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.

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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

<table>
<thead>
<tr>
<th>Alloy</th>
<th>Welding method</th>
<th>Power step</th>
<th>Pulse duration (ms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiron 99</td>
<td>without filling material</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>Wiron 99</td>
<td>with filling material</td>
<td>6</td>
<td>40</td>
</tr>
<tr>
<td>Wirolloy NB</td>
<td>without filling material</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>Wirolloy NB</td>
<td>with filling material</td>
<td>5</td>
<td>40</td>
</tr>
<tr>
<td>Heraenium NA</td>
<td>without filling material</td>
<td>7</td>
<td>40</td>
</tr>
<tr>
<td>Heraenium NA</td>
<td>with filling material</td>
<td>7</td>
<td>40</td>
</tr>
<tr>
<td>Wirobond SG</td>
<td>without filling material</td>
<td>6</td>
<td>45</td>
</tr>
<tr>
<td>Wirobond SG</td>
<td>with filling material</td>
<td>5</td>
<td>45</td>
</tr>
<tr>
<td>Wirobond 280</td>
<td>without filling material</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>Wirobond 280</td>
<td>with filling material</td>
<td>5</td>
<td>45</td>
</tr>
</tbody>
</table>

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).

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.

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).

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.
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.

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


