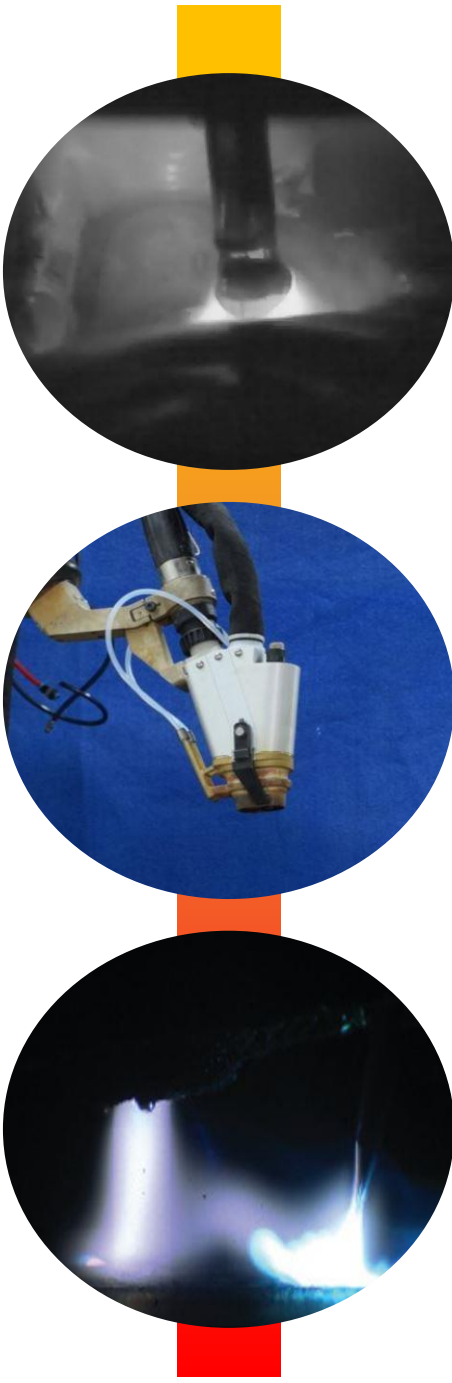




WeldObot Technologies

SuperMIG®

Hybrid Plasma-GMAW

Technology update for NSRP

April 2018

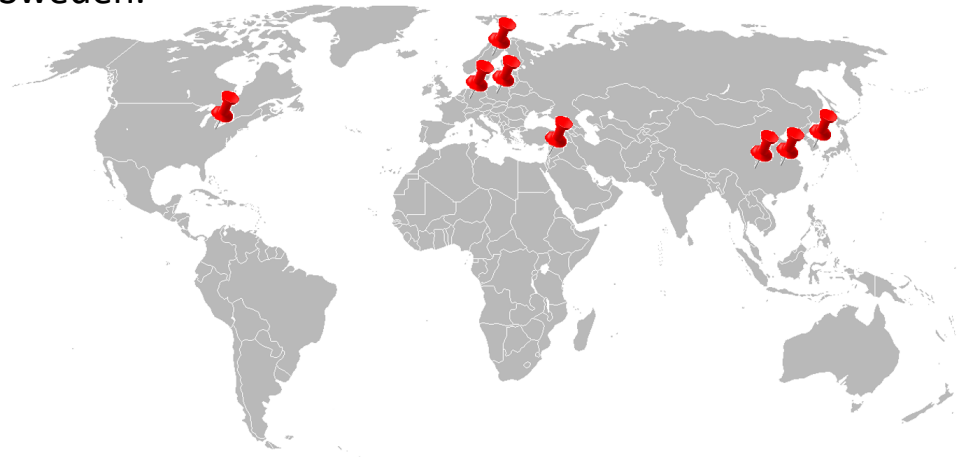
For Public View



Please note that the information in this Update does not constitute a legally binding representation or warranty, and should not be used for any purpose other than for general information.

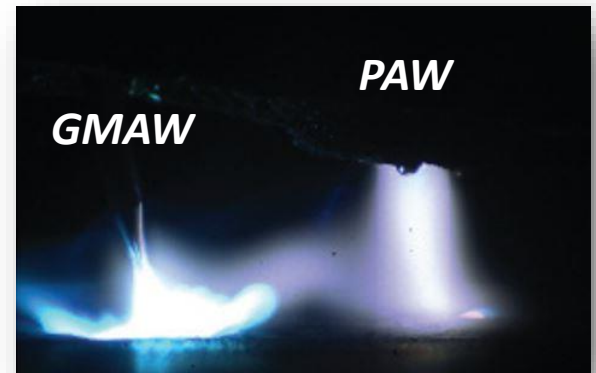
Company Profile

- Founded in 2012 developing and commercializing the WOB101 - orbital robotic system,
- March 2015 purchased all SuperMIG® IP and assets of Plasma Laser Technologies,
- September 2017 launched new and updated SuperMIG® product line.
- Company offices:
 - R&D and manufacturing: Kibutz Eyal, Israel
 - Tech Center: Detroit, MI,
 - Agents: China, Germany, Poland and Sweden.
- Main markets:
 - China,
 - North America,
 - Europe,
 - Japan.



The Technology

- A hybrid welding technology based on two known welding processes:
 - Plasma Arc welding (provides the energy to melt the base material),
 - Gas Metal Arc Welding (provides the filler metal to compose weld metal, plus heat).
- A magnetic mechanism coupled to the torch nozzle is used for controlling the distance between the two electric arcs:
 - Arc stability improvement,
 - Maximization of each processes performance (penetration and deposition rate).

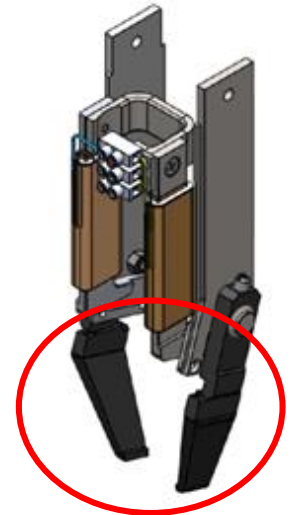


Major benefits

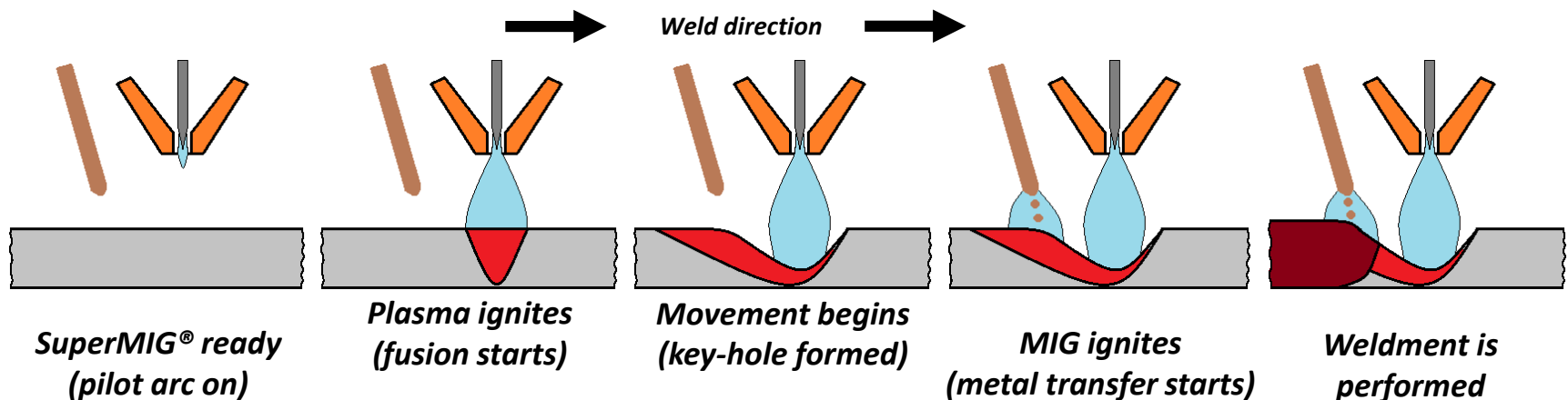
- Higher productivity,
- Less labor due to no or less beveling activities,
- Reduction of number of welding passes (typically from 2 to 1),
- Less wire consumption, due to smaller joint,
- Lower heat input due to higher speed, reduction of passes.

Plasma and GMAW Working Simultaneously

- Single weld pool,
- Two independent electric arcs,
- Plasma arc position corrected through an electromagnetic field promoted by electromagnets located on the nozzle's side.



Process Sequence

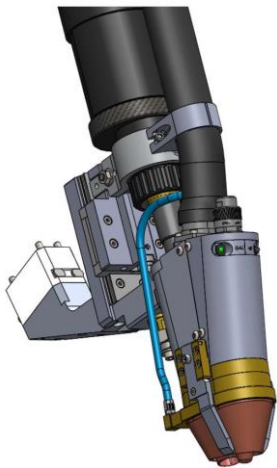


WCM - Welding Control Module

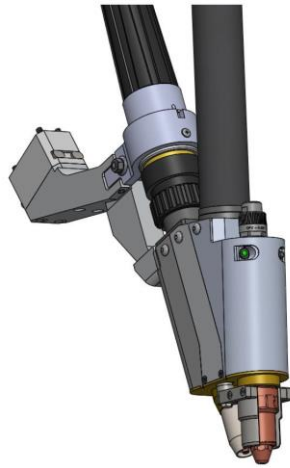
- Incorporates the system controller, plasma power sources, gases panel, cooler, and user interface,
 - GMAW system provided by customer.

Welding Torches

- 3 models for different applications.



HD and Alum



HD Slim

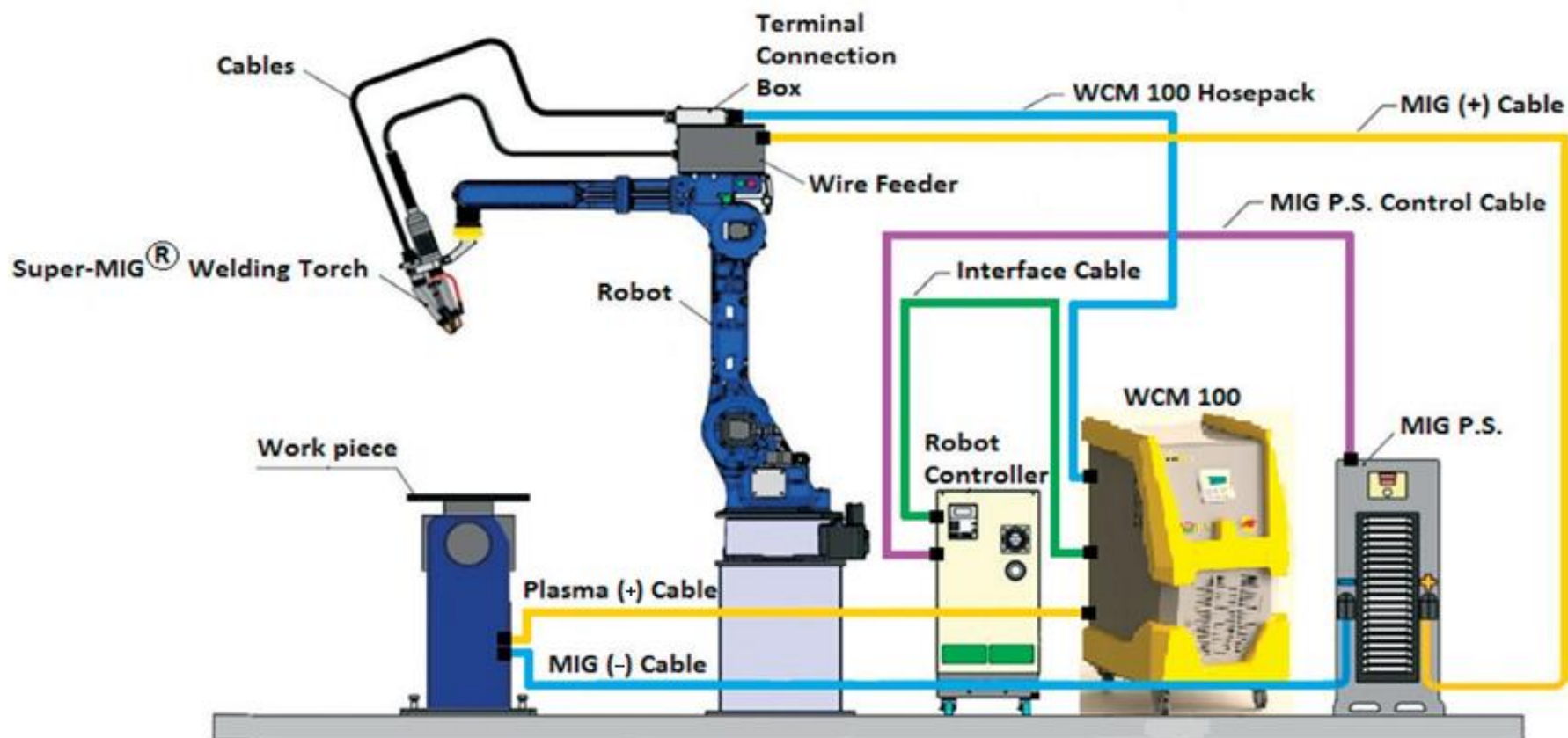


MD



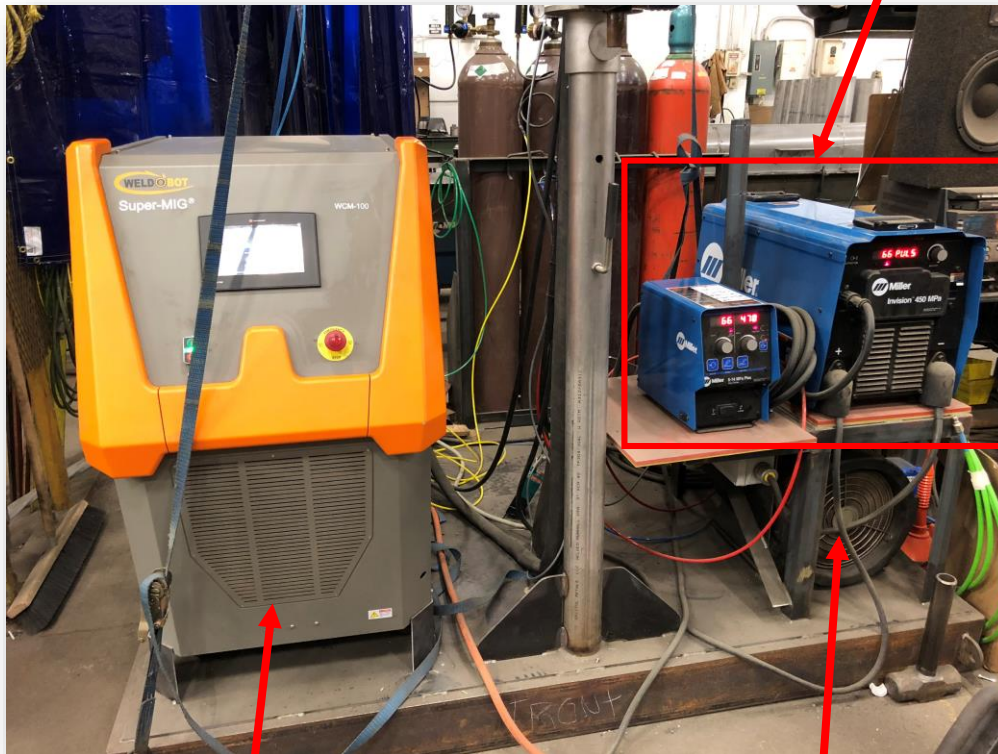
New WCM w/ HD torch

System Configuration



A complete solution for robotic and hard automation systems

System Configuration



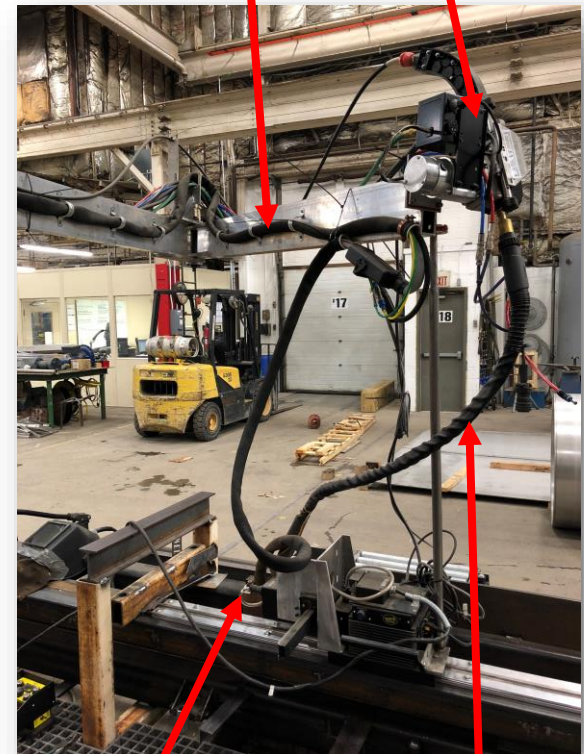
*GMAW power source
and feeder control*

SuperMIG® WCM

*GMAW water
cooler*

Hose pack (plasma)

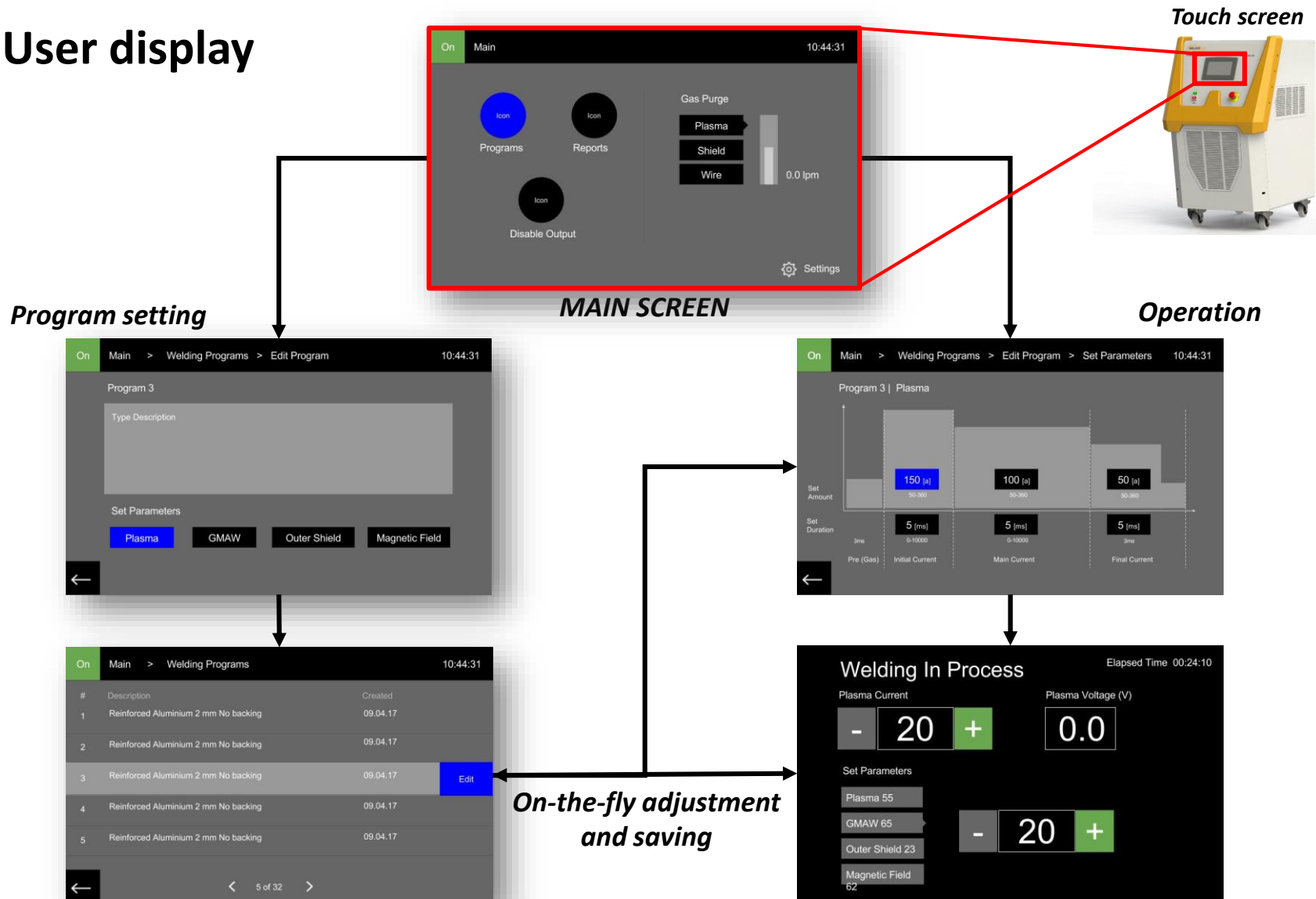
*GMAW wire
feeder*



*SuperMIG®
HD Torch*

GMAW Cable

User display



Objective



- Evaluate and characterize the potential of the Plasma-GMAW process to produce narrow groove welds in typical naval steel alloys.

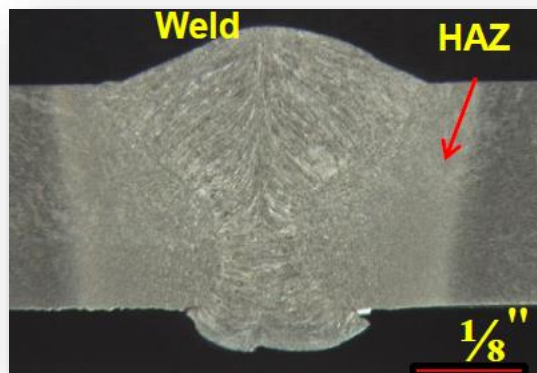
Conclusions

- Hybrid SuperMIG® is capable of producing single-pass butt welds in ¼-inch A-36 steel plate in flat positions with little to no joint preparation:
 - Well-suited for applications such as panel lines.
- Hybrid SuperMIG® was able to successfully produce 'narrow groove' single-V welds in ½-inch A-36 plate in a single pass:
 - Resulted in approximately 50% increase in total weld speed.
- SuperMIG® produced acceptable quality, narrow groove, double-V welds in 1-inch A-36 plate in a single pass:
 - Comparable GMAW welds required two passes on each side.

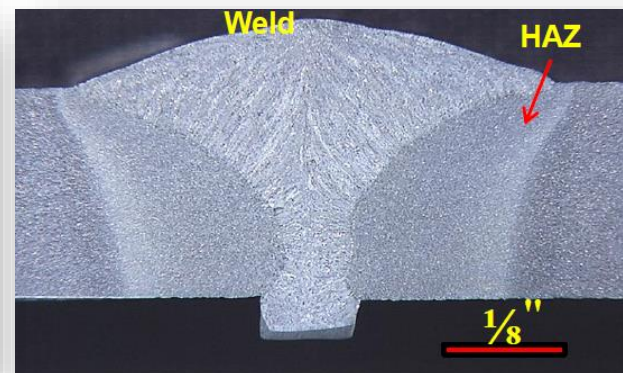
Work presented at 2016 Defense Manufacturing Conference - Denver, CO

Applications (based on the CTC work)

- Welds that require full (or specific depth) penetration,
- When other applications face challenges such as:
 - Hard to control depth of penetration,
 - Excessive reinforcement and waste of consumables,
 - There is a requirement for beveling to reach joint root (up to 12 mm or 1/2").
- Flat position weld development (1/4" – 6.35mm) *
 - No prep, 90° joints, no prep, successfully performed with SuperMIG®,
 - GMAW-only produced acceptable welds with 15° bevel.



SuperMIG® (no prep)



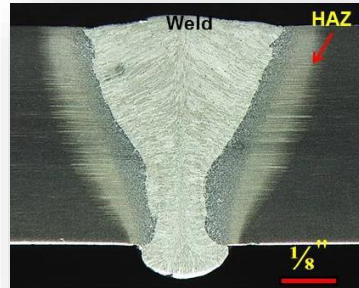
GMAW only (15° bevel – 30° total)

* Work performed by Concurrent Technologies Co. - Johnstown, PA

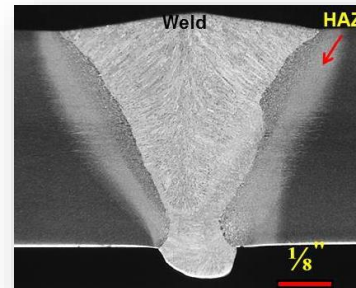
Applications (cont.)

- Flat position weld development (1/2" – 12.7 mm) *
 - Successful single-pass welds were produced with a 0.06" root opening and a copper bar,
 - For comparison purposes, two-pass GMAW-only welds were produced using a 60° joint angle.

***Single pass SuperMIG®
(15° bevel)***

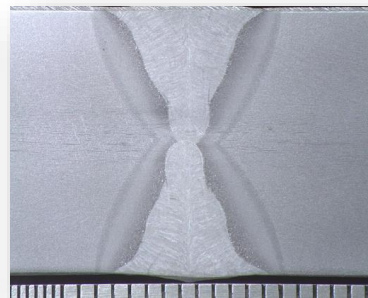


***Two passes GMAW only
(30° bevel)***

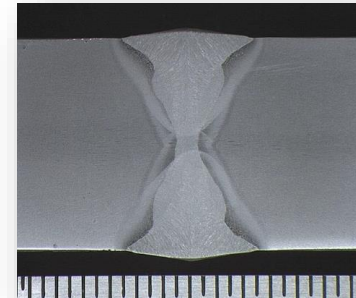


- Fla position weld development (1" – 25.4mm) *
 - Single-pass welds were successfully made on each side (travel speed of 15 in/min),
 - GMAW-only comparison welds were made using 50° double-V welds, two passes.

***SuperMIG®
One pass per side
(15° bevel)***

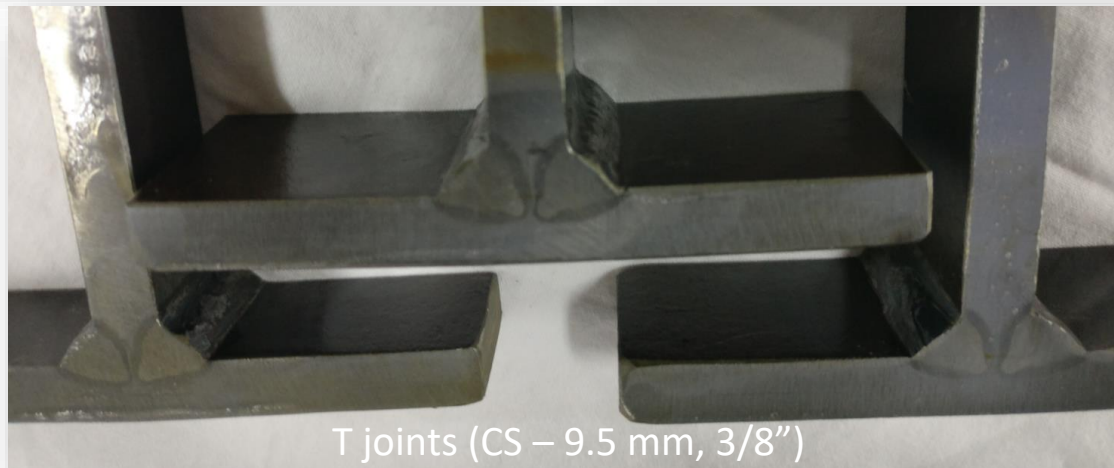
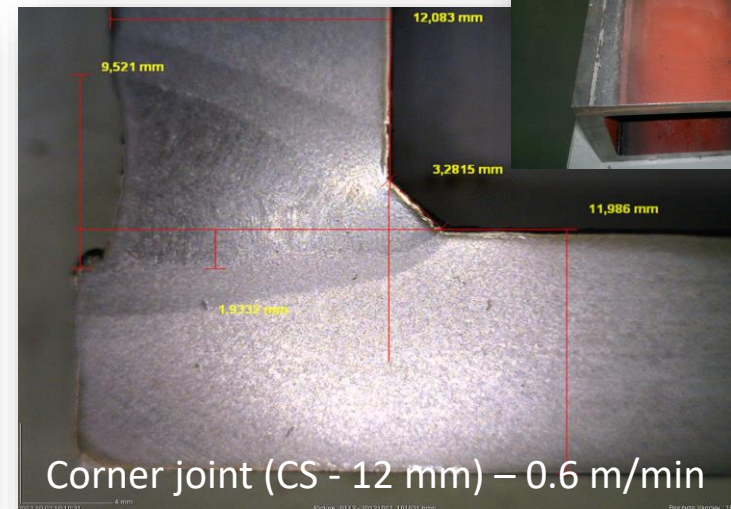
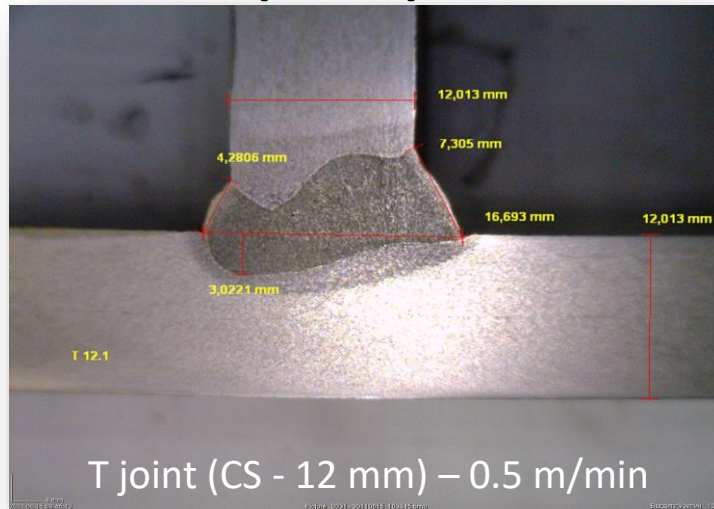


***GMAW only
Two passes per side
(25° bevel)***



* Work performed by Concurrent Technologies Co. - Johnstown, PA

Applications (cont.)



Success Story - Teleskop SP (Poland)

- Teleskop is a manufacturer of telescopic booms for mobile and truck-mounted cranes (from 30 to 750 t) serving companies such as Liebherr, Manitowoc and Cargotec,
- The company has been an early adopter of the SuperMIG® technology and now owns a total of 3 systems for longitudinal seam welding of high-strength steel booms,
- SuperMIG is being utilized to replace the Submerged Arc Welding process (SAW) with the following advantages:
 - Reduction of filler metal utilization,
 - Process time reduction due to reduction of number of passes and joint preparation,
 - Overall welding speed.

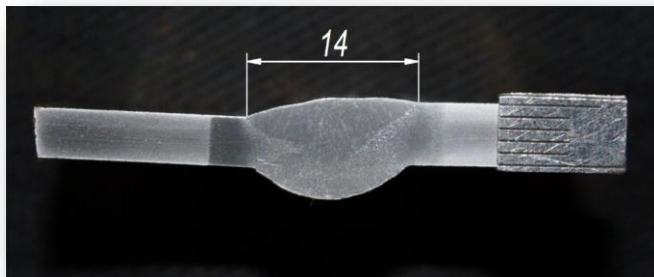


TELEMOND
HOLDING



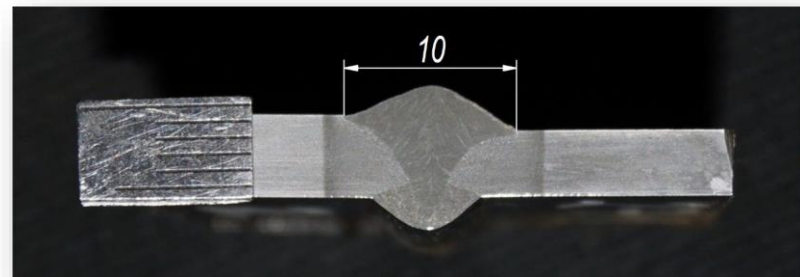
Achieved benefits

- Overall 46% time savings compared to Submerged Arc Welding:
 - 4x faster internal weld (back-side), as that bead can be made smaller/narrower,
 - No grinding of external groove in weld joints performed with SuperMIG®,
 - 2x faster external welding performed with the SuperMIG®,
 - Reduction of flux utilization and disposal of process slag (from submerged arc welding).



Submerged arc

Welding speed: 38 – 48 cm/min



SuperMIG

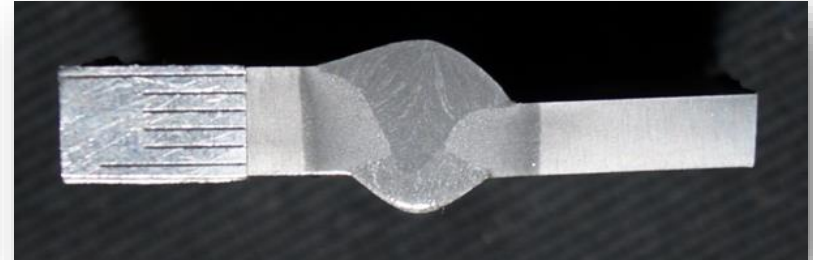
Welding speed: 80 – 100 cm/min

- The investment made by Teleskop included:
 - New gantry mounted on a designated track.
 - Robot (mounted on the gantry), with laser scanning system,
 - SuperMIG® system (Welding Control Module plus HD torch).

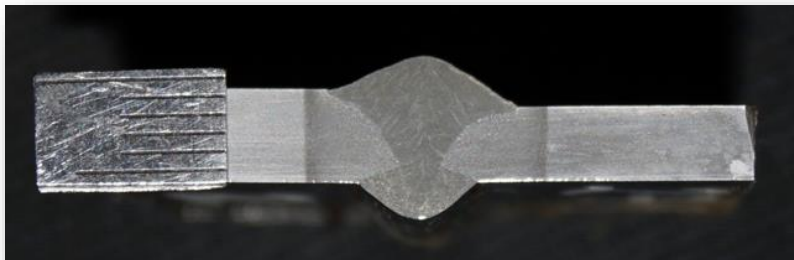
Other examples of SuperMIG® welded joints



SuperMIG® - 6 mm to 5 mm



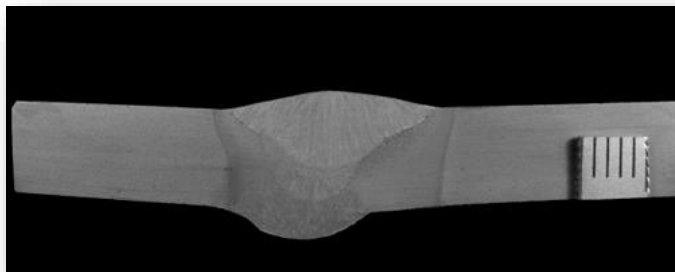
SuperMIG® - 6 mm to 4 mm



SuperMIG® - 5 mm to 4 mm



SuperMIG® - 4 mm to 4.5 mm



7 mm (SAW – 2 passes)



7 mm (SuperMIG – single pass)

SuperMIG® - Success Story



Heisey Mechanical (USA)

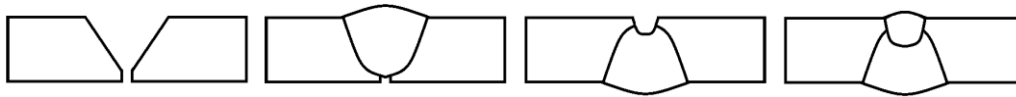
- Heisey Mechanical, Ltd. is a service contractor that specializes in projects for the food, chemical, manufacturing, and waste water treatment industries,
- The company has been an US early adopter of SuperMIG®, owning 1 system for longitudinal seam welding of SS plates to convert them into pipes,
- SuperMIG® is being utilized to replace the GMAW used to weld in both sides of the joints, with the following advantages:
 - Reduction of filler metal utilization,
 - Number of passes reduction (from two to one),
 - Elimination of beveling operation,
 - Overall welding speed.



SuperMIG® - Success Story

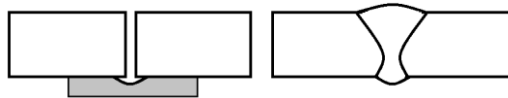


Previous process – manual MIG (five steps)



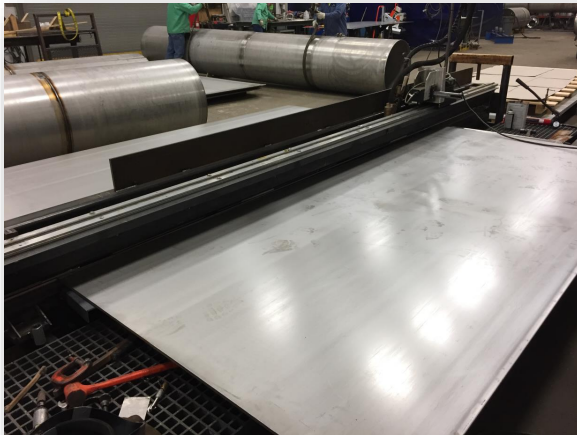
- 1 – Beveling
- 2 – Top side welding
- 3 – Flip part
- 4 – Grinding
- 5 – Back side welding

SuperMIG® (2 steps)



- 1 – Seam welder positioning
- 2 – One-sided welding

Production steps



Before welding



After welding



Rolling

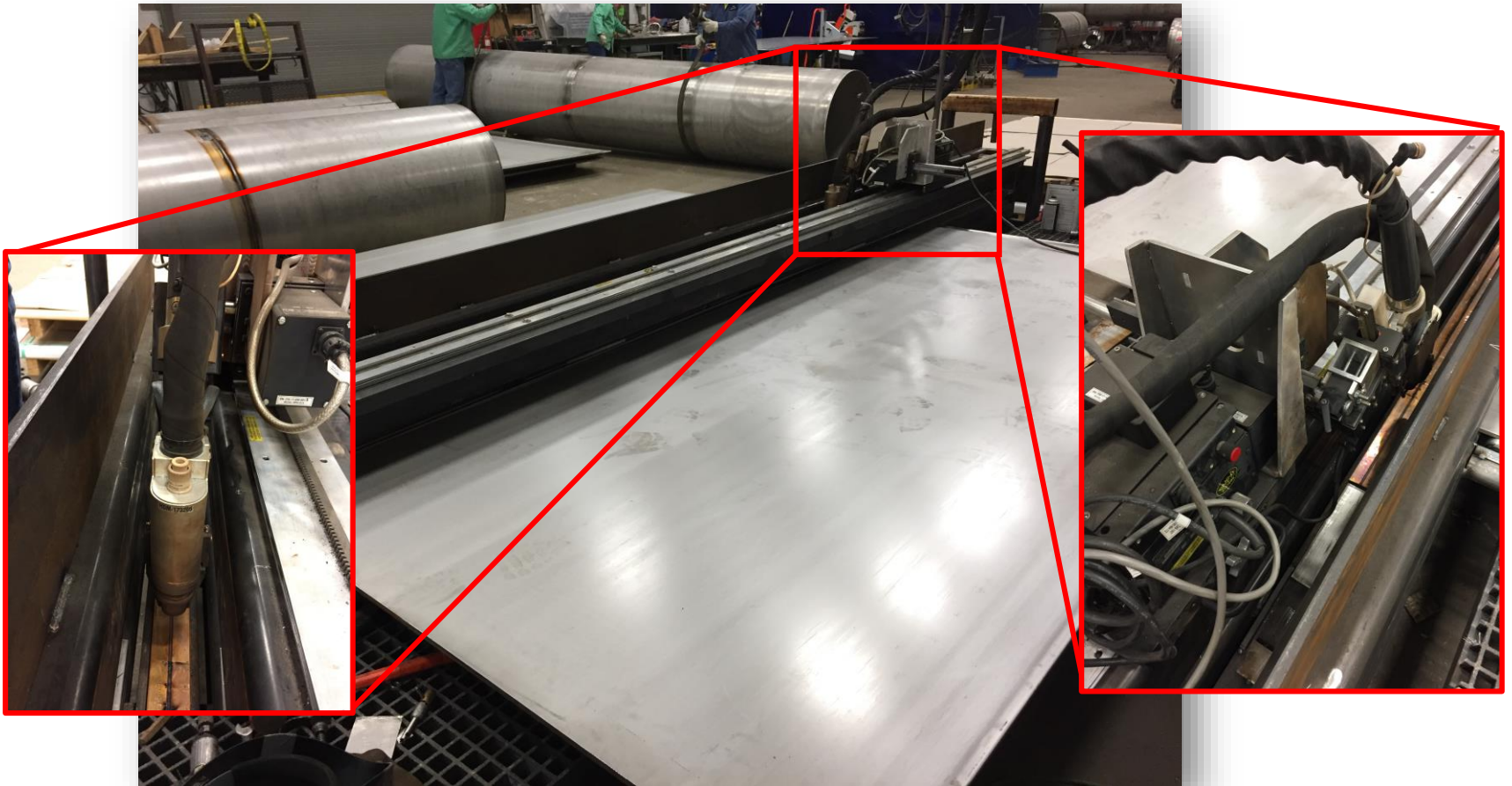


Final product

Success Story - SuperMIG®



Primary operation – seam welding



Achieved benefits

- Enabled customer to significantly increase welding productivity and overall manufacturing process of stainless steel pipes, with results such as:
 - Reduction of number of operations from going from 2-sided welding to single-sided,
 - Over 50% reduction of filler metal use,
 - Elimination of beveling/root grinding processes,
 - 120% increase in welding speed.



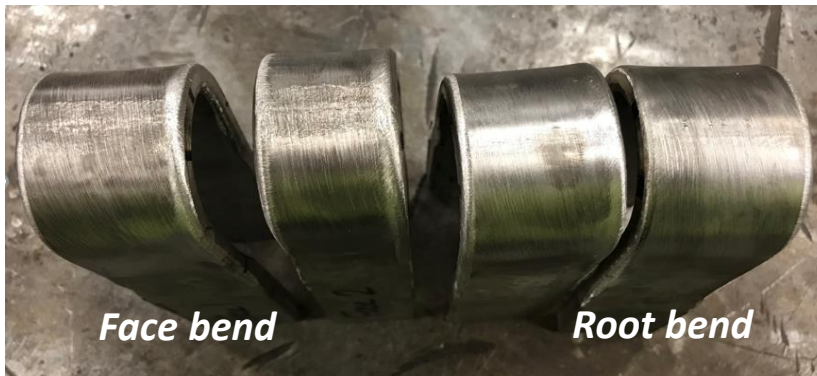
Investment payback achieved in the first job (5 months)

Success Story - SuperMIG®



Process qualification – Mechanical Testing

- ASME: Section IX-2017,
- Guided bend testing (QW-162.1),



- Tensile test (QW-152)

Sample Number	Base Metal Minimum Required Tensile Strength (QW-422)	Tensile Test Results (*)
#1	75,000 PSI	86,800 PSI
#2		87,100 PSI

(*) Performed by HENRY J. YEAGER LABORATORIES

Figure QW-463.1(a)
Plates — Less Than $\frac{3}{4}$ in. (19 mm)
Thickness Procedure Qualification

Discard		this piece
Reduced section		tensile specimen
Root bend		specimen
Face bend		specimen
Root bend		specimen
Face bend		specimen
Reduced section		tensile specimen
Discard		this piece



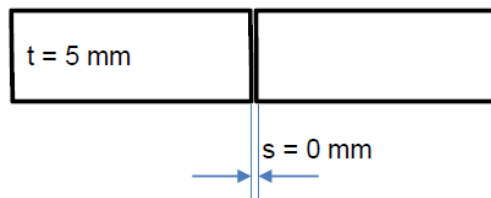
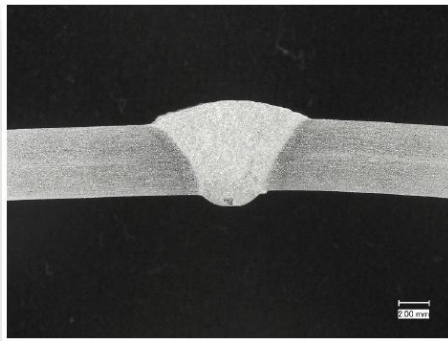
Aachen University

- **Project:** “Serial plasma-MIG hybrid welding using adapted process variants for economic joining of aluminum”.
- **Sponsored by:**
 - Institut für Schweißtechnik und Fügetechnik der RWTH Aachen University,
 - DVS – German Welding Society,
 - Advisory committee and industry participants include companies like Alstom Transport, FORD, Cloos Robotics, Linde, EWM, and Messer Group.
- **Project objective:**
 - Evaluation of a high-quality joining process of aluminum sheets of different thicknesses at low acquisition and operating costs to support small and medium size enterprises not capable of investing on laser-MIG hybrid process.
- **Status:**
 - Project started on Feb 19th, 2018,
 - Expected length of SuperMIG process analysis: 3 months.

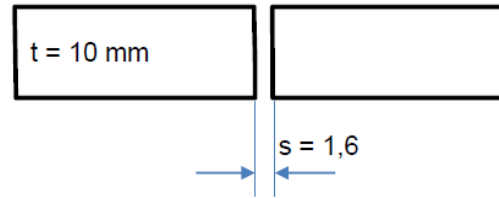
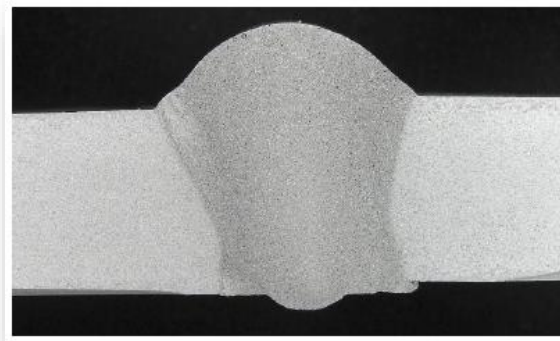


Aachen University

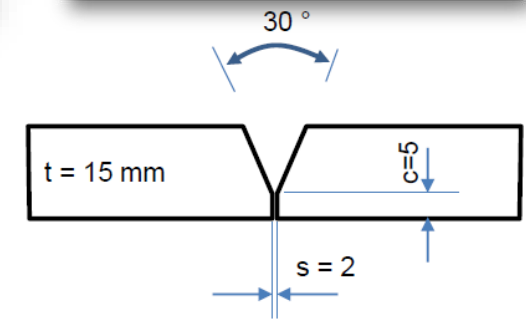
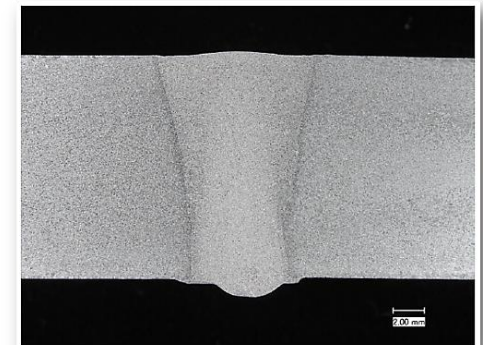
- Preliminary results – weld joints



Speed: 0.7 m/min



Speed: 0.3 m/min



Speed: 0.35 m/min

Special Applications

- TARDEC – Tank Automotive Research, Development and Engineering Center (Warren, MI)
 - Organization with good understanding of hybrid plasma-MIG,
 - In discussions to reconsider process applicability in armored plate welding.
- ARDEC – Army Armament Research, Development and Engineering Center (Picatinny arsenal, NJ)
 - CRADA in place to evaluate armored plate welding as well as aluminum.
 - In discussions to consider applicability in new aluminum alloys.
- Shipbuilding
 - Evaluation of process applicability in vertical-up butt joint welding,
 - In cooperation with CTC (Johnstown, PA),
 - Project closed.

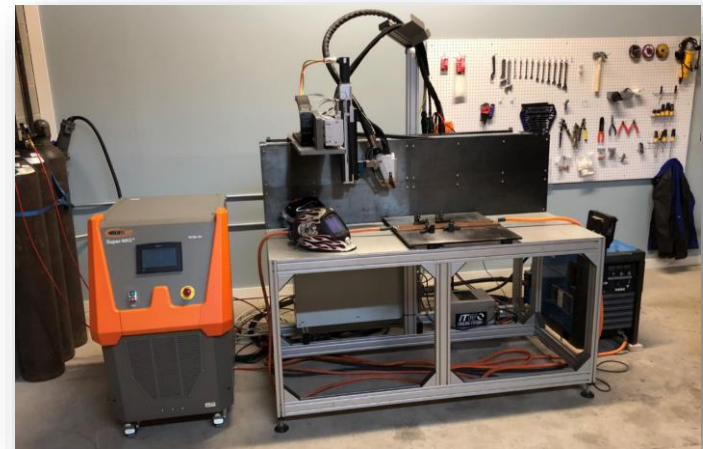


SuperMIG® - US Operation



Detroit Tech Center

- 1683 W Hamlin Rd, Rochester Hills, MI
- Demos and trials,
- Training,
- Maintenance and spare parts.



Tech Center fully operational as of March 2018

Overall Summary

- The plasma-GMAW process (SuperMIG®) has the following benefits:
 - **Deeper weld penetration:** minimizes number of passes,
 - **Reduce material preparation:** due to deeper plasma penetration, beveling can be eliminated (<12mm) allowing for single pass welding when typically 2 or 3 passes are performed with conventional GMAW,
 - Although Submerged Arc Welding (SAW) can also promote similar results, much higher energy (~1,000 Amp) is required. In addition, flux storage and treatment as well as slag disposal is required.
 - **Reduction in filler metal/gas requirements:** as a result of the less preparation (no bevel), less filler metal and shielding gases are required to fill the welding joint,
 - **Greater travel speed:** penetration promoted by the plasma arc allows maximization of GMAW process deposition rate.
 - **Reduced heat input:** higher speeds promoted by the combination of processes allows for higher speed even under the combined energy of the two processes.
 - **Reduced distortion:** plasma-GMAW heat transfer radiates from the joint full section while in other processes that heat radiates from where the process is applied.

Significant potential savings in productivity, labor, and filler metal