fast® SUITE
edition 2 focus on efficiency

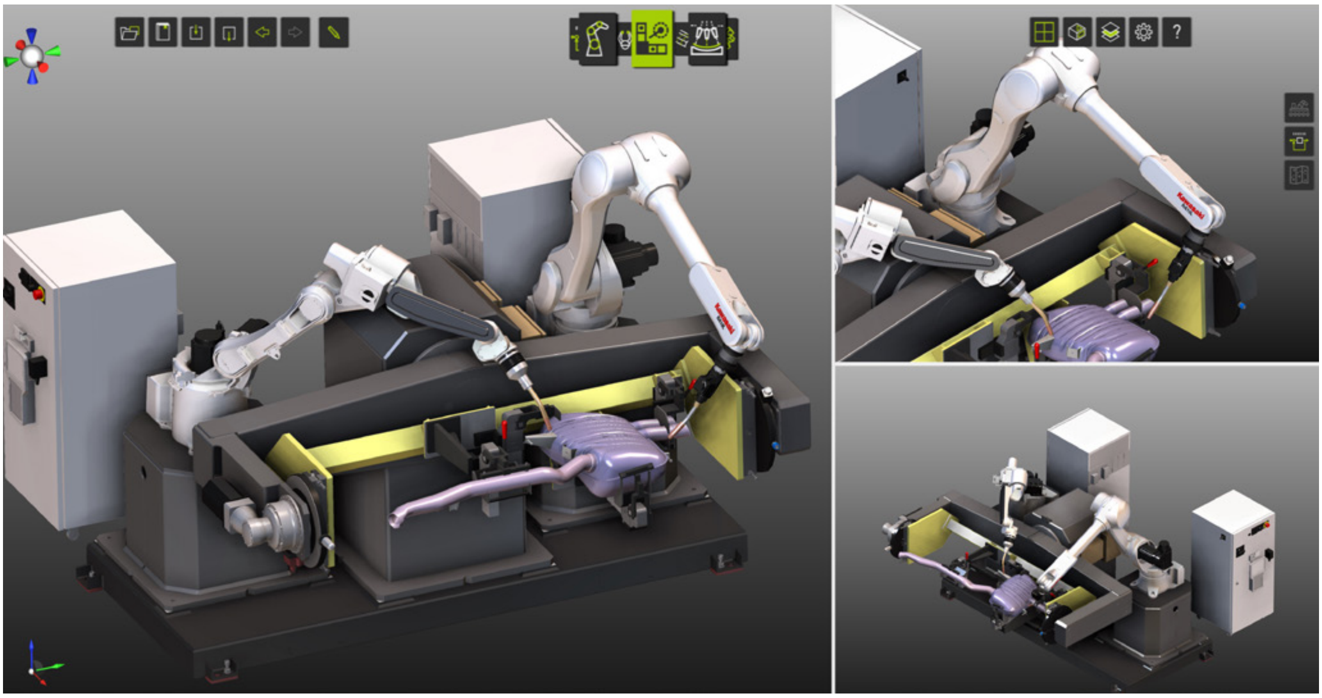
Ready – set – go

Offline programming of arc welding jobs with no downtime

cenit

Content

Offline Programming



The advantage of offline programming (OLP) over manual teaching of machinery is that it does not require any capacity of the production line. This provides an economic benefit especially in the manufacture of small batch sizes and complex components.

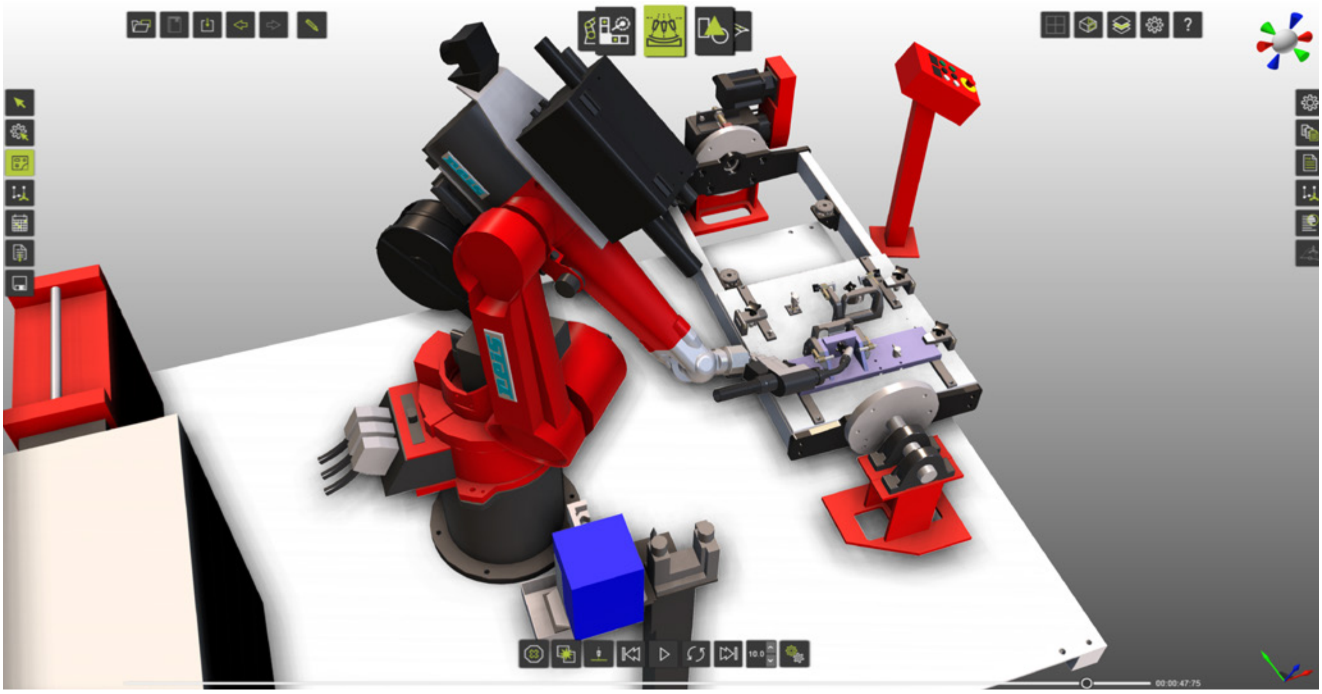
Arc welding is not only a traditional but a high-performance joining technique. Connection technology differentiates between procedures with melting electrodes (MIG/MAG) and non-melting electrodes (TIG). In practice, the terms “arc welding” and “path welding” are used as synonyms. When welding processes are automated using robots, manual teaching competes with offline programming.

In day-to-day operation, manual teaching is still the most commonly used form of programming. This method both requires extensive process knowledge and leaves the system unable to actively produce welds while teaching is in progress. While in manufacture of large quantities of simple parts this may potentially be profitable, the method is quite inefficient for small batch sizes and high variation of workpieces.

Offline programming with FASTSUITE Edition 2 offers an economical alternative. With this OLP software, all arc welding tasks can be programmed in a way that makes the difference for the user: programs can be created in hidden time, i.e. in parallel to ongoing production. The machine can thus continue working while the next workpiece is already being programmed.

The application of welding procedures is clearly predefined. Those who work with a low heat input, visible welding seams and who wish to avoid reworking, will normally use TIG welding. As the melting tungsten needle needs to be applied with high accuracy and minimum distance to the workpiece, TIG welding is not commonly found in automated systems. MIG/MAG welding, on the contrary, is easily automatable as long as the level of precision in prefabrication exceeds manual welding standards. Reworking the program online can be inevitable at times, but only to complete refinements. The use of reference points and precise tensioning systems further reduces reprocessing.

Offline Programming



The ability to simulate all kinds of manufacturing methods in **FASTSUITE Edition 2**, allows for a single source re-construction of complete process chains. In metal sheet forming this could for instance be an upstream bending process or downstream processing, all with customisable user interface of each controller.

FASTSUITE Edition 2 creates precise, faultless welding programs which produce smooth **high-quality welding seams**, independently of the welding application. Even scenarios of two or more robots working on one component simultaneously can be implemented with the software. The robots' working spaces are clearly defined by automatic collision monitoring and identification of intersecting working areas. FASTSUITE can then synchronise such routines with high process safety.

The software is designed to be scalable. In practice this means that programs for simple robotic welding jobs can be achieved as well as those for complex welding cell layouts with multiple robots and external axes.

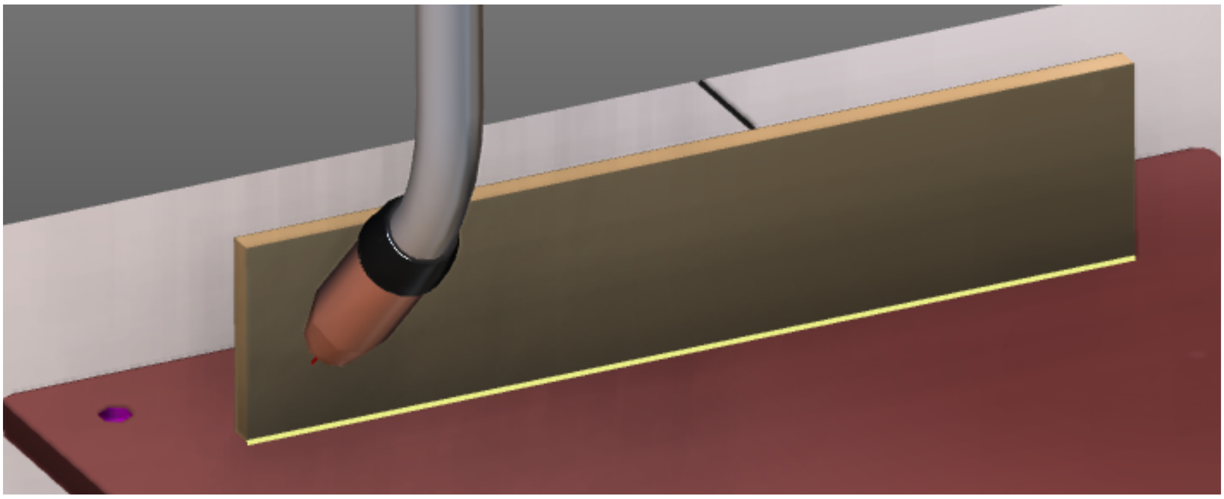
Extensive libraries are available for 3D simulation. Not only can the user find their robot in those libraries, but turn tables, clamping devices, torches and power supplies for welding applications are categorised and instantly accessible as well. An elegant way of customising the standard FASTSUITE software is through so-called 'plugin paths'. This allows for the standard installation to be clearly separated from customer-specific adjustments. For in reality, FASTSUITE is usually installed on respective local computers while the plugin paths are stored in the company's internal network. These plugins may for instance contain default settings and parameters determined for specific tasks. The separation of standard software and plugin paths facilitates the administration of offline programming tools.

CENIT has recently introduced an appealing extension: **additive manufacturing process** based on deposition welding. The highlight of this is the possibility to generate exercise and processing programs directly from CAD data of the workpiece.

Basic Welding Cycle

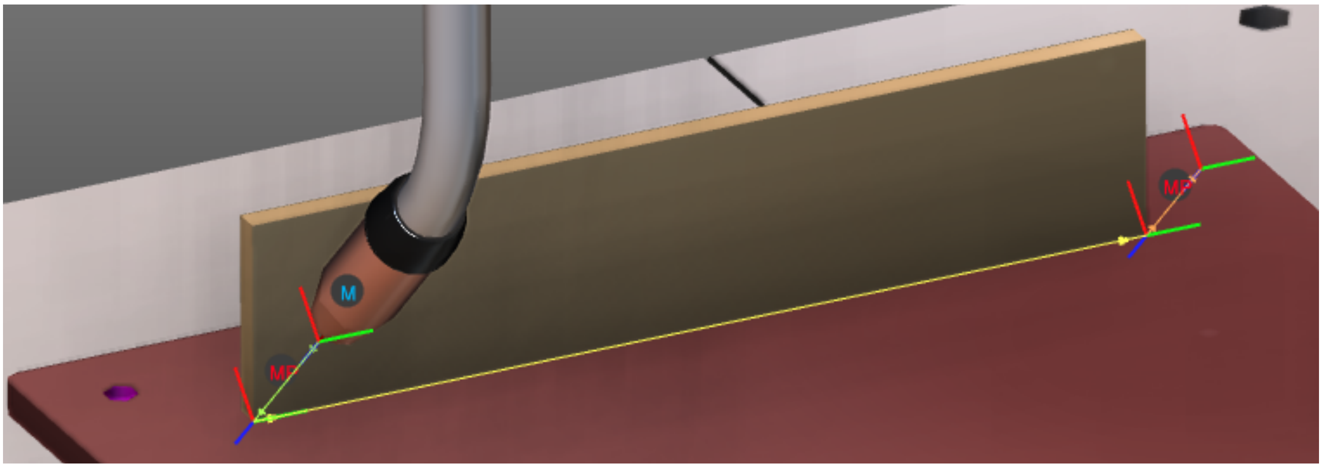
The "Basic Welding" method generates a welding cycle from an existing process geometry defined by any workpiece edge. The welding cycle consists of 3 stages:

- approach (one or two point approach)
- process (process start and end)
- retract (one or two point retract)



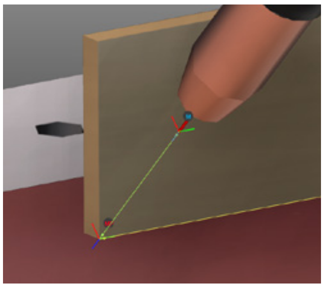
The cycle is controlled by technology attributes:

- process angle (work angle, travel angle, tool rotation)
- approach and retract distance
- speed and accuracy (for approach, process and retract section)



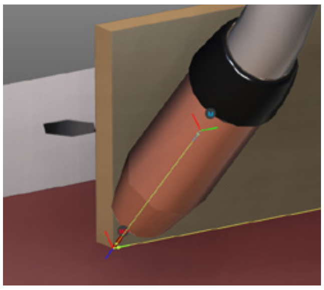
Basic Welding Cycle

The minimal "Basic Welding" cycle consists of 4 toolpath elements (points). The displayed attributes control the behavior of the toolpath. All attributes can be edited at any time. A change of any technology attribute triggers a recalculation of the toolpath.



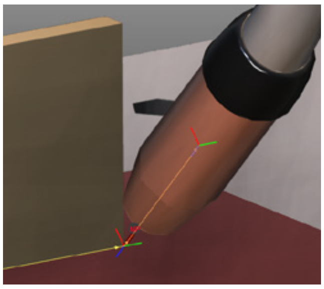
1. Approach

- distance
- motion type
- speed and accuracy event



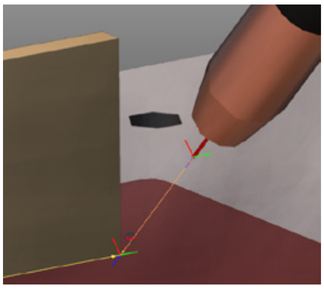
2. Process Start

- arc on event
- process speed and accuracy event



3. Process End

- arc off event
- accuracy event

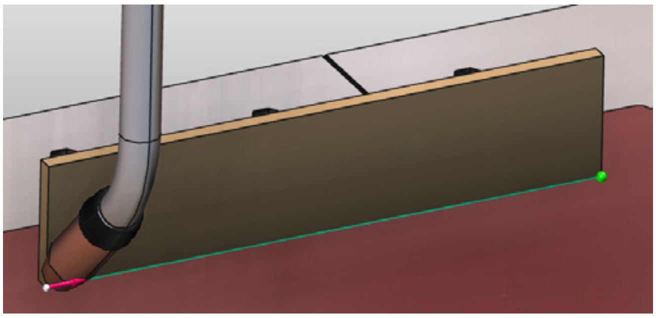


4. Retract

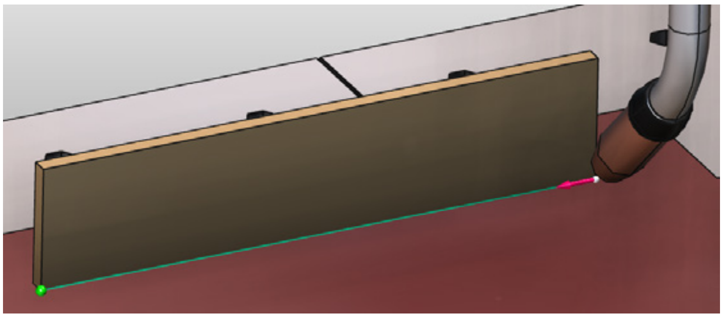
- distance
- motion type
- speed and accuracy event

Welding Direction

The direction can be set and changed via the process geometry. Changing the welding direction changes the complete cycle (approach, process start, process end and retract).



- left to right

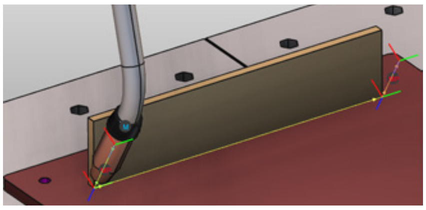
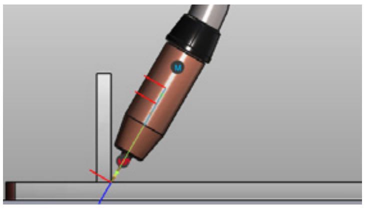


- right to left

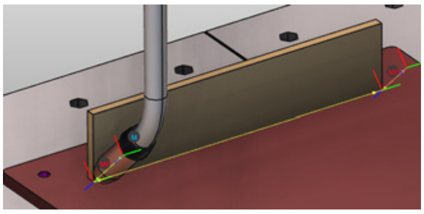
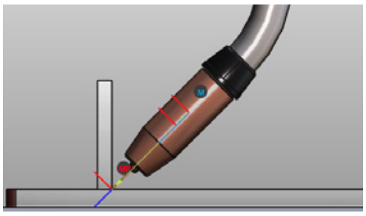
Basic Welding Cycle

Work Angle

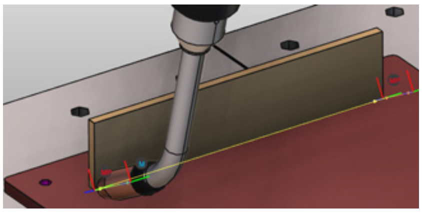
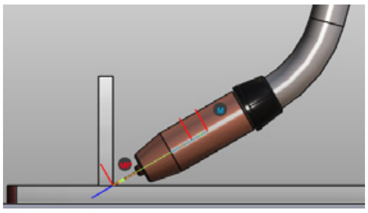
The work angle can be set and changed via the technology attribute “work angle”. Changing the “work angle” changes the complete cycle (approach, process start, process end and retract).

- work angle = 30°

- work angle = 45°

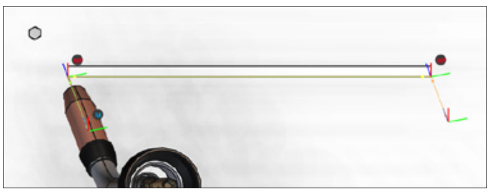
- work angle = 60°

Travel Angle

The travel angle can be set and changed via the technology attribute “Travel angle”. Changing the “Travel angle” changes the complete cycle (Approach, process start, process end and retract).

- travel angle = -15°

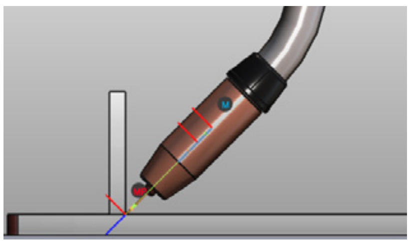
- travel angle = 0°



- travel angle = 15°

IMPORTANT:
Changing the travel angle will not change the work angle!

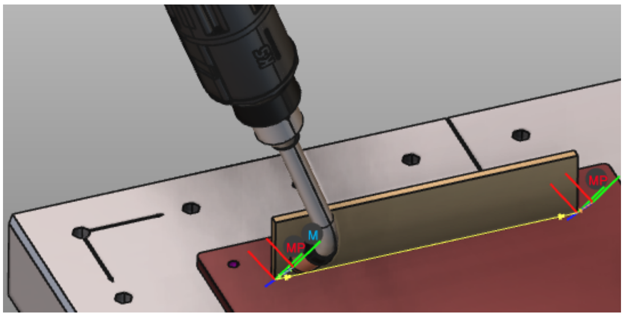
Work angle for all 3 examples = 45°



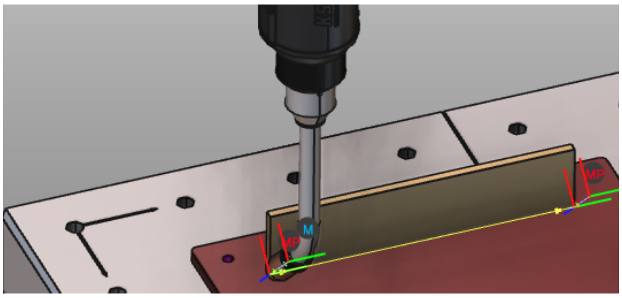
Basic Welding Cycle

Tool Rotation

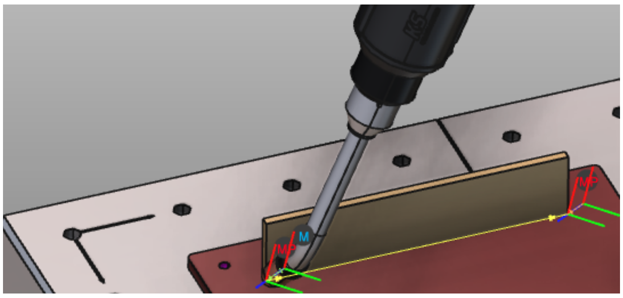
The tool rotation can be set and changed via the technology attribute “tool rotation”. Changing the “tool rotation” changes the rotation about the “normal” direction in all tool path elements from the complete cycle.



- tool rotation = 120°



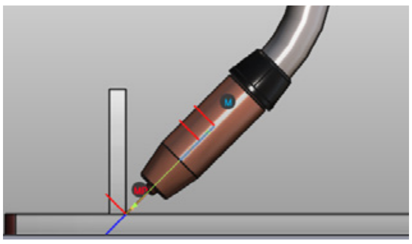
- tool rotation = 90°



- tool rotation = 60°

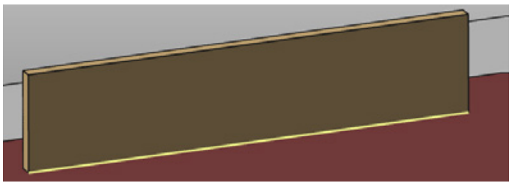
IMPORTANT:

Changing the tool rotation will not change the work or travel angle!
For all 3 examples work angle = 45°, travel angle = 0°



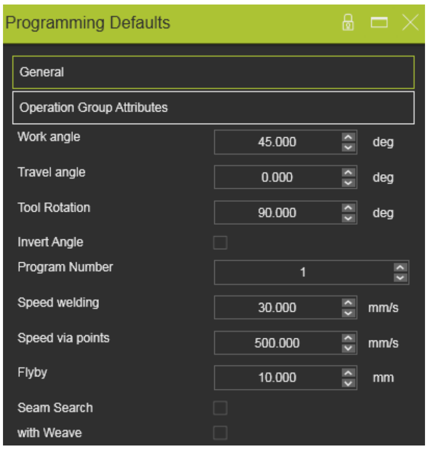
Basic Welding Cycle

How it works – Overview

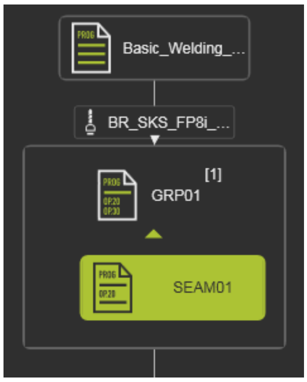


Process Geometry
- workpiece edge with normal and tangent direction

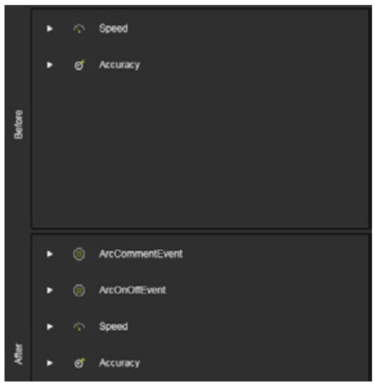
Arc Welding Technology – Method: Basic Welding
- attributes
- events

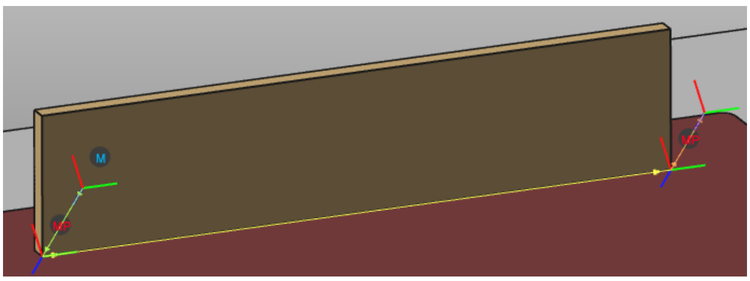


Generate Operation
- transfer programming default attributes to the operation



Toolpath Compute
- tp element and event creation





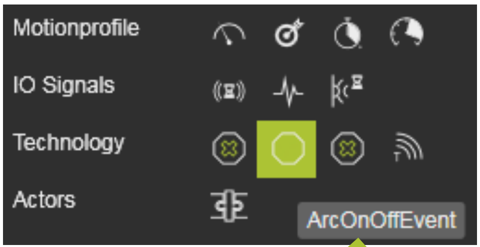
Basic Welding Cycle

Events

Each technology has its own events. The Arc Welding Technology provides the “ArcOnOffEvent”.

All available Events

- common events (speed, acceleration, accuracy, dwell, wait for signal, set signal, wait for sensor, adaptor actor)
- technology events (ArcOnOff)



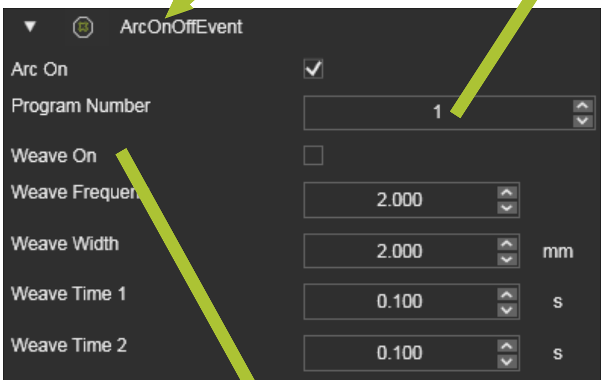
Program Number

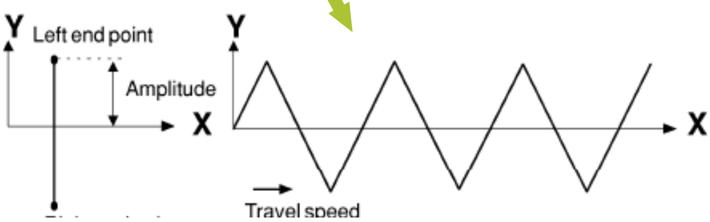
Currently, the most commonly used communication between robot and power source is being used:

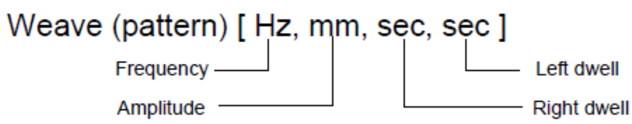
- The robot sends the program number (1, 2, 3, …) to the power source.
- The arc welding process data are stored in the power source (process curve, wire feed speed, gas preflow time, …).
- The process data are called up via the program number.

ArcOnOff Event

- Arc On (1 = On / 0 = Off)
- Program Number (1, 2, 3, …)
- Weave On (1 = On / 0 = Off) If Weave is On: Weave “Pattern” attributes

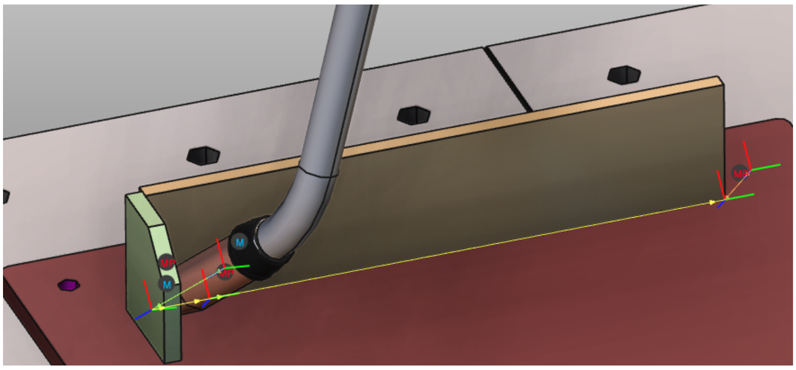






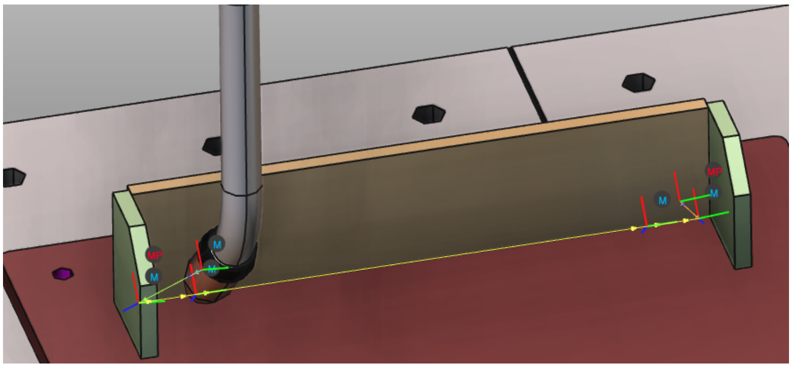
Box Welding Cycle

The "Box Welding" method expands the basic welding cycle. The welding adjustment in corners must be different to the rest of the seam.The welding cycle consists of 4 or 5 stages depending on the constraints.



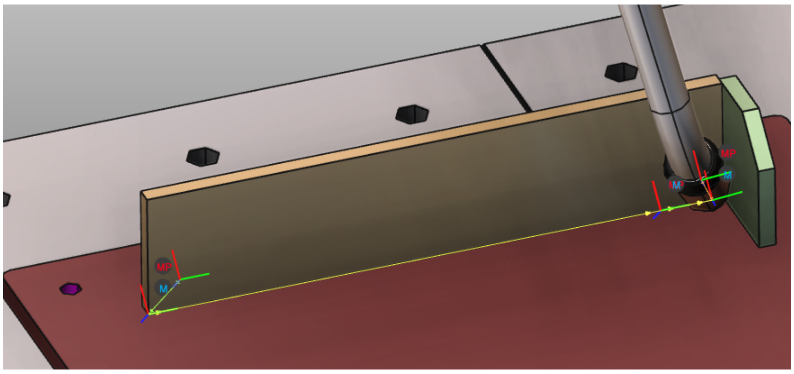
Corner at the Start Point

- approach (one or two point approach)
- process start (limited adjustment)
- process (optimal adjustment until end)
- retract (one or two point retract)



Corner at Start and End Point

- approach (one or two point approach)
- process start (limited adjustment)
- process (optimal adjustment)
- process end (limited adjustment)
- retract (one or two point retract)

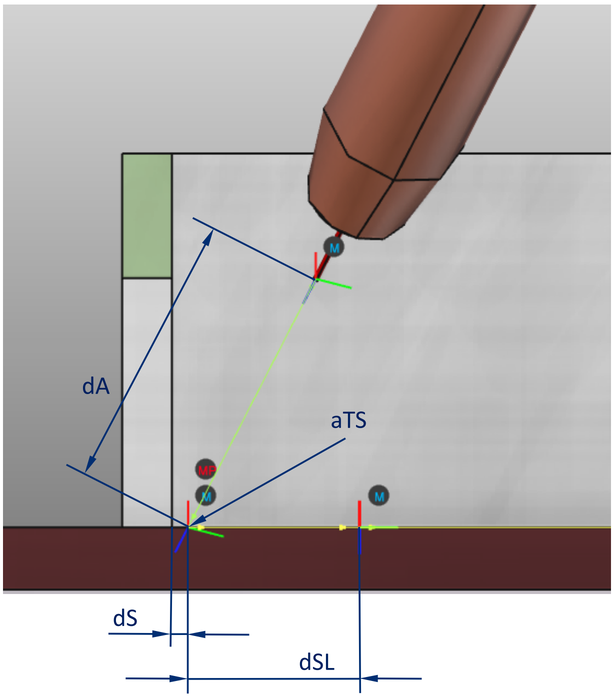


Corner at the End Point

- approach (one or two point approach)
- process start (limited adjustment)
- process (optimal adjustment until end)
- retract (one or two point retract)

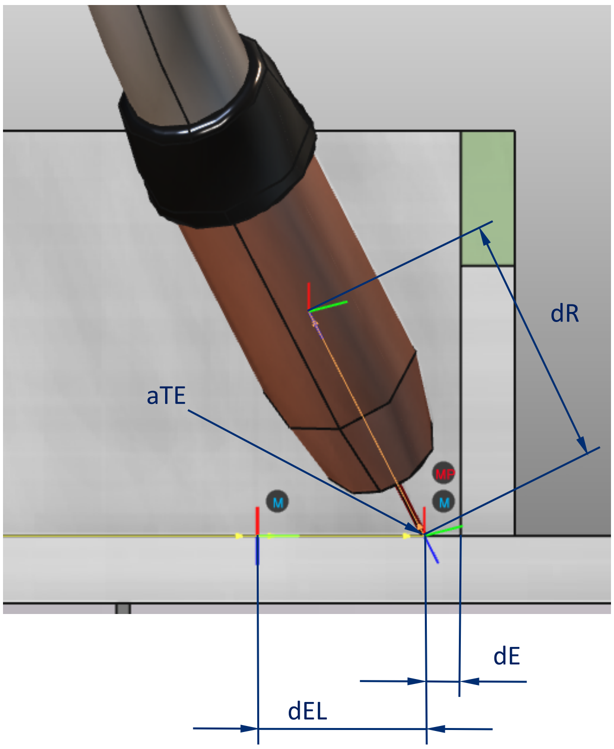
Box Welding Cycle

The minimal "Box Welding" cycle with a corner at start and end point consists of 6 toolpath elements (points). The displayed attributes control the behavior of the toolpath. All attributes can be edited at any time. A change of any technology attribute triggers a recalculation of the toolpath.



Corner at the Start Point

- da = approach distance
  (example one point approach)
- ds = start point distance
  (to avoid a collision, the start point can be moved out of the corner)
- ats = travel angle start point
  (to define the limited adjustment at the start point)
- dsl = Start Length (distance from limited adjustment to optimal adjustment)



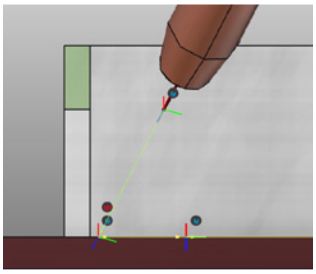
Corner at End Point

- del = End Length
  (distance from limited adjustment to optimal adjustment)
- ate = travel angle end point
  (to define the limited adjustment at the end point)
- de = end point distance
  (to avoid a collision, the end point can be moved out of the corner)
- dr = retract distance
  (example one point retract)

Box Welding Cycle

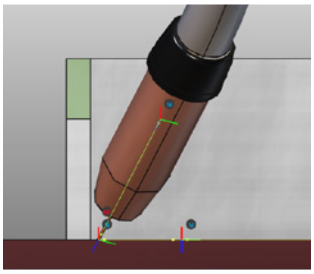
Attribute Overview

With the following attributes the work method “Box Welding” generates a tool path by a selected process geometry (workpiece edge):



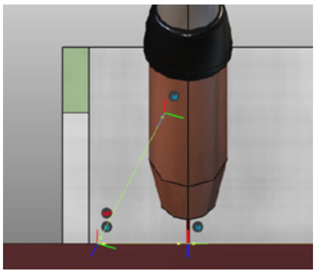
1. Approach

- distance
- motion type
- speed and accuracy



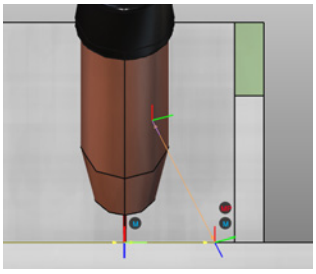
2. Process Start (limited)

- start point distance
- travel angle start point
- arc on
- process speed and accuracy



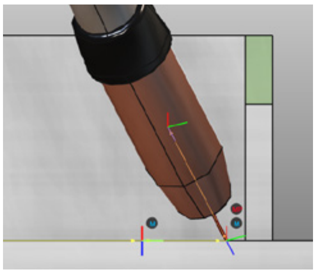
3. Process (optimal)

- start length
- work angle, travel angle and tool rotation are defined by the cycle (operation attributes)



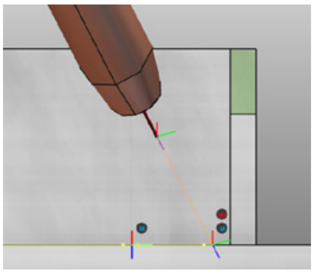
4. Process (optimal)

- end length



5. Process End (limited)

- travel angle end point
- end point distance
- arc off
- accuracy

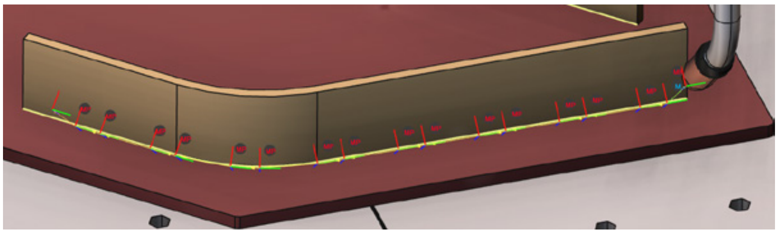


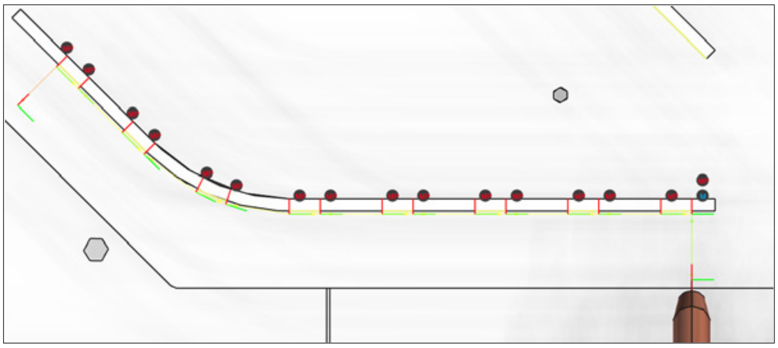
6. Retract

- distance
- motion type
- speed and accuracy

Stitch Welding Cycle

The "Stitch Welding" method expands the "Basic Welding" cycle. The work method "Stitch Welding" produces several seams on one selected process geometry (workpiece edge). The tool path can be generated and edited by different "Recipes".





Example

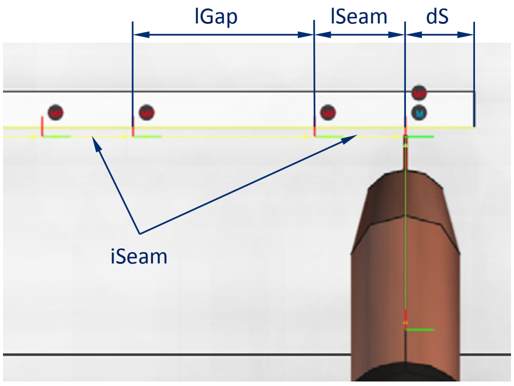
The pictures shows one "Stitch Welding" operation.

The technology attributes are

- work angle = -45°
- travel angle = 0°
- tool rotation = -90°

The Recipe attributes are

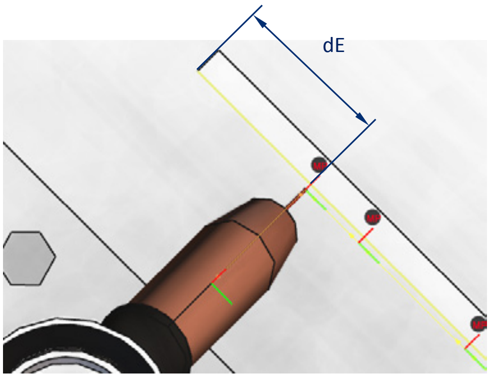
- start point distance dS = 15 mm
- seam length lSeam = 20 mm
- numbers of seam iSeam = 8
- gap length lGap = 40 mm



Recipe 1:

- Input of start point distance (dS)
- Input of seam length (lSeam)
- Input of number of seams (iSeam)
- Input of gap length (lGap)

➔ distance between end point of the tool path and end point of the process geometry is calculated (dE)



Recipe 2:

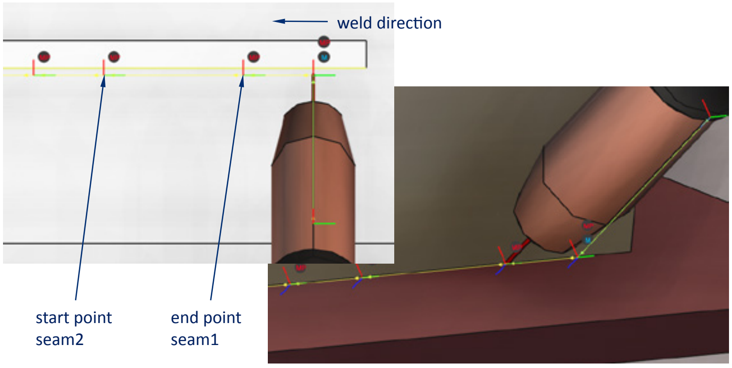
- Input of start point distance (dS)
- Input of seam length (lSeam)
- Input of number of seams (iSeam)
- Input of end point distance (dE)

➔ gap length is calculated (lGap)

Stitch Welding Cycle

The work method "Stitch Welding" offers 3 possibilities to move from seam to seam:

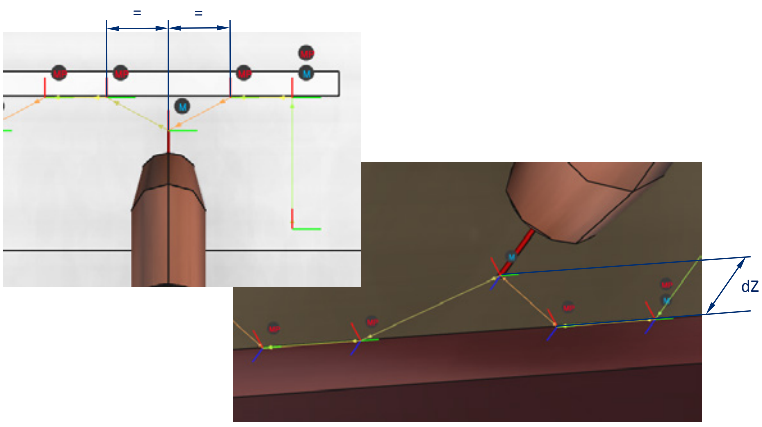
- no connect
- one point connect
- two point connect
- for all connections the motion type between two seams is "linear"
- the user can define a "via speed" over the operation attribute



No connect:

The technology calculates no connection point.

All events (arc event, speed event, accuracy event) and operation attributes (work angle, travel angle, ...) will be "rule based" applied by the technology (see description "Basic Welding").

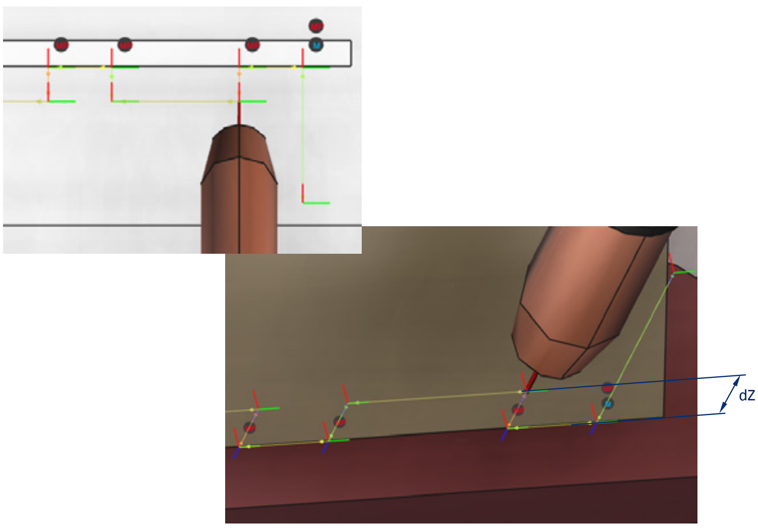


One point connect:

The technology calculates one connection point between two seams (between end point seam1 and start point seam2).

The user can set a distance in normal direction (dZ).

All events (arc event, speed event, accuracy event) and operation attributes (work angle, travel angle, ...) will be "rule based" applied by the technology (see description "Basic Welding").



Two point connect:

The technology calculates two connection points:

- one connect point with distance "dZ" at the end point of seam1
- one connect point with distance "dZ" at the start point of seam2

The user can set a distance in normal direction (dZ).

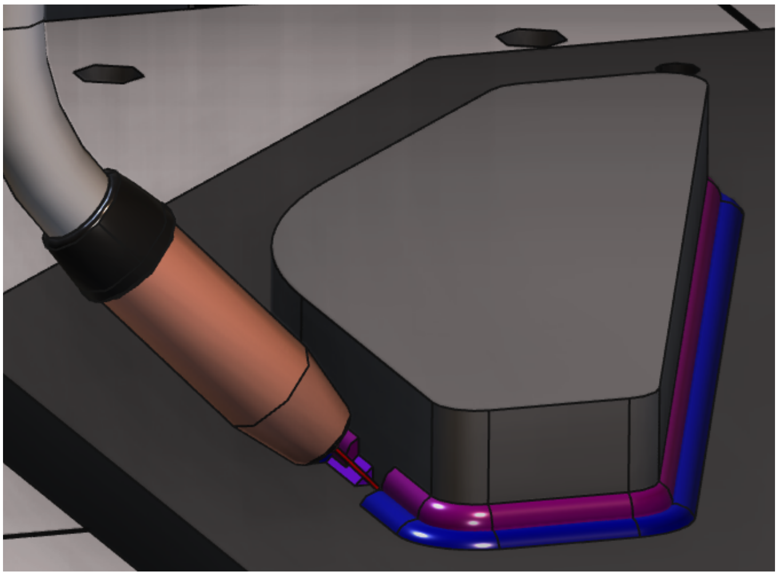
All events (arc event, speed event, accuracy event) and operation attributes (work angle, travel angle, ...) will be "rule based" applied by the technology (see description "Basic Welding").

Multi Layer Welding

The "Multi Layer Welding" method expands the basic welding cycle. The work method "Multi Layer Welding" produces several seams on one or multiple selected process geometries (workpiece edge). The tool path can be generated and edited by different "Recipes".

Example:

The pictures shows one "Multi Layer Welding" operation



The technology attributes are

- travel angle = 0°
- travel angle = -90°

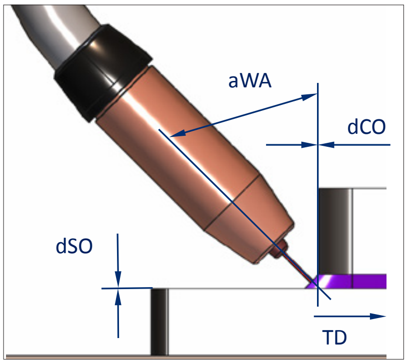
The Recipe attributes are

- number of layer ilayer = 3
- offset layer 1 (cutter comp. / sheet offset) = 0 / 0 mm
- work angle layer 1 = 45° / travel direction = in PG dir.
- offset layer 2 (cutter comp. / sheet offset) = 1.5 / 5 mm
- work angle layer 2 = 55° / travel dir. = reversed
- offset layer 3 (cutter comp. / sheet offset) = 5 / 1.5 mm
- work angle layer 3 = 30° / travel direction = in PG dir.

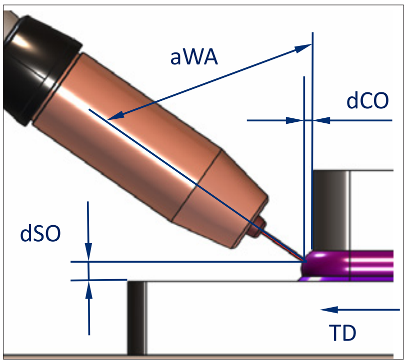
Recipe 1 (Welding Layer by Layer for each Seam – bidirectional / unidirectional) Each Layer has its own attributes:

- work angle (aWA)
- offset in normal direction of the process geometry (sheet offset dSO)
- offset perpendicular to the normal direction (cutter compensation dCO)
- travel direction (same as process geometry / reversed TD)

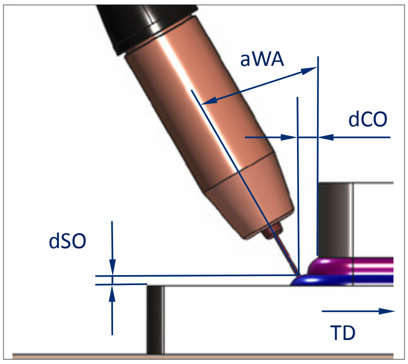
Layer 1 (Root)



Layer 2



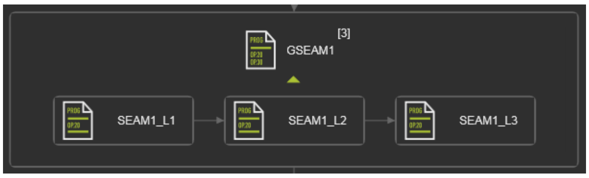
Layer 3

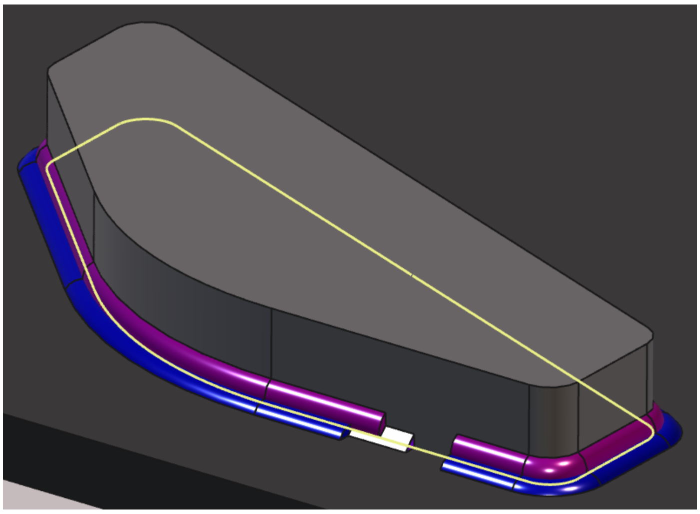


Multi Layer Welding

Recipe 1 (Welding Layer by Layer for each Seam – bidirectional / unidirectional) FASTSUITE Edition 2 Structure:

- Recipe 1 generates one operation group for each selected process geometry.
- Each layer is one operation within the group.



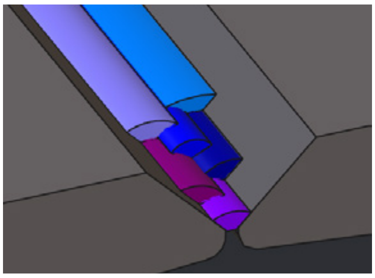


Example

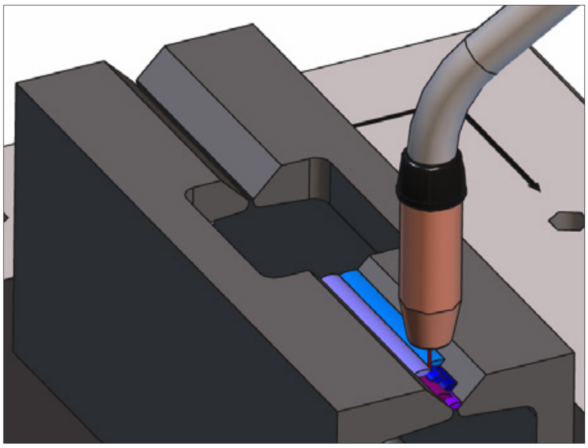
1 Process geometry = 1 Operation Group (GSEAM1) with 3 Operations (SEAM1_L1, SEAM1_L2, SEAM1_L3), bidirectional

Recipe 2 (Welding Seam by Seam for each Layer – bidirectional / unidirectional) each Layer has its own attributes:

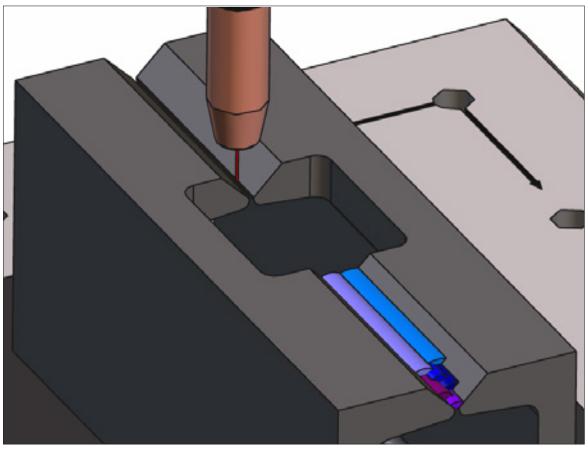
- work angle (aWA)
- offset in normal direction of the process geometry (sheet offset dSO)
- offset perpendicular to the normal direction (cutter compensation dCO)
- travel direction (same as process geometry / reversed TD)



Seam 1 Layer 1 (Root)



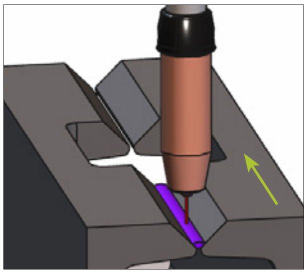
Seam 2 Layer 1 (Root)



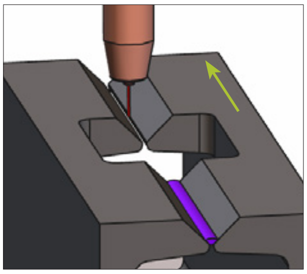
Multi Layer Welding

Recipe 2

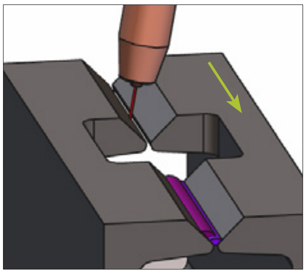
(Welding Seam by Seam for each Layer – Example 2 Seams, 4 Layers, bidirectional)



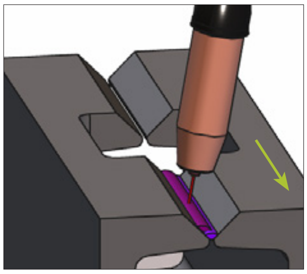
Seam 1 Layer 1
(Root)



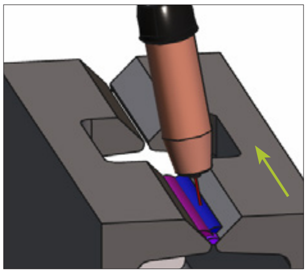
Seam 2 Layer 1
(Root)



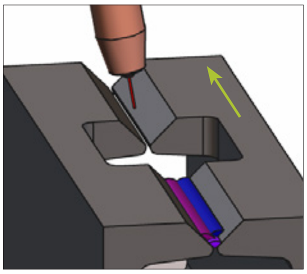
Seam 2 Layer 2



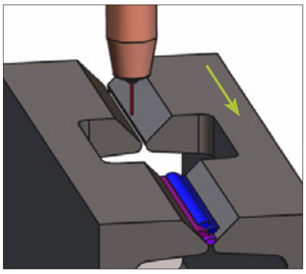
Seam 1 Layer 2



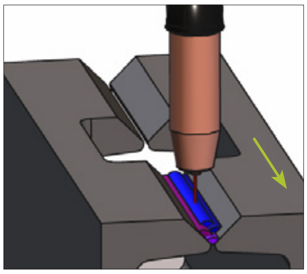
Seam 1 Layer 3



Seam 2 Layer 3



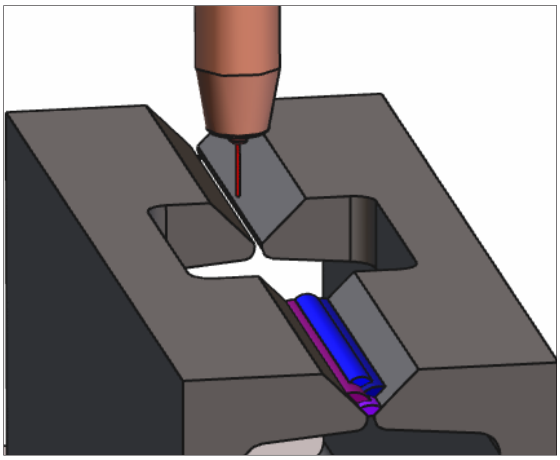
Seam 2 Layer 4

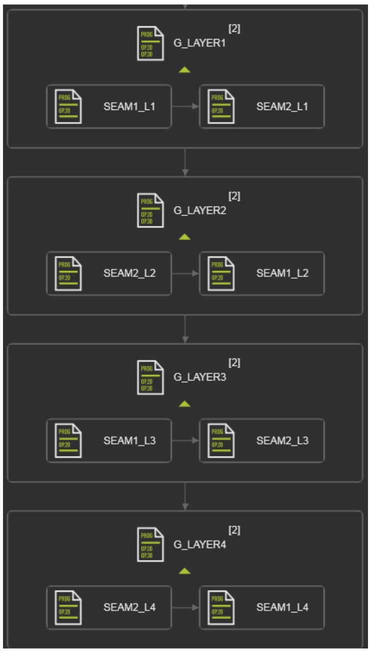


Seam 1 Layer 4

Recipe 2 (Welding Seam by Seam for each Layer – Example 2 Seams, 4 Layers, bidirectional) FASTSUITE Edition 2 Structure:

- Recipe 2 generates one operation group for each layer.
- Each selected process geometry (seam) is one operation within the group.





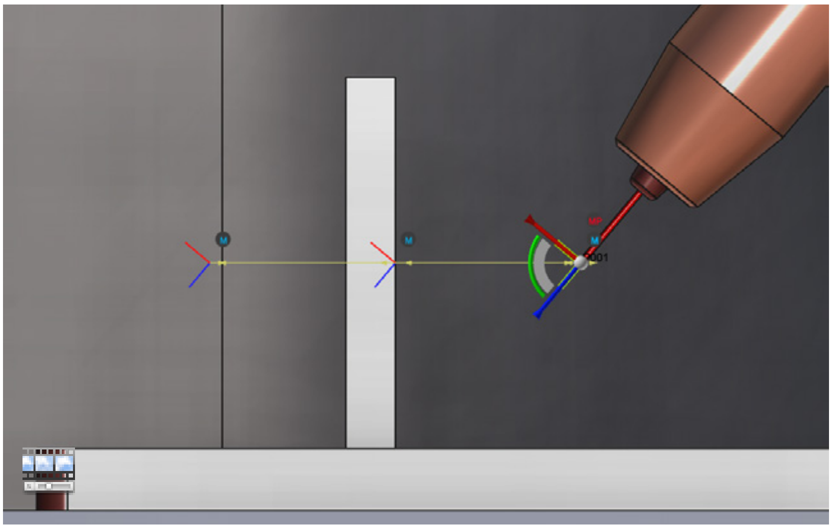
Example

2 Process geometry = 4 Operation Group (G_LAYER1, 2, 3, 4) with 2 Operations (SEAM1_L1, SEAM2_L1), bidirectional.

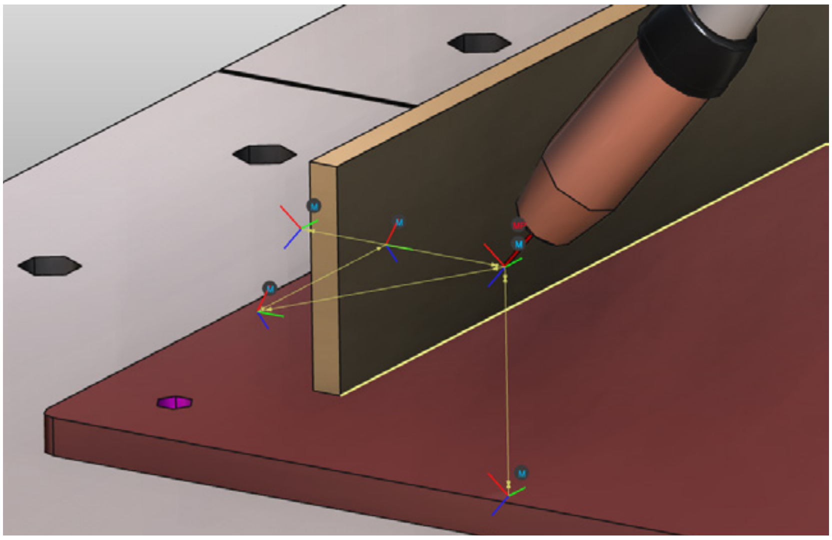
Seam Finding

"Seam Finding", also referred to as "Joint Finding", describes the ability to compensate for an offset in the real workpiece through the application of a locating pin. Alternatively, the welding wire or burner nozzle can function as electronic locating device. An 'ideal' contact point is used as reference and the 'actual workpiece' is found by contact. The difference is calculated and stored in a variable which can later be used as offset in programs.

A search starting point, a contact point (defining the direction) and a search path are the input parameters for this working methods. From this, seam finding procedures can be generated and used for either of the following methods: Method 1 – Single direction (x,y or z) or Method 2 – Multidirectional search (combination).



Method 1:
Single search operation



Method 2:
Multidirectional search operation (3-ways)

Technologies:
Spot Welding
Roller Hemming
Arc Welding
Laser Cutting
Sealing
Gluing
Riveting
and others

Modular and scalable:
Flexible development
of new functions

Software Development Kit:
API,
CLI customization,
Python

Libraries:
Production components:
Various robots and Machines
Logistics: materials handling,
pallets, Trucks, etc.
Peripherals: external axes,
End effectors, tables, etc.
Other: fencing, shelving,
Buildings, etc.
Human Models, Downloader

Data interfaces:
CAD: CATIA, NX, STEP,
JT, IGES,
Parasolid, SolidWorks, etc.
Layouts: AML, PLM XML
Process Data: Customized
Configurator PMI (JT)

Robotics and machine-specific applications:
Component handling,
Layout design
Automation technology,
Process hedging,
Offline programming,
Virtual Commissioning

A qualified team at your disposal!

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