without short cirquit (30 V)

New Task: Optimize Parameter for Position PF

K1

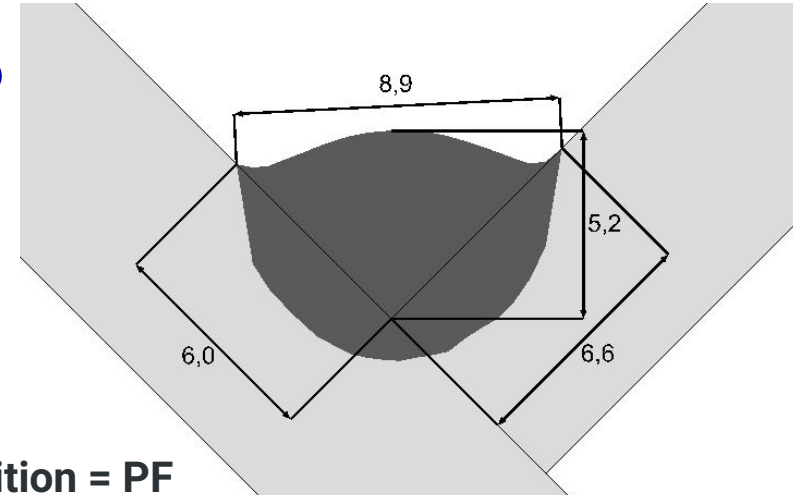


K5



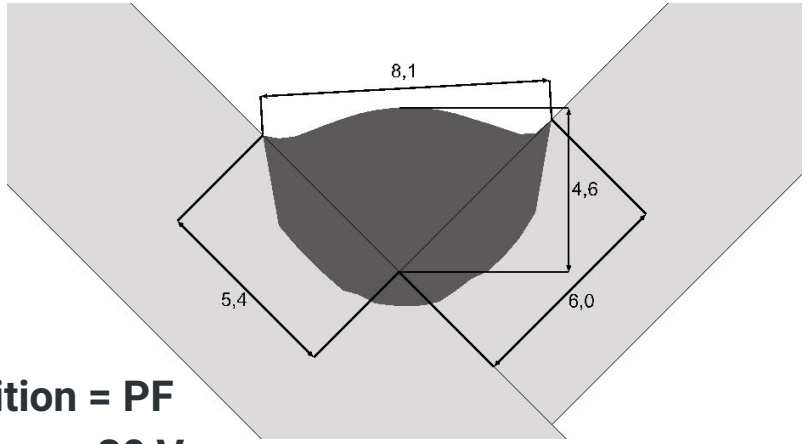
Postition = PF

K6



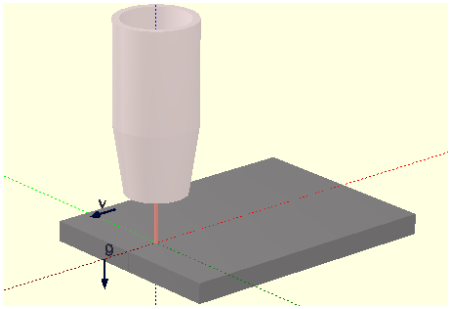
Position = PF
Voltage = 30 V

K7



Postition = PF
Voltage = 30 V
Travel Speed = 30 cm/min

Example: Butt Weld - PA
Definition

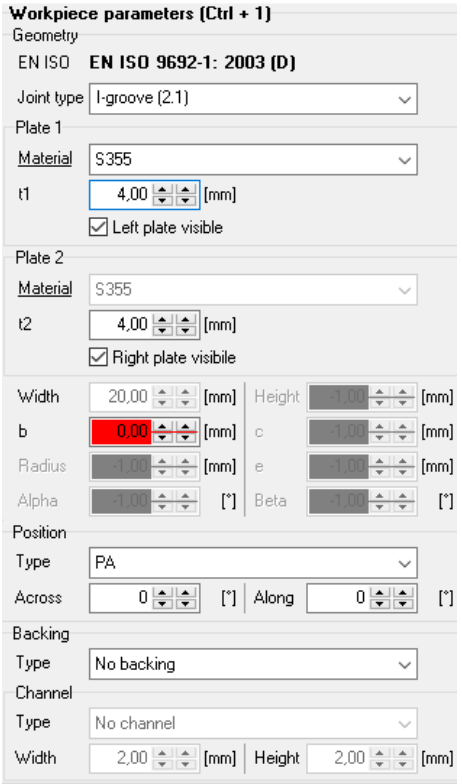


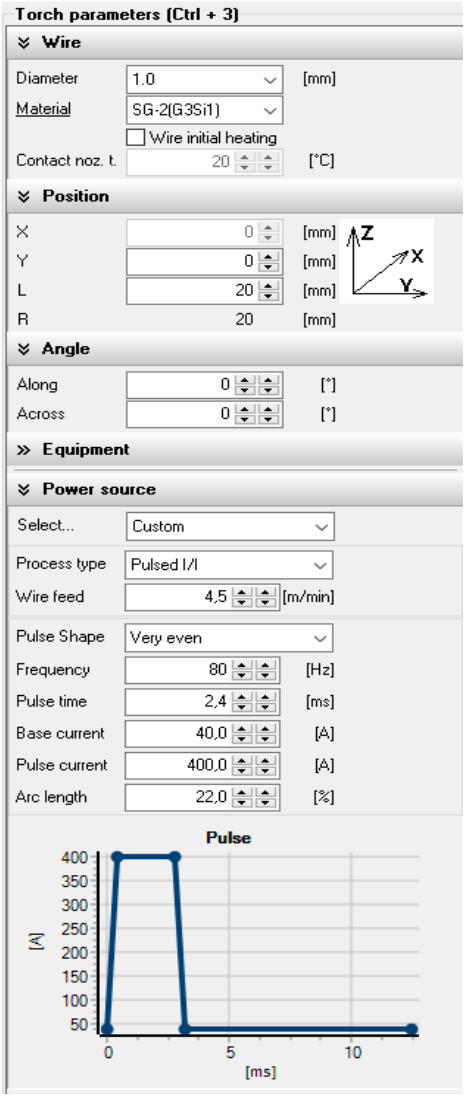
Process Parameter

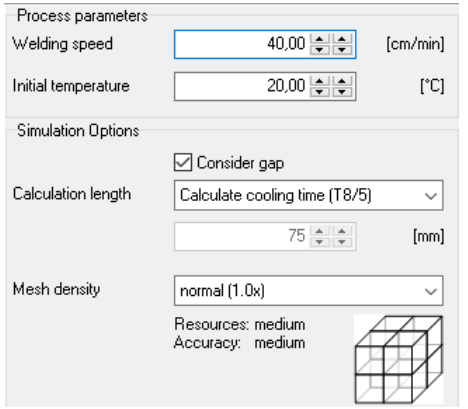
Travel speed	40 cm/min
Wire diameter	1 mm
Wire speed	4,5 m/min
Pulse Process	
I Base	40 A
I Pulse	400 A
Frequency	80 Hz
Pulse time	2,4 ms

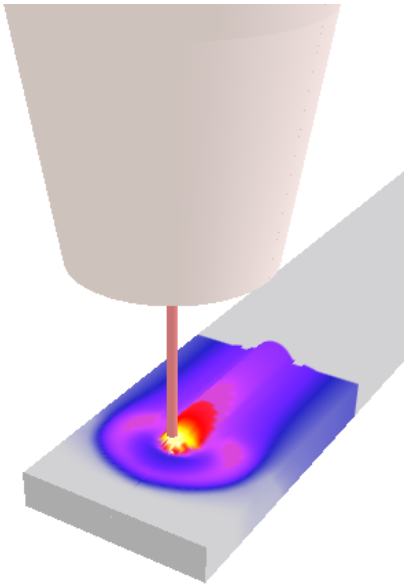
Geometry Parameter

Plate 1 S355	4 mm
Plate 2 S355	4 mm
Postition	PA

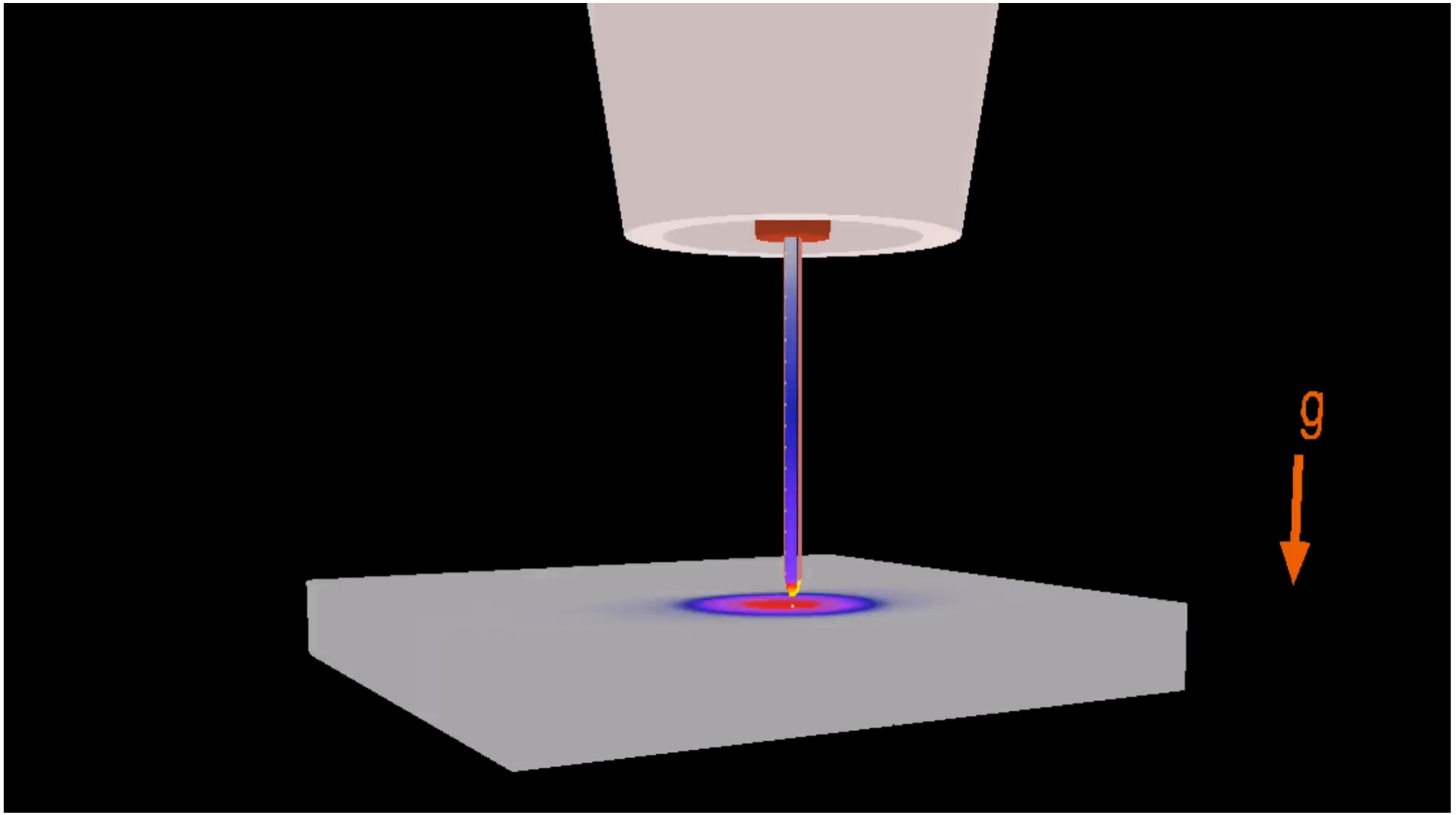








Animation

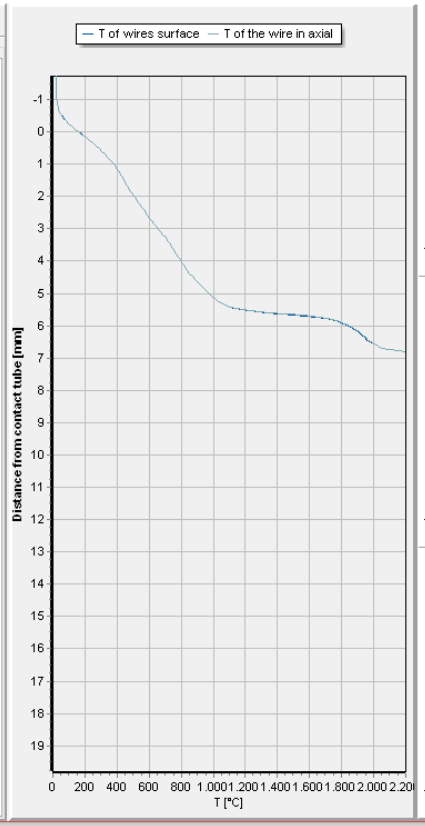


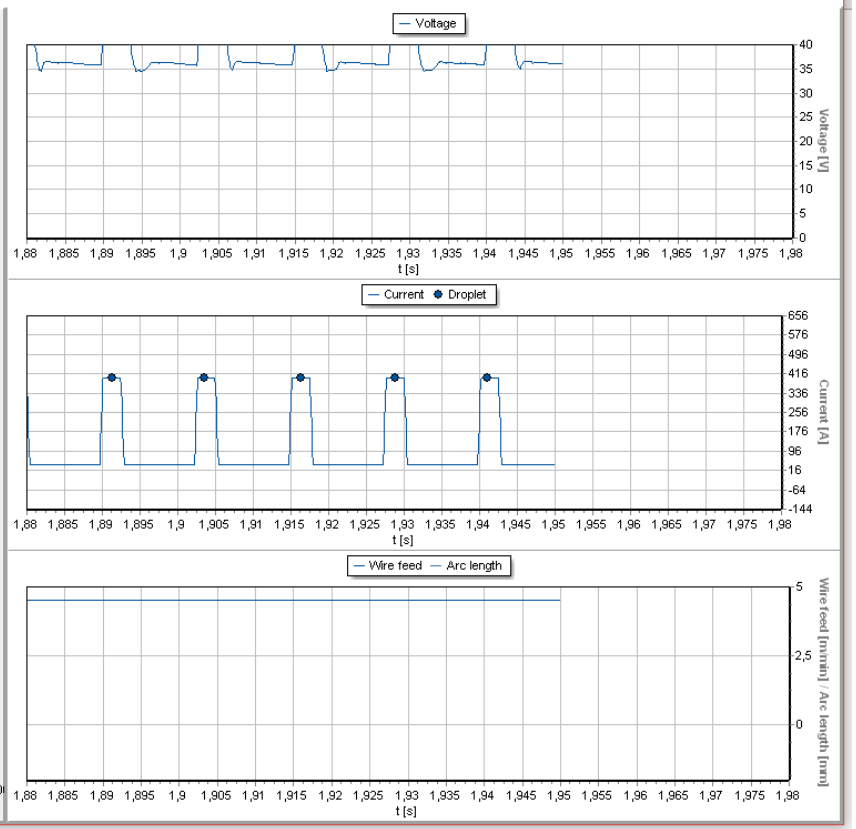
Example: Butt Weld - PA
Results

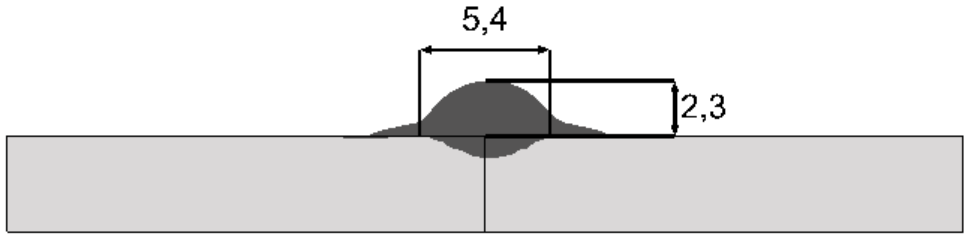
SimWeld GMAW V3.3.0 Beta Signals of wire and arc

Average result values

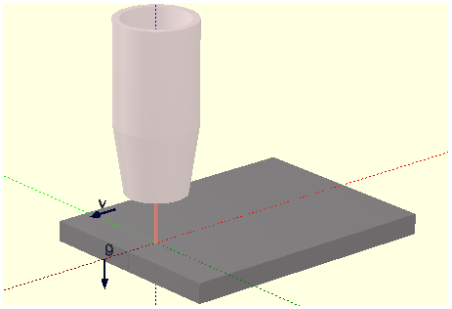
	Results
Wire voltage drop, [V]	1,9
Anode volt. eqv., [V]	5,2
Volt.drop column, [V]	19,3
Volt.drop cathode, [V]	10,7
Voltage at arc, [V]	37,6
Cable losses, [V]	0,7
Average current, [A]	120,8
RMS current, [A]	189,1
WireFeed, [m/min]	4,5
Anode+wire power, [W]	1180,5
Droplets power, [W]	1149,7
Cathode power, [W]	1673,2
Total electric power, [W]	4937,0
Efficiency factor, [%]	57,8
Evap.loss abs., [W]	30,8
Evap.loss rel., [%]	2,6
Droplet Temp., [°C]	2642,0
Droplet diameter, [mm]	-
Droplet detachm. freq., [Hz]	-
Pulse freq., [Hz]	0,0
Short circuit freq., [Hz]	0,0







Example: Butt Weld - PA
Modification 1

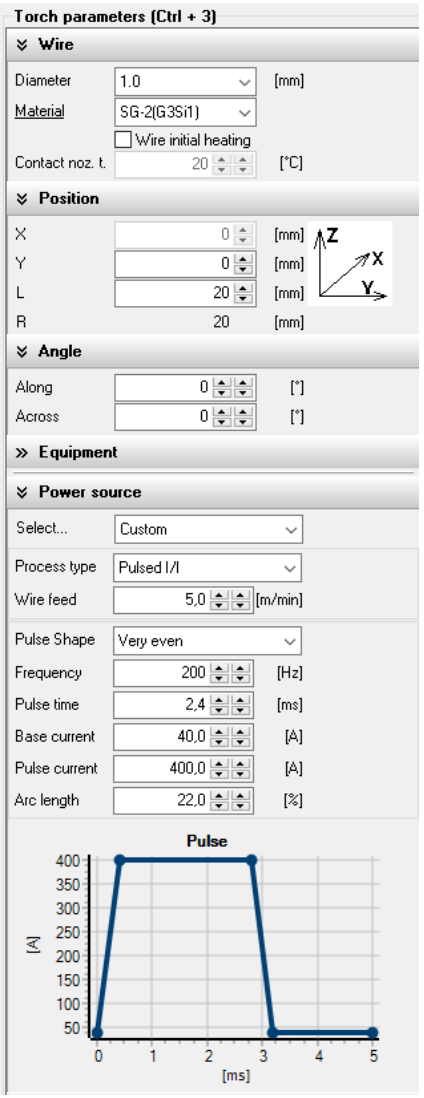


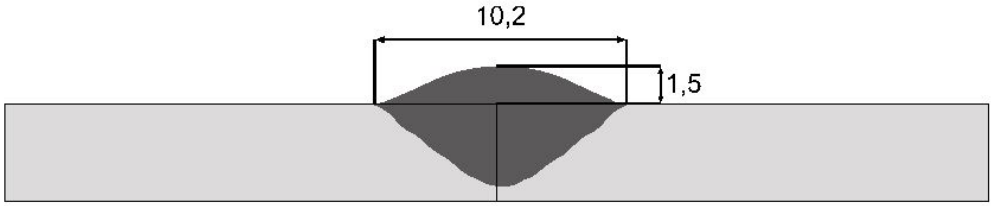
Process Parameter

Travel speed	40 cm/min
Wire diameter	1 mm
Wire speed	5,0 m/min
Pulse Process	
I Base	40 A
I Pulse	400 A
Frequency	200 Hz
Pulse time	2,4 ms

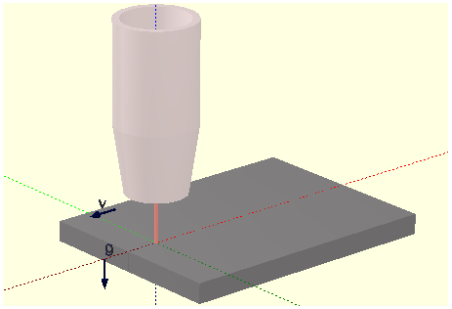
Geometry Parameter

Plate 1 S355	4 mm
Plate 2 S355	4 mm
Postition	PA





Example: Butt Weld - PA
Modification 2

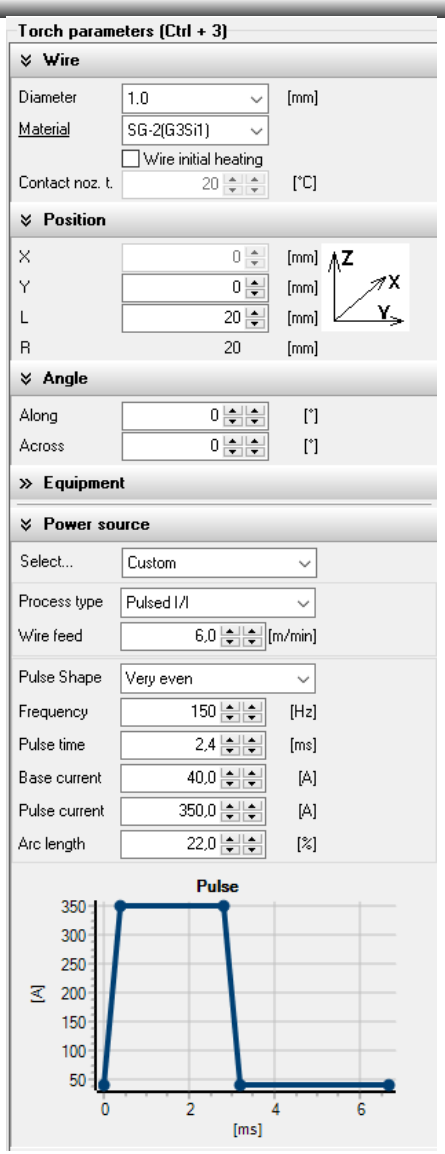


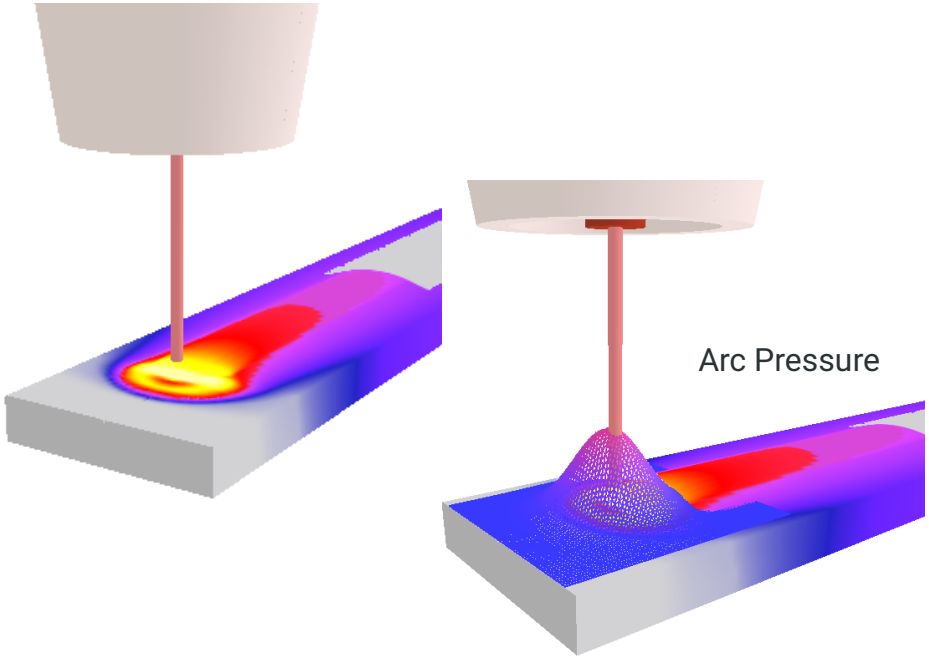
Process Parameter

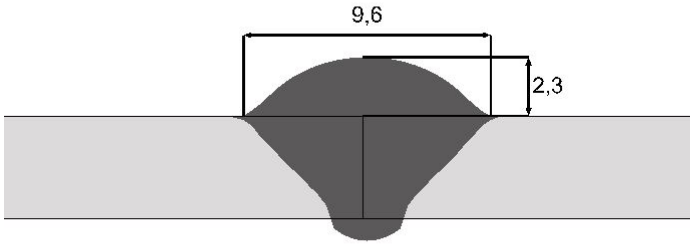
Travel speed	30 cm/min
Wire diameter	1 mm
Wire speed	5,0 m/min
Pulse Process	
I Base	40 A
I Pulse	350 A
Frequency	150 Hz
Pulse time	2,4 ms

Geometry Parameter

Plate 1 S355	4 mm
Plate 2 S355	4 mm
Postition	PA







… can we predict weld geometry by simulation?

The **Input**: Geometry, Postition, Material, Process

The **Job**: Process Simulation with SimWeld

The **Output**: Weld-Pool, Energy, Temperature,
Monitoring of Voltage, Current and Droplet

… yes we can!

Tanks for your attention!