

LASER BEAM EFFECT UPON STEELS REACHES IN MANGAN AND CROM

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ABSTRACT

The purpose of this paper is to analyze the behavior of austenitic manganese - Hadfield steel during laser beam welding in continuous regime. In order to limit the number of experiments, a 2^4 type factorial experiment was used, with 16 assays, after a frequently used program matrix for these situations. Fusion lines at different service regimes, as well as head-to-head welds were performed. Microhardness measurements and microstructure modifications that appear as an effect of laser irradiation are also analyzed.

KEYWORDS laser welding, steel, fusion lines, head to head welds

1. INTRODUCTION

The main advantages of laser beam welding are:

- superior quality of the joint;
- minimum changes to appear undesired structures in HAZ;
- possibility to obtain even micro-welds;
- can be joined materials that are difficult to weld by other welding processes;
- can be highly automated.

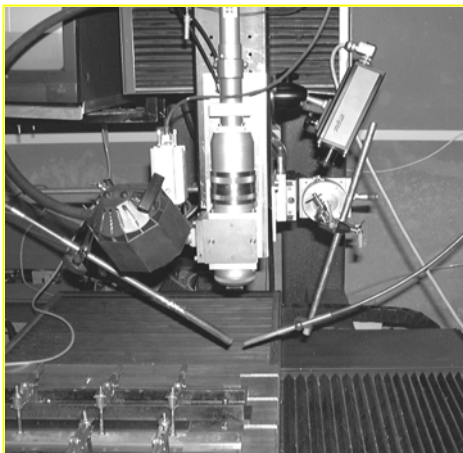


Fig.1. The working head of HL 3006D LASER

Manganese steel welding by this technology presents a challenge, because these steels present technological difficulties as a result of their significant tendency to become fragile and their pronounced crack sensitivity.

2. EXPERIMENTATION AND TESTING CONDITIONS

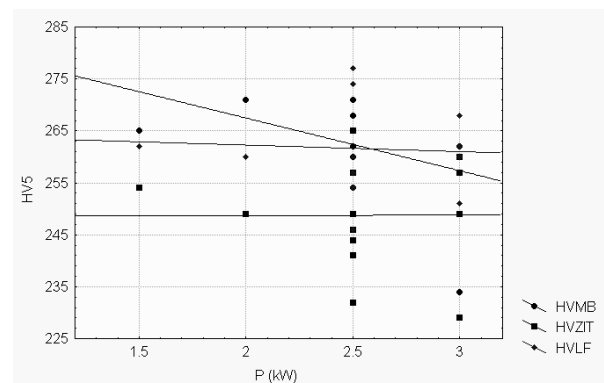


Fig.2. Regression lines $HV5=f(P)$

The experiments were performed on a HL 3006D LASER, with Nd-YAG active medium, in continuous emission, which can develop a maximum power of $3kW$. It stands out with its remarkable quality of the beam, characterized by a very low divergence for this power range. The beam transmission to the welding sample was achieved through an optic fiber, with a $600\mu m$ diameter and with a convergence distance of $200mm$, the convergence point being on the surface of the sample. During the process, argon backing was used as protecting medium, with a flow rate of $20l/min$. The tests were carried out on samples with a thickness of $2mm$, detached from a Hadfield steel bar, forged and annealed. The hardness of the samples was measured using a Vickers

hardness tester equipped with a 0,2N applied load. The microstructure was examined by optical microscopy. In figure 1 is presented a picture of the working head used for experiments.

Table 1. The welding parameters values and the hardness obtained

Sam ple no.	LASER power [kW]	Welding speed [m/min]	HV5		
			Base material	HAZ	Joint line
1	2,5	1,5	268	257	274
2	3	1,5	262	260	262
3	2,5	2	249	241	260
4	3	2	257	229	260
5	2,5	1,5	271	232	257
6	3	1,5	234	249	251
7	2,5	2	262	244	260
8	3	2	262	257	260
9	1,5	2	265	254	262
10	2	2	271	249	260
11	2,5	2	260	244	277
12	3	2	260	260	268
13	2,5	1,5	271	246	274
14	2,5	2	271	244	260
15	2,5	2,5	271	265	246
16	2,5	3	254	249	254

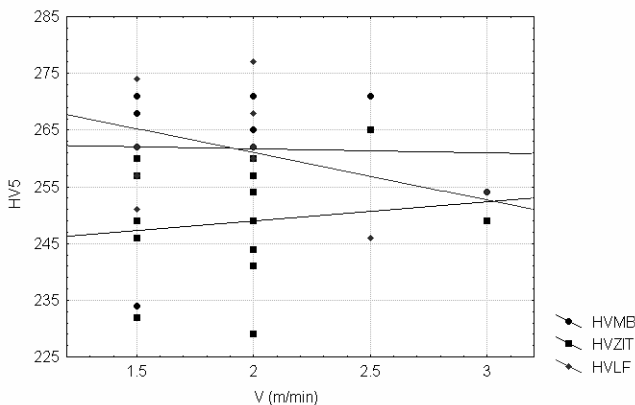


Fig.3. Regression lines $HV5 = f(v)$

3. THE CHARACTERISTICS OF THE WELDING STEEL

Chemical composition analysis (1, 72% C; 11.57% Mn; 1, 46% Cr) indicates that this steel belongs to the category of chrome alloyed austenitic manganese - Hadfield steel, used for its increasing wear-resisting

properties during its utilization in shock stress (phenomenon known as work hardening). The presence of manganese in the steel composition, in this percentage, has a negative effect, as the steel is prone to crack during heating, and also has a tendency to become brittle.

As a consequence the steel's weldability is conditioned by its significant cracking sensitivity. The advisable processes are those that slightly heat the material, with high speeds and low currents.

4. THE ORGANIZATION OF THE EXPERIMENTATION

The following process parameters were taken into account:

- the laser's power at 4 levels, P: 1,5; 2; 2,5; 3 kW ;
- the welding speed at 4 levels, v: 1,5; 2; 2,5; 3 m/min .

Microhardness in the heat-affected zone (HVZIT) and in the joint line (HVLF), were measured and were compared with that of the base material (HVMB).

The welding parameters values and the hardness obtained for each case are presented in table 1:

The hardness regression lines as a function of the laser power and the welding speed are presented in the figures 2 and 3.

Three dimensional representations of the variations of hardness in base material, HAZ and joint, as a function of the 2 welding parameters, obtained using the STATGRAPHICS software, are presented in the figures 4, 5 and 6.

The hardness regression equation in the HAZ is:

$$HVZIT = 240,057 + 0,734P + 3,516v \quad (1)$$

And in the fusion line:

$$HVLF = 284,824 - 9,265P - 2,485v \quad (2)$$

These equations allow us to evaluate the hardness for every chosen welding regime. The analyzed steel has a rather low quality. It presents an accentuated austenitic type cellular-dendritic structure, with pronounced carbide and foreign inclusions at the grain

boundaries, with crack and pores, which accentuates the risks of compromising the good behavior during exploitation (figure 7.a, b).

A quenching heat treatment at 1050°C, with water cooling leads to an improved quality of the steel, determining an optimum structure, without carbides separation at the grain boundaries (figure 8.a, b).

A first conclusion drawn from the structural analysis of the welded sample and from hardness measurements is that there are no substantial differences between the different welding regimes. In all cases, the welded joint structure presents the following characteristics:

- the welded joint, having the same composition as the base material, presents a very fine dendritic structure, without carbide separations; the presence of deformation twinning, and also the fact that the main austenite dendritic axis are oriented parallel with heat exhaust direction during solidification (figure 9.a, b).

- the heat-affected zone (HAZ) is slightly influenced, it can be appreciated that because of the high temperatures and quick cooling, the grain structure in the metallic mass presents the same tendency for fine dendritic structure on a thickness of at up to 100 μm .

5. CONCLUSIONS

Laser beam welding in continuous regime modifies in a significant manner the thermal influenced zone. The regression equations that were obtained lead to maximal variations in microhardness up to 10..15HV units.

It is also important to mention the presence of cracks caused by the steel's poor quality and probably the LASER welding conditions, of which effects are not fully understood.

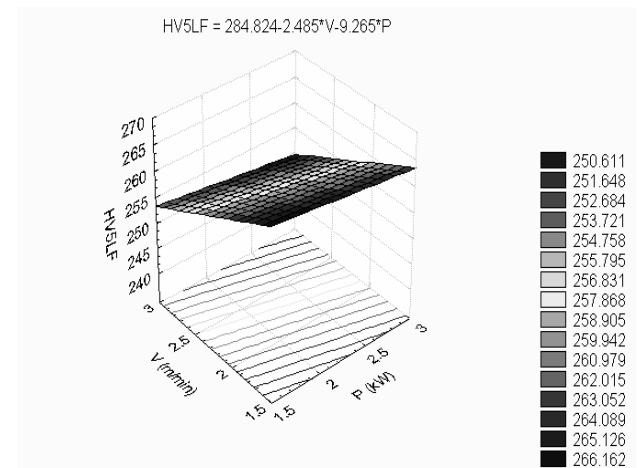


Fig.4. Variation of hardness (base material)

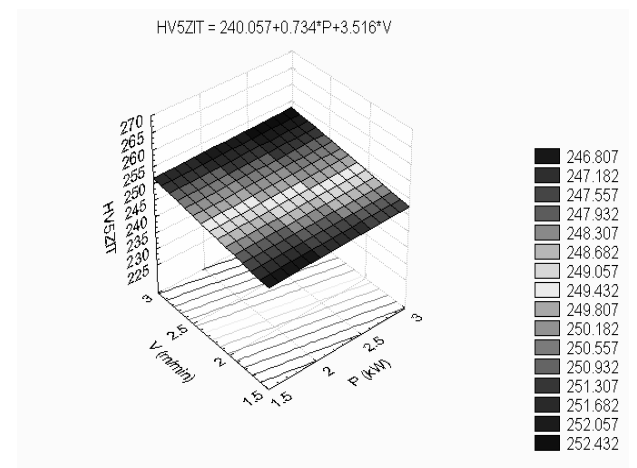


Fig.5. Variation of hardness (HAZ)

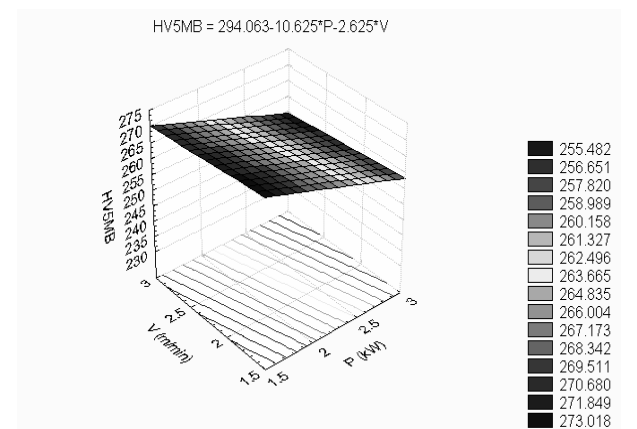
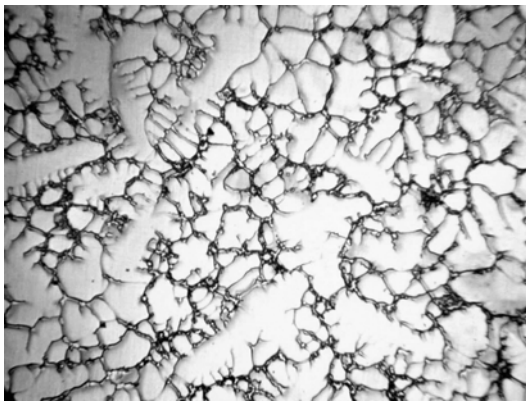
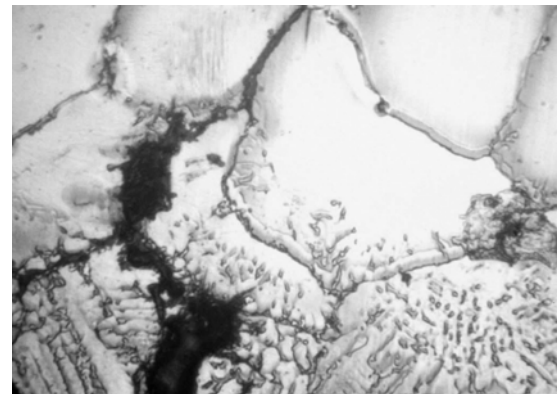


Fig. 6. Variation of hardness (joint line)

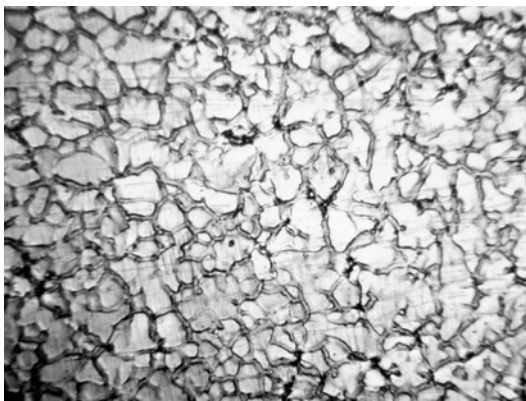


a) O. M..100x

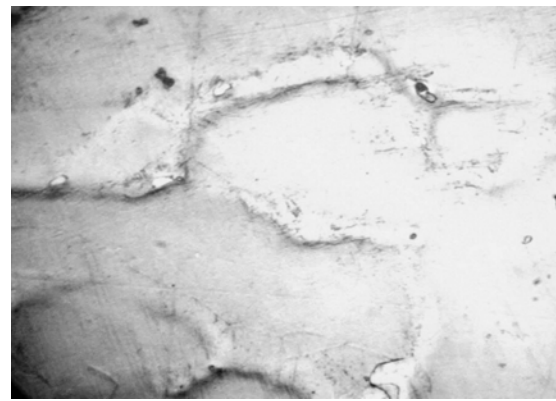


b) O.M. 500x

Fig. 7 Microstructure of base material

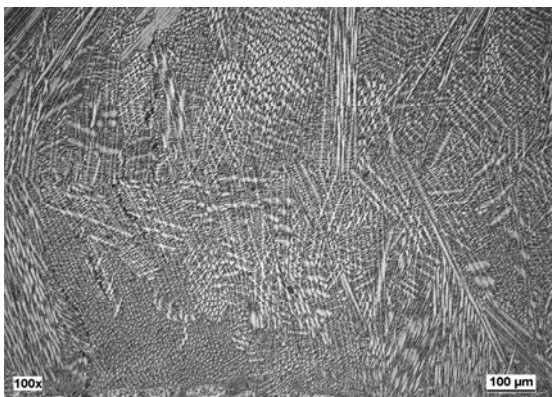


a) O M.. 100x

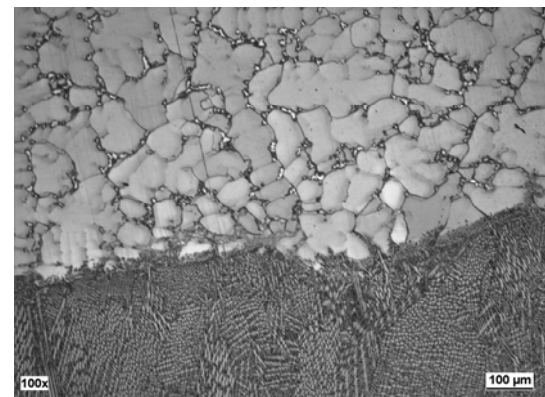


b) O. M. 500x

Fig. 8 Microstructure of base material (after quenching heat treatment)



a) O. M. 100x



b) O. M. 100x

Fig. 9 Dendritic structure of welds

REFERENCES

- [1] I. DAVID, E. CICALĂ – *Establishing the regression polynoms for the objective function that defines the dimensional accuracy in the case of LASER welding.* Romopto '97, Proceedings of SPIE, vol 3405, pg 299-305.
- [2] I.DAVID, V.SERBAN - *Preliminary studies concerning hadfield steel behavior during laser beam welding.* Romopto '06, proceedings of SPIE.

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