PROCESSING OF TTF CAVITIES AT DESY

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Abstract

The superconducting (s.c.) 9 cell-cavities of TESLA /TTF design are produced by industry. The preparation by surface treatments like chemical etching (buffered chemical polishing (BCP)), electro polishing (EP), high pressure rinsing (HPR) and the assembly take place inside the TTF clean room. At first the cavities are treated without their individual He-vessel for the acceptance test. This test is done vertically in cw mode operation at 2 K. After meeting the specification (E_{acc} > 25MV/m; Qo >5 *10 ^{9}), the cavities are welded into their He-vessel. Also this is a complex procedure with several steps and up to now standardized for BCP-cavities only. After this welding process the BCP treated cavities get a final chemical etch. This final preparation step can not be applied to electro polished resonators. Here a HPR is done for preparation of module assembly. As an option, the cavities can be tested in a horizontal cryostat (CHECHIA).

Finally eight cavities, each equipped with pick up antennas for higher order mode (HOM) absorption, field probe and the power coupler, are connected. One beam position monitor (BPM) and one s.c. quadrupole complete the TTF module string assembly.

The actual cavity preparation process at DESY will be represented in flow diagrams. The difference between the He-vessel-welding-procedure of etched cavities and the first attempt for EP cavity vessel-welding will be shown. We will summarize cavity preparations and cavity test results of the last year. In several cases correlations between preparation expiration and the cavity performance will be discussed.

INTRODUCTION

It is well known that a damage layer of about 100µm of the Nb bulk material has to be removed from the inner surface of a s.c. cavity by BCP or EP to obtain a good rf performance of s.c. cavities.

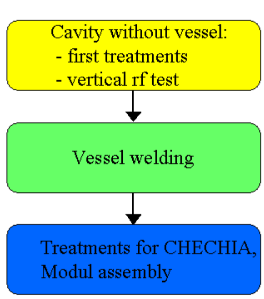

Figure 1: Flow diagram of the cavity process at DESY.

For both cases the whole cavity process, done at DESY, is shown in figure 1. The process can be separated into three sections:

1. Cavity without vessel.

Here all treatments are included that are done on cavities without He vessel. This preparation process is followed by the acceptance test in the cw mode.

2. The He-vessel-welding-procedure.

Two rings and the He vessel are welded to the cavity. This is complex procedure with several steps.

3. CHECHIA Test

The cavity gets its final treatments for the so called CHECHIA Test, a pulsed rf test in the horizontal state [1]. After the CHECHIA Test 8 cavities are connected to a complete module string.

In the first paragraph these three sections are shown in more detail in the flow diagrams of figures 2-4. Starting by the preparation sequences, necessary for the vertical rf test, the standardized BCP process is described. This is compared to our first experiences of processing an EP resonator for the CHECHIA Test. Especially for the vessel-welding-procedure the processes differ and are described in detail.

The often used and standardised procedures of the cavity process, especially done in the clean room, are described at the beginning of the first paragraph. Finally rf results of cavities, which have under gone the described treatments are presented and discussed in the second paragraph.

CAVITY PROCESS

Often used treatments are explained in the following and are shown in the flow diagrams.

Standardized Treatments

First treatments

After delivery a layer of 80µm Nb is removed by BCP and the cavities are rinsed in ultra-pure water (UPW). After that the cavities are annealed at 800°C to remove hydrogen from the Nb. In addition most cavities are annealed up to 1400°C in order to improve the heat conductivity and to reduce the oxygen contain in the Nb [2]. This procedure includes the titanisation of the cavity surface and the removal of the titanium layer by BCP after the treatment. In the following these treatments at the beginning of the cavity process will not be discussed in detail.

2-stage-cleaning

To enter the clean room the cavity has to be cleaned up. Residues on the cavity surface are removed by so called carwash and ultrasonic cleaning.

Table 1: The assemblies and installed components.

Assembly	components
Flanges 1	pickup, pump flange, remaining flanges blind
Flanges 2	pickup, pump flange, HOM s with fresh etched antennas, remaining flanges blind
Pumpflange	Pumpflange
Coupler	power coupler
Ring welding	pickup with HOM-antenna, power coupler with small Cu-Antenna, remaining flanges blind
Fieldprofile	fieldprofile-measurement-system
Antenna	variable antenna

In the material sluice of the TTF clean room a cavity gets its first cleaning by the car wash cleaning . Here a water jet of 100 bar pressure of decalcified water and a 3% solution of Tickopur R33 (produced by Bandelin) is sprayed on the cavity surface to solve grease and oily contaminations. Then the solvent is rinsed away by the 100 bar water jet of decalcified water. Without an intermediate drying the cavity is carried into the class 10000 area.

Here a second cleaning in an ultrasonic bath is done: At a temperature range from 44°C to 50°C the cavity is cleaned by ultrasound for 25 minutes in a 3% solution of Tickopur. After the US cleaning process the cavity is rinsed in a second bath with ultra-pure water. The purity of the water is monitored by the electrical resistance. At the start of the rinsing the specific electrical resistance is18.2 MΩcm. The cavity is rinsed until the specific electrical resistance, measured in the draining line of the bath, has reached 12,4 MΩcm. Usually this value occures after 7-10 minutes. A higher electrical resistance cannot be reached, because of the solved CO_2 in the ultra-pure water. For drying the cavities are stored in the class 10 or 100 area.

BCP

For the BCP process a mixture of 1 volume part HNO3 (65%), 1 volume part HF (40%) and 2 volume parts of H3PO4 (95%) is in use. The acid mixture is pre cooled to 9°C and reaches a temperature below 20°C during the polishing inside the cavity. After polishing the cavity is immediately rinsed with ultra-pure water to take out the acid. This final rinse is done in a closed loop until the specific electrical resistance of the water has reached 18 MΩcm.

High pressure rinsing (HPR)

To remove particles from the cavity inner surface high pressure rinsing at 100 bar with ultra-pure water is done. The water is coming out of 8 nozzles on top of the feeding cane, which moves up and down inside the cavity while the cavity is rotating.

During one about 2 hours lasting rinse up to 2000 l water are sprayed onto the surface. During the HPR the water, draining of the cavity, is controlled. An inline particle filter, which can hold back particles of more than 3 µm size is scanned under a light microscope after each HPR. After flange assembly (see below) the cavity is rinsed two times. Between the HPR sequences the cavity is taken out of the rinsing stand, turned by 90 degree to drain water out of the He vessel cones. (They are part of the cavity. On the cones the vessel rings will be welded). The cavity is stored in class 10 clean room area. After that about 15 minutes lasting drain the cavity is rinsed again. For drying the cavity is put into the class 10 overnight.

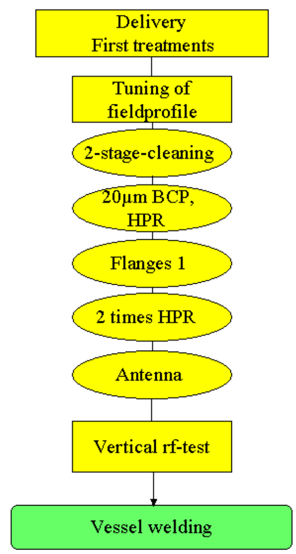

Figure 2: Preparation for the vertical test. Treatments done inside the clean room are shown in elliptical shape, outside in rectangular shape.

Flange assembly

Several kinds of assemblies are done in class 10. The components to be installed during the assembly steps are shown in table 1.

First all components, including screws and nuts, are cleaned in the ultrasonic-bath and rinsed with UPW. After drying in class 10 the residual particle contamination is controlled before installation of components to a cavity. All components are blown very carefully by ionized and particle filtered (0.02 µm filter size) nitrogen gas. The number of particles blown off is controlled by an air particle counter.

For assembly each flange is fixed to the cavity with two screws to seal this connection particle tight . After closing the last flange the remaining screws are set and all bolds are fixed.

For power coupler assembly the cavity is vented with Argon of 100 mbar over pressure. This will cause an ultra clean gas flow out of the cavity flange during opening a flange connection and will prevent particle movements towards the cavity.

After disassembly of the blind flange the power coupler is pushed towards the cavity and fixed with two screws to close the connection particle tight. Finally the remaining screws are set and strongly fixed after.

Cavity Without Vessel

In figure 2 the treatments for the rf -acceptance test of a BCP cavity are shown.

Before preparation for the acceptance test the cavities are tuned to a field flatness of more than 98 %. After the 2-stage-cleaning a final BCP treatment of 20 µm removal in fresh acid is done. The flange assembly is followed by 2 times HPR and the installation of the variable antenna.

Then the cavity is installed in an insert for the vertical rf measurement. After passing this rf acceptance test successfully the cavity is welded into the He vessel.

Vessel Welding

Up to now the electro polishing can not be applied on cavities covered by a He vessel. Therefore the standardized vessel-welding-procedure of a BCP cavity has to be changed for EP cavities (Figure 3).

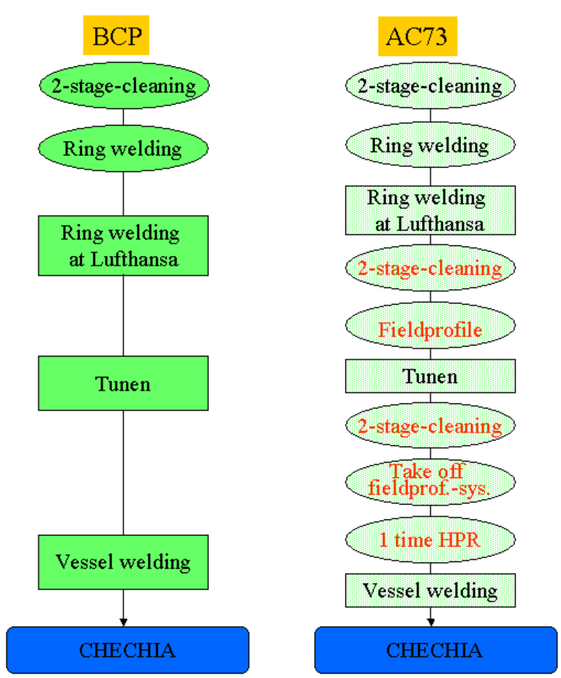

Figure 3: Vessel-welding-procedure. The standardized procedure of BCP cavities is compared to the treatments done at the electropolished cavity AC73.

The vessel-welding-procedure is divided into two independent processes. First two Ti rings are electron beam welded to the Nb cone. Second the cavities are inserted into the Ti vessel and the welds, necessary to close the vessel, are made by TIG welding.

First there are no differences between a BCP cavity and the treatments done during the first vessel welding of an elctropolished cavity (AC73). For the welding of the Ti rings two antennas for mode spectrum measurements during the welding process are installed to control deformations during welding and handling of the cavity (see table 1.). The cavity is filled with ultra clean Argon at normal pressure.

After ring welding at the company Lufthansa and a successful leak check of welds the flanges of standard BCP cavities are disassembled for the final field profile tuning and frequency adjustment . The tuning apparatus is not located inside a clean room. The pi mode frequency of BCP cavities is adjusted with an offset for a final 20 µm BCP treatment done before CHECHIA Test and module assembly.

In comparison to a BCP cavity the tuning of an EP cavity like AC73 needs quite more steps, because up to now an EP cavity cannot be electropolished with vessel. Usually a BCP cavity gets its final BCP after vessel welding to get off the contamination inside the cavity taking place during the vessel welding procedure with open cavity. For EP cavities there is no possibility of such removing. So outside the clean room an electropolished cavity has to be sealed against particle contamination at any time.

Therefore AC73 could not be opened outside the clean room. Inside the clean room a closed fieldprofile-measurement-system was assembled to the cavity. Fieldprofile adjustment and frequency tuning for vessel welding were done, while the cavity interior remained sealed against particle contamination.

Due to the fact that no final surface removal can take place on EP resonators the frequency was set to the final frequency before vacuum installation and cool down.

Before vessel welding the fieldprofile-measurement-system was removed to prevent outgasing of the system during welding. A short HPR was applied after removing the measurement-system inside the clean room and the cavity was filled again with ultra clean Ar.

After tuning an open BCP cavity (or the closed AC73 respectively) is inserted into the Ti vessel and the vessel is closed by three TIG welds. Now the cavities are ready for the CHECHIA preparation.

Treatments for CHECHIA

In figure 4 the process for standard BCP cavities and the treatments done at the EP Cavity AC73 are compared to each other.

After a final BCP of 20µm Nb a BCP cavity is assembled and high pressure rinsed two times. Due to the effect that the power coupler can not undergo the HPR cleaning without loosing the rf training, the power coupler is inserted into BCP and also EP cavities after the last HPR. Then the BCP cavity is installed in the CHECHIA cryostat, finished by testing the cavity with rf-power.

Cavity AC73 did not get a final EP as explained before. Instead of it was high pressure rinsed 6 times after assembly. The measurement of the spectrum in the warm state showed a too strong coupling of the pickup. So the antenna had to be changed. The cavity was carried back to the clean room. Due to the assembled power coupler the cavity could not washed by ultrasound. It was wiped carefully with ultra-clean alcohol. Then the power coupler of AC73 was disassembled, the pickup antenna was changed and the cavity was again high pressure rinsed 6 times. As the flow diagram shows the treatments are completely repeated a second time.

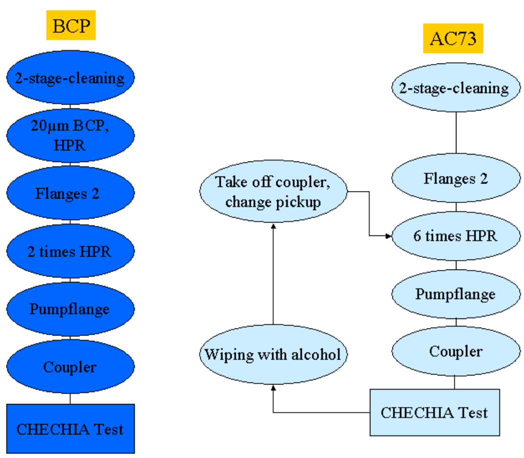

Figure 4: Treatments for CHECHIA. The BCP process is compared with treatments done at AC73.

At last the CHECHIA test was done. The cavity reached 35 MV/m without fieldemission, followed by a long time test of more than 1000 h at 35 MV/m.

CAVITY TEST RESULTS

The cavity results of the vertical rf tests for the last twelve months at DESY are shown in figure 5. You can see the change of the rf performance of cavities, which were the tested several times, due to the treatments done at the cavities.

The electropolished cavities apart from AC70 reached very high gradients from 27 up to 35 MV/m. They will be used in the future for a high gradient module. To find out the best cavities for the assembly of module 2*, cavities with low gradients were treated and tested again in order to repair them. The history of the tested cavities is shown below.

AC78 reached at the end of last year 33 MV/m and fell down to 15MV/m, because during ring welding at the Lufthansa a small antenna fell into the cavity. Therefore the cavity showed strong field emission. After

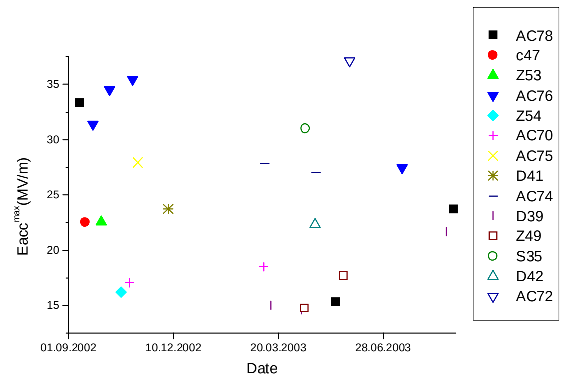

Figure 5: Rf test results. The highest reached gradients of all vertical tests done at DESY since the last twelve months are shown.

electropolishing at DESY and baking at 120°C it reached 23.7 MV/m.

AC76 was first tested up to 31 MV/m, after baking at 120°C we reached 35 MV/m. Due to the falling in of a component of field profile measurement system the gradient is reduced to 27 MV/m.

Since delivery AC70 showed strong field emission. This electropolished cavity could not be repaired by additional 18µm Nb BCP.

D39 reached 15 MV/m and showed strong fieldemission due to some scratches close to the iris. The scratches were ground and 63 µm Nb were removed by BCP. After that it reached 21,7 MV/m and showed no fieldemisssion.

Z49 showed also strong fieldemission due to some scratches close to the iris. It will be repaired by EP similar to that done on D39.

CONCLUSION AND OUTLOOK

In the future the electro polishing of cavities [3] and the processing of EP cavities will be established at DESY. Therefore the vessel-welding-procedure for EP cavities should be changed, because until now EP cavities have to be two times more assembled in the clean room than a BCP cavity. In order to avoid this, we are going to involve a fieldprofile-measurement-system, which can be mounted once for the whole vessel-welding-procedure. The preparation for the CHECHIA Test also has to be checked, especially the number of HPRs after assembly.

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