IMPROVEMENT IN WELDING STAINLESS STEEL GRADES WITH MASH-LAP PROCESS FOR CONTINUOUS PROCESSING LINES[1]

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Abstract

On continuous annealing and pickling lines mash-lap welders are frequently used. Welded joint overthickness is a key point for tightness of the furnace. The objective is to protect seals at entry and exit of the furnace. Stainless steel producers have some difficulty in producing thicknesses over 1.2 mm on APL because of the limitation of standard Mash-Lap welder capacity. With the latest Mash-Lap welder of heavy type designed by VAI CLECIM, joint R&D work between UGINE-ALZ and VAI CLECIM on welding process gave good results. This type of welder thus perfectly matches the requirements of high quality stainless steel welding. Some modifications to adjust more parameters according to stainless strip grades will be available on the welder specially modified for stainless steel market.

Key words: Mash-lap welding; Stainless steel austenitic; Ferritic; Martensitic; Parameters; Overlap; Structure

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ML 21 H abstract

VAI CLECIM, a subsidiary of VAI company, is one of the major companies providing automatic welders for the steel industry. Catalogue includes Flash-butt welders, Mash-Lap welders and laser welders used for tandem mills, processing and finishing lines.
VAI CLECIM has sold around 50 welders for worldwide steel industry in the last 5 years.
Welder HML 21 is a heavy mash-lap welder, with high power for welding force and welding current, able to weld carbon steel strip up to 4.5 mm. Within a range of 800 Mpa or more Tensile Strength for finished product.

Welding force :	500 kN (hydraulic)
Planishing force :	800 kN (hydraulic)
Welding current :	max 45 kAmps (DC)
Welding speed :	max 20 mpm
Thermal Control Quality :	IRRCON sensor
Welding wheels overhung mounted :	30 x 350 mm²

Welding heads are water cooled and hardened on conditioning rolls after each weld.
Strip overlap can be adjusted independently on Op and Drive side with two servo-cylinders. Overhang can also be adjusted. (It is to be noted that VAI CLECIM welder is the only one offering this ability).
One shear with two blades to cut either head end and tail end.
Welder is controlled through one PLC

Welding tests on AISI 304 and 430

Welding tests have been made on grades 430 and 304 with UGINE-ALZ samples in different thickness ranges:
0.38 / 0.59 / 1 / 1.5 / 2.0 / 3.0 mm
AISI 304 - 1.4301 - X5CrNi18-10 for deep drawing quality
C 0,04 - Si 0,50 - Mn 1,50 - Cr 18,20 - Ni 8,70.
AISI 430 – 1.4016 – X8Cr17
C 0,05 - Si 0,35 - Mn 0,40 - Cr 16,5

Standard ML welders cannot weld over 1.2 mm in a fully reliable way. Problems are occurring with shearing (blades have to be changed every three welds), and welding (welding speed very slow). Thus, melted nugget is too big, which leads to non-homogeneous weld).
Besides, with this joint development between UGINE-ALZ and VAI CLECIM, it was the first time that so heavy gauges were welded by the Mash-Lap process with the objective of obtaining an industrial process.
To achieve optimum results, the following rules have to be observed :

- Shearing with hydraulic cylinder fed by 150 bar pressure.
- Overlap and overhang should be adapted depending on strip thickness **and** steel grade. This is a major point compared to carbon steel welding
- Basically, parameters for stainless steel should be in the ratio of 3 compared with carbon steel welding

Erichsen Tests on welded samples have been conducted for all samples.
Macrographies have been made on all welded samples following UGINE-ALZ criteria.
The ratio between thickness of welded nugget and thickness of base metal is one of the key features. This ratio should be between 33 to 66 %.

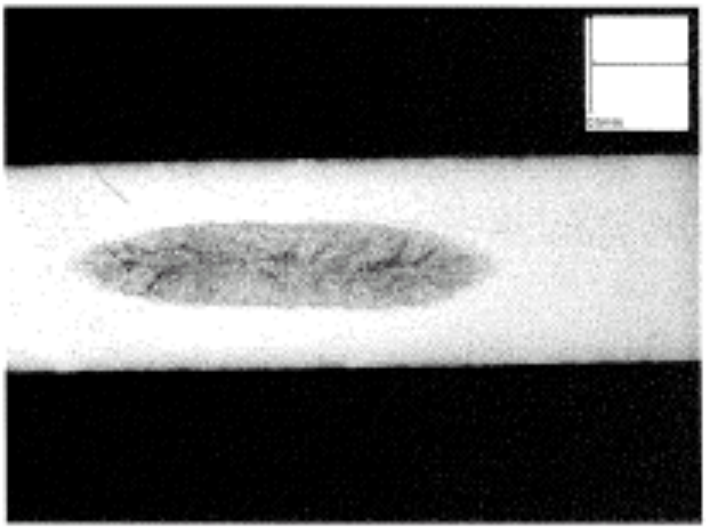
- On 0.38 and 0.59 mm (austenitic), welds are good
- On 1 mm (austenitic), welds are good
- On 2 mm (ferritic), welds are good, but improvement should be done to harmonize size of melted nugget along weld length. Improvement on parameters about compensation to be applied between Op side and Dr side overlapping.
- On 3 mm (austenitic), welds are good
- Welding tests should be done on smallest thickness available which is 0.29 mm. Those tests are scheduled in October 2005 on a VAI CLECIM welder specially adapted for this.

304 – 3 mm thickness

304 – 0.38 mm thickness

Grade	Thickness	Speed	Current	Welding force	Planishing force	Overlap OP side	Overlap DR side
	mm	m/min	kA	daN	daN	mm	mm
304	0.38	15	12	1750	0	2.5	2.5
304	0.59	15	14	2000	0	2.5	2.5
304	1	15	20	2600	4500	0,9	2,3
304	1,5	15	24	3300	4500	1,2	2,9
430	2	12	29	3600	4500	1,5	3,3
304	3	7	32	5000	4500	2	4,3

- The overthickness, linked to nugget size, follows the welding current / welding force ratio. Nugget size is also important for weld strength.
- Structure on AISI 304 (A steel) is mainly austenitic
- Structure on AISI 430 (F steel) is ferritic and martensitic in melted area ; and ferritic in heat affected area.
- Structure is dependent on the size of welded nugget. The bigger the nugget, the more martensite it contains. The less martensite in the weld, the better the joint.

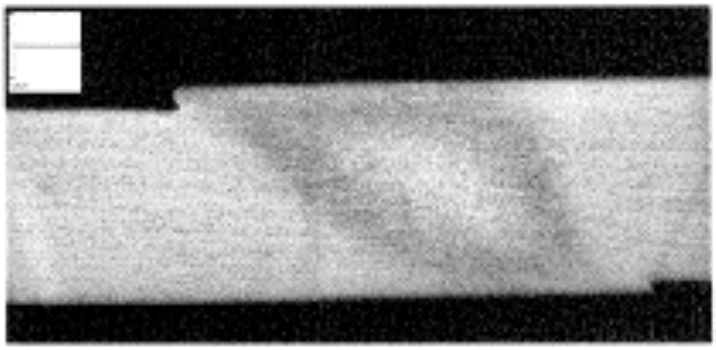


Rec = 2,14 / 2,45 mm
Noyau = 1,62 x 0,33 / 2,18 x 0,44 mm
Sur-épaisseur = 3 % / 3%

304 steel thick. : 1 mm

Essai 6
304 ép. 3,0 mm

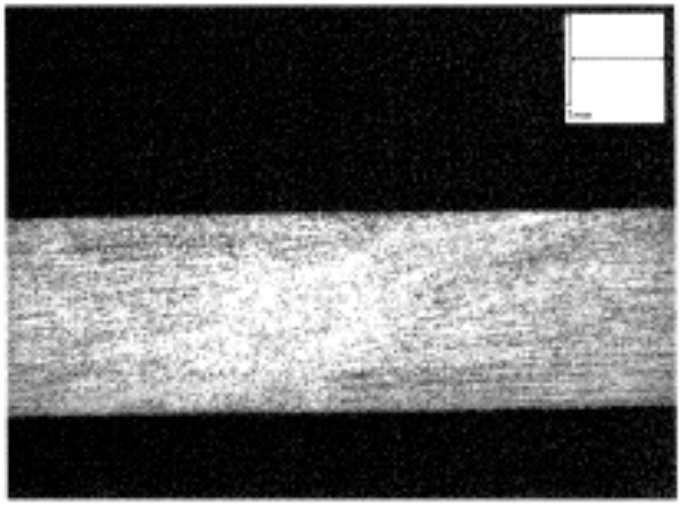
I = 32 KA
F_s = 5000 daN
F_g = 4500 daN
Rec = 2,0/4,3 mm
V_s = 7 m/min



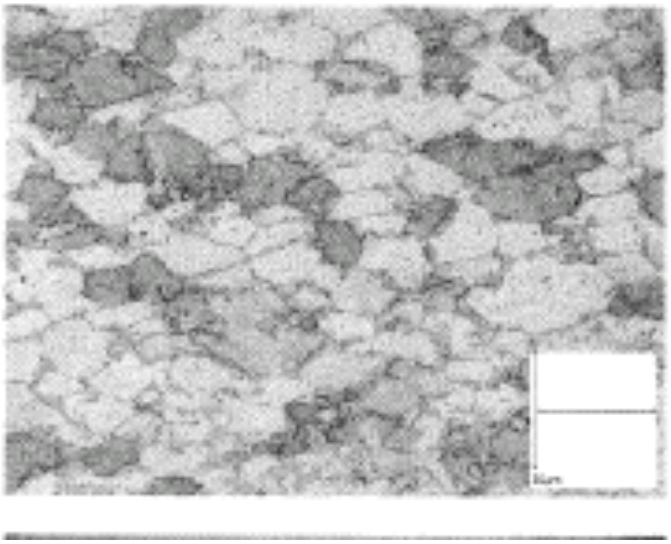
304 steel thick. : 3.0 mm

Essai 3
430 ép. 2,0 mm

I = 29 KA
F_s = 3600 daN
F_g = 4500 daN
Rec = 1,5/3,3 mm
V_s = 12 m/min

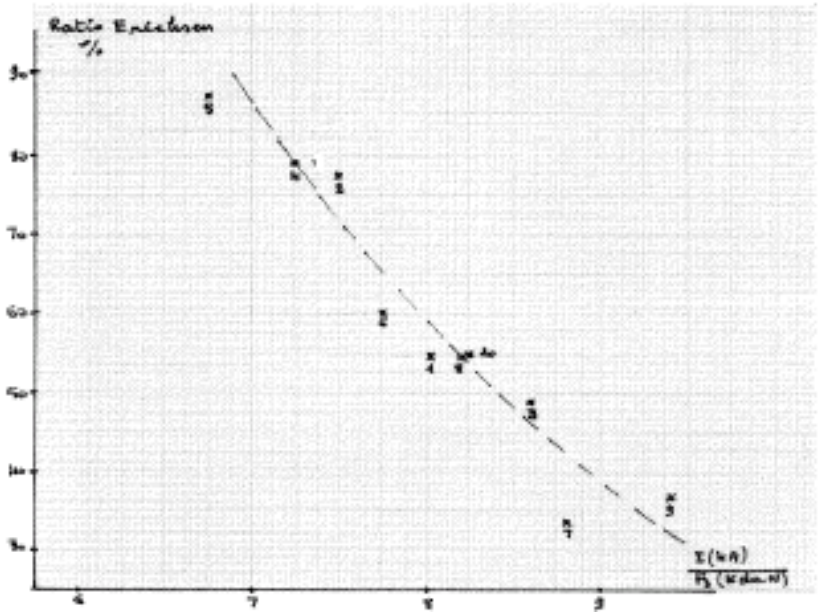


430 steel – 2.0 mm thickness

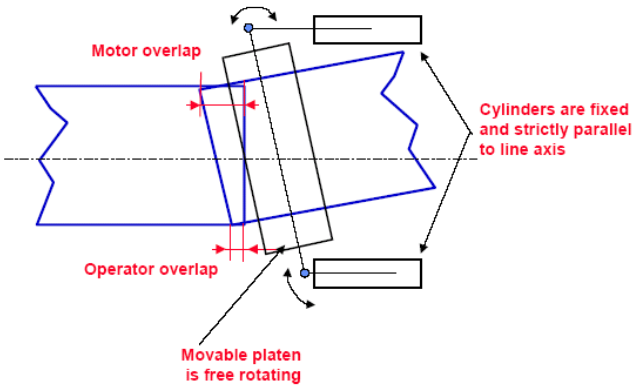


430 steel – 2.0 mm thickness – melted nugget
(Ferritic structure + some elements of martensite)

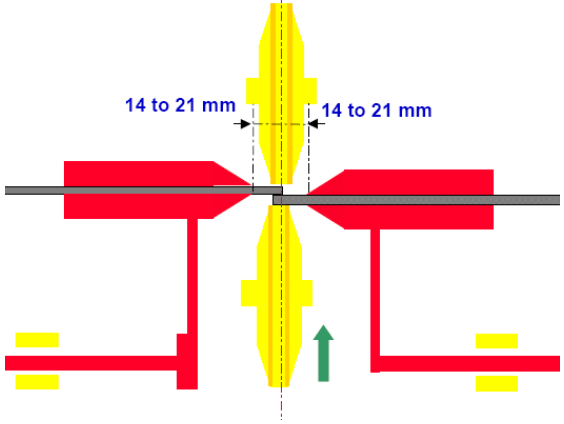
Size of melted nugget in ferritic steel and their metallurgical structure after weld depends directly on welding current / welding force ratio.



ML welder design with independent control on Op side and Dr side of platen position gives easy ability to modify this overlapping which is very useful. The feedback control on position provides reliability and stability.



Strip overlap can be adjusted independently on Op and Drive side with two servocylinders.



Overhang can also be adjusted. (It has to be noted that VAI CLECIM welder is the only one offering this ability).
This is a real advantage for this type of welder, furthermore considering the level of power available.

So first conclusions are :

1 this welder is reliable for steel up to 3 mm, even with full hard material, which can open large opportunities for thickness growth in production.
2 Thermal control quality with IR sensor is useful for weld control.
3 It should be noted that thermal effect during welding leads to tightening the strips. So, final overlap on motor side is bigger than requested by parameters. This effect is exactly the opposite of the phenomena occurring in carbon steel welding.
4 Another point is that ferritic steel needs overlap compensation between motor side and operator side as for carbon steel, but in a different range (less).
Austenitic steel does not need such compensation.
5 Overthickness target is 10 % not to damage furnace seals. This value can be reached in the whole range of strip thicknesses.

CONCLUSION

Joint R&D work between UGINE-ALZ and VAI CLECIM on welding process gave following results:

- Overlapping compensation between OP side and Drive side should be done according to thickness and steel grade (ferritic, austenitic, martensitic)
- Shearing force, clamping force and welding force should approximately be twice as high as the forces applied for carbon steel.
- Welding current should be higher than for carbon steel
- Shear overhang should be according to thickness.
- To be noted is the exceptional power available for process and shearing. This welder is probably the strongest available in the world's modern markets.

Mash-lap welders designed by VAI CLECIM are perfectly adapted for high quality stainless steel welding. An overhang adjustment according to strip grade will be available on welder specially modified for the stainless steel market.
The objective of this work, ie to provide new possibilities for industrial applications, has been reached. Stainless Steel industry has now got a Mash-Lap welder able to be used on processing lines for strip thickness up to 3 mm.

APERFEIÇOAMENTO NA SOLDAGEM DE AÇOS INOXIDÁVEIS COM O PROCESSO MASH-LAP PARA LINHAS DE PROCESSAMENTO CONTÍNUO[1]

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Resumo

Linhas de decapagem e recozimento contínuas utilizam frequentemente máquinas de soldar Mash-Lap. A maior espessura da junta soldada é um ponto essencial para a estanqueidade do forno. O objetivo é proteger as vedações na entrada e na saída do forno. Os produtores de aço inoxidável têm alguma dificuldade em produzir espessuras acima de 1,2 mm em APL devido à limitação da capacidade da máquina de soldar Mash-Lap padrão. O trabalho conjunto entre a UGINE-ALZ e a VAI CLECIM na Pesquisa & Desenvolvimento de processos de soldagem utilizando a mais moderna máquina de soldar Mash-Lap projetada pela VAI Clecim apresentou bons resultados. Assim, este tipo de máquina de soldar atende perfeitamente os requisitos de soldagem de aço inoxidável de alta qualidade. Algumas modificações para ajustar parâmetros adicionais em função do tipo de tira de aço inoxidável estarão disponíveis na máquina de soldar especialmente modificada para o mercado de aços inoxidáveis.

Palavras-chave: Soldagem mash-lap; Aço inoxidável austenítico, ferrítico, martensítico; Parâmetros; Sobreposição; Estrutura

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