RESEARCHES ON CRUCIBLE MATERIALS USED FOR MELTING AND CASTING TITANIUM FOR IMPLANTS

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Abstract:
In order to obtain titanium implants for dentistry, the authors designed and realised an experimental device for melting and casting titanium with the following characteristics: the melting is carried out with electric arc in argon atmosphere, using as electrical source a welding generator, the casting is done with the vacuum-pressure and the protective medium is spectral argon of 99,99 % purity.
Using the above-mentioned system, experiments were carried out with casting in ceramic moulds and casting in graphite moulds. The melting crucible used was made initially of copper. Because of the difficulties occurring during casting, in a second stage a bigger crucible was used, for a better dissipation of the heat developed by electrical arc. This crucible gave better results and casting was successful. Also, experimental researches were carried out with regard to the possibility of using a graphite crucible, but this one gave poor results.

1. INTRODUCTION
In recent years titanium has become the material of choice in dentistry applications, due to the advantages offered compared to other metals: it has a low specific weight, is absolutely biocompatible, has an excellent corrosion resistance, a low heat conductivity etc. In this regard, the main processing method, despite the technological difficulties implied, remains the casting, either for the obtaining of crowns and bridges, or for the obtaining of dental implants.
The most widely used technologies for the casting of small parts for prosthetic applications imply the heating (melting) by electric arc, resistors or electromagnetic induction and casting either through the vacuum-pressure method or by centrifugation.

2. THE EXPERIMENTAL EQUIPMENT USED FOR MELTING AND CASTING TITANIUM IMPLANTS
In order to obtain titanium implants for dentistry purposes, the authors of the present paper have designed and realised an experimental device for melting and casting small parts made of titanium.
The realised equipment uses the principle of melting by means of an electric arc, established between a non-fusible tungsten electrode, alloyed with zirconium or thorium and the titanium part placed in a copper crucible, which assures the electric contact needed for the arc's electric circuit.
Considering the physical characteristics of titanium, and especially its low density (4510 kg/m³), which is half or even a third of the density of other materials commonly used in dentistry, using a centrifugal casting device was not necessary. Therefore the authors adopted the solution of casting under gas pressure. The gas employed for the protective atmosphere was spectral argon of 99,99 % purity.
The experimental equipment used comprises 2 chambers, placed one under the other. In the upper chamber, the melting of titanium takes place in a copper crucible, cooled with water, and in the chamber below is placed the casting mould. The titanium part that will be molten is placed in the copper crucible and, after vacuumising the chamber and starting the electric arc in argon atmosphere, the melting takes place. This is quickly followed by the tipping of the molten metal in the preheated mould, placed in the lower chamber, which is under vacuum. The mould's filling is facilitated by gradually increasing the protective gas pressure in the upper chamber and the constant vacuumising of the lower chamber. The actual casting process consists of 5 phases, presented in figure 1. These phases are the following ones:

- Phase 1: the vacuuming of both chambers;
- Phase 2: the admission of argon in the upper chamber and the maintaining of vacuum in the lower chamber;
- Phase 3: the melting of titanium part by electric arc, in the same conditions as in phase 2;
- Phase 4: the pouring of the molten metal in the casting mould, by tipping the crucible, at the same time with the rapid increase of argon pressure in the upper chamber;
- Phase 5: the cooling of the cast metal (the lower chamber is maintained under vacuum and in the upper chamber the admission of argon is stopped).

Using the equipment described above for static casting under vacuum and protective argon atmosphere, it was tried to carry out the casting both in ceramic molds and in graphite molds, in order to determine the optimal solution.

3. THE CRUCIBLES USED FOR CASTING

As it was explained above, the authors first used a copper crucible cooled in water. But casting titanium is not a simple thing, because of the very high temperatures of the process (over 1700ºC) and its great reaction capacity with other elements at these high temperatures. However, this first crucible was heavily affected by the heat, turning completely red and the molten titanium stuck to the crucible and did not flow into the lower chamber. In order to overcome these difficulties, it was tried to carry out the melting in a crucible of larger dimensions, in order to increase the mass into which the heat emanated by the electric arc could dissipate. Indeed, this second crucible gave better results and the casting could be completed. Both crucibles employed for this experiment are presented in figure 2.
During the experimental researches, that authors have studied also the possibility of using a graphite crucible. The crucible designed and realised for this purpose is presented in figure 3.

Fig. 2. The copper crucibles used for melting titanium

Fig. 3 Graphite crucible used in experimental researches
This crucible gave unsatisfactory results from the point of view of part quality, but led to the idea of using a thin layer of graphite powder as coating for the copper crucible. This idea was successful and it was possible to realise, in this manner, small titanium parts with a very good detail quality.

4. CONCLUSIONS

The authors succeeded in designing and realising an experimental equipment for the casting of titanium in small parts used as dental implants. This equipment uses a vacuumised melting chamber and casting under a protective atmosphere of high purity argon. The melting crucible from this equipment was analysed from the point of view of the material employed, but also from the point of view of the size. The analysis led to the conclusion that a larger crucible offers better results and that it is best to use a copper crucible coated with a thin layer of graphite powder.

BIBLIOGRAPHY

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