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Microscopic Analysis of Welded Dental Alloys

S. Porojan, L. Sandu, and F. Topală

***Abstract*—**Microplasma welding is a less expensive alternative to laser welding in dental technology. The aim of the study was to highlight discontinuities present in the microplasma welded joints of dental base metal alloys by visual analysis. Five base metal alloys designated for fixed prostheses manufacture were selected for the experiments. Using these plates, preliminary tests were conducted by microplasma welding in butt joint configuration, without filler material, bilaterally and with filler material, proper for each base metal. Macroscopic visual inspection was performed to assess carefully the irregularities in the welds. Electron microscopy allowed detection of discontinuities that are not visible to the eye and revealing details regarding location, trajectory, morphology and size of discontinuities. Supplementing visual control with microscopic analysis allows to detect small discontinuities, which escapes the macroscopic control and to make a detailed study of the weld.

***Keywords*—**base metal alloys, fixed prosthodontics, microplasma welding, visual inspection

I. Introduction

BECAUSE restoration price is a factor in dental therapy, the use of new welding processes is a procedure of choice for the optimization of framework defects.

Errors in achieving technological steps of cast fixed prosthetic restorations may compromise part or total the integrity of the restoration. Damage may be minor, which can be corrected by modern welding processes or major, requiring restorations rebuilding.

Microplasma welding is a less expensive alternative to laser welding in dental technology.

Nondestructive tests are used to qualify welding, welding process and product quality control. The advantage of these methods is that on the same components more tests can be done, without destroying samples. Sometimes only parts will be analyzed to save time and money. In case of critical areas complex analyses are necessary.

Visual inspection is the most frequent method of nondestructive testing and the first step in the analysis methods [1].

II. Aim

The aim of the study was to highlight discontinuities present in the microplasma welded joints of dental base metal alloys by visual analysis.

Porojan S. is with the "V. Babeş" University of Medicine and Pharmacy Timişoara, Romania (e-mail: sorin_poro@yahoo.com).
Sandu L. is with the "V. Babeş" University of Medicine and Pharmacy Timişoara, Romania (e-mail: lilianasandu@gmail.com).
Topală F. is with the "V. Babeş" University of Medicine and Pharmacy Timişoara, Romania (e-mail: florin.topala@gmail.com).

III. Materials And Method

Five base metal alloys designated for fixed prostheses manufacture were selected for the experiments, of which three Ni-Cr: Wiron 99, Wirolloy NB (Bego, Bremen, Germany), Heraenium NA (Heraeus Kulzer GmbH, Hanau, Germany) and two Co-Cr: Wirobond SG, Wirobond 280 (Bego, Bremen, Germany).

The filler materials were proper wires based on Ni-Cr for the Ni-Cr alloys and on Co-Cr for the Co-Cr alloys, with a diameter of 0.35 mm.

Experimental metallic plates (0.8 x 10 x 20 mm) were achieved by the classical melting-casting laboratory procedure. Using these plates, preliminary tests were conducted by microplasma welding in butt joint configuration, without filler material, bilaterally and with filler material, proper for each base metal. For microplasma welding the Welder device (Schütz Dental, Rosbach, Germany) was used. Weld quality was optimized by varying the process parameters, adapted to the material and welding method (Table I).

TABLE I
PROCESS PARAMETERS USED FOR THE WELDING PROCEDURE.

Alloy	Welding method	Power step	Pulse duration (ms)
Wiron 99	without filling material	5	40
Wiron 99	with filling material	6	40
Wirolloy NB	without filling material	5	40
Wirolloy NB	with filling material	5	40
Heraenium NA	without filling material	7	40
Heraenium NA	with filling material	7	40
Wirobond SG	without filling material	6	45
Wirobond SG	with filling material	5	45
Wirobond 280	without filling material	8	40
Wirobond 280	with filling material	5	45

Macroscopic visual inspection was performed to assess carefully the irregularities in the welds. The weld width, craters on the surface, the continuity of weld, visible cracks penetration of the spot, any surface inclusions were analyzed.

To highlight the discontinuities that are not macroscopically visible, the electron microscopy was chosen. A scanning electron microscope (SEM) with integrated EDS system inspected EDAX GENESIS XM + 2i (FEI Company, Eindhoven, Netherlands) was used.

IV. Results And Discussions

Making comparison between Ni-Cr alloys taken in the experiment, the best alloy welds appear at Heraenium NA, both without filler material and with filler material. Macroscopically uniform welding ribs were observed, with a proper overlap of the spots and good penetration (Fig. 1).

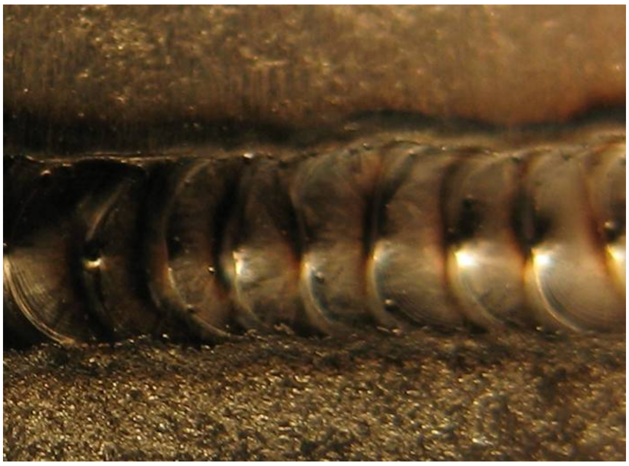

Fig. 1 Macroscopically image of a Heraenium NA alloy welded without filler material: uniform welding ribs, with a proper overlap of the spots and good penetration

Regarding the other two alloys, welding with filler material is better for NB Wirolloy than for Wiron 99, but there are visible defects in both cases. Welding without filler material has fewer discontinuities in Wirolloy NB compared to Wiron 99.

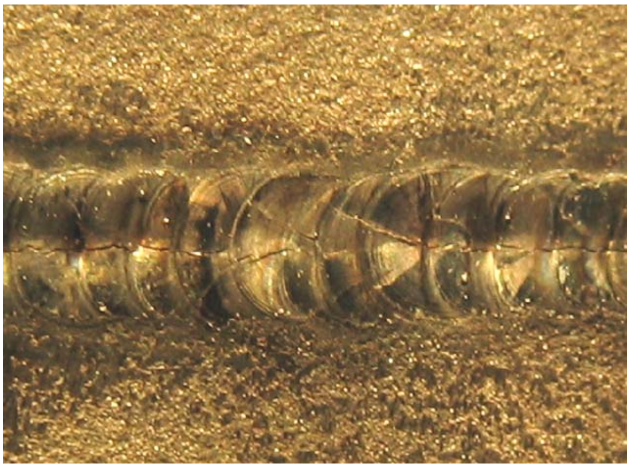

Fig. 2 Macroscopically image of a Wiron 99 alloy welded without filler material: longitudinal discontinuous crack on the weld trajectory

Both Co-Cr alloys show a crack along the joining line, for butt joint welding. The Wirobond SG alloy welding rib is more uniform. The rib for Wirobond 280 includes numerous transverse cracks and is nonuniform. Therefore welds of Wirobond SG alloy samples are better, although different discontinuities are present.

Electron microscopy allowed detection of discontinuities that are not visible to the eye and revealing details regarding location, trajectory, morphology and size of discontinuities (Fig. 3-7).

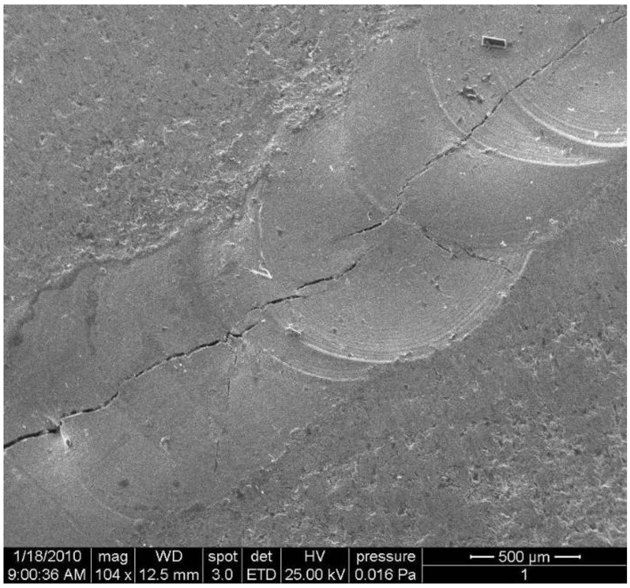

Fig. 3 Electron microscopically image of a Wiron 99 alloy welded without filler material: longitudinal discontinuous crack on the weld trajectory

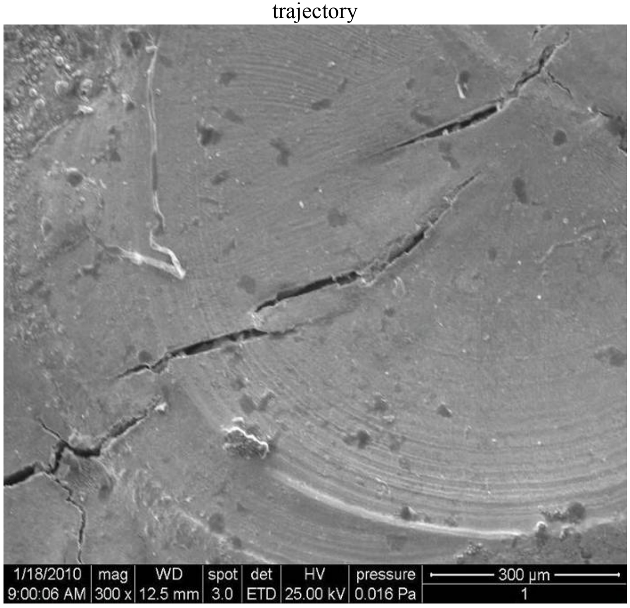

Fig. 4 Electron microscopically image of a Wiron 99 alloy welded without filler material: detail of an interrupted longitudinal crack on the weld trajectory

On these pictures details the spots appearance, their overlapping, filler material distribution can be seen. Sometimes, by macroscopically visual inspection very small cracks are not noticed. At electron microscopically examined samples very small cracks both longitudinal and transverse or oblique were detected in the welding rib. Some start from the main longitudinal cracks, some from the middle spot, others are completely isolated.

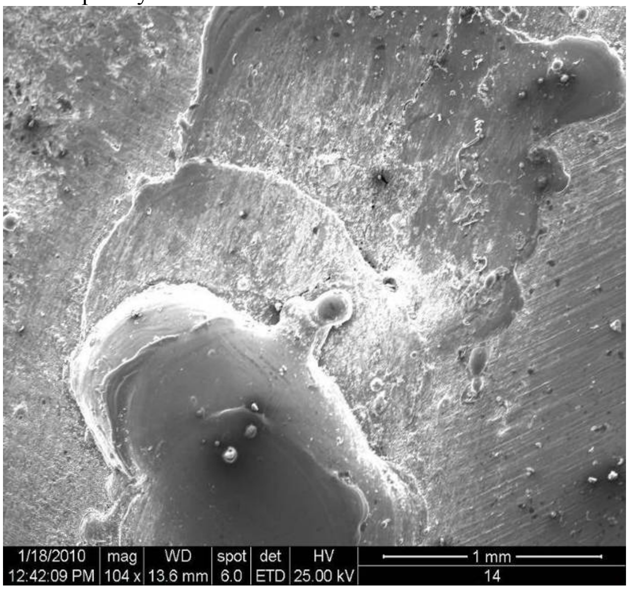

Fig. 5 Electron microscopically image of an SG Wirobond alloy welded with filler material: detail of ununiform distribution of the filler material

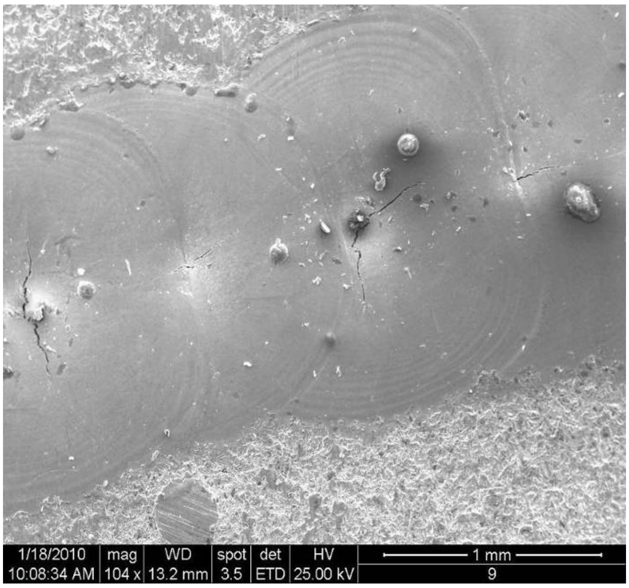

Fig. 6 Electron microscopically image of Heraenium NA alloy welded joints, without filler material: detail of short, radial cracks in the middle of the spot

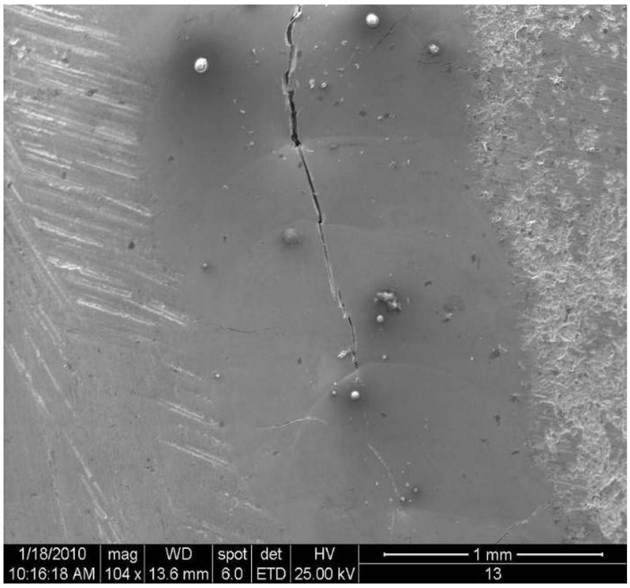

Fig. 7. Electron microscopically image of an SG Wirobond alloy welded without filler material: detail of a continuous longitudinal crack, and isolated oblique cracks in the welding rib.

In the welding process the first step is to establish welding parameters. In practice the thickness of metal frameworks variates. Even if the weld penetration produces more power too much strong power may induce the formation of pores, which implicitly reduces the weld strength. A too low penetration may also not determine a maximum strength. Therefore it is very important to determine the optimal parameters to obtain the proper penetration. Welding on both sides could prevent these inconveniences [2, 3].

Strong penetration cannot be achieved by microplasma welding, as confirmed by various studies [4], [5]. Other authors however believe that microplasma welding is comparable to laser welding [6].

V. Conclusions

Within the limitations of the study, the following conclusions were obtained:

Nondestructive tests are essential to evaluate the quality of welds, are the first step in the complex experimental testing and in practice even unique.

Supplementing visual control with microscopic analysis allows to detect small discontinuities, which escapes the macroscopic control and to make a detailed study of the weld. Electron microscopy allowed revealing of discontinuities that are not visible to the eye and details of location, trajectory, morphology and size.

References

[1] L. Jeffus, *Welding: Principles and applications,* 6th edition. Thomson Delmar Learning, New York, 2008.
[2] I. Watanabe, J. Liu, M. Atsuta, "Effects of heat treatments on mechanical strength of laser-welded equi-atomic AuCu-6at%Ga alloy" in *J Dent Res,* 2001 Sep;80(9):1813-7.

[3] N. Baba, I.Watanabe, "Penetration depth into dental casting alloys by Nd:YAG laser" in *J Biomed Mater Res B Appl Biomater,* 2005, 72(1):64-8.
[4] M.O. Neumann, J. Lindigkeit, "Mechanische Festigkeit von geschweißten EMF-Legierungen" in *Quintessenz Zahntech*, 2005, 31(9):966-73.
[5] A. Reichert, "Untersuchung der Schweißnahtqualitäten von Laser und Phaser" in *Quintessenz Zahntech*, 2005, 31(3):264-79.
[6] H.J. Burkhardt, "Ein wirtschaftlicher Weg mit Erfolgschancen - Schweißen mit dem CeHa Phaser MX1" in *Quintessenz Zahntech*, 2005, 31(2):136-42.