Microstructure Study of the Stainless Steel Layer on AlSi Cast Alloy Prepared by Laser Deposition

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The main aim of this study is structural changes on the layer of Al-Si cast alloy by laser austenitic stainless steel 17 246 deposition. In order to remelt the Al-Si alloy surface the laser of 1, 9 kW has been used for facing area, and 1.6 kW for the edge. The linear laser scan rate of the beam was set 450 mm.min-1 for facing area, and for the edge 550 mm.min-1. We observed that the thin surface made of austenitic stainless steel had a lot of splits. The purpose of this study is also to enhance inherent properties of the surface materials to create new product or improve on existing one.

Keywords: laser stainless steel deposition, austenitic stainless steel 17 246, Al-Si cast alloy, microstructure of layer, fusion, splits.

1 Introduction

Laser metal deposition (LMD) is an additive manufacturing technique. This process make use of feeding powder into the melt pool that is produced by sharply focused collimated laser beam on the substrate. Existing commercial LMD system utilize a wide range of laser technologies. The power ranges from around 1W to 6 kW, and wave length from the ultraviolet (354, 7 nm) to the infrared (10, 6 nm). Requirements vary from process to process. The metallic materials, which are used for the build-up of layers, are available in fine powder. Usually powder material, which is transported to the substrate in a transport gas by means of a nozzle, is used as feedstock. The schematic diagram of the laser metal deposition process is shown in Figure 1.

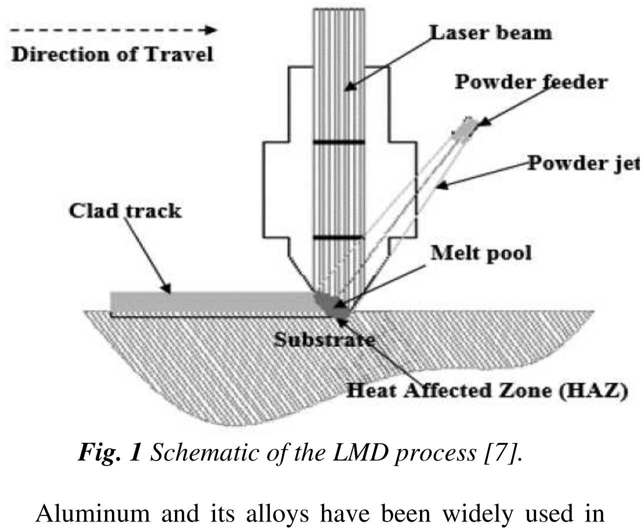

Fig. 1 *Schematic of the LMD process [7].*

Aluminum and its alloys have been widely used in aerospace, automotive, and transportation industry owning to their excellent properties such as high specific strength, good ductility, and light weight. Surface modification is of crucial importance to the surface properties of aluminum and its alloys since high coefficient of friction, wear characteristics, and low hardness have limited their long term performance. Laser surface alloying is one of the most effective methods of producing proper microstructure by means of non-equilibrium solidification which results of rapid heating and cooling.

The laser surface of aluminum alloys with feeding powder is injecting directly into the molten pool was investigated by many authors [1] - [4], [11]. Modification of surface properties of aluminum alloys play an important role in optimizing a material´s performance for a given application. A material´s susceptibility to wear and surface damage can be reduced by alteration of its surface chemistry, morphology, and microstructure. Modern industrial application require materials with special surface properties such as high hardness, wear and corrosion resistance [5] - [10]. The laser method deposition as an innovation repair technology is continuously increasing [5]. The low density of aluminum compared to steel, good resistance to corrosion and simple possibility the improve wear resistant and mechanical properties by deposition of stainless steel on its surface could be very important application for many industries like an automotive industry, aerospace and air transport. Laser beam provides a very precise introduction of energy and consequently can be better and faster implement industrial operation in the technology of layer treatment.

LMD offers in particular the possibility of laser remelting freeform surfaces in a uniform way by its multiaxis degree of freedom. Yasa et al [9] report that laser remelting is an effective strategy to reduce the surface roughness of parts fabricated by selective laser melting.

2 Results and discussion

2.1 Chemical analysis

Chemical composition of stainless steel powder 17 246 is given in Table 1, and Al-Si alloy substrate is given in table 2.

Tab. 1 *Chemical composition of stainless steel powder [wt. %].*

C	Cr	Ni	Mn	P	S
0.09	18.3	11.04	0.78	0.01	0.01

***Tab. 2** Chemical composition of Al-Si alloy [wt. %].*

Si	Fe	Cu	Mn	Mg	Cr	Ni	Ti
9.1	0.28	0.023	0.15	0.39	0.012	0.0058	0.096

2.2 Microscopic analysis

The microstructure of the deposited stainless steel powder was observed under the laser optical microscope LS3100. The microstructural evolution was investigated in order to establish the effect of surface quality of laser stainless steel deposition. The bonding and the penetration of stainless steel into the Al-Si alloy (substrate) were also investigated. The fusion of the stainless steel into Al-Si alloy was expected because of the higher density of stainless steel (≈7.9 g.cm-3) compared to that of Al-Si alloy (≈2.7 g.cm-3). The results revealed that stainless steel powder deposited on the Al-Si alloy were characterized with white coloration. Columnar dendritic structure was the dominant feature of the substrate. Typical microstructure of deposited stainless steel powder is shown in Fig. 2. The Figure shows the various sample region with a lot of split on the stainless steel deposited surface.

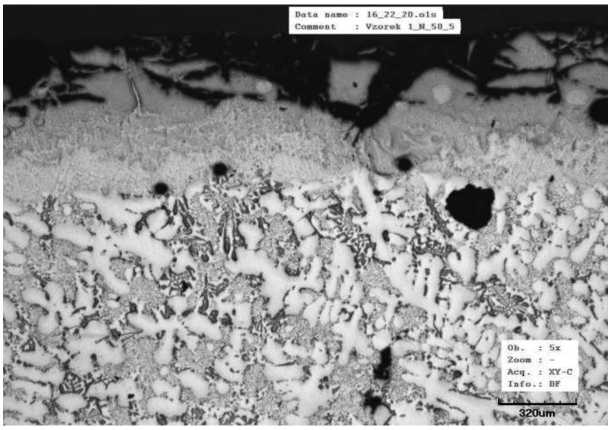

***Fig. 2** Splits on the stainless steel deposited surface.*

Typical microstructure of the deposit stainless steel powder on Al-Si substrate with three different zone is shown in Fig. 3.

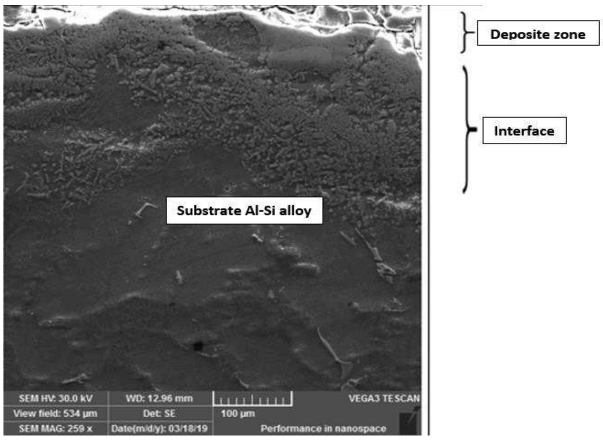

***Fig. 3** Microstructure of deposit stainless steel and three zone*

The Figure shows the various sample regions such as the deposition layer with the high Heat Affected Zone (HAZ) more than 100 µm.

EDS analysis proof that in the interface layer are present such elements as Mo and Ni, Figure 4, 5. Source of these element is stainless steel powder.

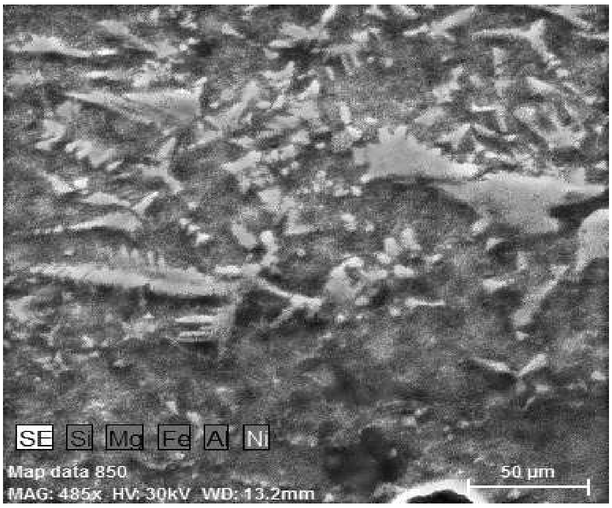

***Fig. 4** Presence of Mo and Ni in the interface layer.*

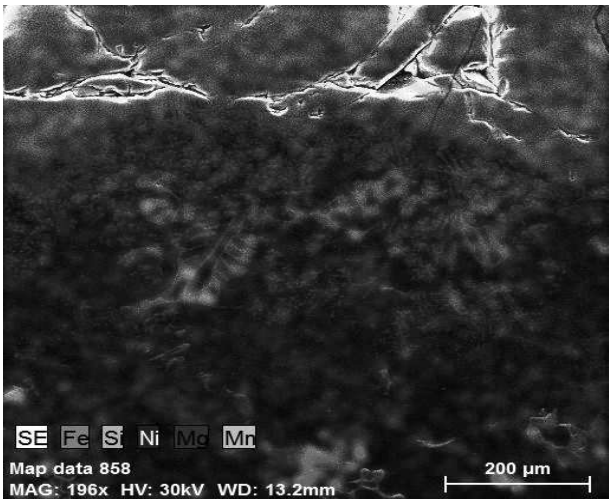

***Fig. 5** Presence of Ni, Mo in the interface layer.*

The measured dimension at the 12 positions of the deposited height with the HAZ of the deposited stainless steel are presented in Table 3.

***Tab. 3** Dimension of deposited stainless steel track [µm].*

Position	Minimum	Maximum
1	650	746
2	502	657
3	195	741
4	218	715
5	206	666
6	188	605
7	638	757
8	520	786
9	522	836
10	417	730
11	303	665
12	427	770

3 Conclusion

According to experimental results the following conclusions can be done.

1. Laser deposited austenitic stainless steel powder on Al-Si alloy substrate was successfully conducted to determine the effect of the fusion austenitic stainless steel into Al-Si alloy substrate.
2. Upper austenitic stainless steel layer shows a lot of splits.
3. Source of the presence Ni, Mo, Cr, elements in the interface layer is due to chemical composition of the austenitic stainless steel deposition into Al-Si substrate.
4. Dimension of the deposited austenitic stainless steel track varies from 206 to 770 µm.
5. Columnar dendritic structure was the dominant feature of the substrate near the interface boundary.

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