INDUSTRIAL APPLICATIONS FOR MSG - LASERHYBRID WELDING PROCESS

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ABSTRACT: For an optimal utilisation of the benefits of the two separate joining processes, the laser beam and the MSG arc combine in this new process to form a common melting pool. The high energy density of the laser beam melts the material ensuring a good penetration and a slim fusion zone. Metallographic analyses show a relatively wide focus of the light source. The combined filler wire provides high integrity welds. The combined process now considerably increases its potential areas of use and MSG-Laser-Hybrid Welding can be used anywhere where MSG-arc welding is used, for example with low- and high-alloy steels, and aluminium and its alloys. Depending on the base metal, different solid and filler wires are used for steel according to the actual requirements. The separate selection of each process is still a key factor. Laser beam performance as well as the values of the MSG-arc are as normal. The ratio of the power contributions of the energy sources affects the character of the arc and the seam appearance as well as the form of penetration. Several examples of realised welded joints, as well as potential industrial applications are described further. Concrete cost calculations prove once again the economicity of this new welding procedure.

Keywords: welding, laser beam, MIG/MAG, LaserHybrid, joint

INTRODUCTION

Nowadays, one of the most important MIG/MAG (sub)processes in the heavy industry is a peculiar combination between MSG and laser welding, known as LaserHybrid.

Due to its promising perspectives, a lot of welding equipment producers developed lately some – more or less experimentally – welding systems for LaserHybrid welding. Most of these producers are supplying welding heads and/or MSG equipments, being understood that one must purchase the robot, the laser generator and accessories or the control systems from specialized companies.

The main disadvantage of the [classical] MIG/MAG process consists in the impossibility to adjust separately the energetic input and the material flow.(In order to increase the welding current one must rise the welding speed, which means more metal will be brought into the welding pool.

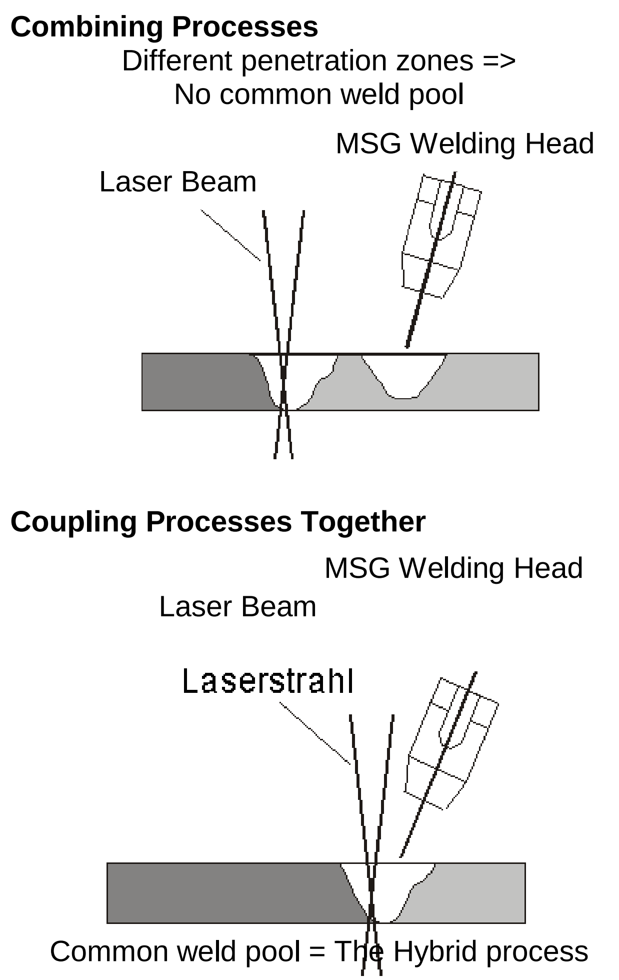


Fig. 1. Principle of the LaserHybrid welding process

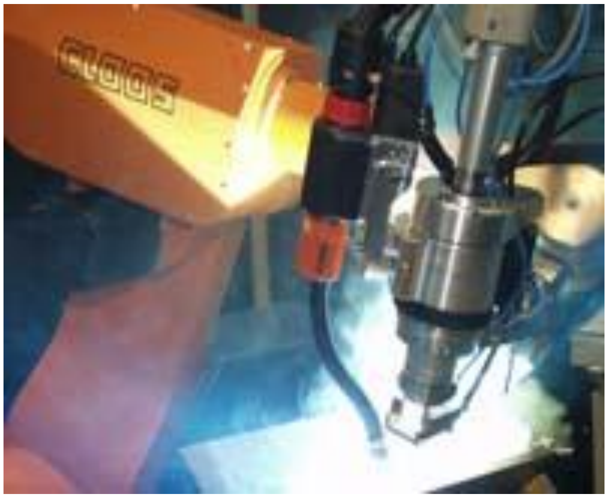


Fig. 2. Compact welding head with integrated axes

Besides the fact that it is a high productivity process, LaserHybrid welding allows a welding pool to provide an additional quantity of energy, very precisely dosed.

For practical use, LaserHybrid process provide:

- a much better tolerance to dimensional variations of joint; thus, parts with greater opening and irregular edges of the gap can be welded;
- much higher speeds than ones obtained with the same power of MIG/MAG arc
- a much deeper penetration than one obtained with classic MIG/MAG welding;
- low heat input in joint components, thus, smaller heat affected zones;
- a more stable process, even from ignition: MIG arc is formed in the area ionized by laser and, thus, spatter free;
- less cracking and porosity, there is an increased resistance of joints;
- narrow seams with a better form factor.

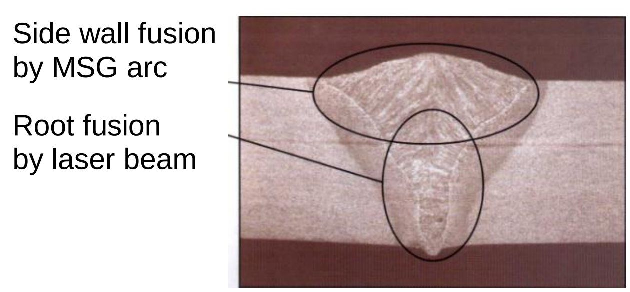
The development of some welding power source Laser Hybrid aims to mantain as much as possible the characteristic advantages of both processes; if at arc welding the power source is cheap, the possibility of gap bridging is high and we can influence the through the type of filler material the microstructure of joint, in laser welding we have:

- increased penetration depth;
- low heat input;
- reduced transverse size (a narrow seam).

At metallic parts, at a given beam energy density, laser produces an effect "seam penetrated, deep", so that it becomes possible to weld parts with medium and large thickness.
From all the presented results it is possible to achieve a much wider range of application, and adding laser allows even extending the application of MIG/MAG process. At the same time and MIG/MAG arc "helps" in a way the laser, because the power needed by the laser is smaller than working "alone": or, it is known how strongly increases the cost of laser machine along with power, i.e. in relation with the thickness needed to be weld.

Beside laser welding, Laser Hybrid process is more economical, because it entails a more reduced seam preparation. Compared with MAG welding, additional gains in productivity lies much higher, even with higher thickness of plates [1].
The defects at the beginning and the end are much lower, there are no longer registered loss of penetration because the lack of melting at the beginning or the end of joints.
The intensified thermal field given by laser reduces the quantity of drops specific to MIG/MAG arc, thus not necessary to remove drops.

Effect of the process visible in micrograph



Weld data:
Y seam 60°

Root gap:	0,3...0,9 mm
Thickness of root:	4 mm
Welding speed:	80 cm/min

Fig. 3. Micrograph of a MSG-Laser-Hybrid weld seam

Other sources of economic efficiency due to lower processing needs of the joint: after [2] is enough an "Y" processing, with approx. ¾ of thickness in bevel form only at 12° and in the lower side as possible in touch.
The melting of the base metal takes place differently in the higher level than in the lower level of the joint (Fig. 3).

By juxtaposing the two thermal sources, as a result of the weld is that of a funnel: the higher part, produced by the action of the MIG/MAG arc is defined by a large melting radius and a lower degree of penetration. The lower part, as a effect of the melting produced by the extremely narrow laser beam, has opposite geometrical features. On the other hand, in some regimes, when the temperature of the welding pool induced by laser is too high, it is possible that metal vapors produced to limit by their opacity the penetration of the light beam.

In Fig. 4 is presented the structure of a robot cell which uses a welding power source Laser Hybrid.

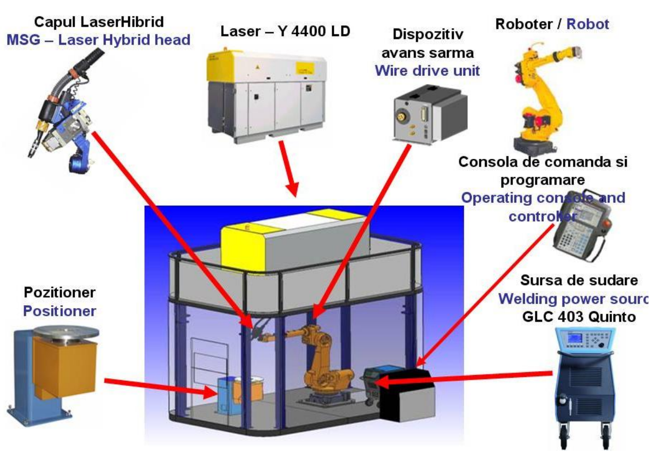


Fig. 4. The composition of a robot cell which uses a welding power source Laser Hybrid

There are possible in practice situations a little bit different than this typical case:

- interaction between the plasma of the MIG/MAG arc and of the „keyhole" determined by de laser beam sometimes lead to a „horn" form, such as the but joint presented in the Fig. 7.
- Also, the shape of the pool differs noticeably in situations when the laser is located in front or in the back of the MIG/MAG welding torch.

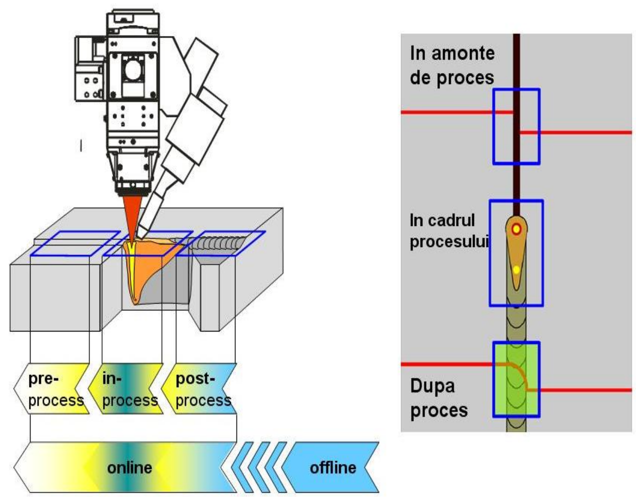
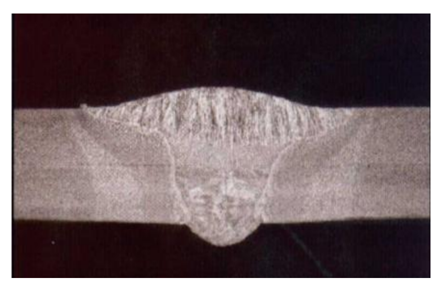


Fig. 5. Categories and types of sensors used in LaserHybrid welding

Butt joint; sheet metal 8; position PA; length of seam 1.000 m

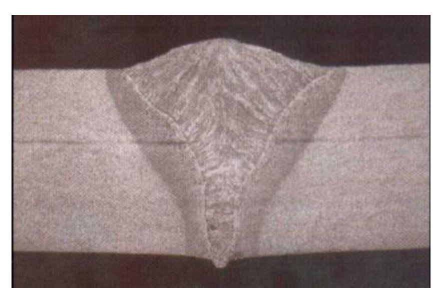
MAG:
Seam preparation:

V-seam, root gap 2 mm; 50°beam width



Wire diameter: 1,2 mm
Welding time: 498 s/m in three passes

MSG LASER-HYBRID:
Seam preparation:
Y-seam, root gap 2 mm; 60°beam width

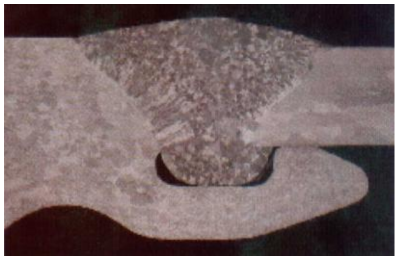


Wire diameter: 1,6 mm
Welding time: 75 s/m in one pass

Fig, 6. Comparison with MAG –process

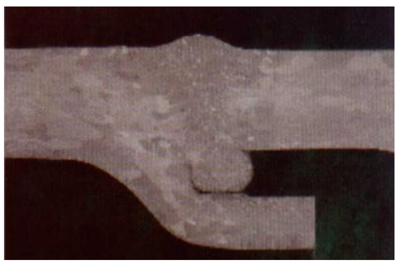
Butt joint; 5 mm aluminium ALMgSi0,7; position PA

MIG:
Seam preparation: no



Wire diameter: 1,6 mm
Welding speed: 0,7 m/min

MSG-LASER HYBRID:
Seam preparation: no



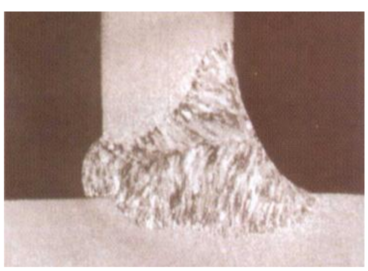
Wire diameter: 1,6 mm
Welding time: 1,8 m/min

Fig. 7. Comparison with MIG –process

T-Joint; 2x8 mm S355 J2 G3; position PA

MAG:

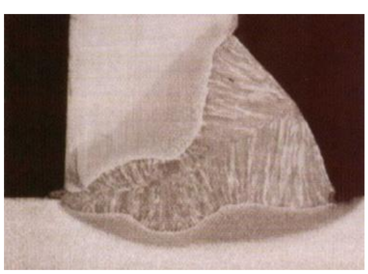
Seam preparation: no



Wire diameter: filler wire
Welding speed: 0,24 m/min

MSG-LASER HYBRID:

Seam preparation: no



Wire diameter: 1,2 mm
Welding time: 1,0 m/min

Fig. 8. Comparison with MIG –process

Table 1. Comparison between LaserHybrid and actual MIG/MAG welding

Welding	Tandem	Laser-Hibrid
1 seam	1,5 min/m	2,10 min/m
2 seam	2,20 min/m	0 min/m
3 seam	0 min/m	0 min/m
Milling	1,20 min/m	0 min/m
Total Processing	4,90 min/m	2,10 min/m
Filler material consumption	0,72 kg/m	0,21 Kg/m

After numerous studies and experiments in laboratories, the companies producing welding machines developed improved versions, for industrial use of Laser Hybrid welding heads previously shown to meet the requirements set out above. The technologic concept long proven in industrial enviroment of robot controller ROTROL® can be adapted with minimal changes to the Laser Hybrid welding. By judicious programming of the laser parameters and the ones for MIG/MAG arc it can be obtained an effect of metal heat treatment „brutalized" by the too high thermal field of the laser beam.

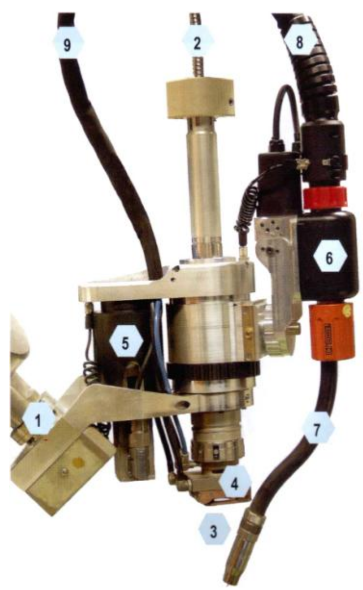
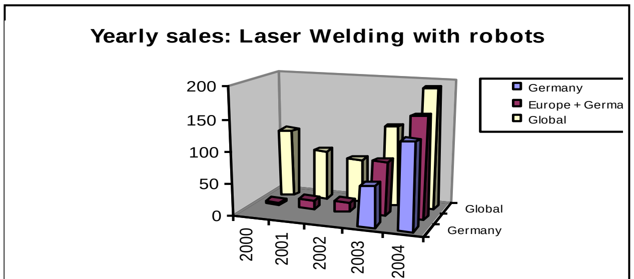


Fig. 9. Welding head developed by CLOOS

The narrow shape, especially in the tip area, torch head and the additional rotation axis (the seventh axis of the tool manipulator, with a rotation freedom of + / - 135°), allow universal access and a great flexibility in practical applications (Fig. 9).

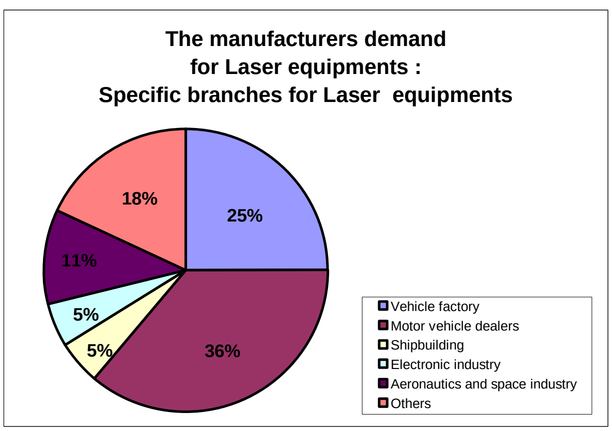
Components of the welding head:

1. Robot mounting flange
2. Connection optical waveguide
3. Outlet of laser beam
4. Air curtain (croos jet) for protection of optics
5. Servomotor of integrated axis
6. Wire drive CDD
7. MSG-welding torch
8. Connection welding machine
9. Connection robot controller



	2000	2001	2002	2003
Germany				63
Europe + Germany	4	14	15	85
Global	110	80	70	128

(a)



(b)

Fig. 10.

Although the implementation of Laser Hybrid process is only at the beginning, its applications already include a wide range in automatic / robotic welding: among other welding components for commercial vehicles [2, 3, 4, 5], railway carriages and their subassemblies [6, 7, 8], construction machinery and for manufacture container in various fields of technology.

The most promising future use seem to be in fact – as shown by Mr. Bertil Pekkari (curent president of the International Institute of Welding – I.I.S / I.I.W), those from shipbuilding construction. Atfer him, [9] until 2008 approx. 70% of all welded joints of ships will be delivered through Laser Hybrid method. The base materials in question are all metals than can be welded currently by MIG/MAG process, especially steel and light alloys.

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