ELECTROPOLISHING OF NIOBIUM MONO-CELL CAVITIES AT HENKEL ELECTROPOLISHING TECHNOLOGY LTD. (GERMANY)

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Abstract

A system for electropolishing niobium 1.3 GHz cavities has been built by Henkel Electropolishing Technology Ltd. (Germany). The system allows electropolishing of mono-cell cavities. The process includes rinsing with hot ultrapure water and diluted nitric acid after the electropolishing process to reduce the risk of a surface contamination by salt residues from the acid mixture. Final cleaning procedures take place in a classified clean room. Two mono-cell cavities have been electropolished showing gradients exceeding 30 MV/m. A modification to electropolish multi-cell cavities is underway.

CAVITY PREPARATION AND TEST SEQUENCE

For the preparation of superconducting cavities electropolishing (EP) of the niobium surface is a key technology to obtain very high accelerating gradients [1-5]. A facility to electropolish niobium single-cells (up to 4-cells) has been implemented at Henkel Electropolishing Technology Ltd.. Additionally a setup for rinsing with diluted nitric acid and high pressure water rinsing has been built. Before shipment the cavities can becleaned and finally packed inside the existing cleanroom infrastructure available at Henkel. The detailed preparation and measurement sequence is as follows:

- degreasing (US-cleaning + pure water rinsing)
- electropolishing (electrolyte 1 x HF : 9 x H2SO4 ; horizontal set-up)
- rinse with diluted HNO3
- high pressure water rinse
- final cleaning in Henkel cleanroom (rinse with hot ultrapure water)
- transportation into DESY cleanroom
- assembly of top flange
- high pressure water rinse (> 2x)
- assembly of antenna with vacuum connection, pumping + leak check
- first vertical test
- low temperature heat treatment between 100 C 140 C (“in-situ bake”)
- second vertical test

The final high pressure rinsing is done at DESY after the installation of the top flange equipped with the pickup antenna to avoid particle contamination from this assembly.

Figure 1: Setup for electropolishing

Figure 2: Setup to rinse cavity with diluted nitric acid and ultrapure water

TESTS OF CAVITIES

In a first test series two cavities have been electropolished at Henkel. A seamless spun cavity manufactured by E. Palmieri (INFN Legnaro) [7] and a standard welded cavity. Both cavities have been electropolished at CERN before in the framework of a collaboration on electropolishing single-cell cavities together with CEA Saclay, CERN and DESY. Therefore it was well known that the cavities were performing up to gradients above 30 MV/m without any sign of a serious defect. These reference measurements are shown in the figures 3-6 together with the results obtained after electropolishing at Henkel.

Measurements without ‘in-situ’ Bakeout

In order to get more data on the ‘in-situ’ bakeout effect [6] both cavities were tested directly after electropolishing. In both cases the performance of the cavities is very similar to the behaviour after the ‘reference’ CERN EP. The achieved gradient as well as the well-known strong degradation of the quality factor at high fields can be seen. During these measurements no X-ray emission could be detected, so that field emission loading can be excluded. This is a clear sign that the EP at Henkel is performing in the same manner as it was done at CERN.

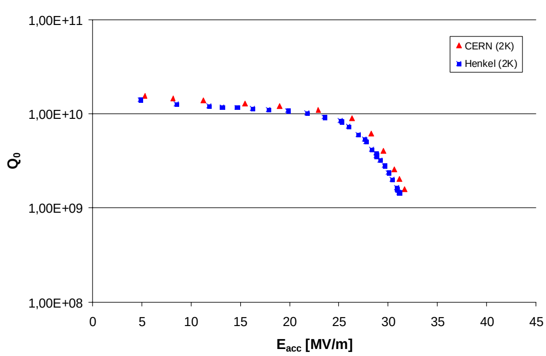

Figure 3: Test of the spun cavity after CERN EP and Henkel EP. The tests were done before in-situ bake. The typical Q-slope can be seen.

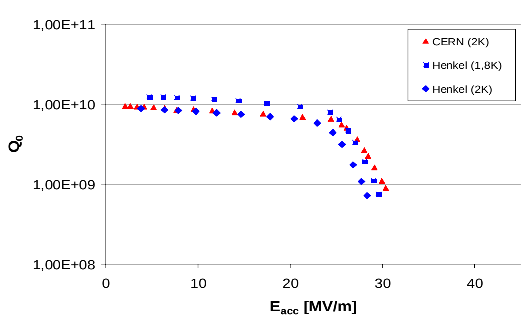

Figure 4: Test of a welded cavity after CERN EP and Henkel EP. The tests were done before in-situ bake. The typical Q-slope can be seen.

Measurement with ‘in-situ’ Bakeout

After these successful tests an ‘in-situ’ bakeout at 130°C was performed. The spun cavity unfortunately suffered from strong field emission during the test after bakeout. Strong emission of X-rays could be observed. Therefore a new high pressure water rinsing was performed. The field emitter was completely removed. X-ray emission was reduced to below the measurement threshold. A gradient of more than 32 MV/m could be achieved. Nonetheless, a degradation of the quality factor could be observed. Presently it is unclear, why the slope was not completely cured by the bakeout.

The welded cavity showed also X-ray emission after bakeout. Additionally, a cold leak appeared so that the test ended prematurely. A second test with after new assembly of flanges and high pressure rinsing yielded 30 MV/m.

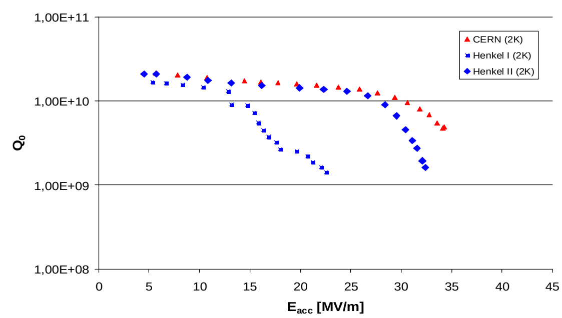

Figure 5: Behaviour of the spun cavity after in-situ bake. The CERN test shows good performance of 35 MV/m. The first test after EP at Henkel was suffering from strong field emission due to problem during the baking preparation at DESY. A new high pressure rinsing improved the performance to fields above 32 MV/m.

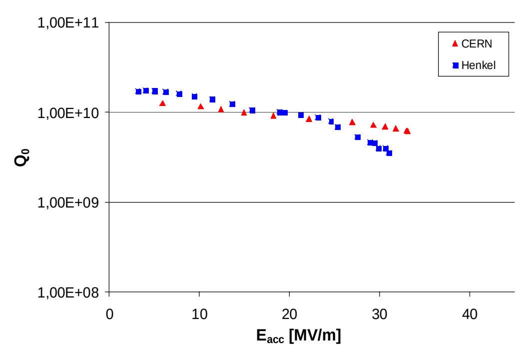

Figure 6: Behaviour of welded cavity after in-situ bake. The CERN test shows good performance of 33 MV/m. The first test after EP at Henkel was suffering from a vacuum leak. The cavity degradation starting at 20 MV/m is due to this problem. The maximum gradient is 31 MV/m. A new test is under preparation.

CONCLUSION

Electropolishing at Henkel gives very similar results to the CERN EP process before in-situ baking. The surface aspect is very similar to the CERN EP. This promising result shows that the EP process can be transferred to industry and yield good results.

Due to problems in the preparation and the in-situ bake at DESY the final gradient is limited to values around 32 MV/m. Further cavities will be treated soon. A modification for the treatment of 2-cells and 3-cells has been implemented

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