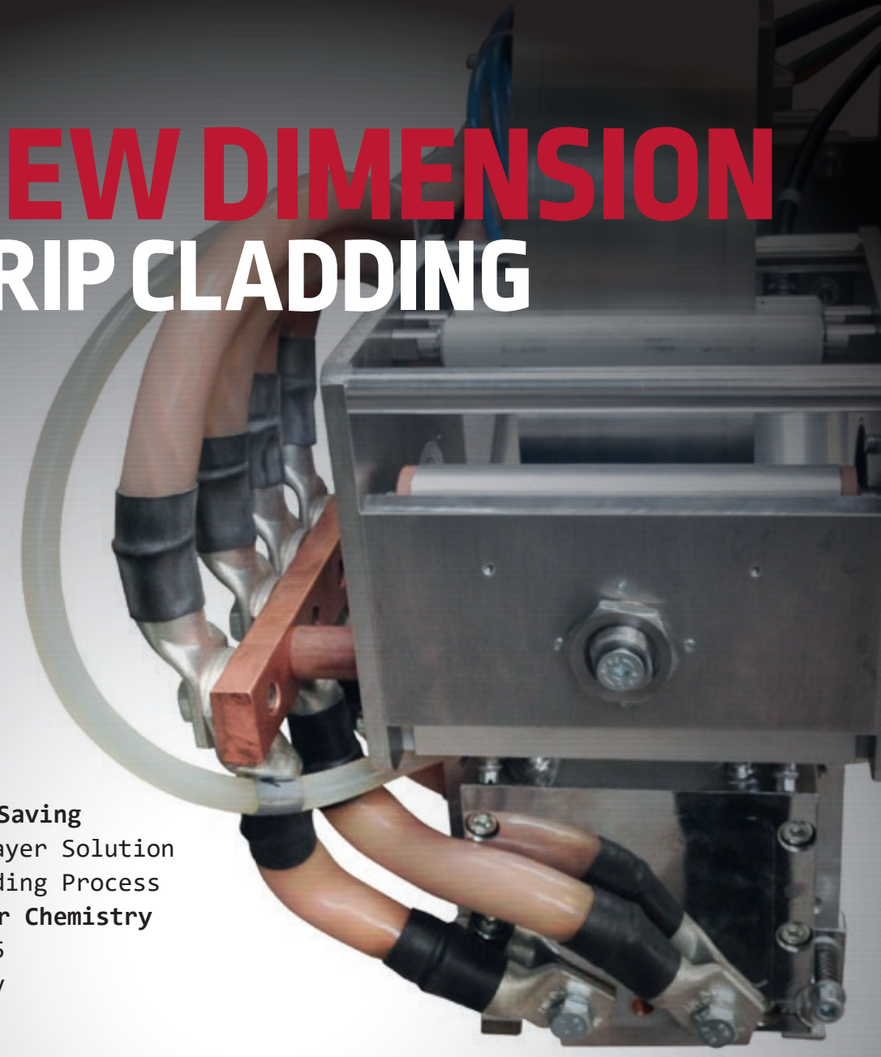
SPECIAL ALLOYS™

THE NEW DIMENSION IN STRIP CLADDING

LINCOLN® ELECTRIC

THE COMPLETE SOLUTION FROM A SINGLE SOURCE

THE NEW DIMENSION IN STRIP CLADDING



70% Time & 40% Cost Saving
- Always Single Layer Solution
- High Speed Cladding Process

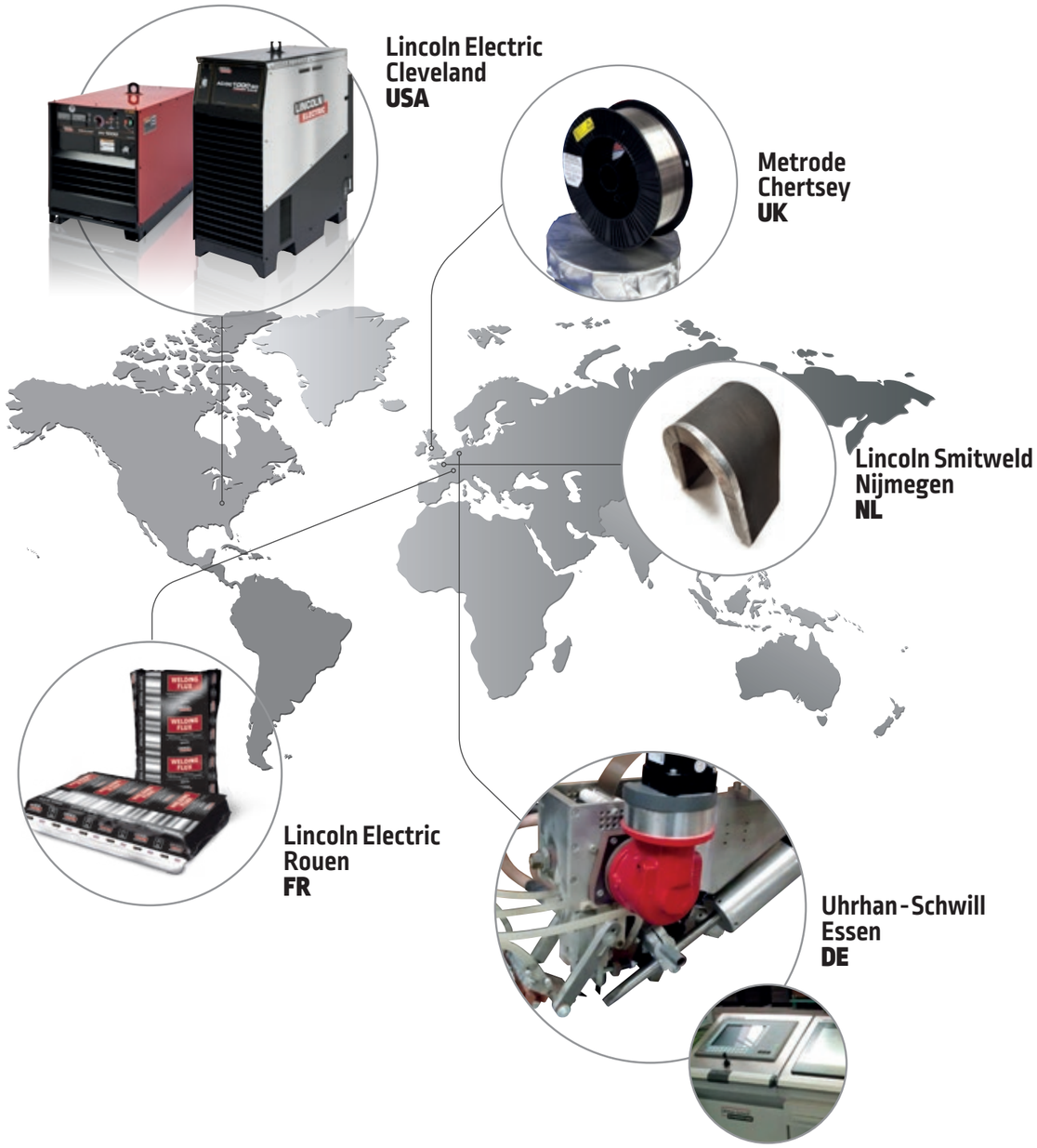
Homogeneous & Cleaner Chemistry
- <5% Fe in Ni-625
- Improved Quality

Full Process Control
- State-of-the-Art Digital Hybrid 3D Z5 Controller
- Real Time Data Logging & Traceability

First Proven Single Layer High Speed Solution with Neutral Flux
- <5% Fe in Ni-625
- Required Undiluted AWS Chemistry for Stainless Steel

Reduction in Working Capital
- Single Stainless Steel Strip for All Austenitic SS Grades
- Faster Delivery of MCW & Full Control of Delivery Time

Instant Technical Service to Customer



THE COMPLETE SOLUTION FROM A SINGLE SOURCE

SPECIAL ALLOYS™

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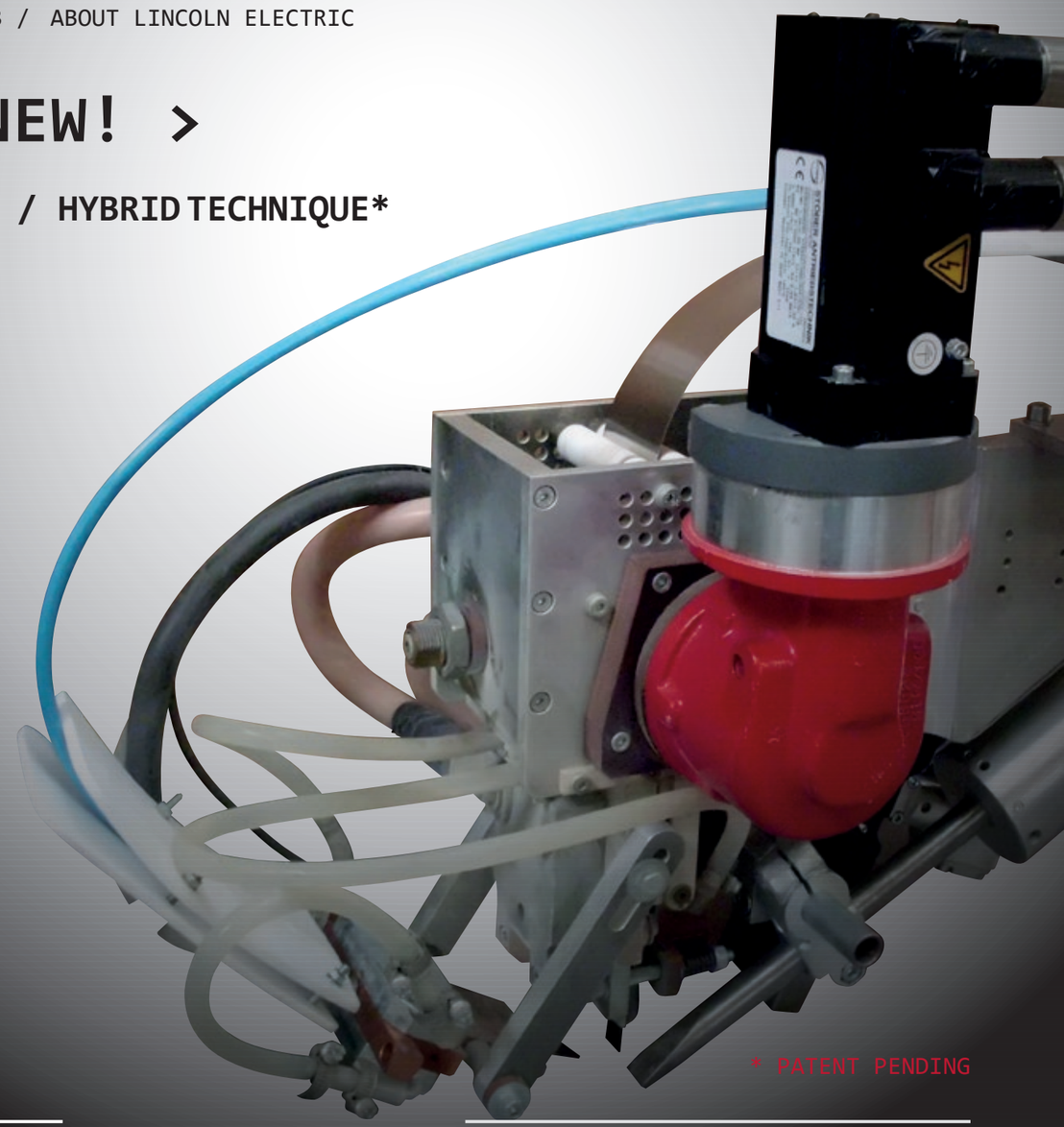


* PATENT PENDING

STRIP CLADDING PROCESSES

INTRODUCTION

Cladding is a fundamental process in the Fabrication industry and is applied across the whole spectrum of applications – from the nuclear, oil & gas industries to petrochemicals and steelmaking. Cladding is required on the process side of high pressure Critical Process Plant Equipment (CPE) to provide corrosion resistance against highly severe corrosive service fluid or to increase wear resistance of a component being subjected to heavy wear & tear applications e.g. continuous casting rollers in Steel mills. While CMn substrates, low alloy steels and other materials provide strength and other physical properties, while cladding provides the desired corrosion and wear resistance. The result is extraordinary flexibility and cost savings.

There are many ways to apply this corrosion resistant layer – either by using roll-bonded or explosive bonded clad plates or by applying our more flexible weld cladding on a CMn or low alloy steel base material.

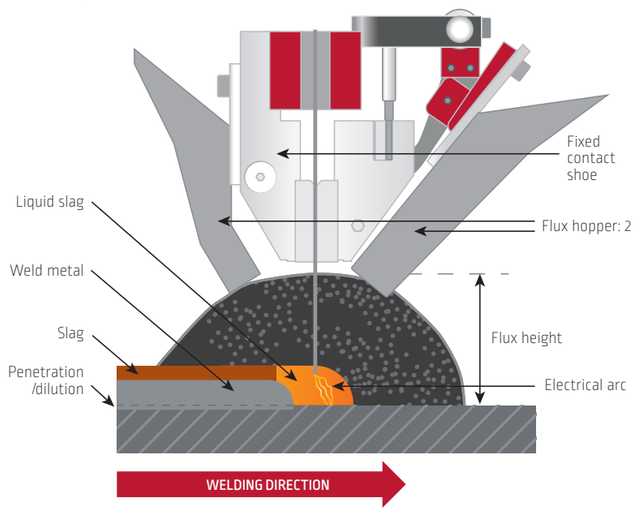
CLADDING PROCESSES

While most of the existing arc and electro slag welding processes can be utilized for weld cladding, strip cladding with submerged arc and electro slag welding process are the most attractive choices for applications that require large surface area coverage due to their substantially higher deposition and surface area coverage rates.

There are two conventional strip cladding processes – Submerged Arc & Electro Slag.

SUBMERGED ARC STRIP CLADDING

- Utilises an arc that runs back and forth at high speed along the strip.
- The arc causes more penetration into the base material, resulting in dilution levels of ~20%.
- Deposition rate: 12-14 kg/h for 60x0.5mm strip.
- Current range restricted to limit dilution.



SPECIAL ALLOYS™

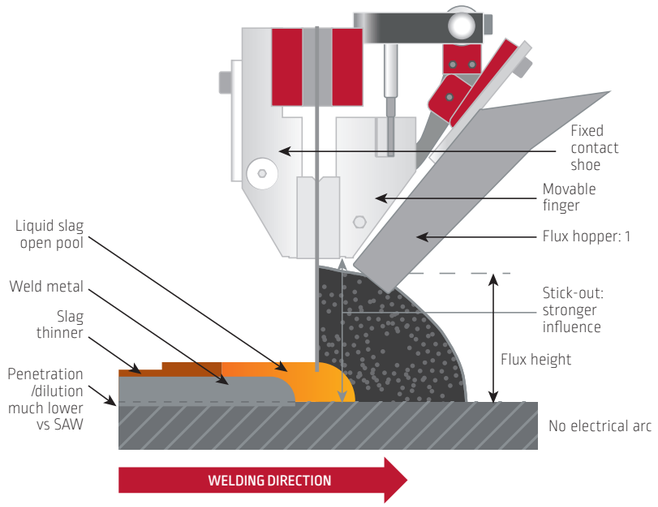
THE NEW DIMENSION IN STRIP CLADDING

ELECTRO SLAG STRIP CLADDING

ELECTRO SLAG STRIP CLADDING

CONVENTIONAL

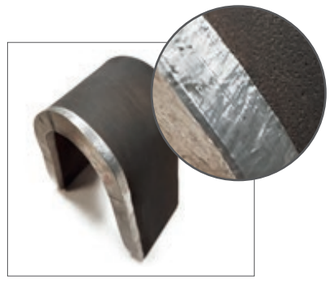
- **Arc-Less** process – uses conductive flux & works on Joule's resistance heating principle.
- The strip current passes through the molten slag. The resulting resistance heating effect melts the strip and deposits the molten weld pool onto the base material.
- Low dilution level (9-12%). Process has significant advantages over SAW.



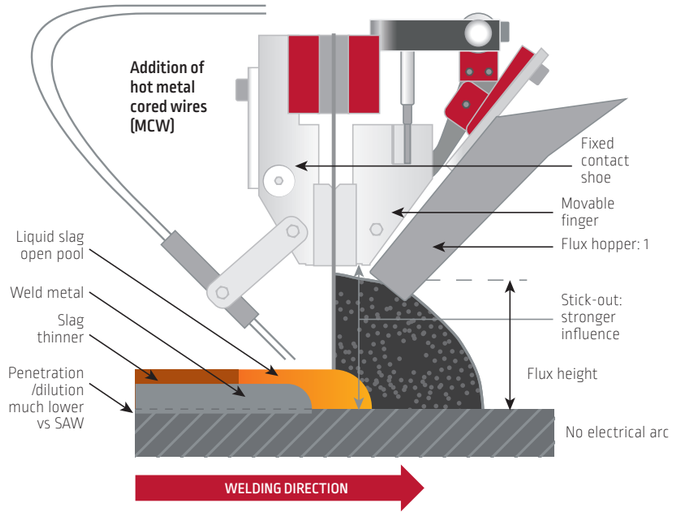
HYBRID TECHNIQUE*

* Patent Pending

- New variant of ESW process
- State-of-the-art technique – **first** introduced by Lincoln Electric
- Hot metal cored wires added to the molten pool as 3rd constituent
- Consistently achieves <5% Fe in single layer for Ni-625 alloys
- **Always in single layer** coupled with **high welding speed**
- Completely eliminates the use of alloyed flux - uses fully neutral flux
- Lowest dilution level coupled with the highest deposition & faster surface coverage rates

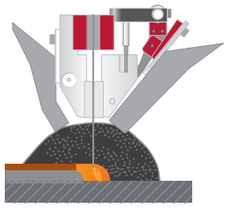
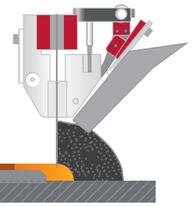
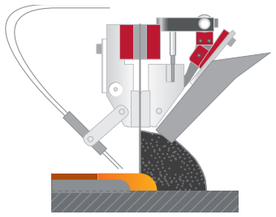


180° side bend sample for Ni-625 cladding with Hybrid Technique

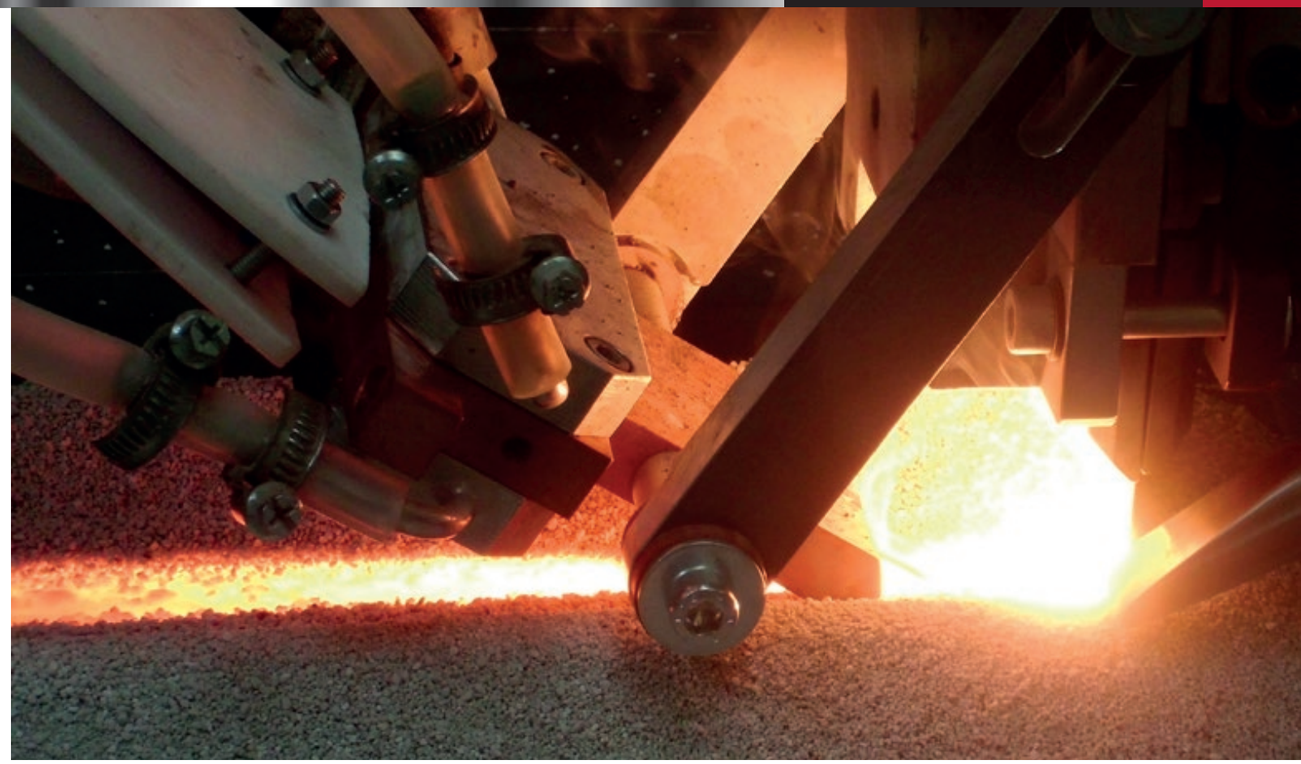


COMPARISON BETWEEN SUBMERGED ARC, ELECTRO SLAG – CONVENTIONAL & H-ESC*

* Patent Pending

		Consumables	Deposition rate (kg/h) 60x0.5 mm strip	Welding speed (cm/min)	Minimum number of layers in Ni-625 to achieve <5% Fe chemistry	Flux type for high speed cladding in single layer
	Submerged Arc	Strip + SAW Flux	12-14	10-14	2	NA
	Electro Slag – Conventional	Strip + ESW Flux	22-30	Normal speed: 15-18 High speed: 24-35	2	Alloyed
	Electro Slag – Hybrid*	Strip + Metal Cored Wire + ESW Flux	28-42	24-40	1	Neutral

SPECIAL ALLOYS™



HYBRID TECHNIQUE*

* Patent Pending

MAIN BENEFITS

Less dilution: always achieves cleaner chemistry in a single layer
- Ni-625: <5% Fe
- Stainless steel & other Ni alloys: required AWS undiluted chemistry

High Speed Single Layer Solution – eliminates one full layer
- Less welding time: faster completion
- Savings in labor costs: more competitive
- Savings in NDE costs & time by eliminating one additional layer

Highest Deposition Rate (1.3-1.5 x)
- Higher stick-out
- Higher current
- Additional deposition from hot MCW

No active flux required
- Strictly meets licensor specification
- Uniform & homogeneous chemistry in production

ADDITIONAL BENEFITS

Single Flux Solution
- Neutral flux
- 3D CladFlux E200: single flux for all Ni alloys
- 3D CladFlux E100: single flux for all SS alloys

Only One Strip for all SS Alloys
- Single strip
- Only metal cored wire changed
- Faster delivery

H-ESC* Flux for HS ESW
- Advanced & cleaner H-ESC* flux can also be used for high speed ESW of Ni alloys & SS alloys

IMPROVED QUALITY

COST BENEFIT ANALYSIS – Ni-625 (TYPICAL)

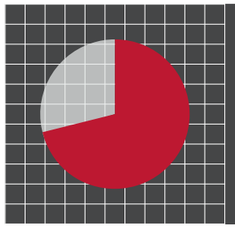
*Patent Pending

INLET SEPARATOR

APPLICATION			
	Cladding	Alloy 625	**Total**
	Diameter	5 m	258.4 m²
	Length	13 m	

			Submerged Arc	Electro-Slag		Hybrid*
				Conventional	High Speed (HS)	
PROCESS	Fe <5%	1 layer				●
		2 layers	●	●	●	
	Layer thickness	[mm]	8.7	8.7	6.5	5.0
	Welding speed***	[cm/min]	12.0	16.0	32.0	27.0
CONSUMABLE COST	Weldmetal	[kg]	2 248	2 248	1 680	1 292
		[€/m²]	2 648	2 602	1 990	1 718
PRODUCTION COST	Number of beads	[#/m²]	34	34	34	17
	Welding time	[min/m²]	287	216	108	64
	Production	[€/m²]**	479	359	180	106
TOTAL CLADDING	Cost saving (excl. NDE of one additional layer)		6%	–	-27%	-38%
	Production Time (excl. NDE of one additional layer)	[h]	1 238	928	464	275
	Production Time saving (excl. NDE of one additional layer)		33%	–	-50%	-70%

* Alloyed flux only suitable for Iron >5% ** Including automation *** For each layer



- The new Hybrid Solution saves an enormous amount of time
- Releasing valuable workshop hours for fabricating more equipment within the same period
- Hybrid is the only existing single layer solution that guarantees Fe <5% in Ni-625 alloy
- Additional saving in time & cost due to elimination of NDE
- Eliminates use of alloyed flux
- The savings from one project will cover the costs of the investment

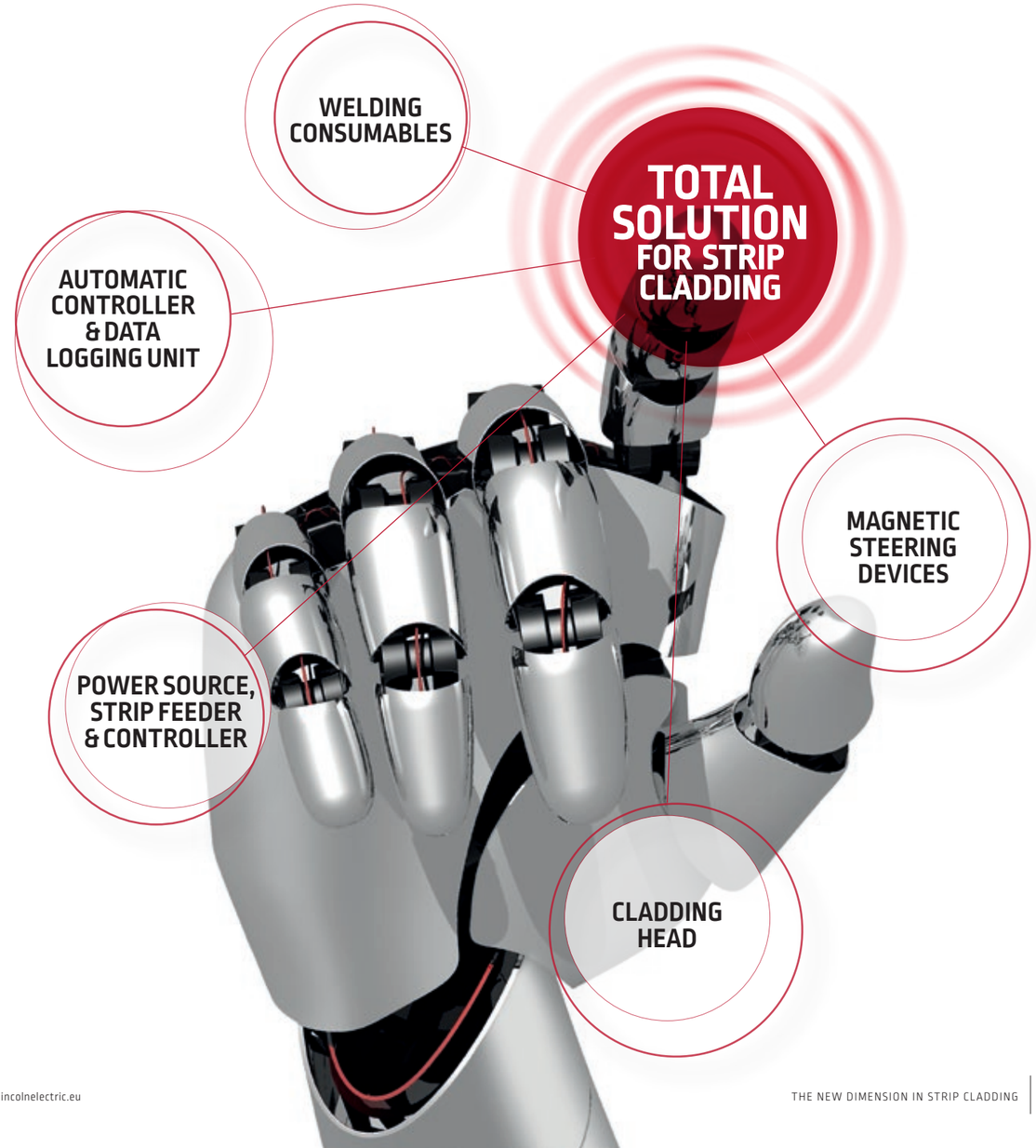
70% TIME SAVING

TOTAL SOLUTION FOR STRIP CLADDING

The most important key to the success of Strip cladding process is to have the **right combination of**:

- Welding Consumables i.e. Strip, Flux and Wire (where applicable)
- Cladding Head
- Magnetic Steering Devices
- Welding Power Sources & Strip Feeding Device
- Hot Wire Feeding Mechanism
- Automatic Welding Control System

If even one of these key elements is absent, the process is likely to fail in achieving its desired output.
Lincoln Electric is the world leader, as it has top quality solutions and the desired expertise in all the above fields.



WELDING CONSUMABLES

* Patent Pending

Lincoln Electric manufactures a wide range of fluxes,strips & metal cored wires for these cladding processes to meet a variety of customer demands. The current range is as follows:

FLUX

- **2D CladFlux E200**
  - Neutral & basic in nature electro slag flux for use with nickel based strips
  - Designed for both normal & high speed cladding
  - **3D CladFlux E200** is the improved version of the same neutral flux, specially designed for H-ESC* application, and produces much cleaner weld metal.
- **2D CladFlux E100**
  - Neutral & basic in nature electro slag flux
  - Used for high speed cladding of stainless steel strips
  - **3D CladFlux E100** is the improved version of the same neutral flux, specially designed for H-ESC* application, and produces much cleaner weld metal.

Lincoln Electric **only** offers **neutral flux** for all ESW & H-ESC* applications, as required by Process Licensors & End Users.

- **2D CladFlux E102**
  - Neutral & highly basic in nature electro slag flux
  - Used for normal speed cladding of stainless steel strips
- **2D CladFlux S200 & 2D CladFlux S100**
  - Submerged arc flux for use with Ni based alloys & stainless steel strips respectively.

STRIP

- All Ni based alloys and stainless strips are specially designed by Lincoln Electric for Submerged Arc / Eletro Slag - Conventional and H-ESC* applications with their corresponding fluxes.
  - Submerged arc strip cladding with double layer technique
  - Electro slag strip cladding at normal speed with single & double layer technique
  - Electro slag strip cladding at high speed with single & double layer technique
  - Hybrid electro slag cladding at high speed with single layer technique

Stainless steel & Ni alloys strips are available in standard sizes of 30x0.5 / 60x0.5 / 90x0.5 / 120x0.5 (only for SS). Strips of other widths and thicknesses may be made available if required.

METAL CORED WIRE

Metal cored wires for Ni based alloys and stainless steel are specially designed and manufactured in the Metrode Division of Lincoln Electric. The end product is a weld metal with the desired properties. This is **always in a single layer**.

These wires have a special composition and are to be used exclusively for H-ESC* application with corresponding strip – flux combination.

CONSUMABLES PORTFOLIO

* Patent Pending

NICKEL BASE ALLOYS

Submerged Arc	Electro Slag: Conventional	Electro Slag: Hybrid*
CladStrip 625 (EQ NiCrMo-3)	CladStrip 625 (EQ NiCrMo-3)	CladStrip 625 (EQ NiCrMo-3)
CladStrip 825 (EQ NiFeCr-1)	CladStrip 825 (EQ NiFeCr-1)	CladStrip 825 (EQ NiFeCr-1)
CladStrip 600 (EQ NiCr-3)	CladStrip 600 (EQ NiCr-3)	CladStrip 600 (EQ NiCr-1)
CladStrip 400 (EQ NiCu7)	CladStrip 400 (EQ NiCu-7)	CladStrip 400 (EQ NiCu7)
2D CladFlux S200	2D CladFlux E200	3D CladFlux E200
2D CladFlux S100		3D CladCore 625
		3D CladCore 825
		3D CladCore 600
		3D CladCore 400

STAINLESS STEEL

Submerged Arc	Electro Slag: Conventional	Electro Slag: Hybrid*
CladStrip 24.13L (EQ 309L)	CladStrip 22.11L (~EQ309L)	CladStrip 300
CladStrip 19.9L (EQ 308L)	CladStrip 21.13.3L (EQ309LMo)	3D CladCore 308L
CladStrip 19.12.3L (EQ 316L)	CladStrip 21.11LNb (~EQ347OA)	3D CladCore 316L
CladStrip 24.13LNb (~EQ 309LNb)	CladStrip 19.9L (EQ308L)	3D CladCore 347
CladStrip 19.9LNb (EQ 347)	CladStrip 19.12.3L (EQ316L)	3D CladCore 317L
2D CladFlux S100	CladStrip 19.9LNb (EQ347)	3D CladFlux E100
	CladStrip 24.13L (EQ309L)	
	CladStrip 24.13LNb (~EQ309LNb)	
	CladStrip 19.13.4L (EQ317L)	
	2D CladFlux E102	
	2D CladFlux E100	

CONSUMABLES – Ni ALLOYS

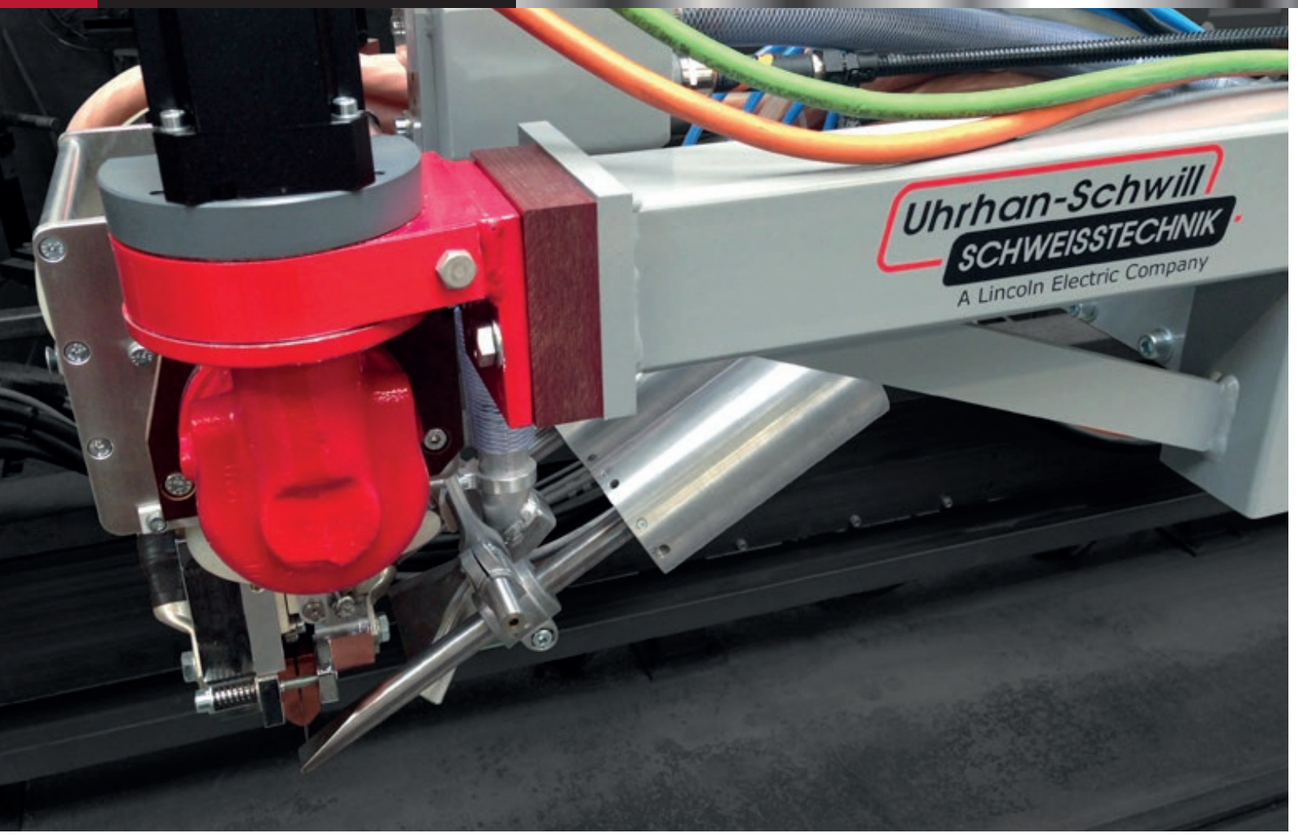
* Patent Pending

				CONSUMABLE DETAILS			
DEPOSIT	PROCESS / TECHNIQUE	SPEED	LAYER	LAYER-1 STRIP	LAYER-2 STRIP	FLUX	MCW
Ni-625	H-ESC*	High	1	CladStrip 625		3D CladFlux E200	3D CladCore 625
	ESW -Conventional	Standard	1			2D CladFlux E200	
		High	2		CladStrip 625		
	SAW	Standard	2			2D CladFlux S200	
Ni-825	H-ESC*	High	1	CladStrip 825		3D CladFlux E200	3D CladCore 825
	ESW -Conventional	Standard	1			2D CladFlux E200	
		High	2		CladStrip 825		
	SAW	Standard	2			2D CladFlux S200	
Ni-600	H-ESC*	High	1	CladStrip 600		3D CladFlux E200	3D CladCore 600
	ESW -Conventional	Standard	1			2D CladFlux E200	
		High	2		CladStrip 600		
	SAW	Standard	2			2D CladFlux S200	
Ni-400	H-ESC*	High	1	CladStrip 400		3D CladFlux E200	3D CladCore 400
	ESW -Conventional	High	2		CladStrip 400	2D CladFlux E200	
	SAW	Standard	2			2D CladFlux S200	

CONSUMABLES – STAINLESS STEEL

* Patent Pending

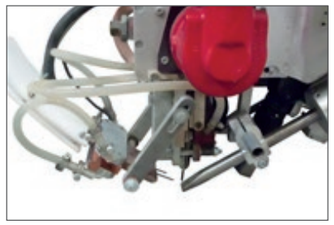
				CONSUMABLE DETAILS			
DEPOSIT	PROCESS / TECHNIQUE	SPEED	LAYER	LAYER-1 STRIP	LAYER-2 STRIP	FLUX	MCW
SS - 347	H-ESC*	High	1	CladStrip 300		3D CladFlux E100	3D CladCore 347
	ESW -Conventional	High	1	CladStrip 24.13LNb		2D CladFlux E100	
			2	CladStrip 24.13LNb	CladStrip 19.9LNb		
		Standard	1	CladStrip 21.11LNb		2D CladFlux E102	
			2	CladStrip 22.11L / CladStrip 21.11LNb	CladStrip 19.9LNb		
	SAW	Standard	2	CladStrip 24.13LNb		2D CladFlux S100	
SS - 308L	H-ESC*	High	1	CladStrip 300		3D CladFlux E100	3D CladCore 308L
	ESW -Conventional	High	1	CladStrip 24.13L		2D CladFlux E100	
			2		CladStrip 19.9L		
		Standard	1	CladStrip 22.11L		2D CladFlux E102	
			2		CladStrip 19.9L		
	SAW	Standard	2	CladStrip 24.13L		2D CladFlux S100	
SS - 316L	H-ESC*	High	1	CladStrip 300		3D CladFlux E100	3D CladCore 316L
	ESW -Conventional	High	2	CladStrip 24.13L	CladStrip 19.12.3L	2D CladFlux E100	
		Standard	1	CladStrip 21.13.3L		2D CladFlux E102	
			2		CladStrip 19.12.3L		
	SAW	Standard	2	CladStrip 24.13L		2D CladFlux S100	
SS - 317L	H-ESC*	High	1	CladStrip 300		3D CladFlux E100	3D CladCore 317L
	ESW -Conventional	High	2	CladStrip 24.13L	CladStrip 19.13.4L	2D CladFlux E100	
		Standard	2	CladStrip 21.13.3L		2D CladFlux E102	

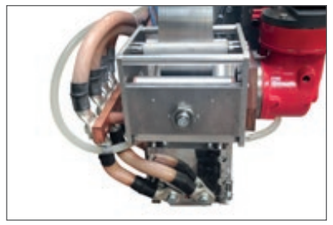


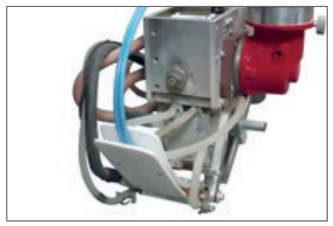
WELDING HEADS, ACCESSORIES & CONTROLLER

CLADDING HEAD

- In-house designed cladding heads for wide range of strip widths (15 to 120 mm)
- Water-cooled and robust modular design
- Power cables can be added as required
- Easily oriented for desired welding direction
- Specifically designed for use in H-ESC* applications involving simultaneous feeding of strip, flux and hot wire







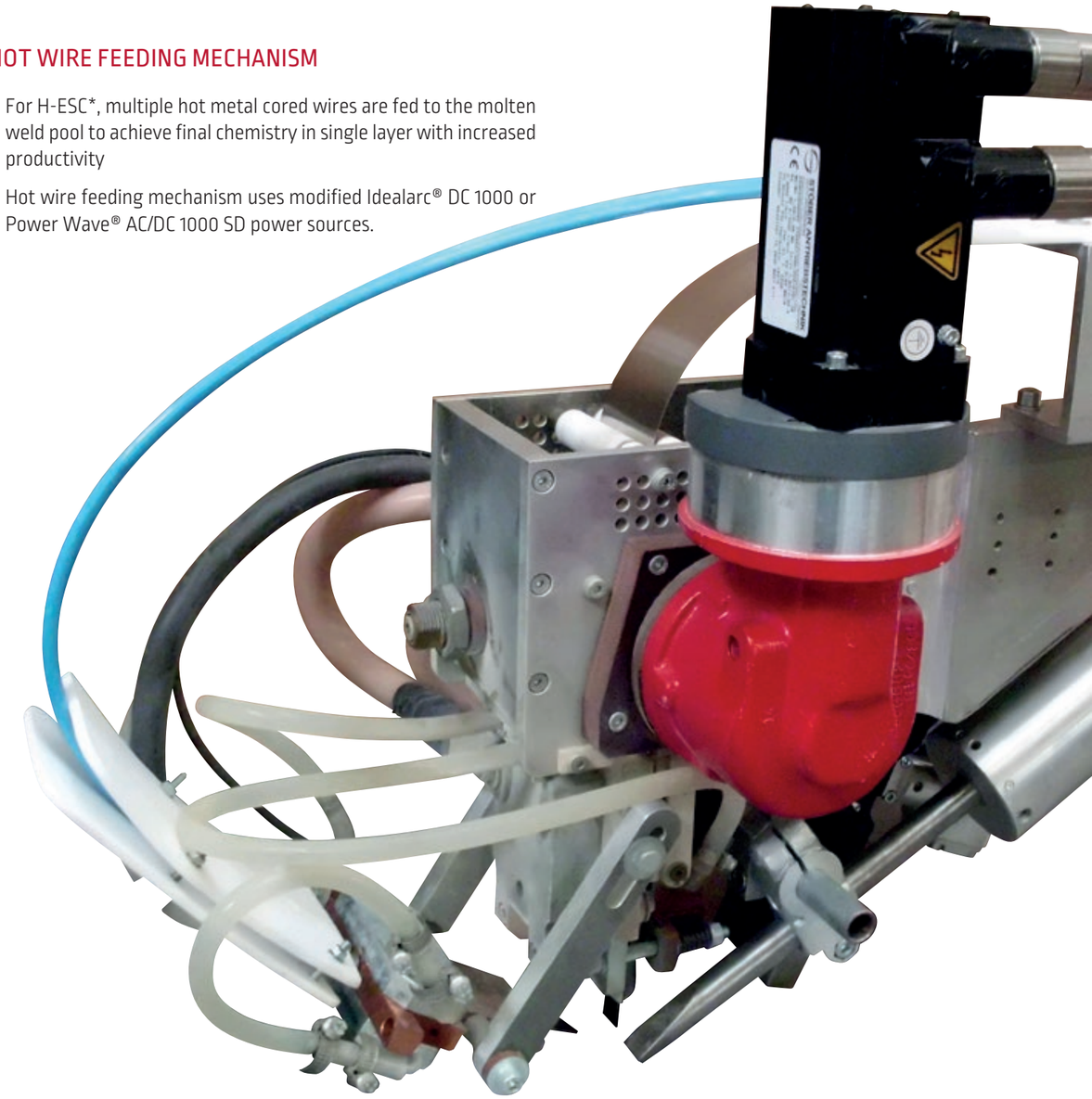
* Patent Pending

MAGNETIC STEERING DEVICES

- Neutralises effect of strong electromagnetic pull generated by high welding current, enabling weld bead to spread wider with smoother overlap and edge profile
- Digitally controlled magnetic steering devices for Submerged Arc, Electro Slag - Conventional & H-ESC* with strip size ≥ 60 mm
- Air-cooled, and field poles can be changed between North & South quickly
- Current range of up to 15A

HOT WIRE FEEDING MECHANISM

- For H-ESC*, multiple hot metal cored wires are fed to the molten weld pool to achieve final chemistry in single layer with increased productivity
- Hot wire feeding mechanism uses modified Idealarc® DC 1000 or Power Wave® AC/DC 1000 SD power sources.



WELDING POWER SOURCES & STRIP FEEDING DEVICE

- Lincoln Idealarc® DC 1000 & 1500 power sources along with NA-5 or NA-3 strip feeding head & controller are the most widely used combinations across the world for conventional strip cladding. Modified Idealarc® DC 1000 will be used as a power source for H-ESC* technique in conjunction with 'Hybrid 3D Z5' control system.
- Multiple power sources can easily be connected in parallel to generate welding currents of up to 3 000A or more.
- Modified new generation inverter-based Power Wave® AC/DC 1000 SD power sources can now be connected in parallel for conventional cladding as well as H-ESC* applications.

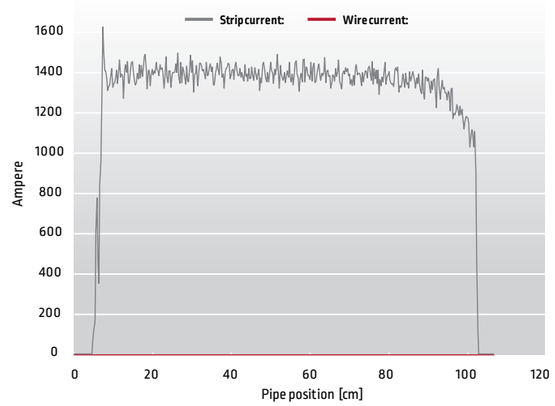
* Patent Pending

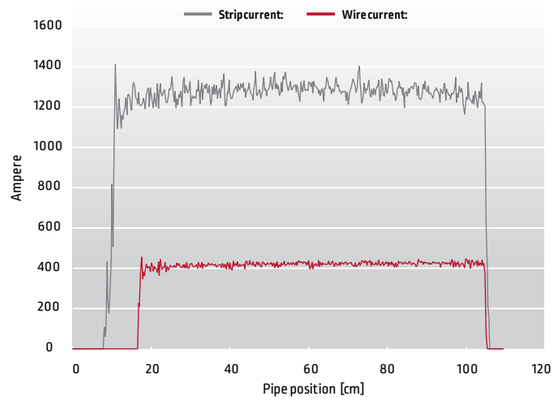
MAIN FEATURES

- The most widely used power sources, controllers & strip feeders in the world.
- Can easily be combined in parallel to supply a current of 3 000A or more.
- Energy saving while using Inverter based power sources.

AUTOMATIC WELDING CONTROL & DATA LOGGING SYSTEM: HYBRID 3D Z5

- Unique development by Uhrhan-Schwill Schweißtechnik.
- Ensures pre-determined ratio of strip & wire feeding maintained for H-ESC* application.
- Effectively controls all the critical parameters and functions in the cladding process
  - current, voltage, welding speed, strip & wire feeding speed, crater filling, magnetic steering device current, electrical stick-out etc.
- Special Access Control features restrict complete control of welding parameters to welding engineers.
- Records and saves minute details of each of these parameters, thus acting as a high-end data logger.
- Fabricators have perfect data traceability and retrieval.
- Specially features can be added, e.g. preheat control, laser seam tracking control, live video recording facility etc.





SPECIAL ALLOYS™

Uhrhan-Schwill SCHWEISSTECHNIK
A Lincoln Electric Company

STRONG GLOBAL BRAND & MARKET LEADER – 120 YEARS YOUNG, KNOWN WORLDWIDE FOR QUALITY, PERFORMANCE AND PRODUCTIVITY

Pipemills

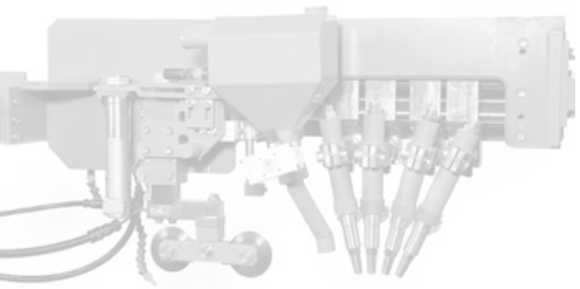
Multi Arc, Sub Arc Technology

Global Leader in Longitudinal Pipe Welding and Leading Position in Spiral Pipe Welding

Critical Process Equipment

Strip Cladding complete solution

Narrow Gap Welding complete solution



10 000	Employees
160	Active in 160 countries
48	Manufacturing locations for consumables and equipment
19	Manufactured in 19 countries
2.9	Billion USD Revenue in 2013

LINCOLN® ELECTRIC

SPECIAL ALLOYS™

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CUSTOMER ASSISTANCE POLICY

The business of The Lincoln Electric Company® is manufacturing and selling high quality welding equipment, consumables, and cutting equipment. Our challenge is to meet the needs of our customers and to exceed their expectations. On occasion, purchasers may ask Lincoln Electric for information or advice about their use of our products. Our employees respond to inquiries to the best of their ability based on information provided to them by the customers and the knowledge they may have concerning the application. Our employees, however, are not in a position to verify the information provided or to evaluate the engineering requirements for the particular weldment. Accordingly, Lincoln Electric does not warrant or guarantee or assume any liability with respect to such information or advice. Moreover, the provision of such information or advice does not create, expand, or alter any warranty on our products. Any express or implied warranty that might arise from the information or advice, including any implied warranty of merchantability or any warranty of fitness for any customers' particular purpose is specifically disclaimed.

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