Plastic Fabrication

Reto Britschgi

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Agenda

- Introduction Plastic Fabrication
- Plastic Basics
- Basic Welding Principles
- Pendulum Welding and Draw Welding
- Hot Air Extrusion Welding
- Arrangement of Welding Constructions
- Test of Weld Seam Quality

Scope

fresh water management

Plastic repair

Transportation

Art & Design

Energy systems

Maritime industry

waste water management

Piping

Air cleaning processes

Galvanic

Tunnelling

Roofing

Chemical industry

Food industry

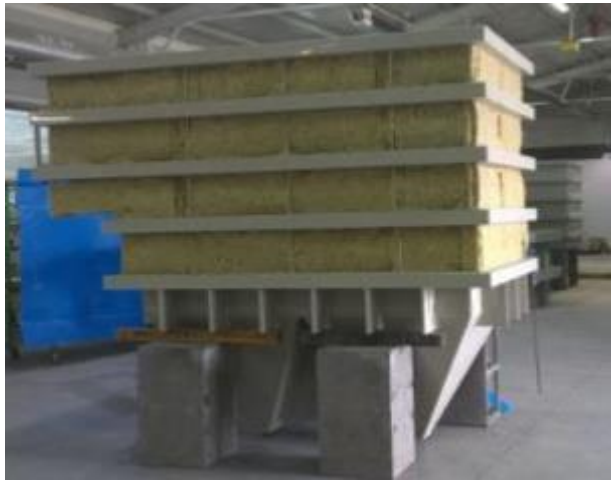
Leisure Applications

Tank Construction

Storage tank Polyethylen (HD-PE)

Fiber glass tank with PP-liner
Material: reinforced
Polypropylene (PP) liner

Galvanic tanks



Aluminum anodisation PP

Galvanic tanks, Hungary (Polypropylene)

Plating line Taiwan PP

Water management

Spring box Switzerland (HD-PE)

Waste water box (HD-PE)

Ventilation

Counter flow scrubber (HD-PE)

Air filters (PP)

Maritime Industry

Work boat AUS (HD-PE)

Coast guard TUR (HD-PE)

Work boat GB (HD-PE)

Floating dock AUS (HD-PE)

float (HD-PE)

Coast guard Vietnam (PP)

Aqua cultures

Fish hatchery NL (HD-PE)

Enclosed fish farm NOR (HD-PE)

Fish farm AUS (HD-PE)

Lobster farm AUS (PP)

Piping

Energy pipes Doha (HD-PE)

District heating Germany (HD-PE)

Plastic repair

Plastic repair on: Kajaks, bumpers, logistic- und trash bins

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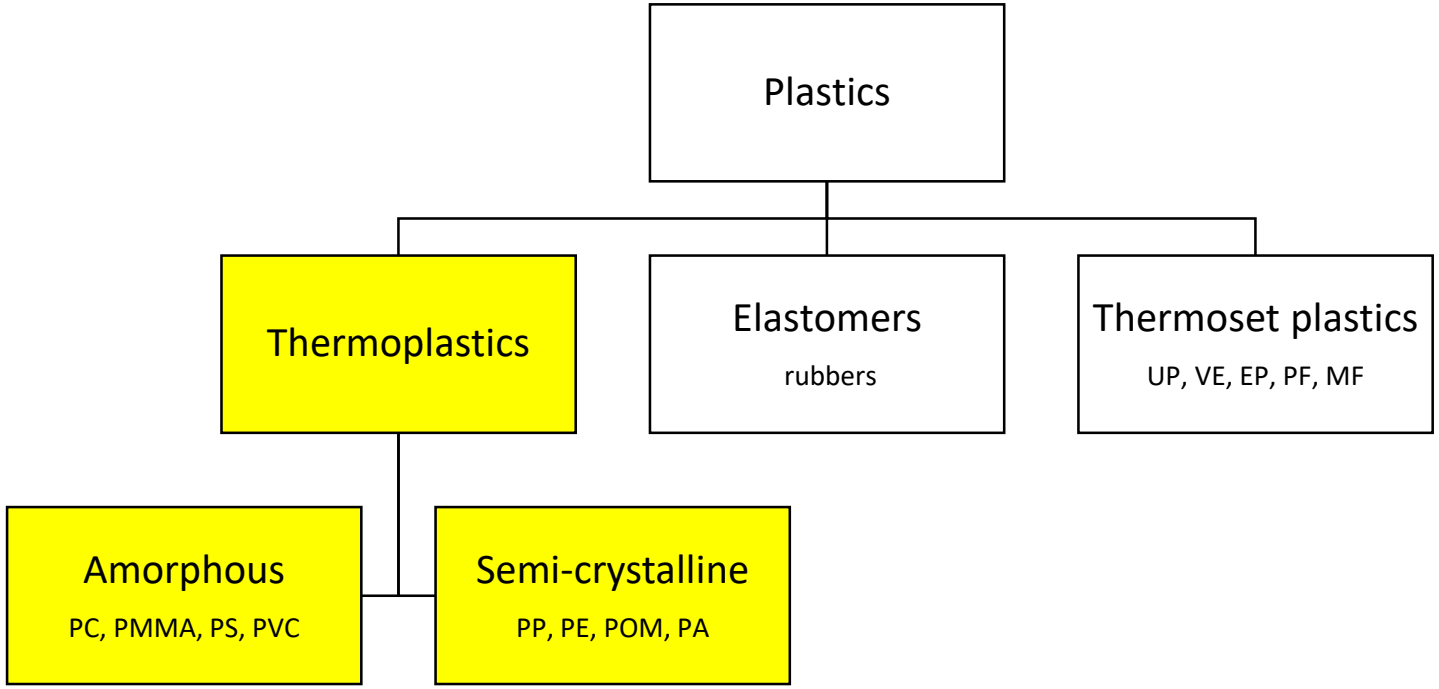
The properties of plastics

+ low weight and good mechanical properties
+ good electrical insulation
+ excellent resistance to chemicals and weathering
+ low thermal conductivity

- low thermal resistance
- large thermal expansion
- low elastic modulus
- Permeation (gas permeability)

Polymer families



Materials in Plastic Fabrication

Material	Abbreviations	Application	Characteristic	Sample
High-density polyethylene	HDPE [4)]	tubes, sheets, tank construction, bins, crates, boxes ….	Excellent resistance to water, acids, alkalis and most organic solvents	
Polypropylene, Types 1, 2, 3	PP-H; PP-B; PP-R	tubes, sheets, tank constructions, bins, crates, boxes ….	Harder than HD-PE. Lower density, higher softening point, poor UV resistance	
Unplasticised polyvinyl chloride	UPVC	Plumbing, piping, sheets, tank construction, chemical storrage	High chemical resistance, flame retardant, flame retardant High thermal stability	
Chlorinated polyvinyl chloride	CPVC	Chemical storrage for higher temperatures	Very high chemical resistance, flame retardant High thermal stability	
Polyvinylidene fluoride	PVDF	Liners, coating, small tanks, for chemical high agressive applications	Very high chemical resistance, High thermal stability	
Thermoplastic olefin	TPO	Membranes, tunneling, roofing	Soft, flexibl, high mechanical resistance, long life time	

Plastic ingredients

carbon

hydrogen

oxygen

nitrogen

sulfur

chlorine

fluorine

silicon

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Welding paramters

- Temperature 
- Pressure 

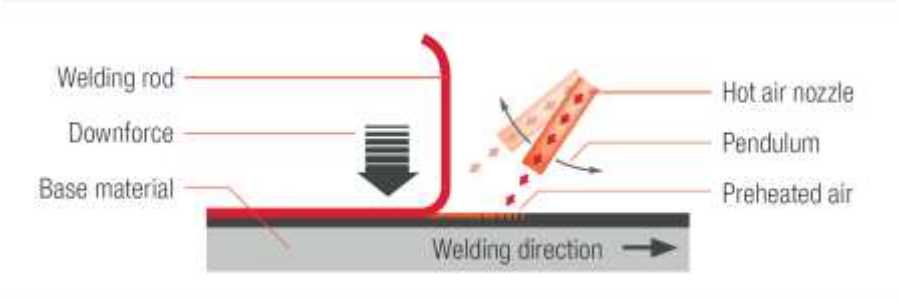
- Time 

Schweissqualität

High quality of the weld depends on the following aspects:

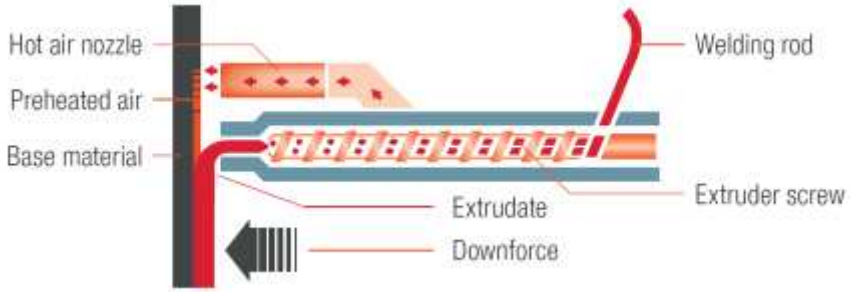
- material
- welding method
- welding equipment
- welding parameters
- ambient influences
- construction
- weld preparation
- welding skills

Welding methods



Pendulum Welding requires a welding rod similar to the base material. Both surfaces are then heated using hot air. Using an up and down, pendulum-like motion and consistent downward pressure, the two are joined.

Draw Welding (Speed Welding) requires the use of a speed welding nozzle. Preheat the surfaces to the appropriate temperature. The surfaces are plasticized by hot air and joined under consistent downward pressure.



Extrusion Welding preheats the substrate with hot air and connects the adding extrudate. The welding rod is fed into the heater barrel and the plast is processed by the extruder screw.

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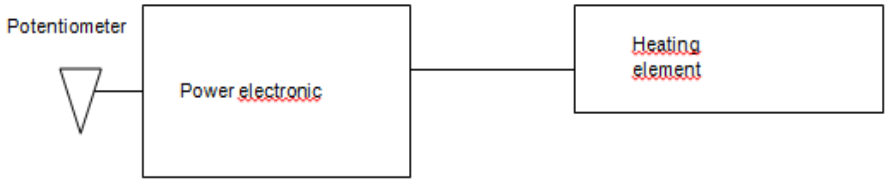
Equipment

hot air hand tools with external air

hot air hand tools with a built in fan

Equipment

Open loop system

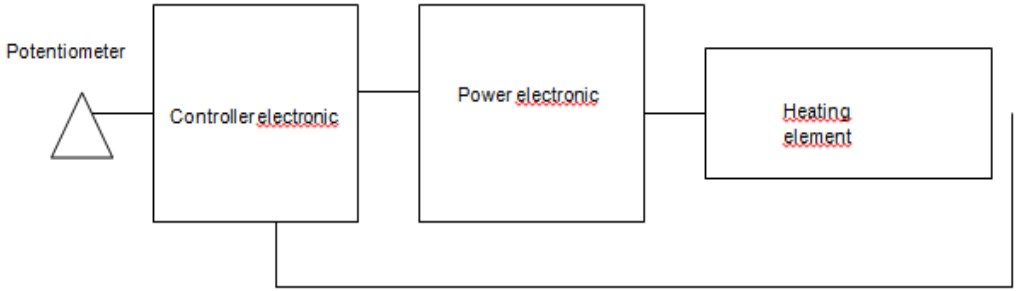


TRIAC ST

WELDING PEN S

DIODE S

Close loop system



TRIAC AT

WELDING PEN R

DIODE PID

Ausrüstung

MINOR

Small mobile blower for indoor and heavy duty use

ROBUST

Industrial blower, individual extenable

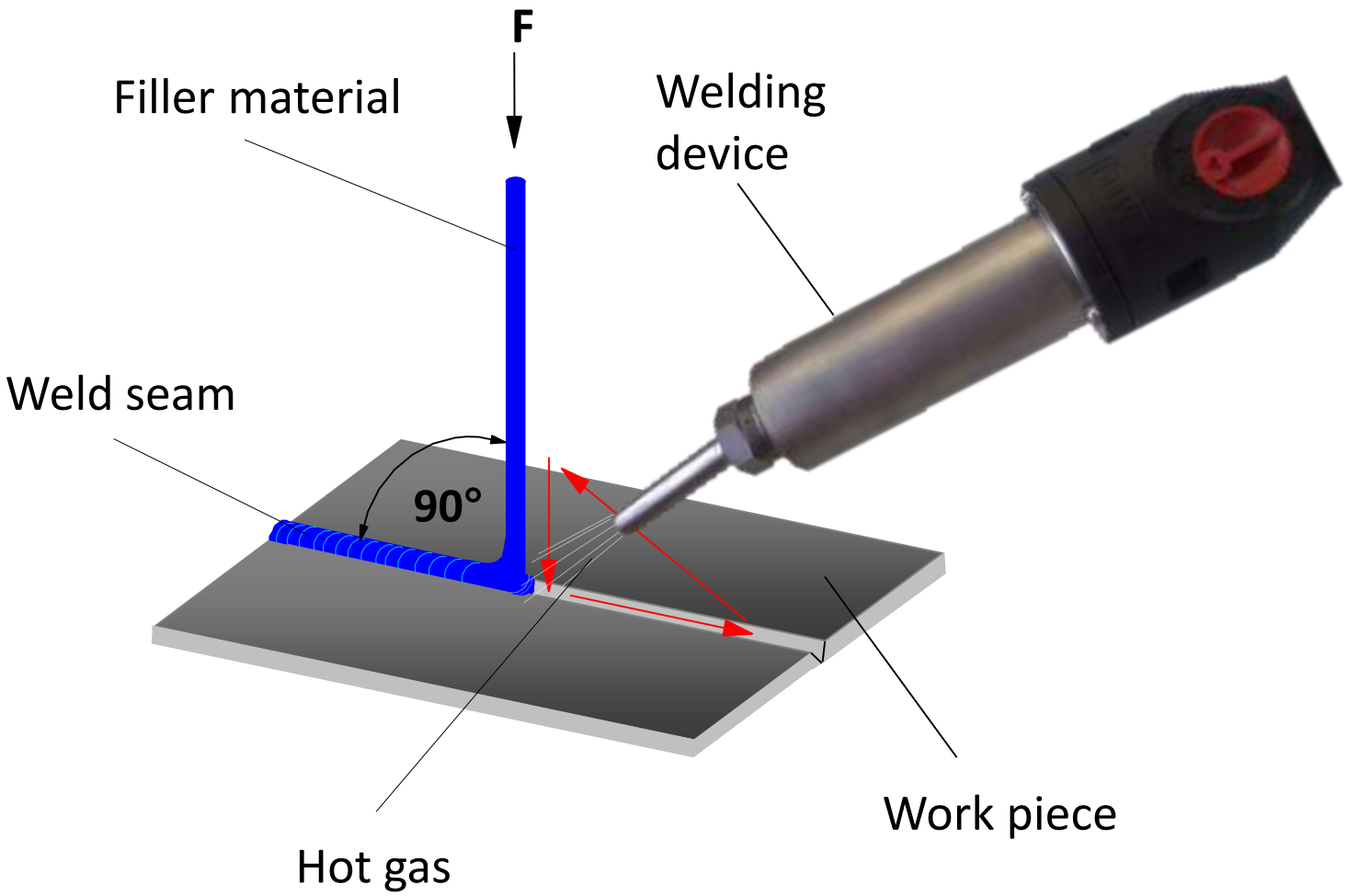
AIRSTREAM ST

All in one solution espetially for plastic fabrication

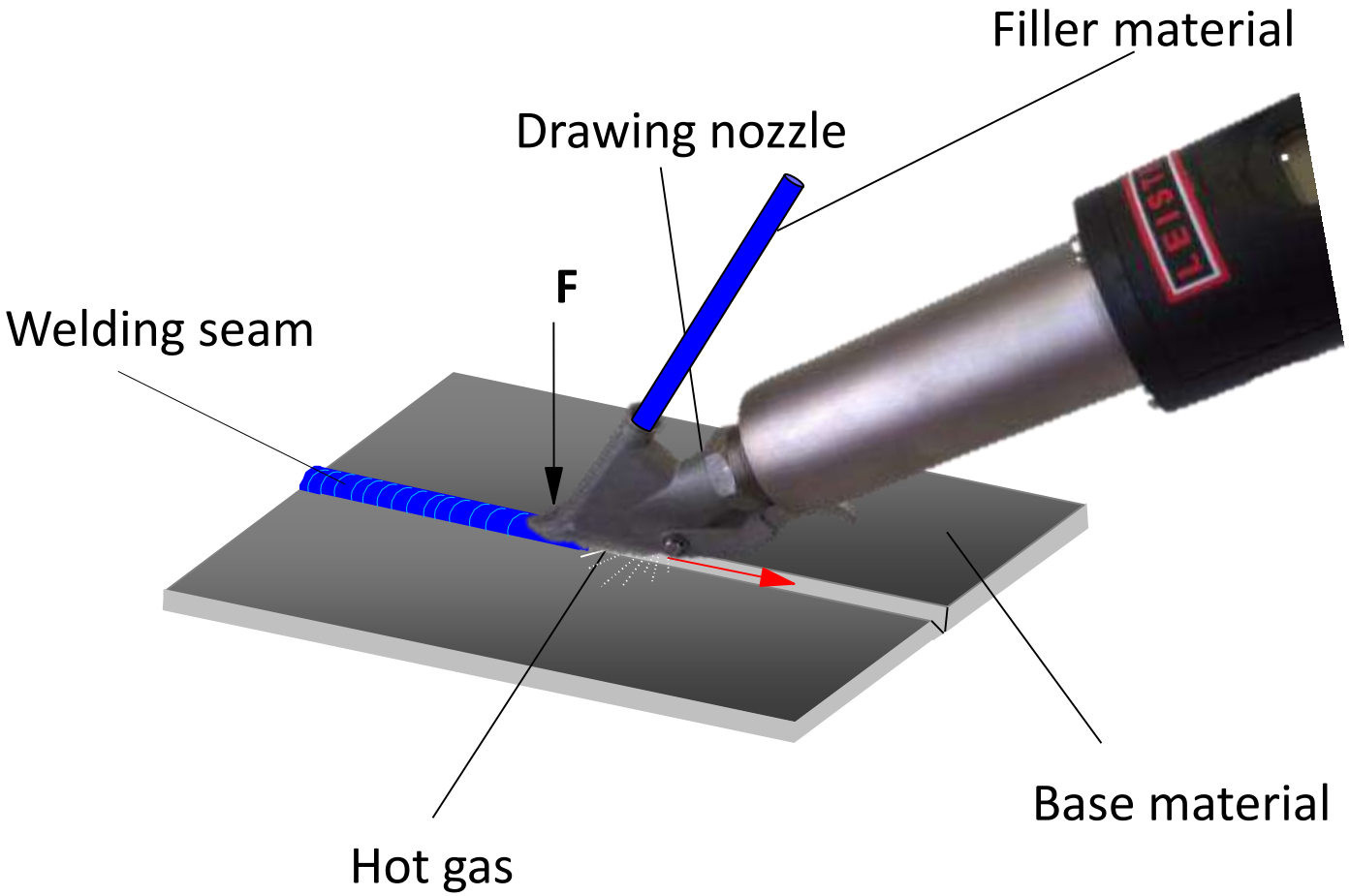
Compressed air / nitrogene

Expensive medium, need a lot of mantenance.

Pendulum Welding (free hand welding)



Draw Welding (Speed Welding)



Weld Preparation

The welding surfaces must be:

- dry, clean, oil- and grease-free
- free of loose shavings and
- free of notches

Joining surfaces, adjacent heat-affected zones and the filler rod must be scraped prior to welding

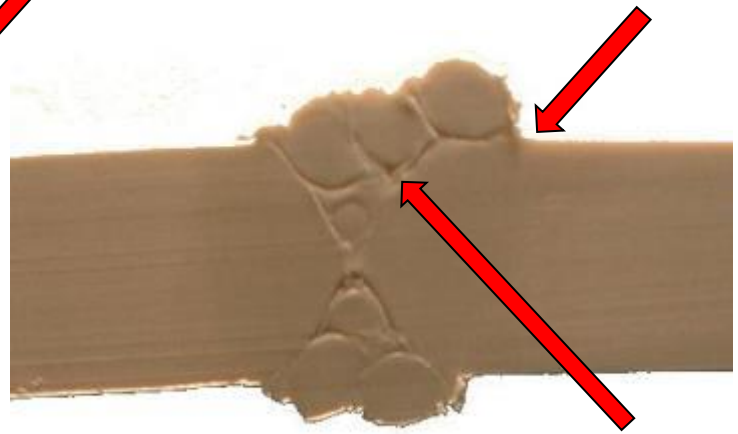
Parameters Draw and pendulum welding

Welding Process	Materials	Abbreviations	Hot gas temperature [1]	Hot gas volume flow [2]	Welding speed [3]	Welding force (N) with wire ø	
			°C	l/min	mm/min	3mm	4mm
Free hand welding (WF)	High-density polyethylene	PE-HD [4]	300 … 320	40 … 50	70 … 90	8 … 10	20 … 25
	Polypropylene, Types 1, 2, 3	PP-H; PP-B; PP-R	305 … 315	40 … 50	60 … 85	8 … 10	20 … 25
	Unplasticised polyvinyl chloride	PVC-U	330 … 350	40 … 50	110 … 170	8 … 10	20 … 25
	Chlorinated polyvinyl chloride	PVC-C	340 … 360	40 … 50	55 … 85	15 … 20	20 … 25
	Polyvinylidene fluoride	PVDF	350 … 370	40 … 50	45 … 50	15 … 20	25 … 30
	Acrylonitrile butadiene styrene	ABS [6]	350	N/A	N/A	N/A	N/A
	Polycarbonate	PC [6]	350	N/A	N/A	N/A	N/A
	Polyamide	PA [6]	400	N/A	N/A	N/A	N/A
	Polybutylene terephthalate	PBT [6]	350	N/A	N/A	N/A	N/A
	Low-density polyethylene	PE-LD [6]	270	N/A	N/A	N/A	N/A
	Polyurethane	PUR (Thermoplast) [6]	300	N/A	N/A	N/A	N/A
	XENOY	XENOY PC/PBTB [6]	350	N/A	N/A	N/A	N/A
	Plasticised polyvinyl chloride	PVC-P [6]	350	N/A	N/A	N/A	N/A
	Polyethylene terephthalate glycol-modified	PETG [6]	200 … 215	N/A	N/A	N/A	N/A
Draw welding (WZ)	Polyvinyl chloride	PE-HD [4]	300 … 340	45 … 55	250 … 350	15 … 20	25 … 35
	Polypropylene, Types 1, 2, 3	PP-H; PP-B; PP-R	300 … 340	45 … 55	250 … 350	15 … 20	25 … 35
	Unplasticised polyvinyl chloride	PVC-U	350 … 370	45 … 55	250 … 350	15 … 20	25 … 35
	Chlorinated polyvinyl chloride	PVC-C	370 … 390	45 … 55	180 … 220	15 … 25	30 … 35
	Polyvinylidene fluoride	PVDF	365 … 385	45 … 55	200 … 250	15 … 25	30 … 35
	Ethylene Chloro Tri Fluoro Ethylene	E/CTFE [5]	350 … 380 [5]	50 … 60 [5]	220 … 250	10 … 15	N/A
	Fluorinated ethylene propylene	FEP	380 … 390	50 … 60	60 … 80	10 … 15	N/A
	Tetrafluorethylen Perfluormethylvinylether	MFA	395 … 405	50 … 60	60 … 80	10 … 15	N/A
	Perfluoroalkoxy alkanes	PFA	400 … 410	50 … 60	70	10 … 15	N/A

Welding faults

Notch effect!

Overheated!



Notch effect!

Hollow chamber!

Advantages of Pendulum Welding and Draw Welding

- Low puchase costs
- Applicable for a wide variety of materials
  - Amorphous thermoplastics can also be processed very well with pendulum welding
- Very well applicable for detail work
  - Due to the small design of the units, even details that are difficult to access can be welded.

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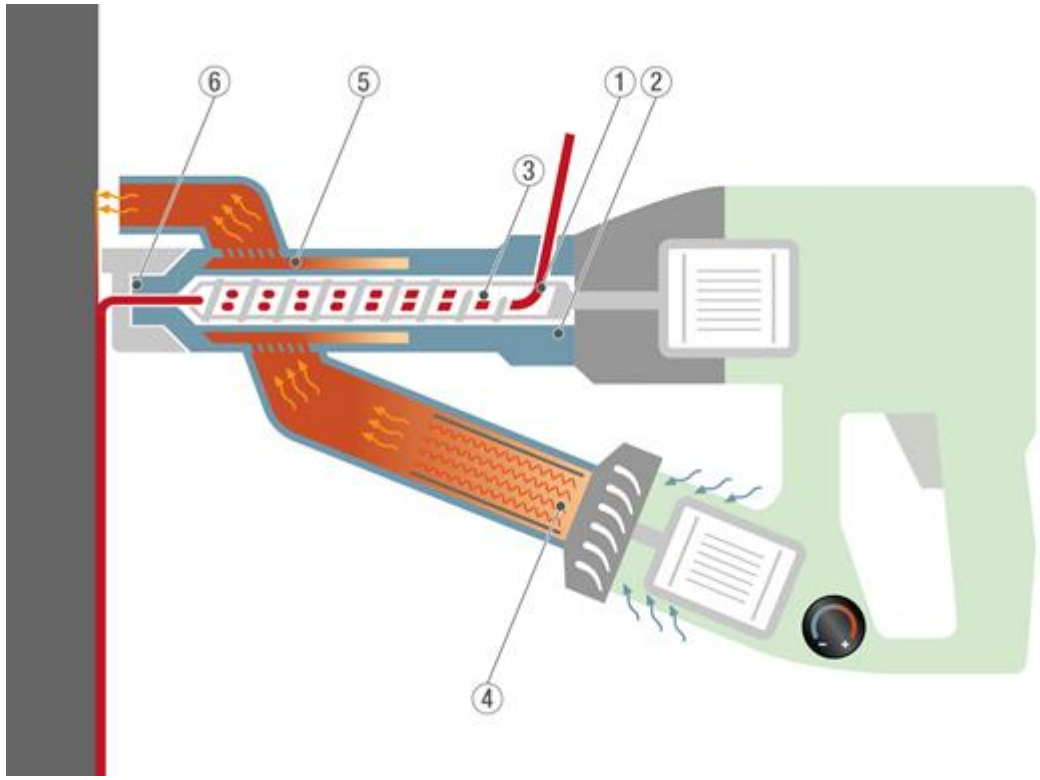
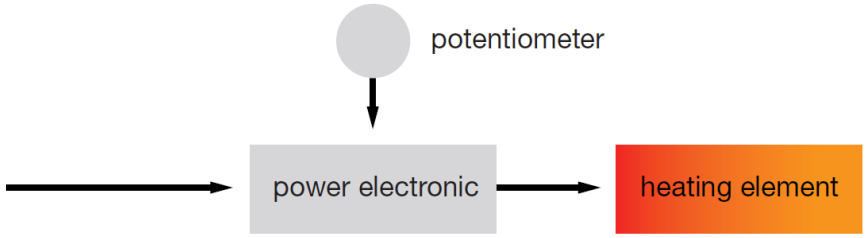
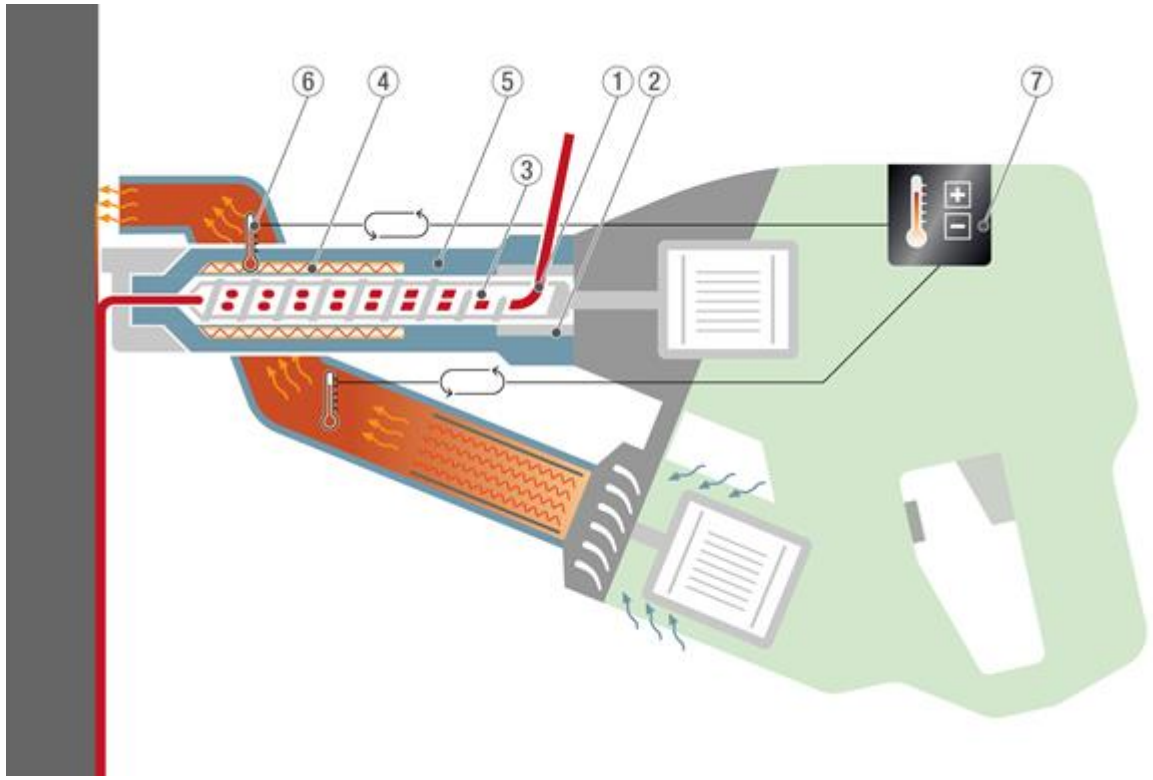
Screw Extruder with Hot Air Heating

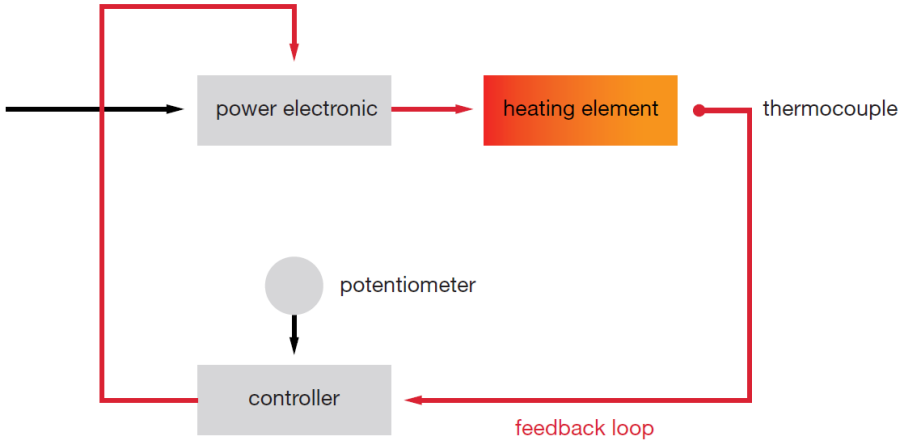




- Open-loop control
- Requires more welding experience
- Neither display nor temperature probe
- Temperature depends on environmental factors and voltage source

Screw Extruder with Electric Heating





- Closed-loop control
- Little welding experience required
- Integrated display and temperature probe
- Precise temperature independent of environmental factors or
- quality of voltage source -> process reliability
- DVS-compliant

Product comparion

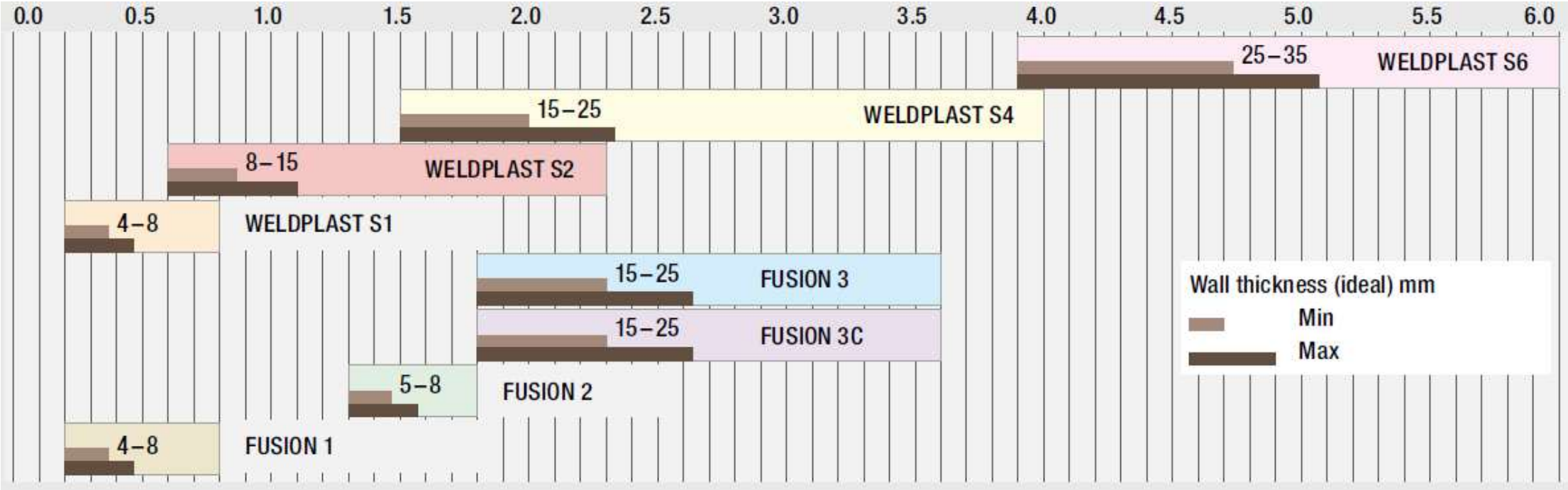
	Digitally regulated extrusion welders				Air heated extrusion welders			
								
Device type	WELDPLAST S6	WELDPLAST S4	WELDPLAST S2	WELDPLAST S1	FUSION 3	FUSION 3C	FUSION 2	FUSION 1
Output (HDPE) kg/hr	3.9 – 6	1.5 – 4	0.6 – 2.3	0.2 – 0.8	1.8 – 3.6	1.8 – 3.6	1.3 – 1.8	0.2 – 0.8
Material	HD-PE, PP	HD-PE, PP	HD-PE, PP, PVC	PE, PP, PVC, etc.	HD-PE, PP	HD-PE, PP	HD-PE, PP	PE, PP
Wall thickness mm	15 – 40	8 – 35	4 – 20	4 – 10	8 – 25	8 – 25	6 – 15	4 – 10
Welding rod ∅ mm	4 – 5	3 – 4 / 4 – 5	3 – 4	3 – 4	3 – 4 / 4 – 5	3 – 4 / 4 – 5	4	3 – 4
Weight kg	14	8.7	5.8	4.7	7.2	6.9	5.9	3.4
Length mm	821	560	450	435	690	588	450	435
Voltage V~	230	230	230	230 / 120	230	230	230	230
Screw extruder	yes	yes	yes	yes	yes	yes	yes	yes
Container construction	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
Pipeline construction	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓
Landfills / civil engineering	✓✓	✓✓	✓	❍	✓✓	✓	❍	❍
Brushless blower	yes	yes	yes	yes	no	no	no	no
Remarks	1	1	1	1	2	2	2	3

1: Air and Plast temperatures electronically controlled with integrated display.

2: Hot air heated extruder temperature controlled manually.

3: Hot air heated extruder, air temperature electronically controlled with integrated display.

Extruder selection



The choice of extruder size depends on sheet thickness, preheated air, weld geometry and dimension. Ideally, a maximum welding speed of 25 - 30cm/min should be aimed for.

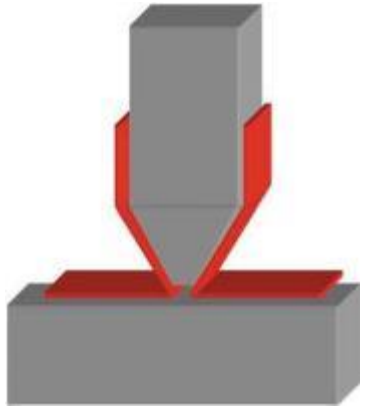
Advantages of Hot Air Extrusion Welding

- More economical than hot gas pendulum and drawing welding for larger welding seam geometries
  - Larger seam cross-section
- Fewer welding errors possible
  - usually only one welding layer
  - less notching effect
  - fewer cavities
- Less welding preparation
  - Welding wire must not be deoxidized

Weld Preparation

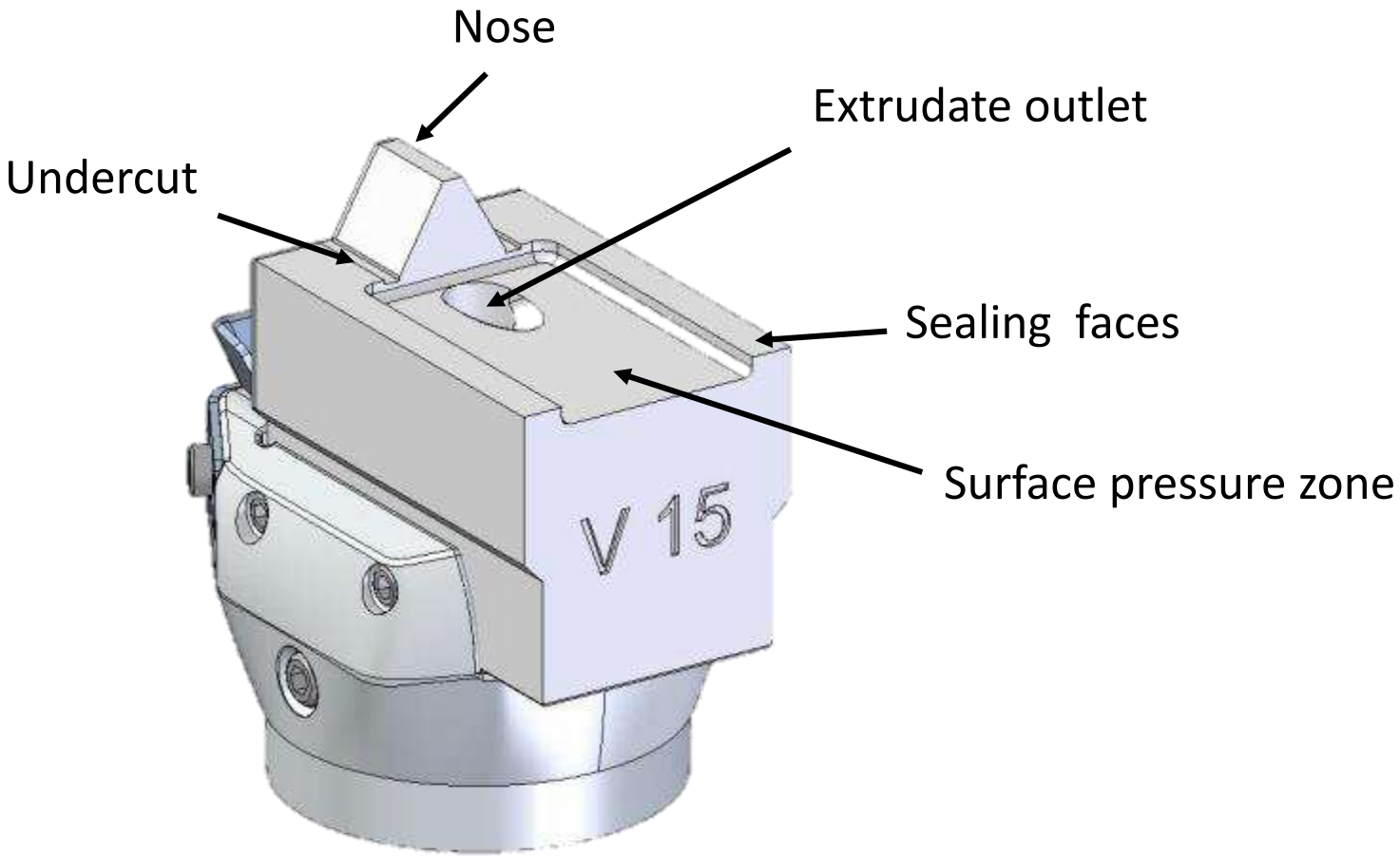
Die Schweißflächen müssen:

- dry, clean, oil- and grease-free
- free of loose shavings and
- free of notches

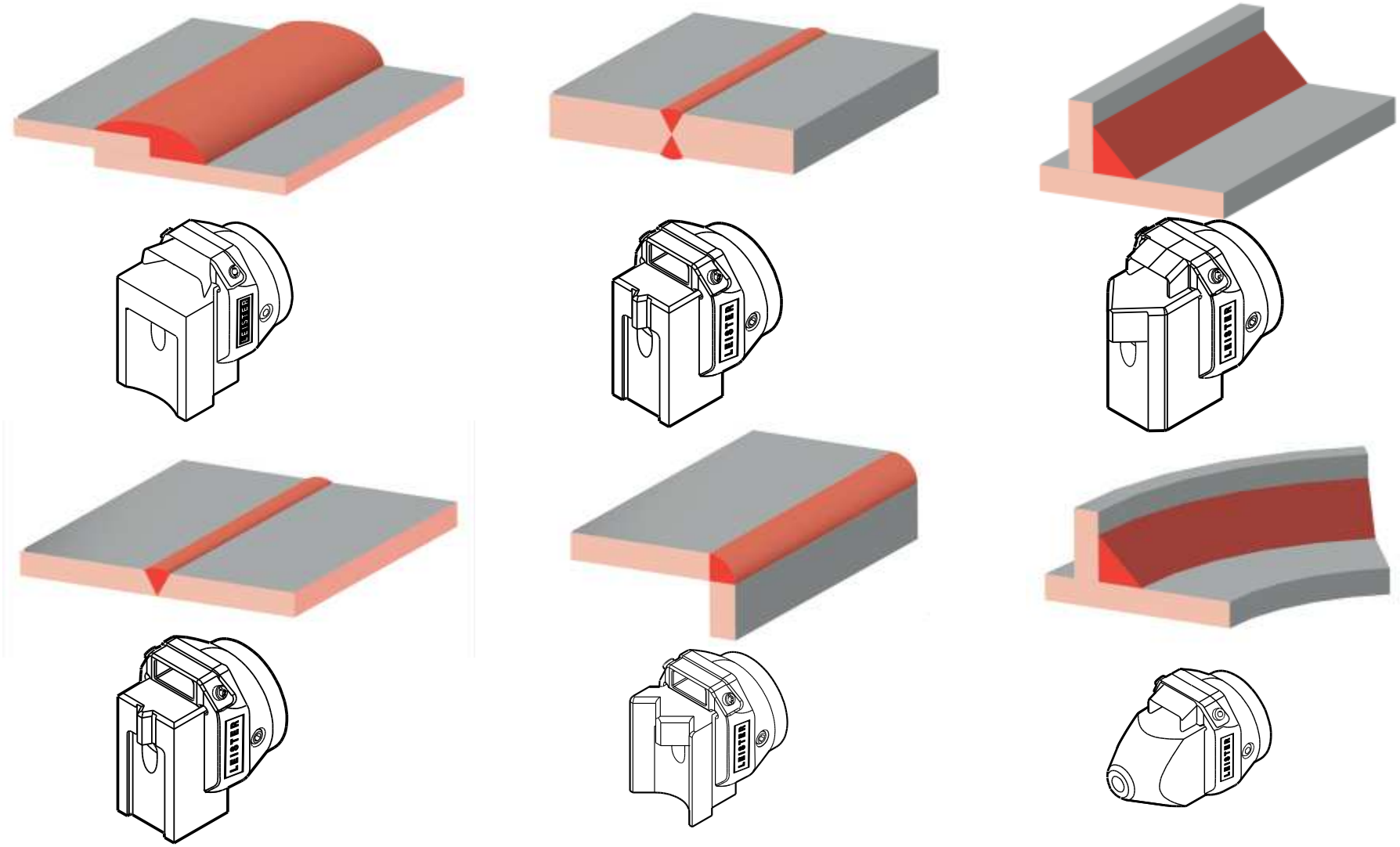


Joining surfaces, adjacent heat-affected zones must be scraped prior to welding

Welding Shoe Design



Weld types



Welding faults

Building of blowholes

- Plast temperature too high
- humidity in welding addition
- High ambient humidity
- or wet hands

Building of vacuoles

- cool down time to short

Rough surfaces on welding seam

- Welding shoe too short
- Cold welding shoe
- Rough surface on pressure zone

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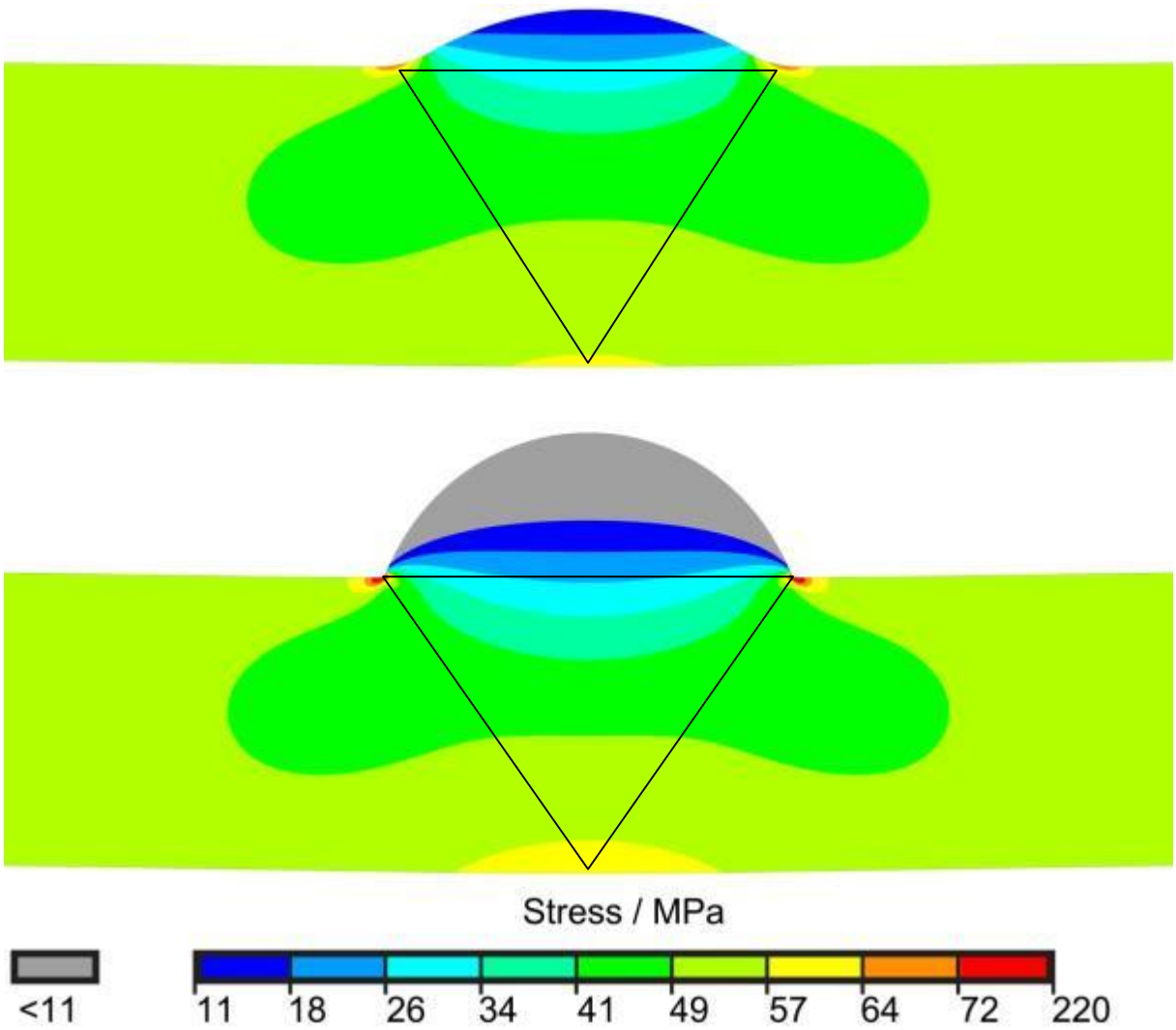
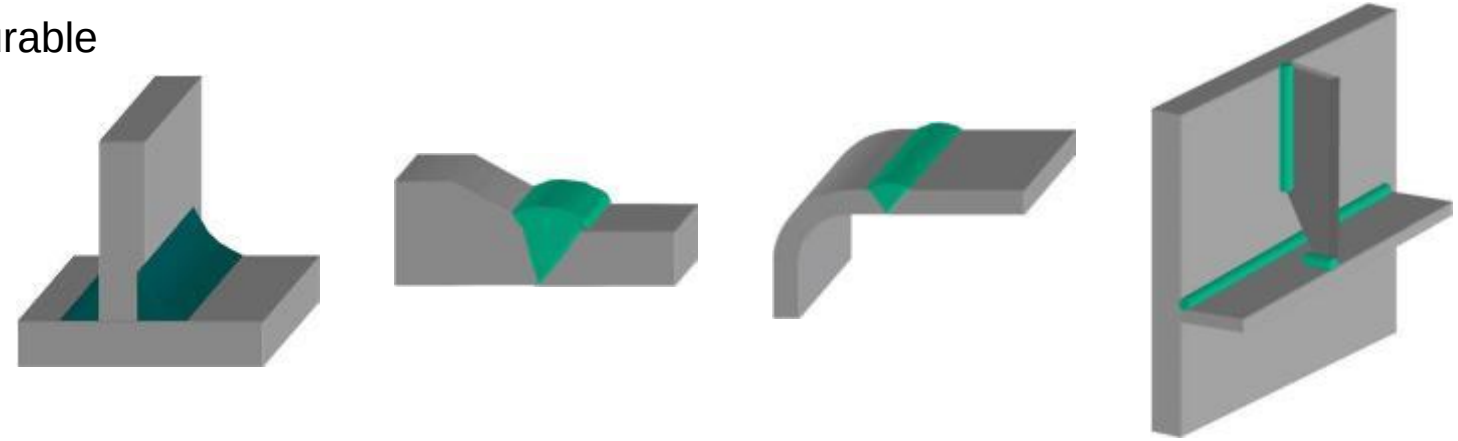
Force deflection & notch effect

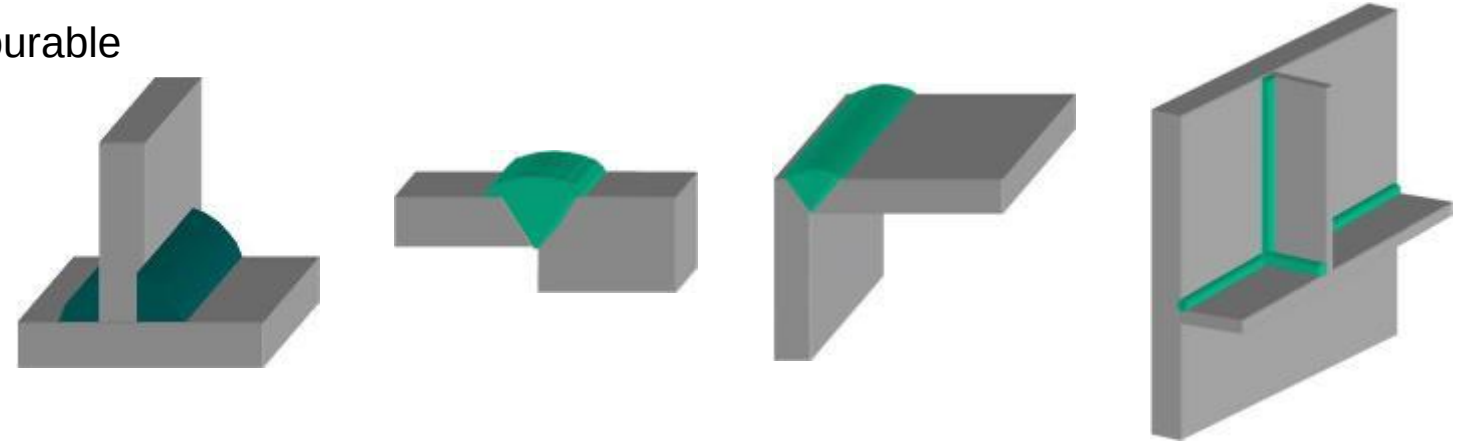


Design recommendation

favourable



unfavourable



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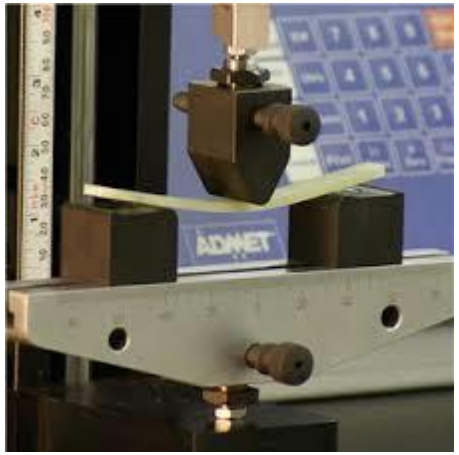
Non destructive tests

- Visual check
- Spark test
- Flooding

Destructive tests

- Tensile test
- Impact tensile test
- technological bending test



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