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DEVELOPMENT OF VACUUM FEEDTHROUGHS FOR THE TCABR ANTENNA SYSTEM

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Resumo

O desenvolvimento dos alimentadores de tensão das antenas de Alfvén, a serem instaladas no tokamak TCABR é apresentado. A preparação das diferentes partes e o procedimento adotado no processo de brasagem são descritos em detalhe.

Abstract

The development of the vacuum feedthroughs for the Alfvén antennae to be installed in the TCABR tokamak is presented. The preparation of the different parts and the procedure followed in the brasing process are described in detail.

1. Introduction

Vacuum feedthroughs for high voltages and currents are components extensively used in particle accelerators, plasma technology, and other scientific and industrial applications. Excluding low-current applications, where glass-metal sealing can be employed, most of the feedthroughs for usual applications are made with brazed ceramic-metal joints [1]. Small size feedthroughs are standard and inexpensive components supplied by different manufacturers. However, when special size or large compontents are required, the prices can increase substantially and become a major concern in the planning and design of new experiments.

The antenna system of the TCABR tokamak is essentially a set of circular copper loops, that surround the plasma column in the poloidal direction, installed inside the vacuum chamber of the device [2]. Each loop is divided into two parts that are fed in parallel. The common or *ground* point of the two halfs are connected to a bar that goes through a CF38 flange, in the inner part of the toroidal vacuum chamber. The two other points, or *live terminals* have to be independently connected through impedance matching capacitors. They are electrically connected to a double feedthrough, assembled in a coaxial arrangement, through a CF63 vacuum flange. The radio-frequency voltage and current through the antenna loops can be as high as 12 kV and 1.5 kA, respectively, for frequencies around 5 MHz, so that good electrical isolation has to be guaranteed. A total of 72 feedthroughs for the entire antenna system is required, making the price of importation prohibitively high and, therefore, justifying their local development.

Although the technology of ceramic-metal brazing is well established [3], in Brazil different brazing processes are routinely employed only in research laboratories [4]. In particular, at the National Laboratory for Sinchrotron Radiation (LNLS), a brazing process, in which the getter and the filler are combined in just one component, has been long ago developed. However, for the present applications, we found that a different methodology would be more suitable [4]: the filler is made with CuSil (AgCu alloy) and the getter is a TiH_2 paint applied directly on to the slanted edges of the alumina cylindrical isolators. The ceramic is brazed to kovar cups by the formation of TiO on the ceramic surface and formation of an alloy of the titanium, which migrates through the AgCu matrix, with the iron in the kovar [3]. A diagram of the assembly is shown in figure 1.

In the next sections we describe the preparation of the main components and the brazing procedure. We hope that this information will be useful for other potential users.

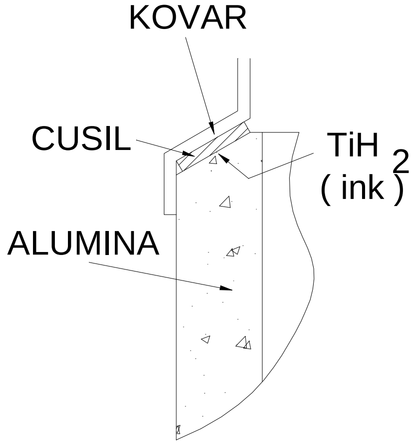

Figure 1: Sketch of the assembly for ceramic-metal joint.

2. Components

2.1 Alumina

The isolators are cylindrical tubes with slanted edges, made with 99.5% pure alumina. Two sizes of tubes are used; for the CF38 flanges, the tubes have diameter 38mm and length 43mm; for the CF63 flanges, the same dimensions are 62mm and 55mm, respectively.

Before the brazing process, special care has to be taken to guarantee proper cleaning of the alumina tubes. They are first submitted to a high temperature, 1000^{o}C, to eliminate dirty and grease, and then a sample piece of the package is checked for quality and purity. This piece is maintained for at least 20 minutes at a temperature of 850^{o}C, in vacuum. Pieces with two much grease or made with improper agglutinator show dark stains after this process and are eliminated. In figure 2 it is shown the photography of a clean piece after being submitted to this heating procedure.

The TiH_2 paint is applied onto the slanted edges of the clean pieces with a soft paintbrush. To control the thickness of the painted layer, the pieces are kept in slow rotation during the process with the paintbrush held fixed. It is necessary to avoid that the paint spreads over the lateral surface of the alumina tube because, during the brazing process, the filler melts and flows over the entire painted region, even against gravity.

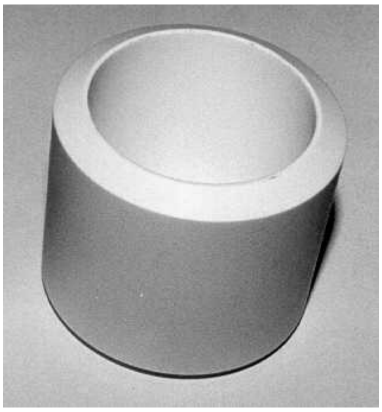

Figura 2: Photograph of a alumina tube after being submitted to the heating procedure.

2.2 Kovar

The kovar metal is chosen as an intermediate piece between stainless steel and ceramic because it has a coeficient of expansion similar to the ceramic material, so that rupture of the welding is avoided [1] .The kovar cups are 26 mm high and have two diameters, 63mm and 50 mm. They are made by dynamically pressing kovar plates, of 92 mm diameter, against a rotating mold held in a lathe machine. Different tools are used to obtain the required profile, shown in figure 3.

Figura 3: Photograph of the kovar metal after spouting operation.

2.3 CuSil

The CuSil plates are made from 50 μm thick foils, which are cut in a ring shape, so that, when the ends are joined, a conic surface is formed which matches the slanted edges at the alumina tubes (figure 4).

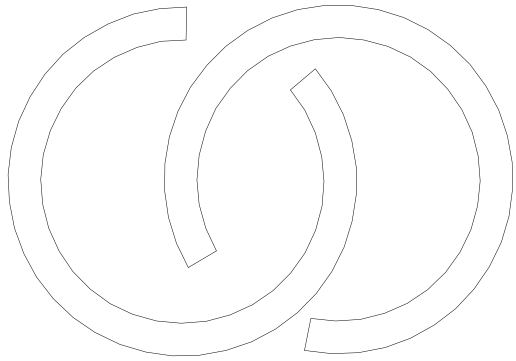

Figure 4: Sketck of the CuSil fillers used on the conic surfaces of the ceramic tubes .

Brazing process

The brazing was processed inside a vacuum oven putting the filler CuSil between the kovar cup and the ceramic (figure 5). After assembling, the pieces are put inside a capsule adapted with a hole in which a termopar to control the brazing temperature is installed (Figure 6). The capsule keeps a good uniform temperature on the entire brazing surface. Both the kovar and the CuSil filler are cleaned for 10 minutes, before the brazing process, in an ultrasonic acetona bath. Another benefit of the capsule device is to provide a good contact of the filler with the alumina.

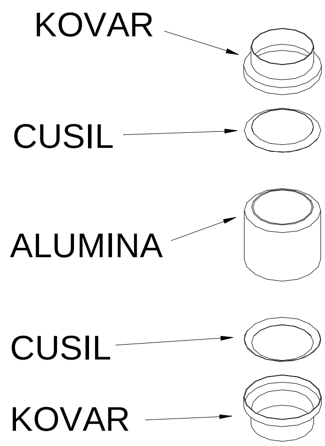

Figure 5: All view of the brazing components.

Figure 6: Capsule device used to brazing.

The temperature is increased at a rate of 2°C/min, aproximately, until a plateau of 780°C is reached in the oven; this temperature is kept for 10 min. The CuSil filler melts and the titanium moves through the alumina and kovar metal, consolidating in a metal alloy. The temperature in the brazing process has to be kept within 5% of the optimum value, 780°C. A much lower temperature prevents metal alloy formation and much above causes early evaporation of the filler.

The success of the brazing can be visually checked by the appearance of a gold yellow colour that indicates the presence of the CuSil filler. We had success with all pieces, which were checked for vacuum leaks in a leak detector with 10^{-10} sensibility.

3. Conclusion

In beginning we had many feilures due to ceramic cleaning, missing filler, excessive time during the brazing plateau and even with brazing temperature control. Nevertheless, we had success completing good brazing operation for twelve feedthroughs of CF63 size and six of CF38 size (Figure 7).

Figure 7: Photograph of one unit of feedthrought after the brazing process.

The estimated cost of producing one piece, including importation of kovar and filler, is US$ 350.00, to be compared with the cost of US$ 1500.00 of importing an unit.

Figure 8 shows a view of the feedthrought tower above the test vacuum vessel with two pieces of the feedthroughs assembled.

Figure 8: Photograph of the feedthrought assembled on the vacuum vessel.

4. Acknowledgments

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