UPDATE ON THE JRA1 PROJECT RESULTS OF ELECTRO-POLISHING OF MULTI-CELL SUPER CONDUCTING RESONATORS

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Abstract

Under the contract RII3-CT-2003-506395 of the European Union improvement on the electro-polishing (EP) of multi cell resonators are made. Several methods to improve resonator performances are studied. Improvement of electrode shape, simulated by numerical computer codes and test set ups are presented. With respect to reproducible cavity performances and industrialization of the EP process, a study for quality control by acid management is started. An automated EP system is developed at INFN Legnaro / Italy and within the collaboration of Legnaro and DESY this automated steering will be integrated into the DESY EP facility. We will report on the status of the WP 5.2.2.and the progress of the transfer of the automated EP

INTRODUCTION

Within the framework of the CARE JRA-SRF program, promoted by the European Union under the contract RII3-CT-2003-506395, improvements were made within the electro-polishing processes of multi cell resonators.

Actually a non homogeneous removal at the iris and equator is observed [Ref.1]. To ensure that all areas of the resonator are polished significantly, a redesign of the electrode shape is started. A computer based development of a new cathode shape to improve the electro-polishing process shows a good progress. A prototype electrode will be fabricated and tested at DESY.

With the automated EP, developed at Legnaro/Italy [Ref.:2], improvements and stabilization of the electro-polishing process can be expected. The transfer of the automated EP process is on the way.

To implement a quality control of the EP process, some efforts in acid management are made. Two aspects of the acid management, the on-line control of the acid during the process and the inspection of incoming deliveries of the acid, are examined.

IMPROVEMENT OF THE ELECTRODE SHAPE

With the help of the simulation software Elsy2D of the company Elsyca [®1] the shape of the existing electrode is calculated [Fig.1]. The calculated cathode shape shows a maximum current density of 2,69 A/dm² in the equator region and max. current density of 21 A/dm² in the iris region. An average current density of 5A /dm² is calculated. Good agreement between calculated current density distribution and removal distribution, measured by RF measurements [Ref3], is found.

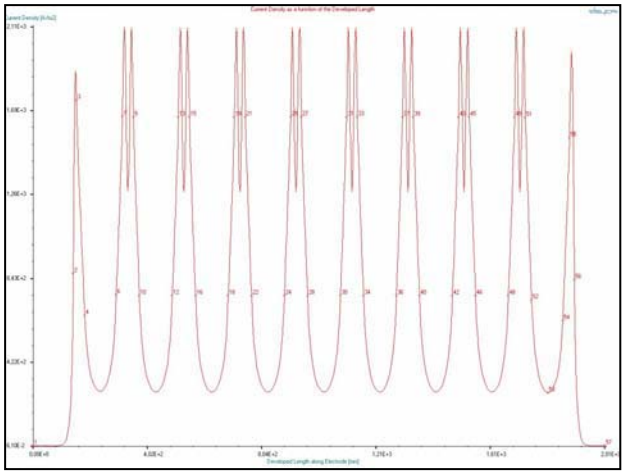

Figure 1: Computation of the existing DESY Electrode design

Various new designs of electrode shapes are calculated and optimized in respect of better current density distribution for homogenous removal. The optimized electrode shape, found so far, is shown in Figure 2

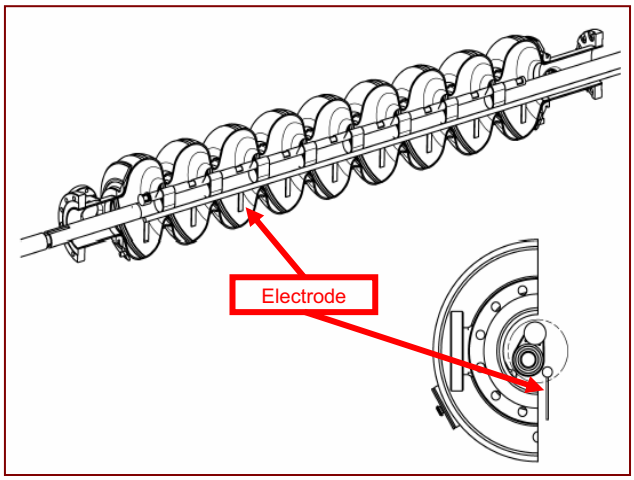

Figure 2: New optimized electrode design with a swinging out electrode extension

The computation of the new electrode design shows a more homogenous ratio between the min. and max.

current density value which is calculated to be 37 A/dm² at the iris and 18,1 A/dm² at the equator.
The ration of Max current density to Min current density of the existing electrode is 7,8 and can be reduced down to 2,05 for the new design.
The new electrode with the optimized cathode shape (Fig.2;3) is under construction and design now.

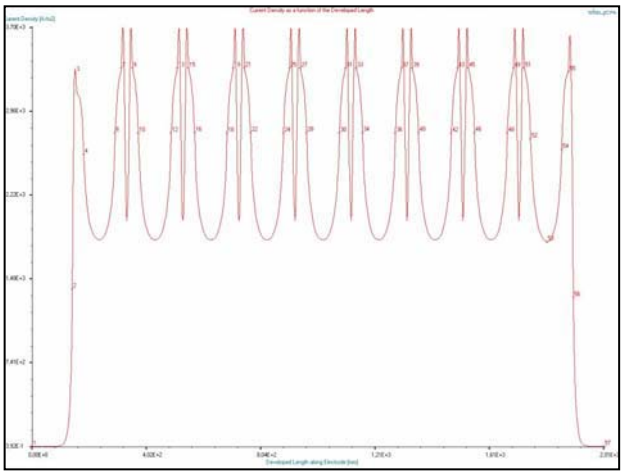

Figure 3: Current density distribution calculated by ELSYCA software [® 1] for the optimized electrode design (Fig.:2)

TRANSFERE OF THE AUTOMATED EP FROM INFN LEGNARO/ITALY TO DESY/GERMANY

Within the EU JARI 1 WP 5 the partners from INFN Legnaro developed the technology to automate and optimize the electro polishing process. The automated EP

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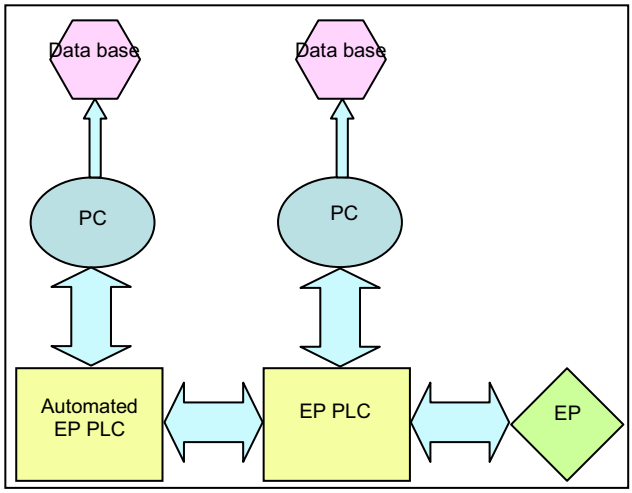

Figure 4: flow scheme of data transfer of the PLC extension for the automated EP plant

determines the I/U curve and follows the relative minimum of the curve (Fig.5). The voltage applied for the EP process is corrected in respect to the aging of the acid. Thereby the process runs more stable. The detailed knowledge on the automated EP and the set up of AEP is under transfer from the Legnaro institute to the DESY nine cell resonator EP facility now. Several meetings and a training of DESY personal took place at Legnaro. For the transfer of the automated EP an additional PLC unit, which has to communicate with the existing PLC, needs to be inserted and implemented into the software, controlling the DESY EP set up, without loosing any safety feature installed in (Fig.4). The hardware for multi cell application is under construction and the necessary hardware extension of the DESY PLC controlling the DESY EP bench is ordered.

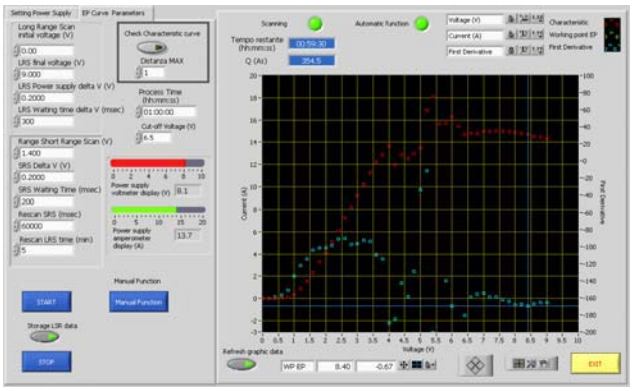

Figure 5: Screenshot of the Labview surface of the automated EP at Legnaro

QUALITY CONTROL BY ACID MANAGEMENT

An important point for a stable electro polishing process is the acid management. This contains two different methods of chemical analysis, first the online analysis of the acid and secondly the inspection of incoming acids.

Inspection of Incoming Acids

To find suitable methods for the analysis of the EP acid mixture, a study was placed to Henkel Lohnelektropolitur [® 2]. Background of the study is to determine the composition of the acid qualitatively as well as quantitatively in a production foreseen for the XFEL project. This study is done in three steps. In the first step the market of commercial available chemical analysis instruments is analyzed and nine different analysis methods are tested in respect to their applicability and cost. From this analysis three methods are chosen as best candidates [4] and will be examined in more detail in respect to sensitivity and reproducibility in the second part of the study. In part three it is foreseen that this instruments will be tested in the filed during the EP processes at DESY and at the supplied of acid.

Table 1: Examined analysis methods in part 1 of the acid management study (Highlighted methods are chosen as best candidates for the following steps of the study).

Method	**Type of Analysis**
AAS	Elemental Analysis
ICP-OES*	Elemental Analysis / all E. parallel
IC Ion Chromatography	Ions (SO4, F-, FSO3H)
TOC Total Carbon	Organically Impurities
FTIR-ATR (Infrared)*	Ions (SO4, F-, FSO3H)
NMR	Organically Impurities
Capillary Electrophoresis	Ions (SO4, F-, FSO3H)
ITP Isotachophoresis	Ions (SO4, F-, FSO3H)
Titration*	Total Acidity

SURFACE CLEANING BY OXI-POLISHING

Cavity limitations by field emission are one of the major limitations reported during the last years. It can be assumed that a removal of a few nm of the Nb surface will also remove particulates fixed on there. Actually no cleaning method for dressed cavities, with exception of a BCP treatment, is reported. Oxi-polishing could be a method to serve as minimum surface removal without major impact on the cavity surface and being applicable on dressed cavities as well. The oxi-polishing process is a two step procedure (Fig.7). In the 1st step the Niobium surface is anodized and builds up a niobium pent oxide (Nb_2O_5) layer. In the 2nd step the oxide layer is removed by hydrofluoric acid. Depending on the voltage applied in step one the oxide layer can be build up from some Å to 100 Å.

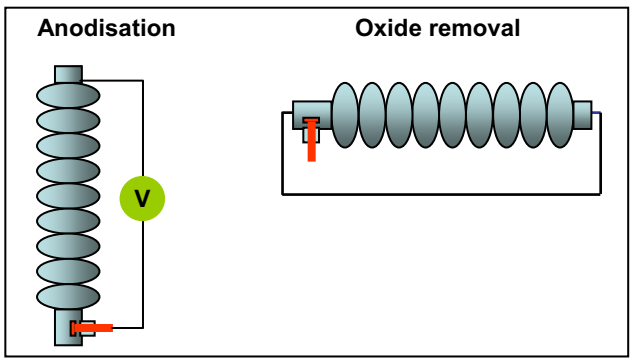

Figure 7: Principle scheme of the two oxi-polishing steps proposed fo the DESY cell resonators

For the test application of nine cell resonators a DESY setup for anodizing of resonators is build up (Fig.8) and will be tested soon. The removal of the Nb2O5 layer will be done in the Ep apparatus where the Ep acid mixture will flush the cavity without voltage applied.

Figure 8: Test apparatus to anodize the cavity for test of surface cleaning by oxi-polishing at DESY

CONCLUSION

In the field of Electropolishing improvements are achieved within some tasks by support of the EU financed Care program. These improvements on automation of the process, the industrialization of the acid management and the test of cleaning method's like oxi-polishing will have a positive influence on the industrialization of the EP-process and the application at the XFEL project.

ACKNOWLEGMENT

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[4] Investigations on electrolyte management, C.Hartmann; TTC Meeting September 2006 KEK Japan.
[®1] ELSYCA Kranenberg 6 B-1731 Zellik Belgium
[®2] Henkel Lohn Elektropolitur, An der Autobahn , Neustadt Glewe Germany