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Dental Alloys structural analyses of welded frameworks

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Introduction

Dental alloys structural analyses are important in order to obtain quality prosthetic pieces. The defects appeared in removable partial dentures metallic compounds are in connection with the casting, processing and welding.

Objectives

The aim of study was to detect casting, processing and welding optimal parameters for some long lasting prosthetic pieces.

Material and Methods

CoCrMo alloys were used: "C" alloy (Vaskut Kohàszati Kft - Budapest, Hungary), WIRONIT (Bego - Bremen, Germany) and HERAENIUM CE (Heraeus Kulzer, Hanau, Germany). They were analyzed both as metallic frameworks of removable partial dentures and as metallic cast plates (dimensions: 10x20mm and thickness of 0,4mm - 1mm). The welds were made in butt joint configuration with or without filling material. As filling material a special 0.5 mm diameter Co-Cr Finalloy - Fino, Bad Bocklet, Germany wire was used. Equipments like: Nd:YAG lasers - HL 124P LCU TRUMPF (TRUMPF GmbH Ditzingen Germany) and Welder (Schütz Dental, Rosbach, Germany) were used for welding.

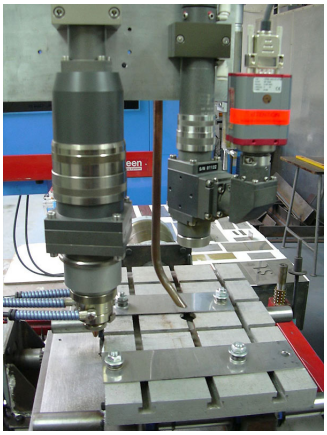


Fig. 1a: Welding equipments: Nd:YAG laser - HL 124P LCU TRUMPF

Fig. 1b: Welding equipments: microimpulse Welder.

Radiographic, metallographic and microhardness analyses were made in order to certify welding quality, casting alloys structural defects, to stand out possible the cracks within the base material. The welding parameters used for laser welding were: P med(W): max.120; Pp(KW) max. 5; tp(ms) 0,3-20; f max (Hz) 600; Ep (J) 0,1-50 and for microimpulse were: power - level 4, overlapping more than ½, time delay 40 milliseconds, one side welding.

Fig. 1c: Welding equipments: Nd:YAG laser - HL 124P LCU TRUMPF

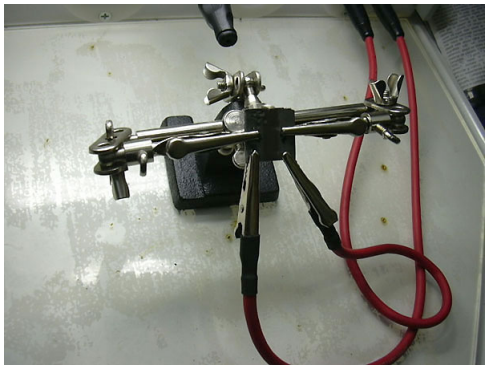


Fig. 1d: Welding equipments: microimpulse Welder.

Fig. 2a: Different welding types: Cast plates

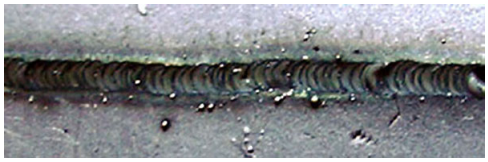


Fig. 2b: Different welding types: Laser welding

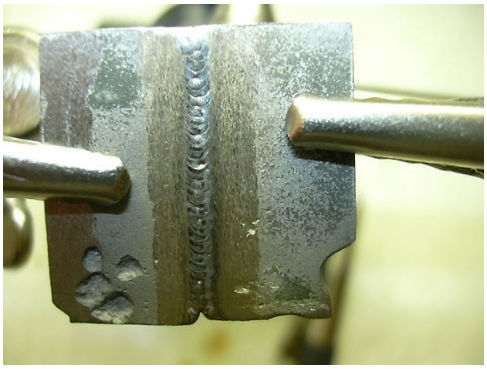


Fig. 2c: Different welding types: Microimpulse welding

Fig. 3a: Heat treatments for dental alloys: Preparing for heat treatment

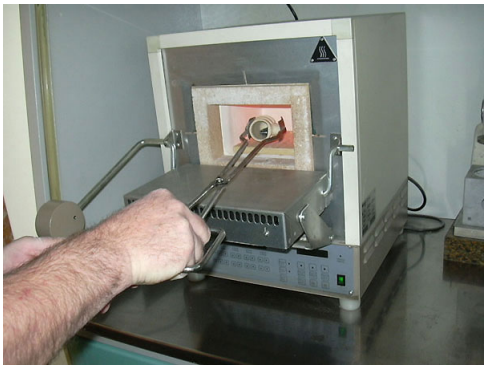


Fig. 3b: Heat treatments for dental alloys: Alloy heating

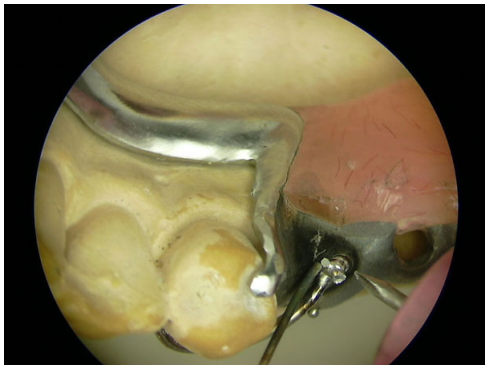


Fig. 4a: Welding of RPD framework: Details of clasp welding

Fig. 4b: Welding of RPD framework: Welded Mc Cracken clasp

Fig. 4c: Welding of RPD framework: Crack of circumferential clasp

Fig. 4d: Welding of RPD framework: Preparing for welding

Fig. 4e: Welding of RPD framework: Detail of welded clasp

Results

Noninvasive analyses methods point out casting alloys structural defects, distinguish the cracks within the base material. The cracks appear mostly in base material, being caused by casting, non-adequat processing and rapid cooling of weld. Structural analyses present dendritic structure specific for cast alloys, non-metallic inclusions and some temporary particles. Intergranular pellicular precipitations and spherical shape compounds placed inside the crystalline grains appear on some welding. Welded area alloys chemical composition discreetly differs from the base material.

WIRONIT alloy -FIROFINE (BEGO) investment material

HV5 hardness

Nr.	zone	HT and welding			without HT and welding
		850°C / 1h	950°C / 1h	1050°C / 1h	
1	BM1	401	367	362	367
2	HAZ	460	423	407	386
3	WM	502	454	412	418
4	HAZ	460	412	381	376
5	BM	401	371	371	345

"C" alloy -FIROFINE (BEGO) investment material

HV5 hardness

Nr.	zone	HT and welding			without HT and welding
		850°C / 1h	950°C / 1h	1050°C / 1h	
1	BM1	412	423	371	367
2	HAZ	418	391	412	435
3	WM	418	371	381	429
4	HAZ	423	441	429	376
5	BM	412	401	391	362

HERAENIUM CE alloy -FIROFINE (BEGO) investment material

HV5 hardness

Nr.	zone	HT+ welding			without HT and welding
		850°C / 1h	950°C / 1h	1050°C / 1h	
1	BM1	367	336	371	336
2	HAZ	435	412	412	381

3	WM	460	429	391	412
4	HAZ	412	376	381	376
5	BM	441	366	332	329

Tab. 1: Microhardness values of welded joints

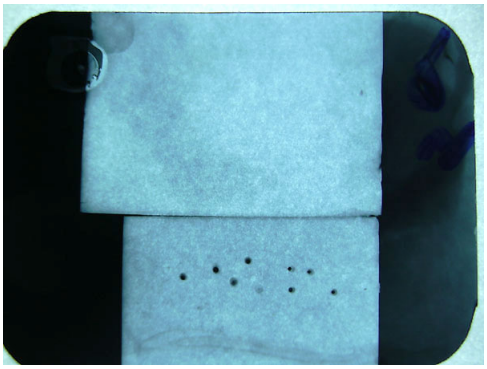


Fig. 5a: Non invasive procedures to analyse the welded zone: X-rays

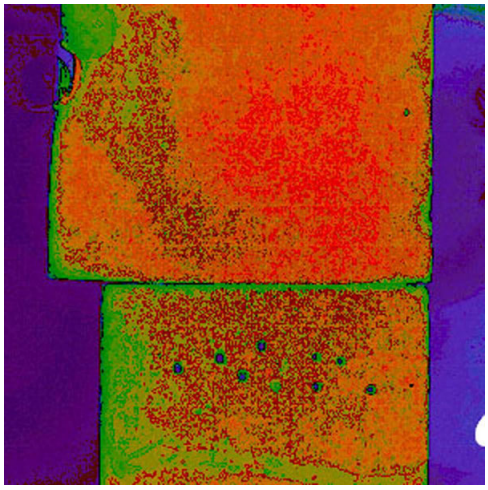


Fig. 5b: Non invasive procedures to analyse the welded zone: pseudo chromatisation

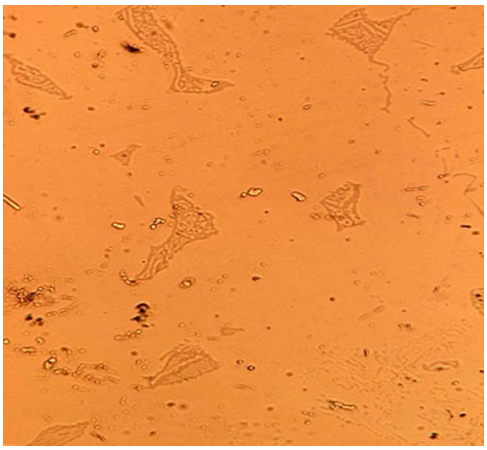


Fig. 6a: Metallographic aspects: discontinuous precipitation in metallic matrix

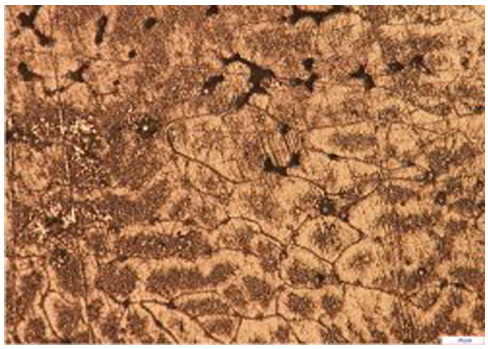


Fig. 6b: Metallographic aspects: non-uniform dendritic structure with interdendritic microporosities

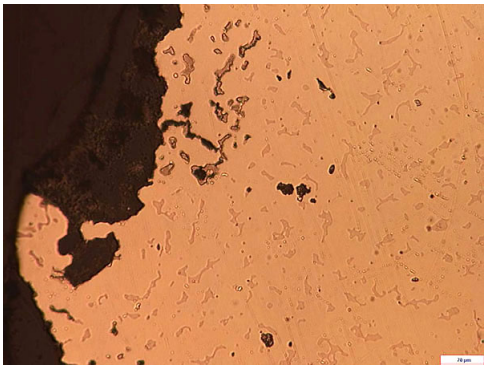


Fig. 6c: Metallographic aspects: interdendritic cracks in a structure with fine lace eutectic

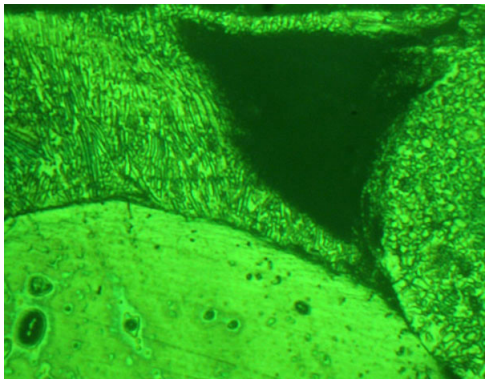


Fig. 6d: Metallographic aspects: welded areas

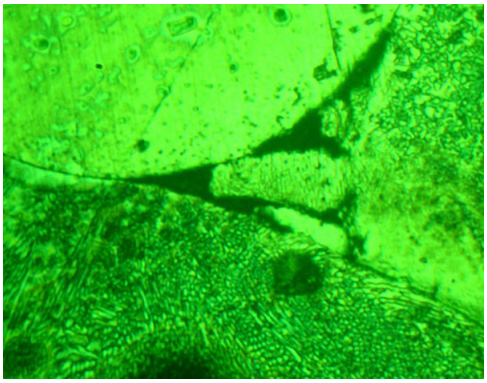


Fig. 6e: Metallographic aspects: welded areas

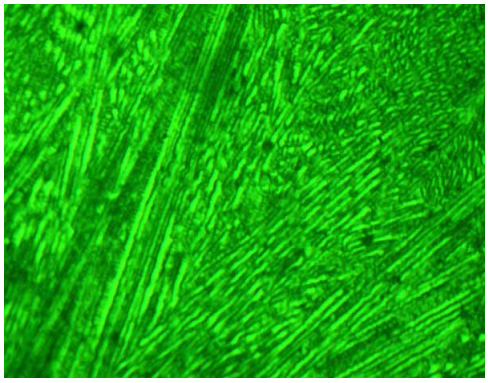


Fig. 6f: Metallographic aspects: welded areas

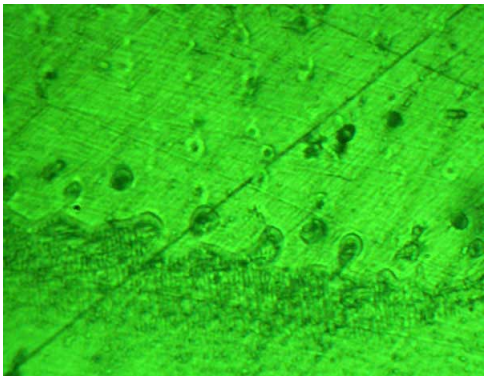


Fig. 6g: Metallographic aspects: Heat affected zone

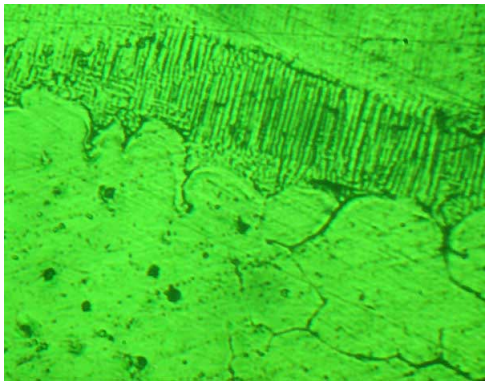


Fig. 6h: Metallographic aspects: Heat affected zone

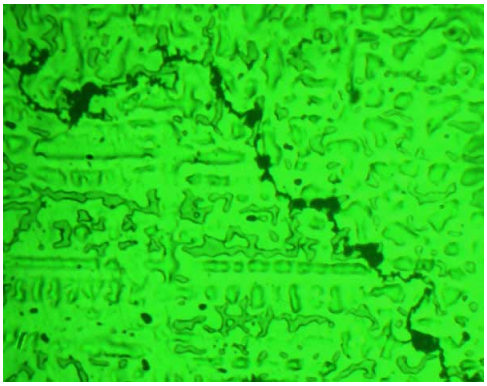


Fig. 6i: Metallographic aspects: Base metal

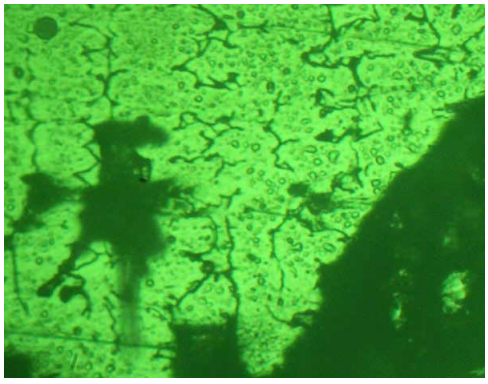
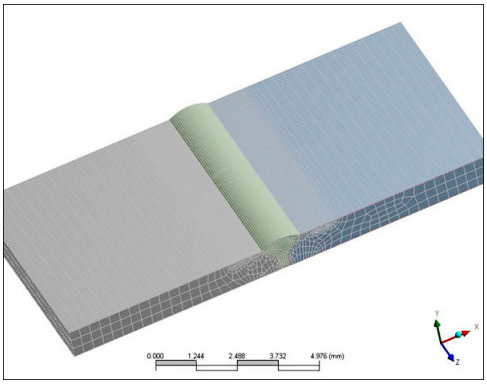


Fig. 6j: Metallographic aspects: Base metal



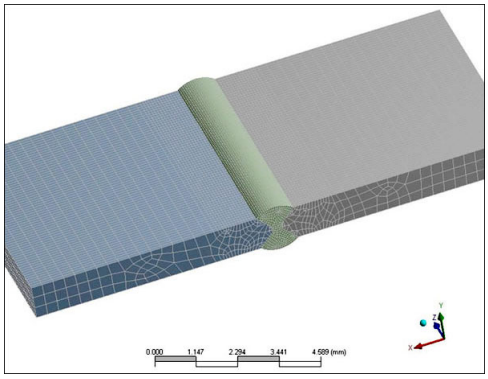


Fig. 7a: Numeric analyses of welding: Welding type no.1

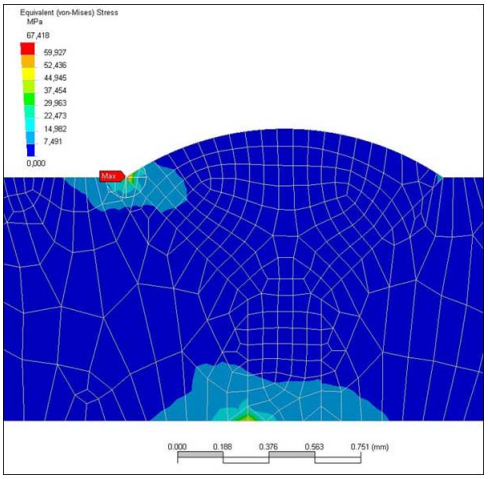


Fig. 7b: Numeric analyses of welding: Welding type no.2

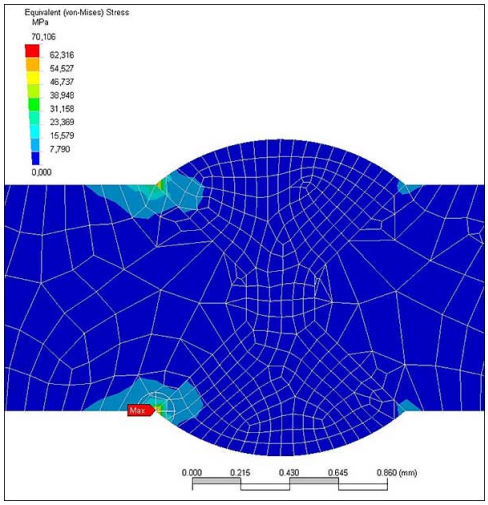


Fig. 7c: Numeric analyses of welding: Stress distribution in alloy

Fig. 7d: Numeric analyses of welding: Stress distribution 2

Conclusions

Dental alloys structural analyses are important for structural defects knowledge. The cracks appear mostly on base material, being caused by casting, non-adequate processing and rapid cooling of the weld.

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