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*Make Harmony Between Technology and Nature, and Your Mind will Fly Free as a Bird*
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# LASER QUALITY OF A DENTAL AUSTENITIC STAINLESS STEEL

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***Abstract:*** *Different modern techniques are used for optimization of dental metallic components, laser welding being one of them. The aim of present study is to put in evidence the quality of a dental austenitic stainless steel which is often used for orthodontic appliances, such as rests, clasp arms and lingual bars, and also pre-formed crowns, instruments, pins and root posts. The experimental alloy is used for long lasting dental pieces. Laser welding equipments was a Mini Laser XXS (Orotig Verona, Italy) and the tested samples were welded in butt joint, without filler material. There are presented in comparison results concerning macro and micro structural analysis made on Olympus stereomicroscope and Reichert microscope. Finally a correlation between different welding parameter values and structural features was made.*
***Key words:*** *orthodontic appliances, austenitic stainless steel, laser welding, macrostructure, microstructure.*

## 1. INTRODUCTION

Stainless steel may be used in sheet form for fracture resistant orthodontic devices (18/8 austenitic stainless steel: 18%Cr-8%Ni). The wire form is used for orthodontic appliances and is often austenitic stainless steel. It may also be used for clasp arms and lingual bars. Pre-formed crowns can be made from work-hardened stainless steel. Dental instruments, pins and root posts can all be made from stainless steel, (Bertrand C., 2004, Bortun C.M, Ghiban A., 2009, Ghiban B., 2009, Kou Sindo 2002, Watanabe, 2006). Many problems are met when metallic components are broken, and so may be reoptimized by laser welding. The aim of present paper is to make a correlation between welding parameters and macro and micro-structural aspects from stainless steels used for different dental metallic orthodontic appliances.

## 2. MATERIAL AND METHODS

Specimens were subjected to analysis of type AISI 316 LN austenitic stainless steel, in different states (solid solution at 1050°C/30min/ water cooling, solid solution and sensibilization at 650°C/1h/air and hardened and cold formed at 80% degree). Chemical compositions of experimental melts, in cast state with dimensions 10x20mm and thickness of 0,4mm - 1mm, is: C=%, Si=%, Mn=%, S=%. P=%, Cr=%, Ni=%, Mo=%, Fe=rest. The welds were made in butt joint configuration without filling material. Equipment parameters of laser welding are adjustable: impulse power, period and frequency. Samples were welding joined by applying different parameters of laser welding, power from 0.5 W up to 2W, duration of keeping the spot from 0.8 to 3 seconds and frequency of 1 to 3 Hz and small spot . Different investigations were made on welded samples: macrostructural analysis made on a stereomicroscope type OLIMPUS SZX and microstructural analysis made on Reichert microscope. Stereomacrostructural analysis was made using different magnification, putting in evidence the structural discontinuities. Metallographic analyses were made on Reichert microscope, in two states, etched and non etched, using IMAGE PRO soft for image processing.

## 3. RESULTS AND DISCUSSION

As a general remark is that the macro analysis showed only external cracks in weld state, while the microstructural analysis, performed in cross-section allowed highlighting the depth of penetration of laser intensity. Stereomacrostructural aspects of the experimental test samples are given in Figure 1, while micro structural issues are given in Figure 2.

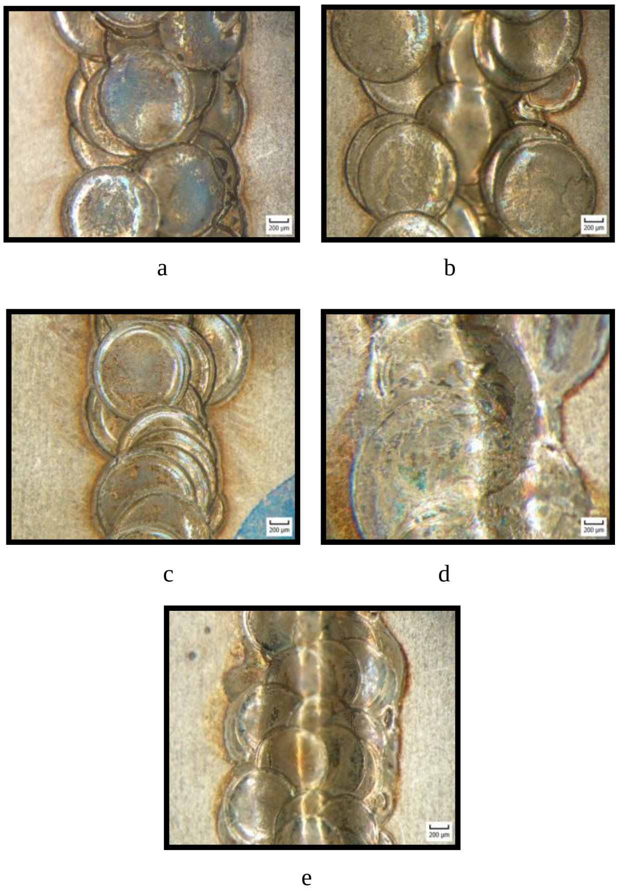
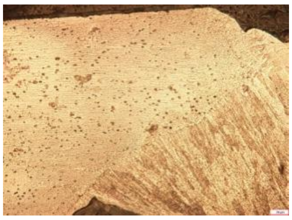



Fig. 1. Stereomacroscopic aspect of stainless steel samples in welded state after different heat treatments: (a, c) Solid solution at 1050°C/ air cooling, (b,d) Solid solution at 1050°C/ air cooling + sensibilization at 650°C/ air cooling, (a,b) power 1.5W, 2 seconds, frequency 3, (c,d) power 0.8 W, 1 second, frequency 3, (e) hardened state, power 1W, frequency 3, time 2s (x56)

From the macroscopic analysis, as a general rule, all the samples have similar aspects, no matter heat treatment state was. One may remark in welded zone, the manner of spot position and even the secondary cracks (as is given in fig. 1e). If the spot power is 1.5W, time 2 s and frequency 3Hz (fig. 1a,b) no cracks may be remarked in welded zone. Instead, at

lower spot, about 0.8W (fig. 1c, d) small and fine crack may be revealed for the same time and frequency.
The microstructural analysis, illustrated in fig. 2 may reveal the behaviour of stainless steels, in different states in cross section area, in transversal section.


a b

c d

e

Fig. 2. Microstructural aspect of welded stainless steels samples after different heat treatments: (a, c) Solid solution at 1050°C/ air cooling, (b,d) Solid solution at 1050°C/ air cooling + sensibilization at 650°C/ air cooling, (a,b) power 1.5W, 2 seconds, frequency 3, (c,d) power 0.8 W, 1 second, frequency 3, (e) hardened state, power 1,5W, time 1,5s and frequency 3Hz, (Royal water attack, x200)

Fig. 3. Microstructural aspect of experimental austenitic stainless steel in solid solution state at 1050°C/ air cooling, (Royal glycerinated water attack, x200)

The following remarks may be drawn from microstructural analysis:

- For austenitic stainless steels AISI 316L the spot power must be at least equal to 1W. At lower spots, no matter the time of maintain , one may remark the presence of radial cracks, or even no joining along the depth of the sample,
- For spot power 1W, the longest time of maintain of spot must be 3s. At lower periods, the weldment is not completed.
- Applying laser spot must be minimum 3Hz (from maximum 4 of the device).

As one may see from figure 2, for a power about about 1,5W, time 2s and frequency 3Hz no cracks may be seen in welded zone, abtaining a good joining. For a power about 0,8W, time 2s and frequency 3Hz some superficial cracks may be initiated. In solid solution and sensibilized state, after a spot power about 0,8W, time 1s and frequency 3Hz, the power is not enough to obtain good weldment in depth of the sample, the joining being failed. For a spot power 1W, time 2s and frequency 3Hz, the welded zone is well defined and the joining is successful. For a solid solution and sensibilized state, at applying a power about 1W, time 1s and frequency 3Hz, time of laser spot keeping on the surface is not enough for all depth laser penetration, approximately half of sample being not welded. In case of harded state for a power about 1.5W, time 1.5s and frequency 3Hz, the welded zone is well defined and delimitating from the parent metal. One may remark columnar grains in welded areas.
The experimental austenitic stainless steel consist in solid solution state of homogeneous structure, with fine grains, twins boundaries and no carbids precipitation neither in matric, not at grain boundaries, one may observe from figure 3. This structure is well defined and is commonly met in austenitic stainless steels used as biomaterials, (Ghiban, 1999). All the obtained data may be compared with others (Bertrand , 2004; Bortun, 2008) and they are in accordance.

## 4. CONCLUSIONS

Structural analysis performed on test-pieces joined by laser welding led to the following conclusions apply to all structural states tested:

1. power must be not less than 1W, the smaller powers, regardless of the duration of time is observed either the presence of radial head cracks or incomplet joing,
2. the power higher than 1W, the longest duration of time the spot is the 3s, at smaller times components being not complete welded,
3. the frequency of application of the laser spot must be at least 3Hz for complete joing.

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