ISBN: 978-3-95450-191-5 doi:10.18429/JACoW-SRF2017-MOPB003

A NEW HIGH RESOLUTION OPTICAL SYSTEM FOR INSPECTION OF GUN- AND MULTI-CELL RESONATORS IN ISO-4 CLEANROOMS

Marco Schalwat, Ruediger Bandelmann, Alexej Daniel, Nicolay Krupka, Axel Matheisen, Sven Sievers, DESY, Hamburg, Germany

Abstract

Optical inspection of the inner surface of superconducting resonators was established during European XFEL cavity production by usage of the so called OBACHT optical inspection [1]. In addition to the surface inspection by OBACHT a new optical inspection system with integrated high resolution camera is set up at DESY. It allows inspection of multi-cell resonators as well as gun cavity resonators with only single side accessibility to the inner surface. A prototype was commissioned and optical inspections were done with OBACHT and the new system in parallel. Two SRF gun cavities were inspected by this optical system and origin of limitations of the resonators were identified.

INTRODUCTION

After the European XFEL had been commissioned, tests with SRF gun cavities were done at DESY. These tests have not been as successful as expected. The origin of the problems has been presumed in the welds or inner surface of the cavity. This assumption initiated the development of a new optical inspection system.

If the OBACHT system is used successfully in non-standard cavities it will be necessary to perform a new system without referencing. For the basic settings at the standard OBACHT system, the cavity is needed to be opened on both beam tube flanges, to allow the camera to pass it completely. Our first requirement of the new system was a free view on the back plate of a SRF gun cavity (Fig. 1) or with blind flange closed cavities. Up to now such actions are not feasible with the existing OBACHT system.

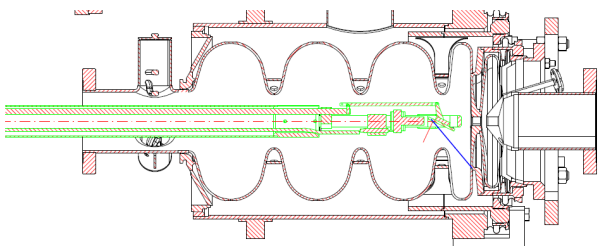

Figure 1: Drawing of 3.5 cell SRF gun cavity with optical inspection system.

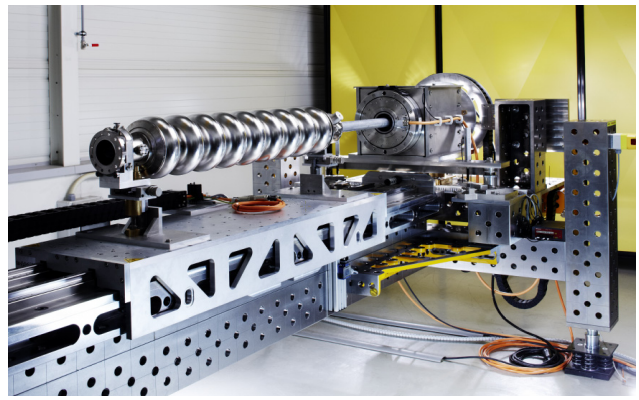

Figure 2: Picture of the OBACHT optical inspection system.

The second purpose was the installation of the new system in a cleanroom. The DESY OBACHT system (Fig. 2) is currently installed in a non-cleanroom area. At the moment it is necessary to transport cavities over long distances within DESY premises for the inspection of the inner surface. After each transport and OBACHT inspection an ultrasonic and UPW rinsing has to be done before the cavity can be used for further actions.

We established a test installation for the inspection of the inner surface of cavities outside the cleanroom to gain experiences on how to set up the new system. The existing devices for the installation of the field profile measurement system (FMS) was modified (Fig. 3).

With the FMS device it was possible to align the camera for the inspection in the centre of the beam tube.

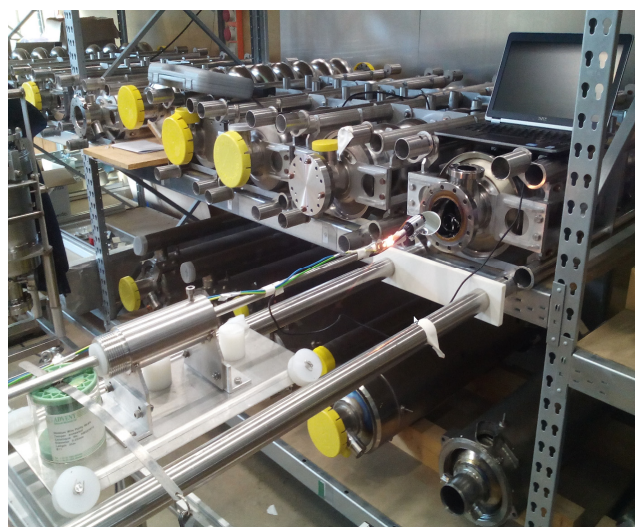

Figure 3: First steps to establish the new system.

ISBN: 978-3-95450-191-5 doi:10.18429/JACoW-SRF2017-MOPB003

A conventional web cam (Fig. 4) was installed in front of the rod, what made it possible to get a horizontal view of the cavity.

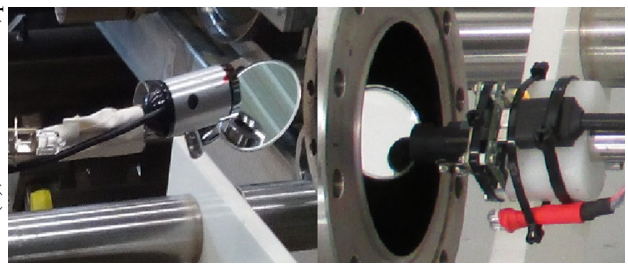

Figure 4: Left conventional camera, Right See3Cam.

It became apparent that the resolution capacity of the conventional webcam is not sufficient for our aim. The inability to create conclusive pictures could be solved by a new camera. A camera designed by e-con System was purchased [2] (Fig. 5).

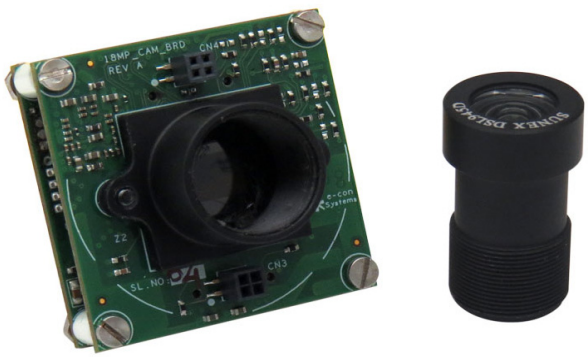

Figure 5: See3Cam_CU 130-13MP USB 3.0.

The camera has the capability of 13 MP optics with manual focus. Usage of USB 3.0 connection is necessary for the data acquisition with standard computer hardware.

To have a glimpse onto the inner surface and the welds, a mirror, connected to the front of the camera optic is needed. Due to that necessity a holder for the fixture of the camera and the mirror was designed and connected.

The conventional OBACHT is equipped with an automatic focus system. A difference between both devices is the focusing. Conventional OBACHT is focusing automatically, the new inspection system is focusing manually. The image sharpness is set with a vernier height gauge (Fig. 6). Small letters, type size 2, were attached to the bottom of the scriber. This modification makes the adjustment of the camera focus easy. We defined an increment of 30° for each picture to ensure an overlap of 7-10° to exclude gabs of a 360° image.

In addition to the new camera a LED lamp with potentiometer, for setting the light intensity was set up to guarantee a perfect illumination of the cell surface. To get reproducible results a linear measurement system was installed (Fig. 7).

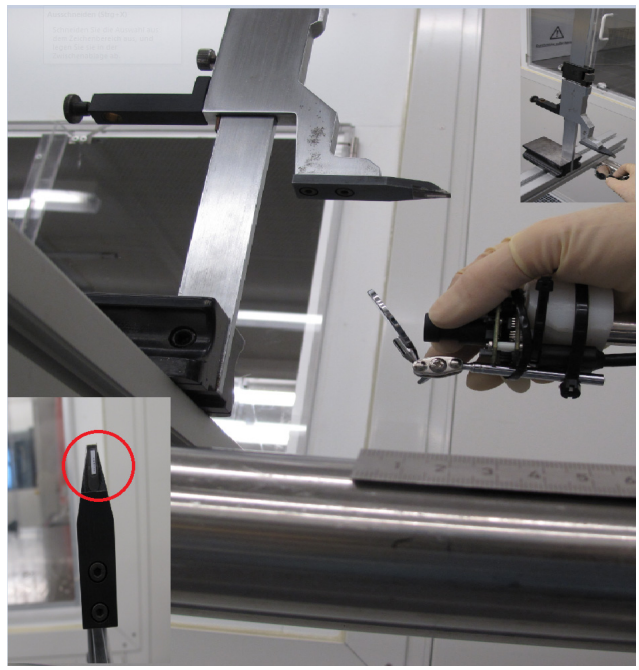

Figure 6: adjustment of the focus via vernier height gauge.

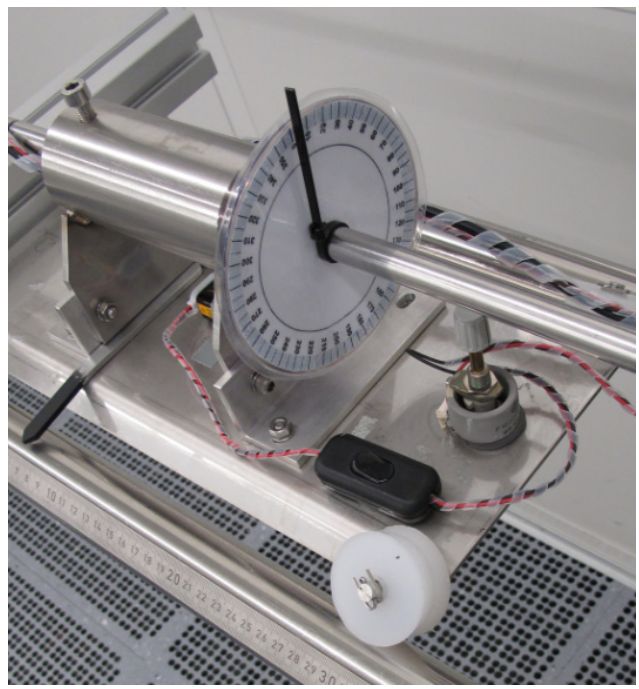

Figure 7: Measurement and orientation tools.

ISBN: 978-3-95450-191-5 doi:10.18429/JACoW-SRF2017-MOPB003

FIRST EXPERIENCE WITH INSPECTION OF CAVTIES

The first cavity which was inspected was a 3.5 cell SRF gun cavity, commissioned for the Helmholtz Centre Dresden Rossendorf (Fig. 8)[3]. This cavity was inspected with a conventional Web Cam.

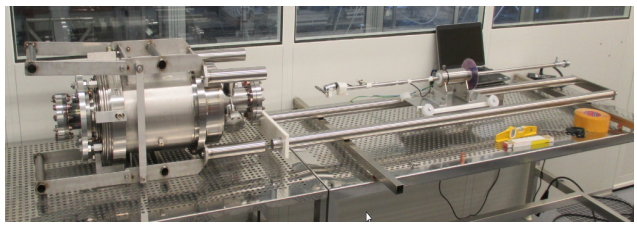

Figure 8: 3.5 cell SRF gun cavity installed in the cleanroom.

Weld Inspection

Our first test set up with the conventional web cam was unsatisfactory. The resolution of the pictures had low quality (Figs. 9, 10).

Figure 9: View to the back plate of the Rossendorf SRF gun cavity with webcam.

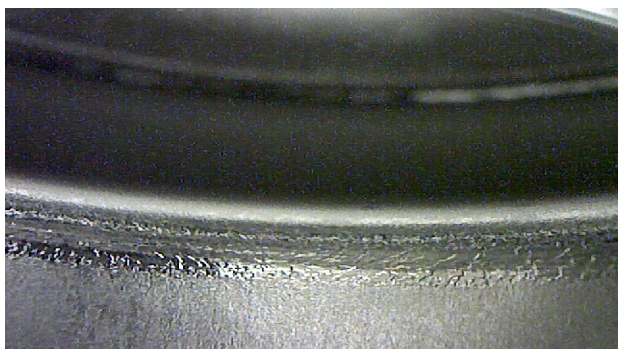

Figure 10: View to an inspected iris weld of the Rossendorf SRF gun with webcam.

After a new camera system had been installed a second inspection on the SRF gun cavity could take place. The quality of the pictures were significantly better (Figs. 11, 12), however no reason for bad measurement results could be detected.

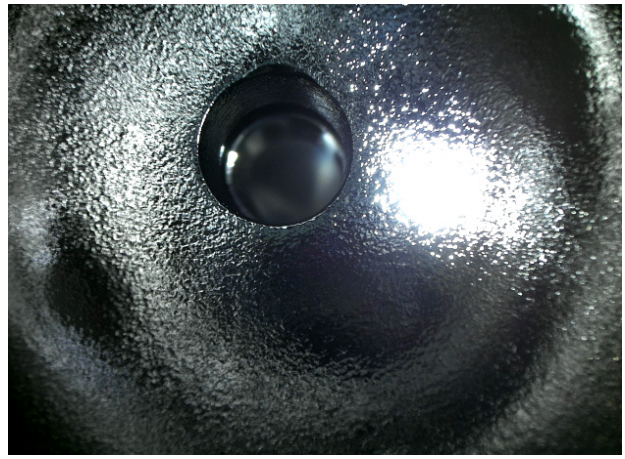

Figure 11: Inspection of the back plate with new camera.

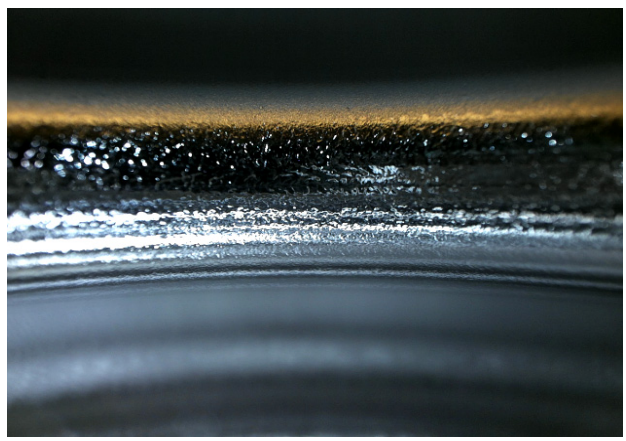

Figure 12: Inspected weld with new camera.

DEFECT ON SRF GUN CAVITY WAS FOUND

The inspection of the 1.6 cell DESY SRF gun cavity has shown irregularities. In the middle of the back plate at the cathode hole, damages were found (Fig. 13). Closer investigations showed indium which is used for sealing of the lead plug.

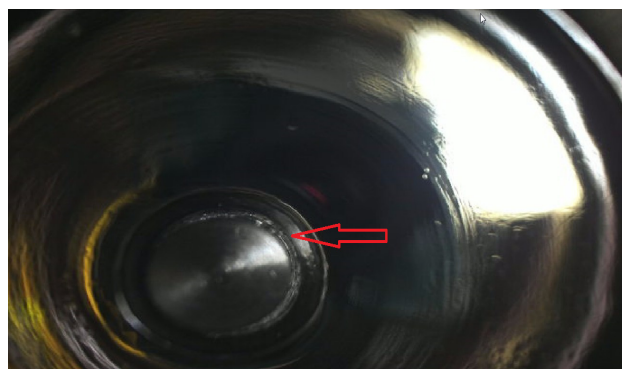

Figure 13: View to the back plate of the DESY SRF gun cavity.

ISBN: 978-3-95450-191-5 doi:10.18429/JACoW-SRF2017-MOPB003

CONSTRUCTION OF A NEW SETUP

The first experiences during the cavity inspections have shown that parts of the device have to be revised.
Due to the thin rod, the weight of the holder and the camera, the rotation of the camera causes vibrations during movement. The minimum number for the new design is an adapter for the camera, a tilted mirror, a rod which is picking up the camera, and a lengthwise adjustment. A new device is under construction.

In the future it will be possible to adjust the mirror during inspection (see Fig. 14). Due to the stiffer rod there will be less vibrations. The lightening will be axial.

A support which can capture cavities up to nine cells, with or without helium vessel, will be included to guaranty a better horizontal orientation.

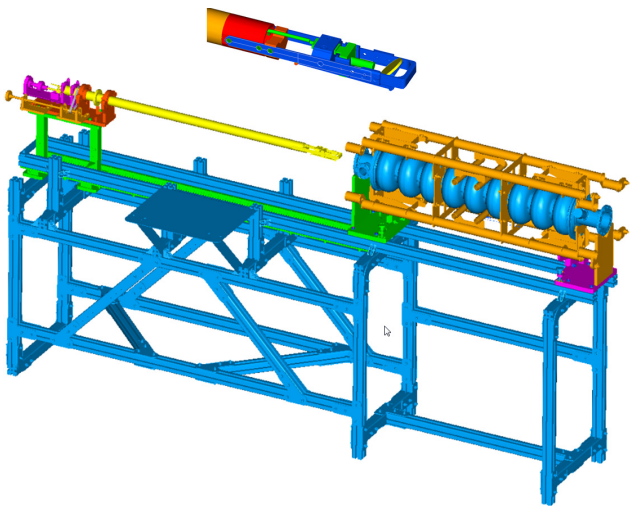

Figure 14: View to the improved device.

SUMMARY

To preserve cleanliness of cavities, whose inner surfaces should be inspected, a new high resolution optical inspection system for non-standard cavities was set up in a cleanroom at DESY. Since the optical inspection system was built and put into operation, four single cell and two SRF Gun cavities (1.6 and 3.5 cell) were inspected.

Visible defects on one SRF gun cavity were detected. It should be noted that, the OBACHT system and the new one are not comparable. OBACHT is fully automated and has higher resolution and the new system is manually operated.

All goals were achieved. Various improvements took place during the first experiences. A suitable device for the compliance of the quality is under construction.

The comprehensive work done for the OBACHT system enabled us to develop a usable optical inspection unit for cleanrooms quickly, cost-efficient and with little implementation difficulties.

REFERENCES

[1] Schlander, F, " OBACHT – Optical Bench for Automated Cavity inspec- tion with High Resolution on Short Time Scales"， *Tesla Technology Collaboration (TTC) Meeting*, IHEP, Beijing, China, 2011.

[2] *See3CAM_CU130 - 13MP USB 3.0*, e-con Systems, Inc, 11027 Sandistan Mancor Ct, St. Louis, MO 63146 USA.

[3] A. Arnold *et al*, "Rossendorf SRF-Gun Cavity Characteristics", *AIP Conference Proceedings*, pp, 1149-1125 2009.